Dictionary of Ecological Economics: Terms for the New Millennium

Brent M. Haddad
Barry D. Solomon

DICTIONARY OF ECOLOGICAL ECONOMICS

This Dictionary is dedicated to the memory of Herman E. Daly (1938-2022), a visionary without whom Ecological Economics would not exist.

Dictionary of Ecological Economics

Terms for the New Millennium

Edited by

Brent M. Haddad

Professor of Environmental Studies, University of California, Santa Cruz, USA

Barry D. Solomon

Professor Emeritus of Geography and Environmental Policy, Michigan Technological University, USA

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CONTRIBUTORS

Fikret Adaman, Professor of Economics at Boğaziçi University, Turkey.

Bernardo Aguilar-Gonzalez, Fellow, Institute for Environmental Diplomacy and Security, University of Vermont, USA.

Mona Ahmadiani, Postdoctoral Research Associate, Department of Agricultural Economics, Texas A&M University, USA.

Emma K. Aisbett, Associate Professor, ANU School of Law, Australian National University, Australia.

Bengi Akbulut, Associate Professor of Geography, Planning and Environment, Concordia University, Canada.

Aura M. Alonso-Rodríguez, PhD Candidate in Natural Resources, University of Vermont, USA.

Ali Eren Alper, Associate Professor of Economics, Nigde Omer Halisdemir University, Turkey.

Jeffrey S. Althouse, PhD Candidate in Economics, Université Sorbonne Paris Nord, France.

Joseph A. Ament, Lecturer in Ecological Economics, University of Vermont, USA.

Tihomir Ancev, Associate Professor of Economics, University of Sydney, Australia.

Jan Otto Andersson, Associate Professor Emeritus of International Economics, Abo Akademi University, Finland.

Mark A. Andor, Head of Research Group "Prosocial Behavior," RWI—Leibniz Institute for Economic Research, Germany.

Diego Andreucci, Postdoctoral Researcher in Economics, Universitat de Barcelona, Spain.

Aurelio Angelini, Professor of Sociology of the Environment and the Territory, Kore University of Enna, Italy.

James C. Aronson, Senior Scientist Emeritus, Missouri Botanical Garden, USA.

Janne V. Artell, Senior Scientist, Natural Resources Institute, Finland.

Graeme Auld, Director of the School of Public Policy and Administration, Carleton University, Canada.

Yuhao Ba, Assistant Professor of Public Policy, National University of Singapore, Singapore.

Michael L.R. Babcock, PhD Candidate in Natural Resource Sciences, McGill University, Canada.

Jean-Baptiste Bahers, CNRS Researcher, Spaces and Societies, Nantes University, France.

Rob Bailis, Senior Scientist, Stockholm Environment Institute, USA.

Abhijit Banerjee, Professor of Environmental Studies, O.P. Jindal Global University, India.

Matthieu Barbier, Researcher in Complex Ecological Networks, Plant Health Institute of Montpellier, France.

Lindsay K. Barbieri, PhD Candidate in Ecological Economics, University of Vermont, USA.

David P. Barkin, Distinguished Professor of Economics, Universidad Autónoma Metropolitana, Xochimilco Campus, Mexico City.

Adam B. Barrett, Lecturer in Machine Learning and Data Science, University of Sussex, UK.

Bartosz Bartkowski, Co-Head of the junior research group AgriScape at Helmholtz Centre for Environmental Research—UFZ, Leipzig, Germany.

Amitrajeet A. Batabyal, Arthur J. Gosnell Professor of Economics, Rochester Institute of Technology, USA.

Giandomenica Becchio, Professor in History of Economic Thought and Methodology of Economics, University of Torino, Italy.

Nicolas Befort, Associate Professor of Economics, Chair in Bioeconomy and Sustainable Development, NEOMA Business School, France.

Victor A. Beker, Professor of Economics, University of Belgrano and University of Buenos Aires, Argentina.

Adrian E. Beling, Director of Global Studies Programme, Latin American Social Sciences Institute (FLACSO Argentina), and Executive Director, Ecocene Foundation, Argentina.

Jeff W. Bennett, Emeritus Professor of Economics, Australian National University, Australia.

Paul M. Bernstein, Affiliate Researcher, Economic Research Organization, University of Hawaii, USA.

Elodie Bertrand, Associate Research Professor of Economics, National Center for Scientific Research, France.

Raoul Beunen, Associate Professor of Environmental Governance, Open University, the Netherlands.

Mahadev G. Bhat, Professor of Natural Resource Economics, Florida International University, USA.

Melike E. Bildirici, Professor of Economics, Yildiz Technical University, Turkey

Allen Blackman, Principal Economic Advisor, Inter-American Development Bank, USA.

Brent Bleys, Associate Professor of Economics, Ghent University, Belgium.

Georg D. Blind, Senior Research Fellow in Economics, University of Zurich, Switzerland.

Sam C. Bliss, PhD Candidate in Natural Resources, University of Vermont, USA.

Véronique C. Blum, Associate Professor of Accounting and Finance, University of Grenoble Alpes, France.

Jessica L. Blythe, Associate Professor, Environmental Sustainability Research Centre, Brock University, Canada.

Carol J. Bond, Senior Lecturer in Management, RMIT University, Australia.

Nicolas Borzykowski, Independent Contractor, Haute École de Gestion de Genève, University of Applied Sciences and Arts Western, Switzerland.

Jacob S. Bower-Bir, Affiliated Faculty, Ostrom Workshop in Political Theory and Policy Analysis, Indiana University, USA.

Joao Paulo Braga, PhD Student in Economics, The New School for Social Research, USA.

Lina Brand-Correa, Assistant Professor of Ecological Economics, York University, Canada.

Tania Briceno, Chief Economist, Intrinsic Exchange Group, USA.

Peter B. Bridgewater, Adjunct Professor of Terrestrial and Marine Biodiversity Governance, University of Canberra, Australia.

Paul E. Brockway, University Academic Fellow, School of Earth and Environment, University of Leeds, UK.

Clair Brown, Professor Emerita of Economics, University of California, Berkeley, USA.

Zachary S. Brown, Associate Professor, Genetic Engineering and Society Center, North Carolina State University, USA.

Karl Bruckmeier, Professor of Economics, South Bohemian University, Czech Republic.

Christa Brunnschweiler, Associate Professor of Economics, University of East Anglia, UK.

Hubert Buch-Hansen, Associate Professor of Business and Politics, Copenhagen Business School, Denmark.

Wolfgang Buchholz, Professor of Economics, University of Regensburg, Germany.

Mark C. Buckley, Partner, ECONorthwest, USA.

Jonah Busch, Climate Economics Fellow, Conservation International, USA.

Richard W. Butler, Emeritus Professor of Tourism, University of Strathclyde, UK.

Louison Cahen-Fourot, Assistant Professor, Department of Social Sciences and Business, Roskilde University, Denmark.

Andres F. Cantillo, Associate Professor of Economics, Kansas City Kansas Community College, USA.

Roberta Capello, Professor of Regional and Urban Economics, Politecnico di Milano, Italy.

Jeremy L. Caradonna, Adjunct Professor of Environmental Studies, University of Victoria, Canada.

Stefano Carattini, Assistant Professor of Economics, Georgia State University, USA.

Javier Carrillo-Hermosilla, Professor of Economics, Universidad de Alcalá, Spain.

Danny P. Cassimon, Professor of Development Policy, University of Antwerp, Begium.

Yi-Fang Chang, Professor of Physics, Yunnan University, China.

Wei-Qiang Chen, Professor, Institute of Urban Environment, Chinese Academy of Sciences, China.

Charlie M. Chesney, PhD Student in Environmental Studies, University of California, Santa Cruz.

Garry J. Claridge, Chief Technology Officer at DataWhispering, Australia.

Rebecca K.M. Clube, Post Graduate Researcher in Environmental Policy, Imperial College London, UK.

Oriol Vallès Codina, Research Fellow in Economics, Leeds University Business School, UK.

Benjamin C. Collins, Post-Doctoral Researcher, University of British Colombia, Canada.

Benjamin R. Cooke, Senior Lecturer, Centre for Urban Research, RMIT University, Australia.

Quentin Couix, Researcher, Centre International de Recherche sur l'Environnement et le Développement, France.

Joshua J. Cousins, Assistant Professor of Environmental Studies, SUNY-College of Environmental Science and Forestry, USA.

Adam T. Cross, Senior Research Fellow in Restoration Ecology, Curtin University, Australia.

Michael Curran, Senior Scientist, Research Institute of Organic Agriculture, Switzerland.

Brian Czech, Executive Director, Center for the Advancement of the Steady State Economy, USA.

Gareth Dale, Senior Lecturer in Political Economy, Brunel University, UK.

Herman E. Daly, Former Emeritus Professor of Public Policy, University of Maryland, USA (Deceased).

R.J. Ranjit Daniels, Founder and Trustee of Care Earth Trust, India.

Silvie Daniels, Postdoctoral Researcher, Center for Environmental Sciences, Hasselt University, Belgium.

Adel Daoud, Associate Professor of Analytical Sociology, Linköping University, Sweden.

Federico Demaria, Assistant Professor in Ecological Economics and Political Ecology, Universitat de Barcelona, Spain.

Corinna Dengler, Postdoctoral Researcher, Vienna University of Economics and Business, Austria.

Pat Devine, Honorary Research Fellow, Manchester University, UK.

Fernando Díaz López, Associate Professor Extra-ordinary of Sustainability Systems, Stellenbosch University, South Africa.

Mark O. Diesendorf, Honorary Associate Professor of Environmental Studies, University of New South Wales Sydney, Australia.

Thomas Dietz, Professor of International Relations and Law, University of Münster, Germany.

Tiziano Distefano, Assistant Professor of Economics, University of Florence, Italy.

Jan-Tobias Doerr, Independent Scholar, Germany.

Brett D. Dolter, Assistant Professor of Economics, University of Regina, Canada.

Sheila C. Dow, Emeritus Professor of Economics, University of Stirling, UK.

Luc Doyen, Senior Scientist, Centre National de Recherche Scientifique, France.

Stefan Drews, Postdoc at the Institute of Environmental Science and Technology, Universitat Autònoma de Barcelona, Spain.

David M. Driesen, University Professor of Law, Syracuse University, USA.

Richard W. Dunford, Owner, Environmental Economics Services, USA.

Quentin Duroy, Professor of Economics and Environmental Studies, Denison University, USA.

Chandni K. Dwarkasing, Postdoctoral Fellow in Economics, SOAS University of London, UK.

Joseph Eastoe, Masters Candidate in Global Environment, Politics and Society, Edinburgh University, UK.

Henrik Egelyng, Development Researcher, Denmark.

Megan G. Egler, PhD Candidate in Ecological Economics, University of Vermont, USA.

Paul W. Ekins, Professor of Resources and Environmental Policy, University College London, UK.

Allison R. Elgie, Custom Success Manager, EcoVadis, Canada.

Jon D. Erickson, Blittersdorf Professor of Sustainability Science and Policy, University of Vermont, USA.

Pinar Ertör-Akyazi, Assistant Professor, Institute of Environmental Sciences, Bogazici University, Turkey.

Shaikh Eskander, Assistant Professor of Economics, Kingston University, UK.

Dennis Essers, Economist, National Bank of Belgium, Belgium.

Iker Etxano, Associate Professor of Applied Economics, University of the Basque Country (UPV/EHU), Spain.

Jordan P. Everall, PhD Candidate in Environmental Systems Science, Wegener Center for Climate and Global Change, University of Graz, Austria.

Malte M. Faber, Professor Emeritus of Economics at University of Heidelberg, Germany.

João Ricardo Faria, Professor of Economics, Florida Atlantic University, USA.

Joshua C. Farley, Professor of Community Development and Applied Economics, University of Vermont, USA.

Sally Findlow, Senior Lecturer in Education, Keele University, UK.

Lorenzo Fioramonti, Professor of Political Economy, University of Pretoria, South Africa.

Marina Fischer-Kowalski, Professor Emerita and Senior Researcher, Institute of Social Ecology, University of Natural Resources and Life Sciences, Vienna, Austria.

Gary Flomenhoft, Co-Director, Southern Moreton Bay Islands Community Land Trust, Australia.

Stephen G. Flood, Senior Postdoctoral Scientist, Irish Climate Analysis and Research Units, Maynooth University, Ireland.

Gillian J. Foster, Researcher at Circular Economy & Industrial Leadership Unit, European Commission Joint Research Centre, Spain.

John Bellamy Foster, Professor of Sociology, University of Oregon, USA.

Marco Vianna Franco, Postdoctoral Fellow, Konrad Lorenz Institute for Evolution and Cognition Research, Austria.

Sergio L. Franklin Jr, Independent Scholar, Brazil.

Christian L.E. Franzke, Associate Professor of Climate Physics, Pusan National University, South Korea.

Marc Frick, Academic Assistant to the Head of Research Department, Environmental and Resource Economics, Environmental Management, ZEW-Centre for European Economic Research, Germany.

Manuel Frondel, Head of Department of Environment and Resources, RWI Leibniz Institute of Economic Research and Ruhr University Bochum, Germany.

Felix Fuders, Professor, Economics Institute, Universidad Austral de Chile, Chile.

Giorgos Galanis, Senior Lecturer in Economics, Goldsmiths, University of London, UK.

Ettore Gallo, PhD Candidate in Economics, The New School for Social Research, USA.

Zhengyuan Gao, Independent Scholar, China.

Rafael Garaffa, Researcher, European Commission, Joint Research Centre, Spain.

Junior Ruiz Garcia, Associate Professor of Economics, Federal University of Paraná, Brazil.

Davide Geneletti, Professor of Spatial Planning, University of Trento, Italy.

Jean-David Gerber, Professor of Political Urbanism and Sustainable Spatial Development, University of Bern, Switzerland.

Julien-François Gerber, Assistant Professor of Environment and Development, International Institute of Social Studies, the Netherlands.

Teresa Ghilarducci, Irene & Bernard L. Schwartz Professor of Economics and Policy Analysis, New School for Social Research, USA.

Mario E. Giampietro, ICREA Research Professor, Universitat Autònoma de Barcelona, Spain.

Francesca Giardini, Associate Professor of Sociology, University of Groningen, the Netherlands.

Gerd Gigerenzer, Emeritus Director and Scientific Member, Max Planck Institute for Human Development, Germany.

Stefan Giljum, Associate Professor, Vienna University of Economics and Business, Austria.

Yacouba Gnègnè, Associate Professor of Economics at the United Arab Emirates National Defense College, United Arab Emirates.

Jessica J. Goddard, Chief Science Officer at SimpleLab, Inc., USA.

Tiziano Gomiero, Independent Scholar, Italy.

Neva R. Goodwin, Co-Director of the Global Development and Environment Institute, Tufts University, USA.

Elizabeth J. Gosling, Research Associate in Forest Management, Technical University of Munich, Germany.

Patricia A. Gotschalk, Independent Scholar, USA.

Rachelle K. Gould, Associate Professor of Environmental Studies, University of Vermont, USA.

Raymond Gradus, Professor of Public Economics and Administration, Vrije Universiteit Amsterdam, the Netherlands.

R. Quentin Grafton, Professor of Economics and Chairholder, UNESCO Chair in Water Economics and Transboundary Water Governance, Australian National University, Australia.

Kevin Grecksch, Lecturer in the School of Geography and the Environment, University of Oxford, UK.

Kristine M. Grimsrud, Senior Researcher, Group for Environmental, Resource, and Innovation Economics, Statistics Norway, Norway.

Étienne Guertin, PhD Candidate in Geography, Concordia University, Canada.

Cengizhan Güler, Graduate Research Assistant in International Trade and Finance, Istanbul Gelisim University, Turkey.

Yamini Gupt, Professor of Economics, University of Delhi South Campus, India.

Anil K. Gupta, Founder, Honey Bee Network and Professor of Management in Agriculture, Indian Institute of Management, Ahmedabad, India.

Gabriel Yahya Haage, PhD Candidate in Natural Resource Sciences, McGill University, Canada.

Helmut Haberl, Professor of Socio-Ecological Metabolism, Institute of Social Ecology, University of Natural Resources and Life Sciences, Vienna, Austria.

Brent M. Haddad, Professor of Environmental Studies, University of California, Santa Cruz, USA.

Nick W. Hagerty, Assistant Professor of Natural Resource and Agricultural Economics, Montana State University, USA.

Charles A.S. Hall, Director of the Board and Co-Chairman of the Advisory Board, Biophysical Economics Institute, USA.

Bertrand Hamaide, Professor of Economics and Vice Rector, Universite Saint-Louis, Brussels, Belgium.

Kirk E. Hamilton, Visiting Professor, London School of Economics and Political Science, UK.

Jonathan M. Harris, Senior Researcher, Tufts University Global Development and Environment Institute, USA; & Senior Research Fellow, Boston University Global Development Policy Center Economics in Context Initiative, USA.

Tomás J. Havránek, Professor of Economics, Charles University, Czech Republic.

Reinout Heijungs, Associate Professor of Quantitative Methods, Vrije Universiteit Amsterdam, the Netherlands.

Pasi Heikkurinen, Senior Lecturer in Management, University of Helsinki, Finland.

Eckhard Hein, Professor, Institute for International Political Economy, Berlin School of Economics and Law, Germany.

Martin C. Hensher, Henry Baldwin Professorial Research Fellow in Health System Sustainability, University of Tasmania, Australia.

Robert A. Herendeen, Adjunct Professor of Ecological Economics, University of Vermont, USA.

Marcello Hernández-Blanco, Ecological Economist, Conservation Strategy Fund, Costa Rica.

Arye L. Hillman, Professor of Economics, Bar-Ilan University, Israel.

Indira Hirway, Director and Professor of Economics, Centre for Development Alternatives, India.

Ståle Holgersen, Docent in Human Geography, Uppsala University, Sweden.

Aja Ropret Homar, PhD Candidate in Economics, University of Ljubljana, Slovenia.

Alf Hornborg, Professor of Human Ecology, Lund University, Sweden.

Catherine E. Horner, PhD Candidate in Agroecology, University of Vermont, USA.

Tasos Hovardas, Senior Research Associate, Department of Education, University of Cyprus, Cyprus.

Sonia Mutumbajoy Hurtado, Indigenous Lawyer for the Inga People, Colombia.

Michael Hübler, Lecturer, Institute of Agricultural Policy and Market Research, Justus Liebig University Gießen, Germany.

Raluca-Ioana Iorgulescu, Senior Researcher, Institute for Economic Forecasting-NIER, Romanian Academy, Romania.

Hiroe Ishihara, Associate Professor, Graduate School of Frontier Sciences, University of Tokyo, Japan.

Tomayess Issa, Senior Lecturer in Information Systems, School of Management and Marketing, Faculty of Business and Law, Curtin University, Australia.

Kurt Jax, Professor of Conservation Biology, Helmholtz Centre for Environmental Research, UFZ, Germany.

Bruce Jennings, Senior Fellow, Center for Humans and Nature and Vanderbilt University, USA.

Brad S. Jessup, Senior Lecturer, Melbourne Law School, University of Melbourne, Australia.

Xi Ji, Associate Professor of Economics, Peking University, China.

Nicholas H. Johnson, Associate Professor of Sustainability, Principia College, USA.

Shelly A. Johnson, State Specialized Agent, Natural Resources, University of Florida, USA.

Doramas Jorge-Calderón, Lead Economist, European Investment Bank, Luxembourg.

Jane Kabubo-Mariara, Professor of Economics, University of Nairobi, and Executive Director, Partnership for Economic Policy, Kenya.

James R. Kahn, John Hendon Professor of Economics and Professor of Environmental Studies, Washington and Lee University, USA.

Panos Kalimeris, Research Associate in Ecological Economics, Panteion University, Greece.

Giorgos Kallis, Catalan Institution for Research and Advanced Studies Professor of Ecological Economics, Universitat Autònoma de Barcelona, Spain.

Uma S. Kambhampati, Professor of Economics, University of Reading, UK.

Katrin Karner, Research Assistant, Institute for Sustainable Economic Development, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria.

Prakash Kashwan, Associate Professor of Environmental Studies, Brandeis University, USA.

Habtamu Tilahun Kassahun, Research Fellow, Australian Rivers Institute, Canberra, Australia.

Tracey J. Katof, Analyst, Turbine Asset Holding Group, LLC, USA.

Antonios Katris, Research Associate, Centre for Energy Policy, University of Strathclyde, UK.

Eric Kemp-Benedict, Equitable Transitions Program Director, Stockholm Environment Institute, USA.

Choy Yee Keong, Senior Research Fellow, Keio University, Japan.

Bruno Kestemont, Head of Environment at Cabinet of the Minister of Climate, Environment, Sustainable Development and Green New Deal, Belgium.

Neha Khanna, Professor of Economics and Environmental Studies, Binghamton University, USA.

Iljoong Kim, Professor of Economics, SungKyunKwan University, South Korea.

Thomas C. Kinnaman, Professor of Economics, Bucknell University, USA.

Katie M. Kish, Research Associate, York Ecological Footprint Initiative, York University, Canada.

Olga Kiuila, Associate Professor of Economics, University of Warsaw, Poland.

Matthias Klaes, Honorary Professor of Commerce, University of Dundee, UK.

Kent A. Klitgaard, Professor Emeritus of Economics and Sustainability, Wells College, USA.

Kyle W. Knight, Associate Professor of Sociology, University of Alabama in Huntsville, USA.

Thomas F. Knoke, Professor of Forest Management, Technical University of Munich, Germany.

Duncan J. Knowler, Professor of Ecological and Environmental Economics, Simon Fraser University, Canada.

Benjamin Koch, Research Assistant in Environment and Resources, RWI—Leibniz Institute for Economic Research, Germany.

Vijay K. Kolinjivadi, Postdoctoral Fellow, Institute of Development Policy (IOB), University of Antwerp, Belgium.

Sonja H. Kolstoe, Research Economist, USDA Forest Service, Pacific Northwest Research Station, Portland, OR, USA.

Helen Kopnina, Senior Lecturer in Sustainable Business, Northumbria University, UK.

Lisi Krall, Professor of Economics, State University of New York, Cortland, USA.

Fridolin Krausmann, Professor of Sustainable Resource Use, Institute of Social Ecology, University of Natural Resources and Life Sciences, Vienna, Austria.

Ursula W. Kreitmair, Assistant Professor of Political Science, University of Nebraska–Lincoln, USA.

Christian Krekel, Assistant Professor in Behavioural Science, London School of Economics and Political Science, UK.

Sturla F. Kvamsdal, Senior Researcher, Centre for Applied Research, Norwegian School of Economics, Norway.

Alessandra La Notte, Scientific Project Officer, European Commission, Italy.

Kate M. Laffan, Assistant Professor in Behavioural Science, London School of Economics and Political Science, UK.

Steffen Lange, Economist, Institute for Ecological Economy Research, Humboldt University Berlin, Germany.

Edyta Łaszkiewicz, Assistant Professor of Economics, University of Lodz, Poland.

Tristan Le Cotty, Economist, French Agricultural Research Centre for International Development, France.

Matthew A. Leach, Professor of Energy and Environmental Systems, University of Surrey, UK.

Chien-Ming Lee, Professor, Institute of Natural Resources and Environmental Management, National Taipei University, Taiwan.

Glen D. Lehman, Associate Professor and Senior Research Fellow in Accounting, University of South Australia, Australia.

Raul P. Lejano, Professor of Environmental Conservation Education, New York University, USA.

Marco Letta, Assistant Professor of Economics, Sapienza University of Rome, Italy.

Jarkko Levänen, Assistant Professor of Sustainability Science, Lappeenranta-Lahti University of Technology, Finland.

Meike Levin-Keitel, Professor for Spatial Transformation in the Digital Age, TU Dortmund University, Germany.

Arik M. Levinson, Professor of Economics, Georgetown University and National Bureau of Economic Research, USA.

Harold Levrel, Professor of Ecological Economics, Université Paris-Saclay, AgroParisTech, Centre for International Research on Environment and Development (CIRED), France.

Vincent Liegey, Degrowth Independent Scholar and Practitioner, Hungary and France.

David Lin, Chief Science Officer, Global Footprint Network, USA.

Can Liu, Distinguished Professor of Economics, Nanjing Forestry University, China.

Hongxing Liu, Assistant Professor of Economics, Lafayette College, USA.

Bosco Lliso, Postdoctoral Researcher, Basque Centre for Climate Change (BC3), Spain.

Anastasia Loukianov, Research Fellow, Centre for the Understanding of Sustainable Prosperity, University of Surrey, UK.

Benjamin H. Lowe, Lecturer in Sustainable Management, University of York, UK.

Gabriel A. Lozada, Associate Professor of Economics, University of Utah, USA.

Päivi Lujala, Professor of Geography, University of Oulu, Finland.

Annika E. Lutz, PhD Candidate in Psychology, Simon Fraser University, Canada.

Valerie A. Luzadis, Professor of Social-Ecological Systems and Ecological Economics, SUNY—College of Environmental Science and Forestry, USA.

Gary D. Lynne, Professor Emeritus of Agricultural Economics, University of Nebraska–Lincoln, USA.

Jari M. Lyytimäki, Leading Researcher, Finnish Environment Institute, Finland.

Sherilyn MacGregor, Reader in Environmental Politics, The University of Manchester, UK.

Caroline M.L. Mackay, PhD Candidate in Psychology, Simon Fraser University, Canada.

Meghan Graham MacLean, Lecturer of Quantitative Ecology, University of Massachusetts–Amherst, USA.

Simon Mair, Lecturer in Sustainability, University of York, UK.

Paolo Malanima, Director of the Institute of Studies on Mediterranean Societies, Italy.

Marla Markowski-Lindsay, Senior Research Fellow, Family Forest Research Center, University of Massachusetts–Amherst, USA.

Tatiana G. Marquina, Researcher, Estudios Técnicos, Inc. San Juan, Puerto Rico, USA.

David W. Martin, Professor of Economics and Core Faculty in Environmental Studies, Davidson College, USA.

Joan Martínez-Alier, Emeritus Professor of Economics and Economic History, Universitat Autònoma de Barcelona, Spain.

Nuno O. Martins, Professor of History of Economic Thought, Universidade Católica Portuguesa, Católica Porto Business School and CEGE, Portugal.

Riccardo Mastini, PhD Candidate in Ecological Economics, Universitat Autònoma de Barcelona, Spain.

Leonie Matejko, Research Assistant in Environment and Resources, RWI—Leibniz Institute for Economic Research, Germany.

Igor Matutinović, Professor of Economics, Zagreb School of Economics and Management, Croatia.

Georgia Mavrommati, Assistant Professor of Ecological Economics, University of Massachusetts Boston, USA.

Kozo T. Mayumi, Professor of Economics, Kyoto College for Graduate Studies for Informatics, Japan.

Armelle Mazé, Economist, French National Institute for Agricultural Research, Université Paris Saclay, France.

Peter McAdam, Economic Research, Federal Reserve Bank of Kansas City, USA.

Richard M. McGahey, Senior Fellow, Schwartz Center for Economic Policy Analysis, New School for Social Research, USA.

Judith R. McNeill, Independent Scholar, Australia.

Alistair G. McVittie, Ecosystem Services Economist, Scotland's Rural College, UK.

Rigo E.M. Melgar, PhD Candidate in Ecological Economics, University of Vermont, USA.

Jonathan A. Mendel, Masters Candidate in Psychology, Simon Fraser University, Canada.

Stefano Menegat, Research Fellow in Economics, University of Turin, Italy.

Gordon N. Merrick, Adjunct Professor, Vermont Law and Graduate School, USA.

Khushbu Mishra, Assistant Professor of Economics, Stetson University, USA.

Antoine A.G. Missemer, Researcher at Centre National de Recherche Scientifique, Centre for International Research on Environment and Development (CIRED), France.

Hermine Mitter, Senior Scientist, Institute for Sustainable Economic Development, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria.

Klaus Moeltner, Professor of Agricultural and Applied Economics, Virginia Polytechnic Institute and State University, USA.

Michelle L. Molnar, Technical Director, Municipal Nature Assets Initiative, Canada.

Maya Moore, PhD Candidate in Food Systems, University of Vermont, USA.

Josh Moos, Lecturer in Economics, Leeds Beckett University, UK.

Caitlin B. Morgan, Research Social Scientist, U.S. Department of Agriculture, USA.

Jamie A. Morgan, Professor of Economics, Leeds Beckett University, UK.

Ronaldo Seroa da Motta, Professor of Economics at State University of Rio de Janeiro, Brazil.

Richard Mulwa, Professor of Economics, University of Nairobi, Kenya.

Maddipati N. Murty, Professor, Institute of Economic Growth, India.

Gurumurthy Mythili, Professor of Economics, Indira Gandhi Institute of Development Research, India.

Suranjana Nabar-Bhaduri, Assistant Professor of Economics, Frostburg State University, USA.

Brian M. Napoletano, Assistant Professor, Centro de Investigaciones en Geografía Ambiental, Universidad Nacional Autónoma de México, Mexico.

Grettel V. Navas, Assistant Professor of Government, University of Chile, Chile.

Anitra R. Nelson, Associate Professor, Melbourne Sustainable Society Institute, The University of Melbourne, Australia.

Stijn Neuteleers, Senior Lecturer, Department of Environmental Sciences, Open University of the Netherlands, the Netherlands.

Erik E. Nordman, Professor of Natural Resources Management, Grand Valley State University, USA.

Bryan G. Norton, Distinguished Professor Emeritus, School of Public Policy, Georgia Institute of Technology, USA.

Franklin Obeng-Odoom, Helsinki Institute of Sustainability Science Associate Professor of Global Development Studies, University of Helsinki, Finland.

Kelsey J. O'Connor, Researcher, STATEC Research, Luxembourg, IZA Institute of Labor Economics, Germany, and University of Johannesburg, South Africa.

Oluwaseun A. Odusola, MA Candidate in Economics, New School for Social Research, USA.

Phillip A. O'Hara, Director, Global Political Economy Research Unit, Perth, Australia.

Sabine O'Hara, Distinguished Professor in the College of Agriculture, Urban Sustainability and Environmental Sciences at the University of the District of Columbia, USA.

Laura Schmitt Olabisi, Professor of Community Sustainability, Michigan State University, USA.

Maartje Oostdijk, Research Associate at World Maritime University, Sweden.

Laura Orlando, Executive Director, Resource Institute for Low Entropy Systems, USA.

Jane N. O'Sullivan, Honorary Senior Research Associate, School of Agriculture and Food Sciences, University of Queensland, Australia.

Vladimir V. Otrachshenko, Senior Researcher, Center for International Development and Environmental Research, Justus Liebig University Giessen, Germany.

Konrad Ott, Professor of Philosophy and Ethics of the Environment, Kiel University, Germany.

Ilona M. Otto, Professor in Societal Impacts of Climate Change, Wegener Center for Climate and Global Change, University of Graz, Austria.

Paola Ovando, Associate Research Professor of Economics, Spanish National Research Council, Spain.

Jouni Paavola, Professor of Environmental Social Science, University of Leeds, UK.

Pablo Campos Palacín, Ad Honorem Research Professor of Economics, Spanish National Research Council, Spain.

Francesca Pancotto, Associate Professor of Political Economy, Università degli Studi di Modena e Reggio Emilia, Italy.

Prabha Panth, Professor of Economics, Osmania University, India.

Charles A. Perrings, Professor of Environmental Economics, Arizona State University, USA.

Olivier Petit, Associate Professor of Economics, University of Artois & CLERSE, France.

John C.V. Pezzey, Honorary Associate Professor, Fenner School of Environment and Society, Australian National University, Australia.

Sylvain Pioch, Associate Professor of Geography and the Environment, University Paul Valéry Montpellier 3, France.

Gaël Plumecocq, Research Fellow in Economics, National Research Institute for Agriculture, Food and Environment, France.

John M. Polimeni, Associate Professor of Economics, Albany College of Pharmacy and Health Sciences, USA.

Elena G. Popkova, Professor of Economics, Moscow State Institute of International Relations, Russia.

Olga V. Popova, Senior Researcher, Leibniz Institute for East and Southeast European Studies, Regensburg, Germany.

Gabriel Lopez Porras, Managing Director, Instituto de Resiliencia & Conservación Global, Mexico.

Filippos Proedrou, Senior Lecturer in Global Political Economy, University of South Wales, UK.

Martin Prowse, Evaluation Specialist, Independent Evaluation Unit, Green Climate Fund, South Korea.

Armin L. Puller, Lecturer in Political Science, University of Vienna, Austria.

Martin F. Quaas, Professor of Biodiversity Economics, Leipzig University, Germany.

Stephen Quilley, Associate Professor of Social and Environmental Innovation, University of Waterloo, Canada.

Terrance J. Quinn, Professor Emeritus of Mathematics, Middle Tennessee State University, USA.

Malayna Raftopoulos, Associate Professor of Development Studies and International Relations, Aalborg University, Denmark.

Crelis F. Rammelt, Assistant Professor of Environmental Geography and Development Studies, University of Amsterdam, the Netherlands.

Rupert Read, Associate Professor of Philosophy, University of East Anglia, UK.

Kenneth A. Reinert, Professor of Public Policy, George Mason University, USA.

Lucia A. Reisch, El-Erian Professor of Behavioural Economics and Public Policy, University of Cambridge, UK.

Nicholas E. Reksten, Associate Professor of Economics, University of Redlands, USA.

Stefan Renckens, Associate Professor of Political Science, University of Toronto, Canada.

Robert B. Richardson, Professor of Community Sustainability, Michigan State University, USA.

Irene Ring, Professor of Ecosystem Services, International Institute Zittau, Technische Universität Dresden, Germany.

James A. Rising, Assistant Professor of Marine Science and Policy, University of Delaware, USA.

Chian A. Jones Ritten, Associate Professor of Agricultural and Applied Economics, University of Wyoming, USA.

Julian Rode, Senior Researcher, Department for Environmental Politics, Helmholtz Centre for Environmental Research (UFZ), Germany.

Mikhail I. Rogov, Research Fellow, Higher School of Economics, Russia.

Philippe P. Roman, Associate Professor of Economics, ICHEC Brussels Management School, Belgium.

Sabin Roman, Research Associate, Centre for the Study of Existential Risk, University of Cambridge, UK.

Iván D. Vargas Roncancio, Postdoctoral Researcher in the Leadership for the Ecozoic Program, McGill University, Canada.

Inge Røpke, Professor Emerita of Ecological Economics, Aalborg University, Denmark.

Emilio Padilla Rosa, Professor of Applied Economics, Universitat Autònoma de Barcelona, Spain.

Adam Z. Rose, Research Professor of Public Policy, University of Southern California, USA.

Mark D. Rouleau, Associate Professor of Social Sciences, Michigan Technological University, USA.

Elena Rovenskaya, Program Director, Advancing Systems Analysis, International Institute for Applied System Analysis, Austria.

Nicholas D. Roxburgh, Social Systems Simulation Modeller, The James Hutton Institute, UK.

Gabriela L. Sabau, Professor of Economics and Environmental Studies, Memorial University of Newfoundland, Canada.

Beatriz M. Saes, Professor of Economics, Federal University of São Paulo, Brazil.

Karolina E. Safarzynska, Associate Professor of Economics, University of Warsaw, Poland.

Massimo Scalia, Coordinator, Bioelectromagnetism Section, Interuniversity Research Centre for Sustainable Development, Italy.

Yves Schaeffer, Researcher in Economics, National Research Institute for Agriculture, Food and Environment (INRAE), University of Grenoble Alpes, France.

Anke Schaffartzik, Assistant Professor of Environmental Sciences and Policy, Central European University, Austria.

Heinz Schandl, Research Group Leader, Commonwealth Scientific and Industrial Research Organisation (CSIRO) Land and Water, Black Mountain Science and Innovation Park, Australia.

Arnim Scheidel, Senior Researcher, Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, Spain.

Preston L. Schiller, Affiliate Instructor in Civil and Environmental Engineering, University of Washington, USA.

Maja Schlüter, Professor of Sustainability Science, Stockholm Resilience Centre, Stockholm University, Sweden.

Matthias G. Schmelzer, Postdoctoral Researcher, Friedrich-Schiller-University, Germany.

Michael T. Schmitt, Professor of Psychology, Simon Fraser University, Canada.

Christopher Schulz, Lecturer in Sustainable Development, University of St. Andrews, UK.

Andrew F. Seidl, Professor of Agricultural and Resource Economics, Colorado State University, USA.

Irmi Seidl, Professor and Head of Research Unit, Economics and Social Science, Swiss Federal Research Institute, Switzerland.

Bruno S. Sergi, Economics Instructor, Harvard University, USA.

Martin R. Sers, Postdoctoral Researcher in Civil Engineering, University of Victoria, Canada.

Mark A. Setterfield, Professor of Economics, New School for Social Research, USA.

Amita R. Shah, Fellow, Center for Development Alternatives, India.

Daisaku Shimada, Associate Professor of Agri-food Systems, Ryukoku University, Japan.

Bernd Siebenhüner, Professor of Ecological Economics, Carl von Ossietzky University of Oldenburg, Germany.

Franziska Sielker, Professor of Urban and Regional Research, Vienna University of Technology, Austria.

Steve J. Sinclair, Staff, Arthur Rylah Institute for Environmental Research, Victoria, Australia.

Jagdeep Singh, Associate Professor in Environmental Science, Lund University, Sweden.

Neera Singh, Associate Professor of Geography, University of Toronto, Canada.

Jeffery J. Smith, Independent Scholar, Mexico.

Nina L. Smolyar, PhD Student in Ecological Economics, University of Vermont, USA.

Peter Söderbaum, Professor Emeritus of Ecological Economics, Mälardalen University, Sweden.

Joeri Sol, Assistant Professor of Economics, University of Amsterdam, the Netherlands.

Fritz Söllner, Professor of Public Finance, Ilmenau Technical University, Germany.

Barry D. Solomon, Professor Emeritus of Environmental Policy, Michigan Technological University, USA.

Alevgul H. Sorman, Ikerbasque Research Fellow, Basque Centre for Climate Change, Spain.

John A. Sorrentino, Associate Professor of Economics, Temple University, USA.

Gloria Soto-Montes-de-Oca, Professor of Social Sciences, Metropolitan Autonomous University, Mexico.

Joachim H. Spangenberg, Vice President, Sustainable Europe Research Institute, Germany.

Andri W. Stahel, Independent Scholar, Spain.

Conrad B. Stanley, Independent Scholar, Canada.

Shana M. Starobin, Assistant Professor of Government and Environmental Studies, Bowdoin College, USA.

Joshua J. Sterlin, Leadership for the Ecozoic Doctoral Fellow, McGill University, Canada.

Thomas N. Sterner, Professor of Environmental Economics, University of Gothenburg, Sweden.

Gary C. Stoneham, Director, Policy Projects, Centre for Market Design, University of Melbourne, Australia.

Beth Stratford, PhD Candidate in Ecological Economics, University of Leeds, UK.

Yixian Sun, Assistant Professor in International Development, University of Bath, UK.

Paul C. Sutton, Professor of Geography and the Environment, University of Denver, USA.

J. Kim Swales, Emeritus Professor, Fraser of Allander Institute, Department of Economics, University of Strathclyde, UK.

Miroslav Syrovátka, Associate Professor of Region and Social Development, Palacký University Olomouc, Czech Republic.

Julia Talbot-Jones, Lecturer, Te Herenga Waka—Victoria University of Wellington, New Zealand.

John P. Tang, Associate Professor of Economics, University of Melbourne, Australia.

Yong Tao, Assistant Professor of Economics, Southwest University, China.

Léa Tardieu, Research Fellow in Environmental Economics, National Research Institute for Agriculture, Food and the Environment (INRAE), UMR TETIS, Montpellier, France.

Anat Tchetchik, Associate Professor in Geography and Environment, Bar-Ilan University, Israel.

Andrea S. Thorpe, Associate Professor of Entrepreneurship, Innovation and Strategy, Kedge Business School, France.

Clement A. Tisdell, Professor Emeritus of Economics, University of Queensland, Australia.

Sara Latorre Tomás, Visiting Professor, Latin American Faculty of Social Sciences, FLASCO, Ecuador.

M. Fernanda Tomaselli, Lecturer and Coordinator of Land One Program, University of British Columbia, Canada.

Francisco J. Toro, Professor of Human Geography, University of Granada, Spain.

Mariano Torras, Professor of Economics, Adelphi University, USA.

Georgy Trofimov, Senior Researcher, Institute for Financial Studies, Russia.

Katerina Troullaki, PhD Researcher in Bioeconomy and Biosystems Economics, Technical University of Crete, Greece.

Karen R. Turner, Professor and Director of the Centre for Energy Policy, University of Strathclyde, UK.

Niharika Tyagi, Researcher, TERI School of Advanced Studies, India.

Takuro Uehara, Professor of Environmental Policy, Ritsumeikan University, Japan.

Carlos Valente, Researcher, RAIZ—Instituto de Investigação da Floresta e Papel, Portugal.

Nives Della Valle, Scientific Officer at European Commission, Joint Research Centre, Italy.

Jeroen van den Bergh, ICREA Research Professor, Universitat Autònoma de Barcelona, ICREA Barcelona, Spain; and VU University Amsterdam, the Netherlands.

Jonas Van der Slycken, Guest Lecturer in Economics, University of Antwerp, Belgium.

Madhavi Venkatesan, Associate Teaching Professor of Economics, Northeastern University, USA.

Aviel Verbruggen, Professor Emeritus of Energy and Environmental Economics, University of Antwerp, Belgium.

Daniele Vergamini, Research Fellow in Agricultural Economics, University of Pisa, Italy.

Riccardo Viale, Professor of Epistemology of Social Sciences, University of Milano-Bicocca, Italy.

Peter A. Victor, Professor Emeritus of Environmental Studies, York University, Canada.

Nuno Videira, Associate Professor, Center for Environmental and Sustainability Research, NOVA School of Science and Technology, NOVA University Lisbon, Portugal.

Athanasios Votsis, Assistant Professor, Section of Governance and Technology for Sustainability, University of Twente, the Netherlands.

Mathis Wackernagel, Founder and President, Global Footprint Network, USA.

Sandra Waddock, Galligan Chair of Strategy and Professor of Management, Boston College, USA.

Amentahru Wahlrab, Associate Professor of Political Science, University of Texas at Tyler, USA.

Wayne W. Wakeland, Professor of Systems Science, Portland State University, USA.

Jeremy Walker, Director, Climate Society and Environment Research Centre, University of Technology Sydney, Australia.

Rikard H. Warlenius, Senior Lecturer, School of Global Studies, University of Gothenburg, Sweden.

Phillip M. Warsaw, Assistant Professor of Community Sustainability, Michigan State University, USA.

Haydn G. Washington, Environmental Scientist, UNSW Sydney, Australia.

Mark R. Welford, Head and Professor of Geography, University of Northern Iowa, USA.

Adam M. Wellstead, Professor of Public Policy, Michigan Technological University, USA.

Heinz Welsch, Professor Emeritus of Economics, Department of Economics, University of Oldenburg, Germany.

Yu-Chi Weng, Director, Research Institute for Sustainable Civilization, Kyoto, Japan.

Richard A. Werner, Professor of Banking and Finance, De Montfort University, UK.

Heico Wesselius, Lecturer in Strategic Design, RMIT University, Australia.

Kai Whiting, Lecturer and Researcher in Sustainability, Catholic University of Louvain, Belgium.

Austin M. Williams, Independent Scholar, USA.

Elizabeth A. Wilman, Professor Emerita of Economics, University of Calgary, Canada.

Robert H. Winthrop, Research Professor of Anthropology, University of Maryland, USA.

Michael B. Wironen, Senior Scientist, The Nature Conservancy, USA.

Wiepke W. Wissema, Lecturer in Economics, Wageningen University & Research, the Netherlands.

Jack Wright, Postdoctoral Research Associate, Centre for Research in the Arts, Social Sciences and Humanities, University of Cambridge, UK.

Jianguo Wu, Dean's Distinguished Professor of Landscape Ecology and Sustainability Science, Arizona State University, USA.

Wenchao Wu, Researcher, Japan International Research Center for Agricultural Sciences, Japan.

Su Xiu Xu, Professor of Electrical and Information Engineering, Jinan University, China.

Rintaro Yamaguchi, Senior Researcher, National Institute for Environmental Studies, Japan.

Ewa Zawojska, Assistant Professor of Economics, University of Warsaw, Poland.

Shan Zhou, Assistant Professor of Environmental Policy, Michigan Technological University, USA.

Robert Zwahlen, Environment and Social Development Consultant, Switzerland.

THE ORIGINS OF ECOLOGICAL ECONOMICS

Joan Martínez-Alier

As an organized field of study with an international society, the International Society for Ecological Economics (ISEE) and an eponymous journal, *Ecological Economics*, dates from the mid-1980s. After some informal meetings in Stockholm and Barcelona, the society held its first meeting in Washington, DC in 1990, one of the main reasons being that Herman Daly was working at the World Bank then. A meeting of a few dozen people at Wye Island nearby organized by Bob Costanza (https://www.isecoeco.org/about/) led to a defining publication in 1991, *Ecological Economics: The Science and Management of Sustainability*. The disciplinary origins were varied, with dissident economists in the tradition of Kenneth Boulding and Nicholas Georgescu-Roegen, and systems ecologists (often trained by Howard T. Odum) such as AnnMari Jansson and Bob Costanza. Systems ecologists such as Charlie Hall contributed to ecological economics the interest in the energetics of society, and tools such as the energy return on investment (EROI). This early story was competently summarized by Røpke (2004).

Among the founders and early presidents of ISEE, there were ecologists such as AnnMari Jansson and Bob Costanza, and dissident economists such as Herman Daly, Dick Norgaard, and Joan Martínez-Alier. Other presidents have included John Proops, Charles Perrings, Peter May, John Gowdy, Bina Agarwal, Marina Fischer-Kowalski, Sabine O'Hara, Clovis Cavalcanti, Joshua Farley, Roldan Muradian, and president-elect Erik Gómez-Baggethun. The last three, from a younger generation, are (according to their first university degrees) one biologist, one economist, and one ecologist. But they have been ecological economists from an early age. In contrast, the founding members became ecological economists after working in other disciplines.

There are strong regional societies in Latin America, Europe, the United States, Canada, Australia & New Zealand, and India. The journal has had as editors-in-chief Bob Costanza, Cutler Cleveland, Richard Howarth, Stefan Baumgärtner, and most recently Begüm Özkaynak, and it has been a fundamental research outlet for the practitioners of ecological economics. Some criticisms have been made, not without reason, about the relative absence of feminist economics in ecological economics, and about the relative abundance of mainstream economic articles published in the journal.

The Beijer Institute at the Royal Swedish Academy of Sciences played a role in the establishment and development of ecological economics in the early 1990s. It continued with AnnMari Jansson and her student Carl Folke (today the top author by number of citations in ecological economics) with a focus on energy and human ecology, and in the early 1990s it transformed into the Beijer Institute of Ecological Economics. The relationship between ecological economics and environmental economics was scrutinized in this period. Beijer's Karl-Göran Mäler, and David Pearce and Giles Atkinson (among others) saw the fields as closely aligned. An important debate at the time concerned how to understand sustainability. Pearce and Atkinson (1993) promoted "weak sustainability" (different forms of capital—manufactured capital, human capital, and natural capital—could be measured in the same units and substituted for one another) in contrast to "strong sustainability" (natural capital cannot be limitlessly substituted for other forms of capital and therefore "critical" natural capital must be preserved in physical terms so that its functions remain intact). Many *Ecological Economics* editorial board members and authors have favored the more robust ecological economics approach embodied in strong sustainability (e.g., Ayres et al. 2001; Pelenc & Ballet 2015). Robert Ayres had already in 1969 introduced (with Allen Kneese), in an article in the *American Economic Review*, the accounting of materials in the economy (Ayres & Kneese 1969),

which later flourished in the Vienna group led by Marina Fischer-Kowalski of studies of social metabolism, which measure the material and energy intensities of the economy (e.g., Fischer-Kowalski & Haberl 2007). This work became typical of ecological economics, overlapping with industrial ecology, urban ecology, and agroecology, which are practiced by many other groups.

The debate and tension between, on the one hand, the economic accounting of environmental damages and of nature's services to humans, and on the other hand its biophysical assessment, has persisted in ecological economics. Sometimes even those most favorable to a multi-criteria biophysical and social assessment have opted for an economic methodology such as a modified gross domestic product (GDP) that would produce a single indicator and a single number; for example, the calculation of the Index of Sustainable Economic Welfare (ISEW) was popular for many years. Sometimes, those who started from human ecology and energetics have gone over to the economic accounting of the loss of so-called "natural capital" in an effort to influence policymakers. The basic tenets of ecological economics still go so against the grain that efforts to bridge the gap and communicate with mainstream economists and so-called policymakers have sometimes led to contentious compromises. Such tenets are:

1. The economy is embedded in physical and social realities; it cannot be analyzed as a system of its own. The economists' view of the economy as a circular system (which Nicholas Georgescu-Roegen called "the merry-go-round") in which producers bring their products to the markets where they are bought by consumers who receive their income for the work or services they provide to producers, is wrong. The industrial economy is clearly not circular: it is entropic, resulting in degradation of biospheric functions. It is in fact increasingly entropic because of a still increasing consumption of fossil fuels in absolute terms, despite an increasing role for renewable energy.
2. Externalities are not so much "market failures" as systematic cost-shifting (to use Karl William Kapp's term, in 1950, in his book on what we could now call business ecological economics). Firms systematically avoid including environmental liabilities in their accounts.
3. The damages that the human economy does to Nature (and the contributions that the human economy does sometimes to the reparation and regeneration of Nature) must be counted in a variety of valuation languages. The livelihood values, sacredness, relevance to future generations, and full ecological values cannot be translated into monetary terms. They are not commensurate with money (as Otto Neurath already discussed in the 1920s in the "socialist calculation debate" against Ludwig Von Mises and Friedrich Hayek; see Greenwood 2006).
4. An ecological macroeconomics does not focus on GDP growth but on the social and physical sustainability of the economy. Hence proposals since the 1970 for a "steady state" (originated by Herman Daly) and more recently a vigorous debate on "prosperity without growth" and the need for a period of degrowth of the rich economies.
5. Demography should not be a field of study outside ecological economics; on the contrary, ecological economists have knowledge and opinions on demography, favoring in general a stabilization or reduction in the human population. They emphasize indicators such as the human appropriation of net primary production (HANPP) and the "ecological footprint" to measure human population impacts on natural ecosystems. At the same time, they focus on the enormous inequalities in the exosomatic use of energy and materials by humans.
6. Far from international trade contributing to prosperity, it has contributed to inequality and exhaustion of materials and sources of energy, through "ecologically unequal exchange" that should be measured with physical indicators (Hornborg & Jorgenson 2010). This creates a link from ecological economics to world systems theory, and its concept of frontiers of commodity extraction and waste disposal.

Given the debates and tensions identified in the transdisciplinary field of ecological economics, this *Dictionary* attempts a comprehensive presentation of the richness of the scholarly discourse, which no doubt will continue to evolve well into the 21st century as humanity strives for sustainable development and to live within planetary boundaries.

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PREFACE

Here we present the surprising, invigorating breadth and depth of ecological economics. Its terms span the academy, some rising to breathless philosophical heights, others deeply practical. All are connected by core beliefs that there are meaningful biophysical limits on the Earth's resources and that humans must manage those resources in just and equitable ways. There are terms both ancient and new. They appear herein because together they reveal approaches to knowledge that can help us confront our era's deepest environmental and social problems. Ecological economics is unflinchingly realistic in its assessments of how things stand, and equally idealistic that informed human agency can lead to a better future.

How does one decide which terms go into an ecological economics dictionary? We began with where terms are used, and by whom. If ecological economists frequently use a term, it is included. We combed through countless books and articles from the field's leaders, sometimes reading them page by page and at other times guided by tables of contents, abstracts, indexes, and references. We also reviewed syllabi and curricula from ecological economics programs and courses, and abstracts of meeting papers.

Terms that frequently appear in academic journals, especially *Ecological Economics*, the field's flagship journal, also made the cut. We performed a frequency analysis on the top-ranked occurrences in *Ecological Economics* of single and consecutive terms in the form of unigrams, bigrams, and trigrams. We examined over 30 000 possibilities, and over half the terms now in the *Dictionary* emerged in this way. This got us started.

In addition to term frequency, we selected terms that are important to the history of the field (e.g., *spaceship Earth*, *stationary state*, *steady state economy*, *virtual wealth*), even if they do not appear frequently today. The work of pioneers in the field, such as Nicholas Georgescu-Roegen and Robert Ayres, are featured prominently in the definitions. We also built a "grab bag" list of terms that, when we came across them, we knew they belonged (for example, *non-stationarity*, *indigenous knowledge*, *doubling time*, *ecosystem services potential*, *ecological fiscal transfers*). Soon, in our dialogues with contributors, we received suggestions for many additional terms, as well as how to restate terms to improve clarity and applicability. We also included terms that are more commonly used in ecological economics outside of our home country, the United States (for example, *radical ecological economics*, *common patrimony*, *territorial ecology*, *political-industrial ecology*).

Yet another category of terms is those that help to distinguish ecological economics from other, related fields. These are often shared terms (*free rider*, *resilience*, *human appropriation of net primary production*), as well as terms whose critiques help locate the boundaries of the field (*economic growth* vs. *degrowth*, *economic development* vs. *post-development*). As an emerging field, ecological economics has done its fair share of introspection, so terms are included related to philosophy of science (*methodological pluralism*, *epistemology*, *deontological*). With just one exception (*circumfauna*, successfully argued for by the definition's author), no word has been admitted because it ought to be found in the ecological economics literature but is not.

The next question for a dictionary is what form a definition should take. We asked authors for roughly 50–250 words (with some exceptions), plus related terms and references where a reader can see the term in action. This is less than an encyclopedia entry, but usually more than a sentence or two. If a term has different meanings in different disciplines, we asked for all of them. We also asked that all definitions include how the word relates to ecological economics. Finally, if a term has a very similar meaning to a different term defined in the *Dictionary*, in many cases the reader is referred to the other term in lieu of a unique definition.

Then one must identify authors. The richness of the definitions reveals the care taken by authors to breathe life into every term.

A turning point in producing the *Dictionary* came when we transitioned from the initial approach of one of us (Brent Haddad) to the far more efficient approach suggested by the other (Barry Solomon). Working off the membership list of the International Society of Ecological Economics (ISEE), Brent was reading the works of each member, and then examining the list of terms for potential matches. This approach revealed the breadth of interests, knowledge, skill, and the cumulative effort that has gone into creating this remarkable field. Its drawback was how slow it was: at least a couple of hours spent per scholar, who might then heartbreakingly decline to participate. Based on his prior encyclopedia editing experience, Barry suggested that we start with the terms, not the scholars. We entered terms into search engines, such as the UC Library Search system operated by the University of California, Santa Cruz, and Google Scholar, out of which a list of potential authors and their related works would instantly emerge. From this list we would identify our ideal author and some backups, and reach out to them. The process of identifying authors and defining terms instantly accelerated.

In all, we present here the works of 450 contributors who have provided us with 1129 unique terms, and vastly more references.

Brent M. Haddad and Barry D. Solomon

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We deeply appreciate the assistance of Joan Martínez-Alier, who in addition to authoring definitions, provides an insightful discussion of the origins of Ecological Economics. And several contributors made substantial contributions by submitting a large number of definitions, including Pablo Campos-Palacin, Neva Goodwin, Laura Orlando, James Aronson, Adam Cross, and Rigo Melgar.

Early in the project we were assisted by Sabina Tompkins who programmed the word-frequency algorithm we applied to the journal *Ecological Economics*, covering from its founding through 2018. We also appreciate the detailed responses from Charles Hall, Kozo Mayumi, Joyashree Roy, Karl-Heinz Erb, Sharad Lele, Jouni Paavola, Joshua Farley, and Leonie Pearson to our field survey. We asked them which books, articles, journals, proceedings, and syllabi must be perused for popular terms used in the field.

Rigo Melgar and Teresa Ghilarducci played crucial roles in identifying authors and helping to edit many of the submissions as our project neared the finish line. We also received assistance and advice from Richard McGahey, Richard Norgaard, Robert Costanza, Jon Erickson, Malte Faber, Marc Frick and their team who produced the interesting MINE website on the interplay between nature and the economy (http://nature-economy.de/), and Lucia Orlando. We are grateful for the help of Jonathan Harris, who provided valuable peer review of an earlier draft of the Dictionary as well as several excellent definitions of his own. Special thanks are also due to Anne Aitken for sharing with us the classic photograph of the attendees at the 1990 Wye Island, Maryland ISEE founders' meeting.

We also express appreciation for the Edward Elgar team, including Alex O'Connell, Daniel Mather, Andy Cook, Kaitlin Gray and Cathrin Vaughan. And we offer our deep appreciation to our spouses, Luisa Haddad and Patricia Gotschalk, for their unwavering support throughout this journey.

The Co-editors.

A

Abiotic resources

Ecology: non-living, naturally occurring resources that are integral to ecosystem functions. Includes wind, water, sunlight, minerals, and landscape features necessary for plant growth, energy production, and seed dispersal, and animal shelter and breeding locations.

Economics: non-living goods produced through environmental processes, and which are naturally occurring that can be utilized for development purposes and have a monetary value assigned to them. Includes wind, waves, sunlight, geothermal energy, and fossil fuels. Also includes all elements and organic compounds, including water. Land, mountains, rock formations, and coastlines can be included for their intrinsic, tourism, and hedonic values.

Charlie M. Chesney

Further reading

Swart et al. 2015.

See also: Biotic resources, Ecosystem services, Natural capital, Non-renewable resource, Renewable resource, Intrinsic value.

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Absorptive capacity

See: Waste absorptive capacity.

See also: Waste absorption footprint, Waste management, Sustainable waste disposal.

Abstraction

A methodological tool regarding the set of *a priori* assumptions concerning economic subjects and processes. The aim of abstraction is to simplify real-world complexity through the omission of economic subjects or processes, which are deemed insignificant for the purpose of exposing an economic phenomenon. This is apparent in formal economic models that translate assumptions to variables, mathematical (in)equations, and functions. Since reality is subject to different interpretations and dimensions, abstraction is non-neutral and can be deployed at various levels (Chick & Dow 2001; Nikiforos 2021).

The appropriate level of abstraction depends on the context and economic issue at hand. Some well-known economic examples of abstraction are profit maximization, perfect information, and transitive preferences. Abstraction in ecological economics concerns the assumed relationship between the economic and natural systems. To treat the economy as a system embedded in a limiting biophysical system is an example of a macro-level abstraction. Mathematically, this results in the decomposition of natural systems into natural capital inputs that enter production processes. Since ecological economics supports strong sustainability, it engages in abstraction that assumes the absence of perfect substitution between natural capital and other production inputs. Another example is the designation of ecological degradation as an unwanted by-product of production or an externality; this can be thought of as a micro-level abstraction. More recently, ecological economists have extended input- and externality-oriented abstraction through mathematical formalization practices that relate natural systems to distribution, social reproduction, and the organization of production.

Chandni K. Dwarkasing

Further reading

Mäki 1994; Chick 1998; Dwarkasing 2021.

See also: Models and modeling, Natural capital, Strong sustainability, Complexity, Complexity theory, Complex systems modeling, Bioeconomic modeling, Ecosystem services, Externalities, Limits.

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Abundance

Ecology: abundance is grounded in the relationship between a population's wants W for a resource and the existence of that resource R. That relationship is defined for a particular history h and geography g, and thus varies with h and g. Wants can be essential (for example, need for nutrition) or non-essential. Among other things, cultural and natural factors determine which wants are essential. If the quantity of wants is less than the quantity of available resources, that is, $W < R$, then abundance is present. For $W > R$ and $W = R$, scarcity and sufficiency are present, respectively.

Neoclassical economics: more than enough of something. Abundance rarely arises because an individual has virtually unlimited wants but control over limited resources. In situations of abundance, negative prices may arise. For example, when there is more electricity than demand for it, producers may pay consumers to use electricity. The dynamics of scarcity, abundance, and sufficiency (SAS) (Daoud 2018, 2011, 2010) synthesized opposing positions on how various mechanisms influence W and R to create, maintain, or manipulate abundance. Individuals use entitlements to enable or block others from accessing existing resources, thereby creating artificial abundance for selected people, even when scarcity exists in a population (Daoud 2015).

Adel Daoud

Further reading

Diamandis & Kolter 2012; Gowdy 1998; Hoeschele 2008.

See also: Scarcity, Sufficiency, Resources.

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Accountability

The quality or fact of being responsible for one's actions and being expected to give a satisfactory explanation for them. In governance, it is linked to answerability, responsibility, and liability. For example, in democracies elected politicians are accountable for their actions to their electorate, who can reward or punish (that is, re-elect or not

re-elect, respectively) their elected representatives' actions.

Christa Brunnschweiler & Päivi Lujala

Further reading

Dykstra 1939; Przeworski et al. 2003.

See also: Transparency, Democracy, Environmental governance, Corporate social responsibility.

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Accumulation

a. The build-up of durable assets (capitals). Gross accumulation (GA) is the total build-up of assets; net accumulation is GA minus the consumption of such assets (depreciation).
b. Business capital accumulation (BCA) refers to the build-up of durable assets such as machinery, equipment, and durable production within firms, which is measured by the market value of these resources in monetary terms.
c. The (circular) "treadmill of accumulation" (TOA): the institutional TOA is the driver of BCA, and the main source of ecological destruction, as the inner logic of private profit enhances physical, financial, and relational accumulation through the destruction (consumption) of species and natural/traditional habitats.
d. Ecological capital accumulation (ECA): in the multiple capital paradigm (MCP), BCA is derivative, since BCA transforms (usually destroys) species and natural resource accumulations (ECA), as well as usually social and cultural capital accumulation, through expanding private capitals for profit.
e. Bioaccumulation is the build-up of poisons, harmful gases and chemicals in species and the natural environment. They have risen to high levels, especially in recent decades, most notably in peripheral and semi-peripheral areas. Global warming has markedly reduced biodiversity, resulting in the decumulation of natural assets (lower net accumulation of ecological capital).

Phillip A. O'Hara

Further reading

Blauwhof 2012; Latorre et al. 2015; O'Hara 2009.

See also: Capital, Capitalism, Depreciation, Climate change, Natural capital, Social capital.

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O'Hara, P.A. 2009. Political economy of climate change, ecological destruction and uneven development. Ecological Economics 69: 223–34.

Adaptation

Economics: the process of adjustment made by people to actual or expected changes in economic conditions, technological change, or natural systems, and their effects, to moderate potential harm or exploit potential benefits. Adaptation is usually made incrementally, but in some cases more fundamental and swift adjustments may be required. Adaptation options can be categorized as structural, institutional, ecological, or behavioral (IPCC 2018).

The capacity of people, communities, systems, institutions, and countries to adapt varies widely. An extreme example of adaptation behavior is when people relocate their homes because of job loss, climate change, or increases in extreme weather, or become climate refugees.

Ecology: a dynamic process by which organisms increase their evolutionary fitness to the environment. In general, adaptation is a slow process for most organisms.

Barry D. Solomon

Further reading

Arthur 1992; Brandon 2014.

See also: Adaptive systems, Adaptive governance, Adaptive capacity, Adaptive ecosystem management, Climate change adaptation, Technological change, Fitness, Environment, Darwinian theory, Conservation biology, Evolutionary economics.

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Adaptive capacity

The ability of humans, institutions, human or natural systems, and non-human organisms to adjust to changing internal demands and external circumstances, take advantage of opportunities, and respond to consequences (Carpenter & Brock 2008; IPCC 2014; Vincent 2007). Adaptive capacity is commonly discussed in the contexts of climate change and resilience and can apply to any living system.

Adam M. Wellstead

See also: Adaptation, Climate change adaptation, Adaptive governance, Adaptive ecosystem management, Resilience, Ecosystem resilience, Social-ecological systems, Holling sustainability.

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Vincent, K. 2007. Uncertainty in adaptive capacity and the importance of scale. Global Environmental Change 17(1): 12–24.

Adaptive ecosystem management

A comprehensive approach to environmental management; an approach that models ecosystems as complex, dynamic systems, and rests on an analogy of adaptation in biological systems. Adaptive ecosystem management is often presented as an alternative to scientific resource management, which is associated with the ideas and techniques of Gifford Pinchot, who emphasized resource development to support human activities. Adaptive managers emphasize the dynamism of ecological systems and thereby expect surprises (Gunderson & Holling 2002; Walker & Salt 2006); they try to adapt to the changing nature of these systems while adopting a problem-solving stance.

Adaptive management is characterized by three principles (Norton 2015):

1. Adaptive management is experimental in nature. Managerial action should be undertaken using the scientific method, and these actions should be studied with a specific hypothesis under consideration (Holling 1978; Gunderson & Holling 2002).
2. Adaptive management is multi-scalar in scope. Models of natural systems must include multiple levels to encompass the structure and function of complex, dynamic systems.
3. Adaptive management is place-based (Walker & Salt 2006). Adaptive science is always viewed from a particular place in Earth systems, studying multi-scaled systems from a particular local perspective (Norton 2015). Therefore, problem solutions cannot be one-size-fits-all, but

rather must involve finding adaptive responses to local system development (Walker & Salt 2006, 2012).

BRYAN G. NORTON

See also: Ecosystem management, Ecosystem approach to management (EAM), System scale and hierarchy, Adaptive governance, Surprise.

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Walker, B. & Salt, D. 2006. Resilience Thinking: Sustaining Ecosystems and People in a Changing World. Washington, DC: Island Press.

Walker, B. & Salt, D. 2012. Resilience Practice: Building Capacity to Absorb Disturbance and Maintain Function. Washington, DC: Island Press.

Adaptive governance

Collaborative, flexible, and learning-based institutions designed to adapt to changing relationships in society and between society and ecosystems, connecting state and non-state actors across multiple levels for adaptive management of natural resources and ecosystem services. Although adaptive governance has its roots in Elinor Ostrom's (1990, 2009) research on community-based and self-organized management of common pool resources, it was Dietz et al. (2003) who introduced it as a concept, along with some essential requirements: providing information, managing conflict, inducing rule compliance, providing infrastructure, and being prepared for change.

GABRIEL LOPEZ PORRAS

Further reading

Chaffin et al. 2014; DeCaro et al. 2017.

See also: Adaptation, Adaptive capacity, Adaptive ecosystem management.

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Adaptive systems

See: Adaptive governance.

See also: Adaptive capacity, Adaptive ecosystem management.

Adjusted net saving (ANS)

The total monetary value of the net increase of all types of capital in a national economy during a given period. ANS is an aggregate derived from the capital approach to sustainable development, which links the change in real wealth to social well-being (Pearce et al. 1989; Pearce & Atkinson 1993; Hamilton 2003). In practice, ANS is calculated as the sum of manufactured capital—measured by net national saving—and net investment in all other types of capital, namely natural capital, human capital, social capital, cultural capital, and technical progress (e.g., Hamilton 2005). For example, ANS series are calculated by the World Bank as follows: ANS equals

gross national saving minus consumption of fixed capital, minus depletion of subsoil and timber resources, minus pollution damages, plus education expenditures (World Bank 2021, 1999). ANS was initially denominated as "genuine saving," and it is still referred to as such on an informal basis.

Yacouba Gnègnè

Further reading

Hamilton 1994; Hamilton & Clemens 1999; Hamilton & Naikal 2014.

See also: Objective well-being, Subjective well-being, Capital, Manufactured capital, Human capital, Social capital, Natural capital, Genuine saving, Sustainable development.

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Adverse selection

See: Asymmetric information.

See also: Moral hazard, Principal–agent problem, Insurance value, Risk.

Aesthetics

The sensory experience resulting from the visual appearance of landscapes, determined by the extent to which the view is perceived and interpreted as beautiful, harmonious, or symbolic and manifested by positive emotions. Kaplan and Kaplan (1989) defined aesthetics as a primary aspect of people–landscape interactions. The visual aspect of a landscape may be consumed by looking/gazing at it, drawing it, or taking photos/videos of it. The way aesthetics is interpreted differs according to the viewer's idiosyncrasies, the platform on which the landscape is presented (for example, physically, online/offline, augmented/virtual reality), and other factors.

Environmental aesthetics plays an important role in obtaining health outcomes, reducing stress, and improving cognitive processing; thus, numerous researchers study which landscape patterns are considered aesthetic. For example, it was shown that open space, with green vegetation, is preferred to open space with no vegetation (Ulrich 1981). Yet, open spaces of higher visual complexity, particularly in scenes with water, seem to be preferred over homogeneous green areas (Kaplan & Kaplan 1989).

Being an intangible service with no explicit market, it is challenging to measure the value of aesthetics (Polasky et al. 2019). These valuations are crucial for decision-making aimed at maximizing welfare given scarce resources (for example, land or budget) while accounting for synergies or trade-offs. Such trade-offs exist when there is a conflict between ecological sustainability and the visual aesthetics of landscapes (Junker & Buchecker 2008). Accounting for synergies, the European Union encourages farmers to pursue certain farming practices and to restore specific habitats.

Anat Tchetchik

Further reading

Leopold 1966 [1949]; Cooper et al. 2009; Gobster 1999.

See also: Cultural services, Landscape, Landscape ecology.

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Affluence

Commonly considered the average material standard of living in a nation, typically measured by per capita gross domestic product (GDP) or gross national product (GNP). Due to unequal distribution of wealth within countries, the simple division of total GDP by the human population to arrive at GDP per capita can be a misleading measure of affluence, which necessitates disaggregation among different income groups.

In ecological economics, the role of affluence in determining unsustainability is an essential concept since at least the development of the (environmental) Impact = (human) Population * Affluence * Technology (IPAT) equation developed by Paul Ehrlich and John Holdren (1971). Recently, Wiedmann et al. (2020) have brought renewed attention to the fact that the most affluent citizens of the world are responsible for most of the environmental impacts, and any response to rapid resource depletion and the climate crisis requires a restructuring of our socio-economic systems to be less wasteful and unequal in the consumption and distribution of resources.

Rigo E.M. Melgar

See also: Wealth distribution, Economic inequality, Gender inequality, Environmental impact assessment tools, Ecologically unequal exchange, Affluenza.

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Wiedmann, T., Lenzen, M., Keyßer, L.T. & Steinberger, J.K. 2020. Scientists' warning on affluence. Nature Communications 11(1): 1–10.

Affluenza

A painful, contagious, socially transmitted condition of overload, debt, anxiety, and waste resulting from the dogged pursuit of more (de Graaf et al. 2014). Sometimes described as an addiction, it is characterized by an obsession with economic expansion, an increasing gross domestic product, and mindlessly embracing the tenets of contemporary capitalism, resulting in irrational and unsustainable consumption of consumer goods with immediate but transient feelings of satisfaction and pleasure.

Patricia A. Gotschalk

Further reading

Lo 2009.

See also: Consumption externalities, Capitalism, Urban unsustainability, Debt, Ecosystem health.

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Agent-based modeling (ABM)

A computer simulation technique used to model large numbers of mostly autonomous agents (representing individuals or aggregate actors) interacting with other agents and/or a simulated environment to reproduce and better understand macro-level emergent phenomena (for example, herd behavior within a financial market) or to forecast complex non-linear dynamics over space and time (for example, landscape-wide land-use/land-cover change). This technique centers on simulated agents that typically possess an independent and adaptive decision-making schema, heterogenous preferences, and individualized histories developed through interactions within a localized environment (or via links within a social network) striving to replicate the bottom-up processes responsible for "unintuitive" system-level outcomes.

Many agent-based models build upon the concept of cellular automata, in that they are designed to mimic the heterogeneous interactions of neighboring grid cells, but offer greater modeling flexibility in terms of alternative or non-spatial interaction schemes, reflective rather than reactive agent decision-making, simultaneous implementation of multiple agent types, programming of agent behavior separate from agent environments, and agent mobility.

A key methodological strength is the ability to relax certain problematic assumptions underpinning formal analytical models necessary to gain tractability (for example, ignoring spatial dynamics, imposing actor homogeneity, or relying solely on strict utility maximization); whereas concerns about external validation of model findings and infeasibility of making point predictions regarding complex adaptive systems are potential weaknesses of this approach.

Mark D. Rouleau

Further reading

Railsback & Grimm 2019; Wilensky & Rand 2015; Macal & North 2010; Venturini et al. 2015; Cioffi-Revilla 2014; Epstein & Axtell 1996; Gallegati & Richiardi 2009.

See also: Models and modeling, Complexity, Systems-oriented simulation models, Analytical models, Spatial dynamics, Non-linear, Preference heterogeneity.

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Wilensky, U. & Rand, W. 2015. An Introduction to Agent-Based Modeling: Modeling Natural, Social, and Engineered Complex Systems with NetLogo. Cambridge, MA: MIT Press.

Agribusiness

a. The total of all operations involved in the manufacture and distribution of farm supplies; production operations on the farm; and the storage, processing, and distribution of farm commodities and items made from them (Davis & Goldberg 1957).
b. Originally focused on the business sector encompassing all actors and organizations involved in commercial farm-related activities. This not only includes farm production and distribution, but all businesses in the agricultural value chain, including agricultural inputs, storage,

processing, transportation, marketing, and retailing, regardless of their size or profit-seeking behavior (Van Fleet 2016).
c. The application of theories and practices from business administration to organizations engaged in agriculture and agriculturally related products and services (Van Fleet 2016).

PHILLIP M. WARSAW

Further reading

Cramer et al. 2001.

See also: Agricultural economics, Food system, Sustainable agriculture, Industrial economics.

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Van Fleet, D. 2016. What is agribusiness? A visual description. Amity Journal of Agribusiness 1(1): 1–6.

Agricultural economics

A field of applied economics that applies neoclassical economic theories of the firm, organization, and consumer behavior to the production, processing, distribution, marketing, retailing, and consumption of food and fiber products. Runge (2006) lists seven distinct areas of study within modern agricultural economics: technical change and the returns to human capital investments; environment and resources; trade and international economic development; agricultural risk; price determination and income stabilization; market structure and the organization of agricultural businesses; and food marketing and retailing.

PHILLIP M. WARSAW

Further reading

Cramer et al. 2001.

See also: Agribusiness, Food system, Sustainable agriculture, Industrial economics.

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Runge, C.F. 2006. Agricultural economics: a brief intellectual history. Center for International Food and Agricultural Policy, University of Minnesota, Working Paper WP06-1.

Agricultural ecosystem services

Ecology: the benefits provided by agricultural ecosystems to humans, such as the provision of food, fiber, and fuel. Depends on a variety of supporting and regulating services, including water provision and regulation, pollination, biological pest control, soil formation and fertility, and nutrient cycling, among others (Zhang et al. 2007). Flows of services may be disrupted or degraded but they are not a stock subject to depletion, nor can they be stored for future use (Richardson 2010).

Economics: the services provided by agricultural ecosystems that generate market and non-market economic values. Food production such as the production of crops, meat, fish, fruits by subsistence farming, hunting, gathering, or fishing. Raw materials including production of lumber, fuels, fiber, fodder, and other materials for use as resources or inputs in the production of goods or services (Richardson 2010).

ROBERT B. RICHARDSON

Further reading

Power 2010; Swinton et al. 2007.

See also: Ecosystem services, Food security, Agroecology, Agricultural economics.

References

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Agroecology

A paradigm that attends to ecological, social, and political dynamics across scales in transitions to socially just and ecologically sound agricultural and food systems. The term "agroecology" evolved from the application of ecological methods in agricultural research (Bensin 1930) to the ecology of entire food systems (Francis et al. 2003). Today, agroecology comprises social and ecological principles (e.g., CIDSE 2018) that promote ecological resilience, food sovereignty, and social justice. Emphasizing principles over rigid definitions and prescriptions allows for context-specific approaches that integrate multiple types of knowledge.

The application of agroecology across diverse social-ecological contexts has led to the existence of multiple "agroecologies" (Méndez et al. 2013). Narrow applications of agroecology, focused primarily on Western biophysical science, tend to align with reformist paradigms that maintain existing political and economic systems. In contrast, explicitly political agroecology—also termed "peasant agroecology" and "transformative agroecology"—aims to transform power relations within agricultural and food systems (González de Molina et al. 2019). This approach emphasizes ecologically resilient agroecosystems and equitable social processes related to governance and knowledge production (Anderson et al. 2021). Opposing industrial agriculture and the consolidation of corporate power within food systems, political agroecology and its sister concept, food sovereignty, seek to amplify the voices, agency, and expert knowledge of indigenous and peasant communities, while promoting sustainable livelihoods for smallholder farmers and food producers (Nyéléni Center 2015). Circular and solidarity economies are integral to these efforts.

Catherine E. Horner

Further reading

Méndez et al. 2016.

See also: Ecosystem resilience, Food self-sufficiency, Food security, Sustainable agriculture, Social justice, Political ecology, Paradigm.

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Nyéléni Center. 2015. Declaration of the International Forum for Agroecology. http://www.foodsovereignty.org/forum-agroecology-nyeleni-2015/.

Agroforestry

A form of agriculture and land management that involves the intentional growth of trees and/or shrubs along with food crops or pastureland. In some cases, hundreds of tree

species are used. Agroforestry not only promotes agroecological succession and greater biodiversity, but it also has multiple additional economic, environmental, and social benefits: enhanced crop yields, improved economic livelihoods for farmers, improved soil structure, soil health, reduced erosion, and carbon sequestration. Agroforestry involves management practices that are intentional, intensive, integrated, and interactive. At least five types of agroforestry systems or practices have been recognized (USDA 2019): (1) forest farming; (2) alley cropping; (3) silvopasture; (4) riparian forest buffers; and (5) windbreaks.

Barry D. Solomon

Further reading

Nair 1993; Young 1989; Sanchez 1995.

See also: Forestry, Silviculture, Soil conservation, Soil health, Carbon sequestration, Biodiversity, Ecological succession, Agricultural ecosystem services, Sustainable agriculture, Agroforestry Accounting System (AAS).

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Young, A. 1989. Agroforestry for Soil Conservation. Wallingford: CAB International.

Agroforestry Accounting System (AAS)

An ecosystem accounting system that allows individual economic activities such as total products (outputs) and production costs to be attributed to the property rights associated with the institutional sectors of the farmer (non-financial corporation owner) and the government (collective owner) (Campos et al. 2019a). Its aim is to measure individual activities, and farmer and government sustainable total incomes at observed and simulated transaction prices as the valuation criteria for consumption of final products. It integrates the economic variables of the standard System of National Accounts (SNA) in a consistent manner by overcoming the standard net domestic product omissions and valuation bias shortcomings (European Commission et al. 2009).

The AAS explicitly accounts for ecosystems as biophysical production factors from nature that support economic activities. This economic ecosystem concept has the advantage of direct integration into the ecosystem accounting production and capital accounts. Environmental asset production variables include: depletion (environmental work in progress used), measured as ordinary own environmental intermediate consumption; degradation of environmental fixed assets, measured as environmental consumption of fixed capital; and residual return from environmental fixed assets, measured as environmental net operating margin. Sustainable total income equals net value added plus capital gains. The latter is separated into manufactured and natural capital categories.

Pablo Campos Palacín

Further reading

Campos et al. 2017, 2019b, 2020.

See also: Agroforestry, System of National Accounts (SNA), Natural capital, Manufactured capital.

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study, Arroyo de la Luz. Spain. Environments 4(4): 82.
European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development et al. 2009. System of National Accounts 2008 (SNA 2008). New York. http://unstats.un.org/unsd/nationalaccount/docs/SNA2008.pdf.

Agrowth

A term proposed by Jeroen van den Bergh in response to doubts about both green growth and anti-growth (or degrowth) as scientifically logical and politically wise strategies to achieve sustainability goals (van den Bergh 2011). The starting point of agrowth thinking is that the standard measure of economic growth, gross domestic product (GDP) per capita, is for many reasons an unreliable indicator of social welfare and progress (van den Bergh 2009). GDP should therefore be ignored, resulting in an agrowth position that is indifferent or agnostic about economic growth. Agrowth reflects a precautionary approach in the face of uncertainty about the feasibility of green growth. Holding an agrowth view means that one can be concerned about growth without adopting a dogmatic anti-growth position. Agrowth implies that policy decisions do not prioritize income over welfare, nor assume that growth (or degrowth) is generally required or sufficient for societal progress.

Under an agrowth strategy, periods with high growth might alternate with low or even negative growth, as long as social welfare improves. By ignoring GDP information, under an agrowth paradigm we could implicitly accept less GDP growth for, for example, a better environment, more equality, or more leisure (van den Bergh 2017). Empirical evidence suggests that an agrowth position is already positively judged by many scientists and citizens (Drews & van den Bergh 2016, 2017). In fact, an agrowth strategy helps to depolarize the debate on growth versus environment, by encouraging everyone to reconsider any strict pro- or anti-growth position. This might ultimately weaken political resistance against serious environmental and social policies.

Jeroen van den Bergh

See also: Gross domestic product (GDP), Growth, Economic growth, Income, Welfare, Green growth, Degrowth, Sustainability, Progress, Equitable.

References

Drews, S. & van den Bergh, J.C.J.M. 2016. Public views on economic growth, the environment and prosperity. Global Environmental Change 39: 1–14.
Drews, S. & van den Bergh, J.C.J.M. 2017. Scientists' views on economic growth versus the environment. Global Environmental Change 46: 88–103.
van den Bergh, J.C.J.M. 2009. The GDP paradox. Journal of Economic Psychology 30(2): 117–35.
van den Bergh, J.C.J.M. 2011. Environment versus growth—a criticism of "degrowth" and a plea for "agrowth." Ecological Economics 70(5): 881–90.
van den Bergh, J.C.J.M. 2017. A third option for climate policy within potential limits to growth. Nature Climate Change 7(February): 107–12.

Alienation

The separation of the self from some "other," where the separation prevents full development of the self. Alienation is particularly associated with Marxist (and Marxist-influenced) traditions. For example, Marx (1844 [2009]) argues that labor is alienated under capitalism because workers lack control. Under capitalism, workers do not get to decide what they produce or how they produce it. Workers work to meet the needs of capitalists, rather than their own needs, and they do so in conditions determined by capitalists. For Marx, this separation of the act of working from control of the productive process turns work into something intrinsically against human nature and therefore prevents full development of the self.

A second example, also found in the Marxist tradition, is alienation from nature. This is a separation of the self from the natural world, such that humanity is seen as outside of and able to dominate nature. Alienation from nature is often explained in terms of industrialization and the separation of production from consumption. Alienation from nature is connected to anxiety, loss

of creativity, and an underappreciation of our interconnectedness and position within ecosystems.

SIMON MAIR

Further reading

Leopold 2018; Tickle 2019; Vogel 1988.

See also: Objective well-being, Subjective well-being, Analytical dualisms, Interconnected.

References

Leopold, D. 2018. "Alienation," in The Stanford Encyclopedia of Philosophy. Stanford Encyclopedia of Philosophy University, Fall 2018 edition. E.N. Zalta, ed. https://plato.stanford.edu/archives/fall2018/entries/alienation.

Marx, K. 1844 [2009]. Economic and philosophic manuscripts. https://www.marxists.org/archive/marx/works/1844/manuscripts/preface.htm.

Tickle, L. 2019. The practice of hunting as a way to transcend alienation from nature. Journal of Transdisciplinary Environmental Studies 17(1): 22–37.

Vogel, S. 1988. Marx and alienation from nature. Social Theory and Practice 14(3): 367–87.

Alien species

Ecology: any species of plant, animal, or pathogen that occurs or is introduced by humans outside of its natural range and dispersal potential. Also called exotic species.

BARRY D. SOLOMON

Further reading

Pimentel et al. 2005; Cox 1999.

See also: Species, Invasive species, Endangered species.

References

Cox, G.W. 1999. Alien Species in North America and Hawaii: Impacts on Natural Ecosystems. Washington, DC: Island Press.

Pimentel, D., Zuniga, R. & Morrison, D. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52(3): 273–88.

Allocation

The process of apportioning or dividing up resources between competing uses, which is a fundamental task of all economic systems.

BARRY D. SOLOMON

See also: Resource allocation, Pareto optimality, Intertemporal allocation.

Altruism

The principle, belief, and/or selfless practice of concern for the happiness and welfare of other people or other animals. Many psychologists believe that empathy leads to altruistic rather than egoistic motivation to help others (Batson et al. 1981). Altruistic behavior may even be harmful to the one carrying it out. While altruism is considered a traditional virtue in many cultures and religious practices, the definition of "others" deserving of altruism varies widely. The existence of altruism is a major contradiction of the self-interest hypothesis of neoclassical economics which assumes that material self-interest exclusively motivates all people (Fehr & Schmidt 2006).

BARRY D. SOLOMON

Further reading

Simon 1993.

See also: Empathy, Egoismhedonism, Behavioral economics, Experimental economics, Bounded rationality, *Homo economicus*.

References

Batson, C.D., Duncan, B.D., Ackerman, P., Buckley, T. & Birch, K. 1981. Is empathetic emotion a source of altruistic motivation? Journal of Personality and Social Psychology 40(2): 290–302.

Fehr, E. & Schmidt, K.M. 2006. "The economics of fairness, reciprocity, and altruism—experimental evidence and new theories,"

pp. 615–91 in Handbook of the Economics of Giving, Altruism and Reciprocity, Volume 1. S.C. Kolm & J.M. Ythier, eds. Amsterdam: North-Holland.
Simon, H.A. 1993. Altruism and economics. American Economic Review 83(2): 156–61.

Altruistic value

A type of non-use economic value placed on knowing that the current generation of people can enjoy an environmental asset (good), attribute (natural capital), or ecosystem service (Ojea & Loureiro 2007). However, among the categories of non-use value it is typically difficult if not impossible to separate the subcategories. Thus, there needs to be rigorous valuation techniques to estimate the value of benefits received from environmental goods and services. Also, it may be difficult to separate someone's non-use value from their use valuation, as the value of one may affect the value of the other. Thus, it is risky to estimate non-use value in isolation.

BARRY D. SOLOMON

See also: Non-use value, Altruism, Existence value, Bequest value, Use value, Economic valuation techniques.

Reference

Ojea, E. & Loureiro, M.L. 2007. Altruistic, egoistic and biospheric values in willingness to pay (WTP) for wildlife. Ecological Economics 63(4): 807–14.

Amenity

Site-specific attribute that provides benefits to certain people or firms. These are usually local benefits. Thus, amenity is often defined alternatively as a site-specific attribute that enhances the local quality of life and/or the local attractiveness for certain people or firms. Note that a given attribute may be an amenity for some people but not for others, which raises equality issues. Amenities are diverse and loosely classified (for instance as "modern," "historical," or "natural"). Natural amenities are of particular interest to ecological economics. They can be related to the concept of ecosystem services: a natural amenity is a site-specific piece of an ecosystem that provides services to certain people or firms located nearby (Schaeffer & Dissart 2018).

YVES SCHAEFFER

Further reading

Ahmadiani & Ferreira 2019; Mendelsohn & Olmstead 2009; Waltert & Schläpfer 2010.

See also: Quality of life (QoL), Ecosystem services, Amenity value.

References

Ahmadiani, M. & Ferreira, S. 2019. Environmental amenities and quality of life across the United States. Ecological Economics 164: 106341.
Mendelsohn, R. & Olmstead, S. 2009. The economic valuation of environmental amenities and disamenities: methods and applications. Annual Review of Environment and Resources 34: 325–47.
Schaeffer, Y. & Dissart, J.C. 2018. Natural and environmental amenities: a review of definitions, measures and issues. Ecological Economics 146: 475–96.
Waltert, F. & Schläpfer, F. 2010. Landscape amenities and local development: a review of migration, regional economic and hedonic pricing studies. Ecological Economics 70(2): 141–52.

Amenity value

Economic value of an amenity for some people or firms, that is, what they are willing to sacrifice to acquire more of it. Although total economic value has use, non-use, option, and existence components, and can be associated with marginal or non-marginal changes in supply, amenity value generally refers—more narrowly—only to marginal use or non-use values, measured using revealed preference or stated preference econometric methods (for example, hedonic estimates of price premiums in housing and wage markets).

YVES SCHAEFFER

Further reading

Mendelsohn & Olmstead 2009; Walter & Schläpfer 2010; Schaeffer & Dissart 2018; Ahmadiani & Ferreira 2019.

See also: Amenity, Private amenity value, Aesthetics, Total economic value (TEV), Revealed preference methods, Stated preference methods, Hedonic pricing method.

References

Ahmadiani, M. & Ferreira, S. 2019. Environmental amenities and quality of life across the United States. Ecological Economics 164: 106341.

Mendelsohn, R. & Olmstead, S. 2009. The economic valuation of environmental amenities and disamenities: methods and applications. Annual Review of Environment and Resources 34: 325–47.

Schaeffer, Y. & Dissart, J.C. 2018. Natural and environmental amenities: a review of definitions, measures and issues. Ecological Economics 146: 475–96.

Waltert, F. & Schläpfer, F. 2010. Landscape amenities and local development: a review of migration, regional economic and hedonic pricing studies. Ecological Economics 70(2): 141–52.

Analytical dualisms

Sociology: the binary (zero-sum) distinction between conceptual categories that do not permit spaces for crossover or blending, but rather rest purely on opposition. These include, for instance, perceptions of success or failure, and presence or absence. They also extend to spatial and temporal characteristics such as the urban and the rural; dualisms among the past, present, and future; and between gender distinctions, male and female. Another common analytical dualism is the debate between structure (for example, institutions and relationships of power) and agency (for example, capacity of individuals or collectives to act autonomously). Analytical dualisms rest on the presumption of an absence of subjectivity or normative insertions, even as though dualistic thinking is itself a particular subjectivity.

Critical geography: the consideration of non-human natures as external to human life, and thus amenable to management and manipulation. The ontological distinction of human life from non-human life characterizes a Cartesian binary that equates the human with the mind/mental and the non-human with an external passive physical presence that lacks agency and cannot think. Cartesian dualisms have come to characterize people "saving nature" with the presumptions that a subset of them (for example, people) are outside of a normative conception of it (for example, nature).

Vijay K. Kolinjivadi

Further reading

Giddens 1989; Lockie 2004; Sayer 1991.

See also: Institutions, Autonomous institution, Human agency, Geography.

References

Giddens, A. 1989. The Constitution of Society: Outline of the Theory of Structuration. Berkeley, CA: University of California Press.

Lockie, S. 2004. Collective agency, non-human causality and environmental social movements: a case study of the Australian "Landcare Movement." Journal of Sociology 40(1): 41–57.

Sayer, A. 1991. Behind the locality debate: deconstructing geography's dualisms. Environment and Planning A 23(2): 283–308.

Analytical models

Mathematical models with a closed form solution (Ayres 1978). Examples are many, and include thermodynamic models, models of simple linear components of ecosystems such as food chains, equations used in return on investment, energy return on investment, an input–output analysis portrayal of an economy, and facility location problems (Erkut & Neuman 1989).

Barry D. Solomon

See also: Models and modeling, Classical thermodynamics, Input–output (I–O) analysis, Environmentally extended input–output analysis (EE–IOA), Return on investment (ROI), Energy return on investment (EROI).

References

Ayres, R.U. 1978. Resources, Environment, and Economics: Applications of the Materials/

Energy Balance Principle. New York: John Wiley & Sons.
Erkut, E. & Neuman, S. 1989. Analytical models for locating undesirable facilities. European Journal of Operational Research 40(3): 275–91.

Anthropocene

Environmental systems science:

a. The amalgamation of events and processes, both natural and anthropic, since human activity first affected the Earth's natural global functioning, characterized by our stewardship of the planet. As such, the Anthropocene (from Zalasiewicz et al. 2021) encompasses volcanic eruptions, earthquakes, the passage of ocean currents, and changes of climate, as well as human social and economic activities.
b. (From Crutzen 2006): a new geological epoch, where the human species becomes a force outcompeting natural processes.

Geology: a period demarcated by a substantial anthropic influence on the Earth's biogeochemical processes, resulting in a permanent physical record in the planet's rock strata.

Archaeology: stratigraphic boundaries within archaeosphere deposits, marking the start of processes such as the spread of agriculture, diffusion of pottery or metal technologies, phases of industrialization, introduction of novel materials such as plastics, and the advent of nuclear technology.

Jordan P. Everall & Ilona M. Otto

Further reading

Edgeworth et al. 2015; Hamilton 2015; Olvitt 2017.

See also: Anthropogenic, Biosphere.

References

Crutzen, P.J. 2006. "The Anthropocene," pp. 13–18 in Earth System Science in the Anthropocene. E. Ehlers & T. Krafft, eds. Berlin and Heidelberg: Springer.
Edgeworth, M., deB Richter, D., Waters, C. et al. 2015. Diachronous beginnings of the Anthropocene: the lower bounding surface of anthropogenic deposits. The Anthropocene Review 2(1): 33–58.
Hamilton, C. 2015. Getting the Anthropocene so wrong. The Anthropocene Review 2(2): 102–7.
Olvitt, L.L. 2017. Education in the Anthropocene: ethico-moral dimensions and critical realist openings. Journal of Moral Education 46(4): 396–409.
Zalasiewicz, J., Waters, C.N., Ellis, E.C. et al. 2021. The Anthropocene: comparing its meaning in geology (chronostratigraphy) with conceptual approaches arising in other disciplines. Earth's Future 9(3): e2020EF001896.

Anthropogenic

Caused, relating to, influenced by, or originating in human activity, either directly or indirectly, especially the human impacts on nature. The term "anthropogenic" was first used by Russian geologist Aleksei Pavolv in 1922, and in English by the British ecologist Arthur Tansley (1935, p. 304). Several decades later, the term "Anthropocene," coined by the Dutch atmospheric scientist Paul Crutzen in the mid-1970s, was proposed as a geological epoch to signify that the post-World War II period has been marked by human activity as the dominant influence on climate and the environment.

In the late 20th century and early 21st century, anthropogenic causes have become increasingly important factors in global change, global climate change and global warming, deforestation, biodiversity loss, as well as for traditional environmental problems such as eutrophication, desertification, toxic pollution, and so on.

Barry D. Solomon

Further reading

Yeo 2016; Crutzen 2006; Lewis & Maslin 2015.

See also: Global change, Climate change, Global warming, Biodiversity, Deforestation, Eutrophication, Anthropocene.

References

Crutzen, P.J. 2006. "The Anthropocene," pp. 13–18 in Earth System Science in the

Anthropocene. E. Ehlers & T. Krafft, eds. Berlin and Heidelberg: Springer.
Lewis, S.L. & Maslin, M.A. 2015. Defining the Anthropocene. Nature 519: 171–80.
Tansley, A.G. 1935. The use and abuse of vegetational concepts and terms. Ecology 16(3): 284–307.
Yeo, S. 2016, October 5. Anthropocene: history of an idea. Carbon Brief: Clear on Climate. https://www.carbonbrief.org/anthropocene-journey-to-new-geological-epoch.

Applied economics

Application of a set of economic tools to test economic theories in many areas including in the field of ecosystems and ecology in a real-world situation. Tools used include econometrics, experimental economics, and case studies. Applied economics involves steps including design of analytical framework and methodology, data collection, analysis of data, and interpretation of results. It can also focus only on methodology for analysis. Data analysis provides much-needed quantitative measures to compare various options and different scenarios.

Economic decisions of both production and consumption in an economy impact ecosystems rapidly, as population and material welfare increase over time. Study of the economy–ecology interface became popular with the development of modern approaches provided by Nicholas Georgescu-Roegen (1971), followed by Herman Daly's (1973) celebrated work on steady-state economics. Applied economics can help to derive sustainable production and consumption decisions and design policies on how to incentivize individuals, to influence them to behave in a manner compatible with an ecologically sustainable pathway.

Gurumurthy Mythili

Further reading

Repetto et al. 1989.

See also: Econometrics, Models and modeling, Steady state, Steady state economy, Sustainable development, Natural resource accounting, Benefit–cost analysis (BCA).

References

Daly, H.E., ed. 1973. Toward a Steady-State Economy. San Francisco, CA: W.H. Freeman & Co.
Georgescu-Roegen, N. 1971. The Entropy Law and the Economic Process. Cambridge, MA: Harvard University Press.
Repetto, R., Magrath, W., Wells, M., et al. 1989. Wasting Assets: Natural Resources in the National Income Accounts. Washington, DC: World Resources Institute.

Applied systems analysis

A scientific approach that aims to enhance our understanding of real-world problems arising in dynamic socio-economic–environmental systems at different scales. Applied systems analysis informs decisions of relevant stakeholders, recognizing the trade-offs and synergies between multiple objectives that they wish to pursue, as well as inherent uncertainties of the considered systems. It uses both qualitative and quantitative research methods and tools, most notably, mathematical modeling. Considerations of optimality, scenarios, feedbacks, transitions, trade-offs, emergence, risk, and stakeholder inputs are emphasized.

Elena Rovenskaya

Further reading

Hynes et al. 2020; Meadows 2008; Jackson 2009; Raiffa 2002; Tarasenko 2021.

See also: Coupled human and natural systems, Models and modeling, Dynamic systems, Complex systems modeling, Systems-oriented simulation models, Management science, Social-ecological systems.

References

Hynes, W., Lees, M. & Müller, J.M., eds. 2020. Systemic Thinking for Policy Making: The Potential of Systems Analysis for Addressing

Global Policy Challenges in the 21st Century. Paris: OECD Publishing.
Jackson, M.C. 2009. Systems Thinking: Creative Holism for Managers. New York: John Wiley & Sons.
Meadows, D. 2008. Thinking in Systems: A Primer. White River Junction, VT: Chelsea Green Publishing.
Raiffa, H. 2002. Negotiation Analysis: The Science and Art of Collaborative Decision Making. Cambridge, MA: Harvard University Press.
Tarasenko, F.P. 2021. Applied Systems Analysis: Science and Art of Solving Real-Life Problems. London: CRC Press.

Appropriation

General: taking something, often implying either without a right to do so or when doing so causes negative impacts. The term is often used in reference to land conversion or natural resource consumption (e.g., Schaffartzik et al. 2019; Erb et al. 2009).

Government: part of a government budget allocated for spending on a particular purpose.

Water law: a water right established under the prior appropriation doctrine, which allows the establishment of a water right following declaration of an intention followed by the act of taking the water and putting it to the intended use.

Brent M. Haddad

See also: Eminent domain, Regulatory taking, Resource consumption.

References

Erb, K., Krausmann, F., Gaube, V., et al. 2009. Analyzing the global human appropriation of net primary production—processes, trajectories, implications. An introduction. Ecological Economics 69(2): 250–59.
Schaffartzik, A., Duro, J. & Krausmann, F. 2019. Global appropriation of resources causes high international material inequality—growth is not the solution. Ecological Economics 163: 9–19.

Aquaculture

The breeding, rearing, and harvesting of freshwater or saltwater populations under controlled conditions. Aquaculture encompasses the farming of fish, shellfish, algae, aquatic plants, and other organisms. Aquaculture production has grown dramatically in the last three decades, with China accounting for over 60 percent of global production. While aquaculture helps to meet a growing global demand for fish and shellfish consumption, its growth has raised several environmental challenges, including: freshwater demand, water pollution and eutrophication, release of nutrients and chemicals, habitat loss, declining wild fish populations, fish disease and parasite growth, mangrove deforestation, and greenhouse gas emissions (Ahmed et al. 2019).

Barry D. Solomon

See also: Fishery, Fishery resources, Fisheries management.

Reference

Ahmed, N., Thompson, S. & Glaser, M. 2019. Global aquaculture productivity, environmental sustainability, and climate change adaptability. Environmental Management 63(2): 159–72.

Arbitrage

a. The act of obtaining profits by exploiting differences in prices, by simultaneously buying and selling the same asset in two separate markets. Examples include trading energy or water across markets separated by geography, or trading commodity contracts across spot and futures markets. By closing price gaps, arbitrage can improve the efficiency of market allocations, though it may sometimes also exacerbate externalities.
b. The act of obtaining profits by exploiting differences in willingness to pay and willingness to accept among participants in a single market characterized by low information, transaction costs, or other sources of illiquidity. Examples of such

markets include emissions trading programs and surface water markets.
c. No arbitrage: the lack of opportunities for arbitrage, that is, a state in which there exist no unmodeled differences in price for the same asset. This is a common assumption in economic theory.

NICK W. HAGERTY

Further reading

Arellano-Gonzalez & Moore 2020; Borenstein et al. 2008; Dybvig & Ross 1989; Holzer & DePiper 2019.

See also: Transaction costs, Emissions trading, Willingness to pay (WTP), Willingness to accept (WTA), Externalities.

References

Arellano-Gonzalez, J. & Moore, F.C. 2020. Intertemporal arbitrage of water and long-term agricultural investments: drought, groundwater banking, and perennial cropping decisions in California. American Journal of Agricultural Economics 102(5): 1368–82.
Borenstein, S., Bushnell, J., Knittel, C.R. & Wolfram, C. 2008. Inefficiencies and market power in financial arbitrage: a study of California's electricity markets. Journal of Industrial Economics 56(2): 347–78.
Dybvig, P.H. & Ross, S.A. 1989. "Arbitrage," pp. 57–71 in Finance. J. Eatwell, M. Milgate & P. Newman, eds. London: Palgrave Macmillan.
Holzer, J. & DePiper, G. 2019. Intertemporal quota arbitrage in multispecies fisheries. Journal of Environmental Economics and Management 93: 185–207.

Arithmomorphism

From Georgescu-Roegen (1971), a concept is arithmomorphic if it is "discretely distinct." This neologism is based on the Greek root *arithmos* (number), because real numbers are the most elementary examples of discretely distinct concepts. More generally, discrete distinction is the essence of logic and mathematics. It differentiates them from other modes of reasoning based on dialectical concepts, for which such discrete distinction is absent. The distinction between arithmomorphic and dialectical concepts is particularly useful to think about the role of mathematical models in economics. For Georgescu-Roegen, this role can only be limited and subordinate because arithmomorphic concepts cannot capture the qualitative changes at play in the economic process.

QUENTIN COUIX

Further reading

Georgescu-Roegen 1979; Couix 2021.

See also: Dialectic reasoning, Models and modeling.

References

Couix, Q. 2021. Models as "analytical similes": on Nicholas Georgescu-Roegen's contribution to economic methodology. Journal of Economic Methodology 28(2): 165–85.
Georgescu-Roegen, N. 1971. The Entropy Law and the Economic Process. Cambridge, MA: Harvard University Press.
Georgescu-Roegen, N. 1979. Methods in economic science. Journal of Economic Issues 13(2): 317–28.

Assimilation

Ecology:

a. Absorption of substances or materials into organisms via digestion or photosynthesis.
b. Absorption of contaminants by natural systems, particularly as used in assimilative capacity.

Economics: incorporation of immigrants into a society, including economic and cultural life. Economic assimilation is, for example, evaluated in terms of earnings or occupation.

STURLA F. KVAMSDAL

Further reading

Abramitzky et al. 2014.

See also: Absorptive capacity, Waste absorption capacity, Assimilative capacity.

Reference

Abramitzky, R., Platt Boustan, L. & Eriksson, K. 2014. A nation of immigrants: assimila-

tion and economic outcomes in the age of mass migration. Journal of Political Economy 122(3): 467–506.

Assimilative capacity

The capacity of a system to absorb a substance without significant degradation. Early usage (20th century) in water science to describe processing of simple organic wastes such as sewage by rivers or streams. Later usage includes the ability of natural systems more generally to absorb, break down, or disperse other types of contaminants. Examples include oxidation and sedimentation of metals, and maintenance of the gas balances in the atmosphere. The term "assimilative capacity" has been debated, in particular how "significant degradation" should be understood and measured.

Sturla F. Kvamsdal

Further reading

Cairns 1999.

See also: Assimilation, Absorptive capacity, Waste absorption capacity, Effluent, Waste management.

Reference

Cairns, J., Jr. 1999. Assimilative capacity—the key to sustainable use of the planet. Journal of Aquatic Ecosystem Stress and Recovery 6: 259–63.

Assurance bond

An environmental policy instrument designed to control the external effects from environmental degradation and resource depletion, under which a regulator requires an entity to post a monetary bond covering the value of any potential environmental damages from its activity. The value of the bond is a function of the regulator's estimate of the value of environmental damages of the specified activity.

Tihomir Ancev

Further reading

Ancev & Merrett 2018; Shogren et al. 1993.

See also: Environmental policy instruments, Damages, Damage function, Environmental degradation, Resource depletion.

References

Ancev, T. & Merrett. D. 2018. Security bonding in unconventional gas development: evidence from an economic experiment. Ecological Economics 153: 139–46.

Shogren, J.F., Herriges, J.A. & Govindasamy, R. 1993. Limits to environmental bonds. Ecological Economics 8: 109–33.

Asymmetric information

A situation in which one or more of the parties to a market transaction or interaction has more, less, or different information than the others, and that information affects the value of the good or service exchanged. Sometimes called "information asymmetry." When one party exploits greater material knowledge to their advantage it is called "adverse selection." In practice, most transactions are characterized by asymmetric information. It is noteworthy that generally none of the parties has complete information, which is a violation of one of the assumptions of perfect competition in neoclassical economics and is thus a type of market failure. For example, when concluding an employment agreement, the employer knows better the working conditions at the enterprise (and may deliberately hide shortcomings), and the employee is better aware of their qualifications and productivity (and can also hide their weaknesses), while both the employee and employer know the formal terms of the employment contract that suits both of them.

Asymmetric information theory has been applied in ecological economics in the context of payment for ecosystem services, with suggestions for conservation agents on how they could reduce informational rents to landowners: for example, through contracts (Ferraro 2008). The consequences of asymmetric information are associated with irrational decision-making and distortion of the market mechanism. Overcoming asymmetric information is challenging, though digital

technologies can also help, which make it possible to formalize (digitalize, separate from the carrier) information about market participants.

ELENA G. POPKOVA

Further reading

de Meza & Webb 1987; Khan et al. 2021.

See also: Moral hazard, Market failure, Payment for ecosystem services (PES).

References

de Meza, D. & Webb, D.C. 1987. Too much investment: a problem of asymmetric information. Quarterly Journal of Economics 102(2): 281–92.
Ferraro, P. 2008. Asymmetric information and contract design for payments for environmental services. Ecological Economics 65(4): 810–21.
Khan, M.H., Bhatti, H.Y., Hassan, A. & Fraz, A. 2021. The diversification–performance nexus: mediating role of information asymmetry. Journal of Management and Governance 25(3): 787–810.

Atomism

a. Of or relating to an individual unit of a whole, without respect to the whole, or that unit's interaction with, dependency upon, or contribution to the whole (Merchant 1982; Plumwood 1993).
b. A theoretical approach for understanding the whole by way of analyzing its constituent parts.
c. A methodological approach that reduces the complexity of the whole to a summation of its attendant parts (Ament 2019).

JOSEPH A. AMENT

See also: Analytical dualisms, Complex systems modeling, System scale and hierarchy.

References

Ament, J. 2019. Toward an ecological monetary theory. Sustainability 11(3): 923.
Merchant, C. 1982. The Death of Nature: Women, Ecology, and the Scientific Revolution. New York: HarperSanFrancisco.
Plumwood, V. 1993. Feminism and the Mastery of Nature. London, UK and New York, USA: Routledge.

Auction

A trading mechanism for goods or services that occurs over a bidding process designed through a predetermined set of rules to achieve specific outcomes (Latacz-Lohmann & Schilizzi 2005). In a conservation auction, that is, a type of procurement auction where a buyer (generally a public authority) seeks to buy environmental goods or services from several suppliers by inviting them to bid, the key outcomes are to select the participants with the highest benefit–cost ratio (allocative efficiency) and achieving value for money, that is, using public resources to buy the most conservation benefit.

Different types of auctions can be distinguished according to the nature of the goods to be traded and to the procedural rules that are selected. In the English format, incremental bids are freely made and accepted until there are no buyers that wish to raise their bid. Therefore, once the highest price is reached (that is, the standing bid) if there are no displacing bids within a given time frame, the auction ends and the standing bidder becomes the winner. Unlike the English format, in which bids are publicly disclosed during the auction, in the Vickrey auction the bidders submit sealed bids; the highest bidder still wins but the price paid is the second-highest bid. In the Dutch auction the auctioneer lowers the price of a good until it gets a bid, so the auction ends with the first and only bid.

DANIELE VERGAMINI

Further reading

Milgrom & Milgrom 2004.

See also: Public goods, Emissions trading.

References

Latacz-Lohmann, U. & Schilizzi, S. 2005. Auctions for conservation contracts: a review of the theoretical and empirical literature. Report to the Scottish Executive Environment and Rural Affairs Department. https://digital.nls.uk/pubs/scotgov/2006/0022574.pdf.

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Austrian School of economics

In the transition from classical to neoclassical economics, the Austrian School began with the epistemological (methods) debates of the Marginalist Revolution sparked by its founder Carl Menger (1871) with William Stanley Jevons and Léon Walras over the scientific foundations of economics versus the historical understanding that there were no economic laws. This led to a new theory of marginal utility based on "subjective utility" that for the first time in economics ignored physical inputs and outputs of energy and materials (Jevons's earlier work on *The Coal Question*, Jevons 1865, from which ecological economics derives the Jevons paradox or rebound effect, was the exception).

The new "scientific foundations" of economics became largely based on mechanical physics, and the Austrian School has differentiated itself ever since from the "mainstream" by contesting the logical positivism of neoclassical economics, which is also contested by ecological economics. However, the marginal theory of value is acknowledged to have been developed by the Austrian School (Cachanosky 2021). Furthermore, Menger's work later inspired Ludwig von Mises and Friederich Hayek, who would develop the theoretical foundation for neoliberalism (Rodrigues 2013). In addition to marginalism and methodological subjectivism, other central tenets of the Austrian School of economics include methodological individualism, the importance of individual tastes and preferences, opportunity costs, and the time structure of consumption and production (Boettke & Leeson 2003).

Rigo E.M. Melgar

See also: Marginal analysis, Political economy, Individualism, Subjective preferences, Jevons paradox, Opportunity cost, Logical positivism, Neoliberalism.

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Menger, K. 1871. Principles of Economics. Vienna: Braumüller.

Rodrigues, J. 2013. The political and moral economies of neoliberalism: Mises and Hayek. Cambridge Journal of Economics 37(5): 1001–17.

Autonomous institution

An institution that consciously and reflexively governs itself with its own self-implemented laws. It refers to autonomy in its etymological and strong sense: *auto* = self, *nomos* = law. This contrasts to heteronomous institutions such as governing by the laws of markets or by the order of modern techno-science and experts. Autonomy challenges the role of citizens within democracy framed culturally in terms of daily practice, whether related to economy, technology, production, or law. It involves a decolonization of the dominant social imaginary in deconstructing dominating structures such as patriarchy or capitalism, or ideologies such as development, growth, techno-scientism, or economicism. It is an important approach within the degrowth movement, influenced by Cornelius Castoriadis and Ivan Illich's approaches developed by Serge Latouche. It also refers to John Holloway's distinction between "power over" and "power to."

Autonomous institution theory intends to reject economic "science" as an independent and neutral discipline. It seeks to re-embed the economy within the ecological, cultural, and social realms. It is an invitation to reflect on new types of more horizontal, participatory, inclusive, transparent self-governance,

questioning property through the notion of the commons. Hence the idea of unconditional autonomy allowance proposes a suite of measures on how to achieve autonomous institutions in which basic needs, and how to fulfill them sustainably and fairly, are voluntarily and democratically deliberated upon and decided. As such, autonomy refers to self-organizing governance based on open-relocalization, social and environmental justice, and convivial tools toward self-decided frugal abundance.

VINCENT LIEGEY

Further reading

Illich 1973; Castoriadis 1998; Holloway 2002; Latouche 2009; Asara et al. 2013; Liegey & Nelson 2020.

See also: Democracy, Commons, the, Embeddedness, Economism, Self-organization, Human agency.

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Castoriadis, C. 1998. The Imaginary Institution of Society. Cambridge, MA: MIT Press.
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Latouche, S. 2009. Farewell to Growth. Cambridge: Polity.
Liegey, V. & Nelson, A. 2020. Exploring Degrowth: A Critical Guide. London: Pluto Press.

Available water capacity

Ecology:

a. Internal renewable water resources plus the amount of water flowing in a country, under natural circumstances. Calculated as the sum of total renewable surface water and total renewable groundwater (km^3/year), less any overlapping (FAO 2015).
b. The actual maximum rate of water withdrawal that can be sustained indefinitely in a given country, without permanently damaging the ecosystem on which it depends. Actual and natural available water might differ due to possible agreements between upstream and downstream countries.

Economics: the actual amount of renewable freshwater withdrawal in a given country, including blue (for example, irrigation), green (that is, rainwater), and gray (that is, to assimilate pollutants) water. The volume might vary depending on technological development and infrastructures, climate change, alternative uses, and losses. Can be measured as the total direct water use (blue, green, and gray) necessary for domestic consumption and exports (from Distefano and Kelly 2017).

Social sciences: refers to the amount of water available for a population. Can be measured as a country's actual available water per capita plus the amount of water indirectly embedded in imported goods.

TIZIANO DISTEFANO

Further reading

Smakhtin et al. 2004; Chapagain & Hoekstra 2007; Distefano 2020.

See also: Virtual water, Water resources, Water footprint.

References

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Distefano, T. 2020. Water Resources and Economic Processes. New York: Routledge.
Distefano, T. & Kelly, S. 2017. Are we in deep water? Water scarcity and its limits to economic growth. Ecological Economics 142: 130–47.
FAO (Food and Agriculture Organization of the United Nations). 2015. Aquastat Database. Rome: FAO. http://www.fao.org/3/Y4473E/y4473e07.htm.
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B

Banks

Economics:

a. Central bank: highest institution of the financial system. It acts as the manager and guarantor of the payment system integrity through creating the ultimate form of liquidity as reserves detained by commercial banks and intervening as lender of last resort. In some countries and monetary systems such as the eurozone, the central bank also acts as financial regulator.
b. Commercial bank: financial institution creating money through granting credit to borrowers. Banks can create money *ex nihilo* through balance sheet operations by issuing a liability owed to the borrower of the borrowed amount, and an asset as debt of the same amount owed by the borrower to the bank. Only when the credit is granted banks seek to obtain the corresponding liquidities, either on the interbank market or from the central bank. Thus, contrary to common wisdom, banks are not a simple financial intermediary collecting deposits to lend them.

Ecology:

a. Gene banks: organizations preserving biodiversity through storing sources of genetic diversity such as seeds and buds for plants, or eggs and sperm for animals.
b. Offset banks: organizations selling offsetting certificates aimed at compensating for environmental impacts. When an agent impacts or destroys a wetland or another ecosystem through their activity, they can buy offset certificates that will fund restoration of another one. Banking is also allowed in some air pollution and greenhouse gas emissions trading systems. The extent to which the concept of compensation applies to the natural environment and the relevance of translating ecosystems into abstractions as tradable assets like offsetting certificates is debated.

LOUISON CAHEN-FOUROT

Further reading

Fantacci 2013; Fullwiler 2017; Kemp-Benedict & Kartha 2019.

See also: Money, Habitat banking, Tradable permits, Cap and trade, Carbon trading.

References

Fantacci, L. 2013. Why banks do what they do: how the monetary system affects banking activity. Accounting, Economics and Law 3(3): 333–56.

Fullwiler, S.T. 2017. "Modern central-bank operations: the general principles," pp. 50–87 in Advances in Endogenous Money Analysis. L.P. Rochon & S. Rossi, eds. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Kemp-Benedict, E. & Kartha, S. 2019. Environmental financialization: what could go wrong? Real World Economics Review 87(21): 69–89.

Basic and non-basic goods

Basic goods meet verifiable human needs, while non-basic goods meet wants. As suggested by Corning (2000), human needs are "the inner logic … of economic life" and "the skeletal structure upon which economies are built" (p. 79). As discussed at length by Reinert (2018), identifying the basic goods and services that meet basic needs appears to be possible and is important in setting policy priorities to support human well-being. The

identification of needs as a minimalist ethical floor also has relevance to issues of sustainability, particularly in energy policy and climate change, via the setting of what Rao and Baer (2012) refer to as "decent living emissions." While there is not a definitive list of basic goods and services, Reinert (2018) provides one possible approach that consists of food, clean water, sanitation services, health services, education services, housing, electricity, and human security services. Such a list can form a starting point to distinguishing basic and non-basic goods, as well as a set of basic development goals and subsistence rights (e.g., Reinert 2020).

Kenneth A. Reinert

See also: Human needs assessment, Matrix of human needs, Cultural services, Sustainable Development Goals (SDGs), Millennium Development Goals.

References

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Reinert, K.A. 2018. No Small Hope: Towards the Universal Provision of Basic Goods. New York: Oxford University Press.

Reinert, K.A. 2020. From sustainable development goals to basic development goals. Ethics and International Affairs 34(2): 125–37.

Bayesian belief networks

Bayesian belief networks (BBNs) represent interactions between variables as a directed acyclic graph formed by a series of interconnected nodes linking actions to outcomes (Pollino et al. 2007). The nodes represent the variables of the system, while the linkages among them indicate direct causal dependencies (Pollino et al. 2007). The strengths of the causal relationships are quantified by conditional probabilities that specify the probability of each variable having a particular "state" considering every possible combination of states of the parent nodes linked to it (Pollino et al. 2007).

These probability values can be based on empirical observations, or elicited from literature reviews, stakeholder consultation, or expert judgment (Pollino et al. 2007). BBNs are very flexible in terms of data requirements, and this makes them well suited to modeling complex socio-ecological systems and operationalizing conceptual models such as the ecosystem services cascade (Haines-Young & Potschin 2009). Socio-economic elements can be integrated with ecological process to evaluate the utility impacts associated with system outcomes or specified decisions (Haines-Young 2011; McVittie et al. 2015).

BBNs have been applied across a wide range of disciplines including medicine, finance, industrial diagnosis, as well as an increasing number of environmental and natural resource issues (Landuyt et al. 2013). BBNs can be used both for decision support and as investigative tools to explore how systems operate without the need to know the full functional relationships or the associated data.

Alistair G. McVittie

See also: Networks, Knowledge networks, Decision support systems, Decision-oriented optimization models.

References

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Haines-Young, R.H. & Potschin, M.B. 2009. Methodologies for defining and assessing ecosystem services. University of Nottingham, UK, Centre for Environmental Management, Report No. 14, for the Joint Nature Conservation Committee.

Landuyt, D., Broekx, S., D'hondt, R. et al. 2013. A review of Bayesian belief networks in ecosystem services modelling. Environmental Modelling and Software 46: 1–11.

McVittie, A., Norton, L., Martin-Ortega, J. et al. 2015. Operationalizing an ecosystem services-based approach using Bayesian Belief Networks: an application to riparian buffer strips. Ecological Economics 110: 15–27.

Pollino, C.A., Woodberry, O., Nicholson, A. et al. 2007. Parameterisation and evaluation of a Bayesian network for use in an ecological

risk assessment. Environmental Modelling and Software 22(8): 1140–52.

Behavioral ecological economics

A term that broadly describes the growing body of interdisciplinary research at the interface of ecological economics and the behavioral sciences. Among others, it includes understanding how economic incentives can undermine or reinforce people's intrinsic motivations to engage in biodiversity and ecosystem conservation (Rode et al. 2015), to what extent non-price behavioral interventions can stimulate energy conservation (Andor & Fels 2018), how people think about the growth-versus-environment debate (Drews et al. 2019), how social norms influence pro-environmental behavior (Farrow et al. 2017), why voters support environmental policies (Rhodes et al. 2017), or how behavioral theories are integrated in the analysis of social-ecological systems (Schlüter et al. 2017).

Stefan Drews

See also: Behavioral economics, Pro-environmental behavior (PEB), Motivation crowding, Bounded rationality.

References

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Drews, S., Savin, I. & van den Bergh, J.C.J.M. 2019. Opinion clusters in academic and public debates on growth-vs-environment. Ecological Economics 157: 141–55.

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Rode, J., Gómez-Baggethun, E. & Krause, T. 2015. Motivation crowding by economic incentives in conservation policy: a review of the empirical evidence. Ecological Economic 117: 270–82.

Schlüter, M., Baeza, A., Dressler, G. et al. 2017. A framework for mapping and comparing behavioural theories in models of social-ecological systems. Ecological Economics 131: 21–35.

Behavioral economics

An enhancement of neoclassical economics to take account of empirically supported evidence of human behavior. Behavioral economics has constructively incorporated insights from other social sciences, notably from psychology, anthropology, and neuroscience. Behavioral economics is concerned with how people empirically behave in decision-making situations and how their choices can be improved so that people's welfare is enhanced (Thaler 2015). A primary focus is placed on what is referred to as decision heuristics and biases and the specific effect of the situation or decision context on people's decisions (Thaler & Sunstein 2021).

The insights from behavioral economics are now a well-established feature in economic research and public policy, covering fields from health behavior to pension saving, from investment decisions to healthy and sustainable food choices. The recent interest in the area is based on its empirical success in predicting and explaining human behavior and providing evidence-based policy and entrepreneurial decisions.

Lucia A. Reisch

Further reading

Reisch & Zhao 2017; Sunstein & Reisch 2014.

See also: Behavioral ecological economics, Heuristic, Experimental economics.

References

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Thaler, R.H. & Sunstein, C.R. 2021. Nudge: Improving Decisions about Health, Wealth, and Happiness, 2nd edn. New Haven, CT: Yale University Press.

Benefit–cost analysis (BCA)

A controversial technique based on welfare economics commonly used to help evaluate the net social effects of government policies or projects in environmental policy, among other applications. Sometimes called cost–benefit analysis. The purpose of the technique is to determine whether net benefits of the policy or project are likely to exceed the costs, discounted in real terms on a present value basis. BCA was initially conceived by French engineer Jules Dupuit over 175 years ago (Dupuit 1844 [1952]), and first widely used for the evaluation of proposed United States federal water projects in the late 1930s (Pearce 1983).

Analysts follow several steps:

1. Identify the alternative policies or projects to be analyzed.
2. Decide whose benefits and costs count; usually a national analysis is conducted.
3. Identify the impacts and metrics, in terms of incremental benefits and costs of each option.
4. Predict the physical impacts over the policy or project lifetime, often 20 years.
5. Monetize the impacts; for example, through willingness to pay or willingness to accept estimates. In most cases environmental benefits are more difficult to accurately monetize than costs.
6. Discount to obtain present value estimates. While in most instances a social discount rate is used for public policy analysis, and a constant discount rate, this step is controversial and other options have been proposed.
7. Calculate the net present value of each option, that is, net benefits minus net costs.
8. Conduct sensitivity analysis to test the robustness of the findings.
9. Reach a conclusion and recommendation for policymakers.

An additional step to determine the distributional effects of the BCA is sometimes added. BCA is based on the Kaldor–Hicks efficiency criterion, which requires that policies only be adopted if they yield positive net benefits, and either full compensation or a set of transfers can be made that make at least one person better off without making anyone else worse off.

Barry D. Solomon

Further reading

Pearce et al. 2006; Saarikoski et al. 2016.

See also: Environmental valuation, Discounting, Social discount rate, Distributional effects, Kaldor–Hicks efficiency criterion, Cost-effectiveness analysis (CEA), Multi-criteria assessment, Deliberative multi-criteria analysis.

References

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Pearce, D.W. 1983. "The origins of cost–benefit analysis," pp. 14–24 in Cost–Benefit Analysis, 2nd edn. London: Palgrave.
Pearce, D., Atkinson, G. & Mourato, S. 2006. Cost–Benefit Analysis and the Environment: Recent Developments. Paris: Organisation for Economic Co-operation and Development.
Saarikoski, H., Mustajoki, J., Barton, D.N. et al. 2016. Multi-criteria decision analysis and cost–benefit analysis: comparing alternative frameworks for integrated valuation of ecosystem services. Ecosystem Services 22(B): 238–49.

Benefit transfer

A method to use pre-existing economic value information from research study sites or situations to assess the economic value of policy sites or situations that lack prior economic value information. The values can be transferred over time and space, often with some adjustments made for spatial heterogeneity

between sites or situations. Often used in benefit–cost analysis (BCA). Benefit transfer can be conducted using a range of methods: unit-value transfer, function transfer, and meta-analysis.

JANNE V. ARTELL

Further reading

Bateman et al. 2011.

See also: Total economic value (TEV), Spatial heterogeneity, Benefit–cost analysis (BCA).

Reference

Bateman, I.J., Brouwer, R., Ferrini, S. et al. 2011. Making benefit transfers work: deriving and testing principles for value transfers for similar and dissimilar sites using a case study of the non-market benefits of water quality improvements across Europe. Environmental and Resource Economics 50(3): 365–87.

Bequest value

A type of non-use economic value placed on knowing that future generations of people can enjoy an environmental asset (good), attribute (natural capital), or ecosystem service (Walsh et al. 1984). However, among the categories of non-use value it is often difficult if not impossible to separate the subcategories. Thus, there need to be rigorous valuation techniques to estimate the value of benefits received from environmental goods and services. Also, it may be difficult to separate someone's non-use value from their use valuation, as the value of one may affect the value of the other. Thus, it is risky to estimate non-use value in isolation.

BARRY D. SOLOMON

See also: Environmental goods and services, Non-use value, Altruistic value, Existence value, Use value, Economic valuation techniques.

Reference

Walsh, R.G., Loomis, J.B. & Gillman, R.A. 1984. Valuing option, existence, and bequest demands for wilderness. Land Economics 60(1): 14–29.

Best management practices (BMPs)

A suite of techniques and practices to manage land and land use to mitigate or prevent pollution of surface and ground water. Such practices are promoted in North America as a means of non-point water pollution control. BMPs are considered a form of pollution prevention, and are practiced in agricultural, forestry, and urban settings. Examples of BMPs include: (1) conservation tillage; (2) conservation buffers; (3) pest management; (4) grazing management; (5) animal feedlot operation management; (6) erosion and sediment control; (7) forest wetlands protection; (8) forest stream-side management zones; (9) revegetation; (10) forest chemicals management; (11) fire management; (12) ensuring that the ground is stable enough for heavy logging equipment; (13) urban green infrastructure and impervious surface reduction; (14) porous pavements; (15) green roofs; (16) rain barrels and cisterns; and (17) detention and retention ponds. This is not an exhaustive list, and taken together BMPs can result in the most cost-effective forms of water pollution control.

BARRY D. SOLOMON

Further reading

Ripa et al. 2006; Lynch & Corbett 1990; Field et al. 2006.

See also: Agroecology, Pollution, Pollution prevention (P2), Pollution abatement, Land use planning.

References

Field, R., Tafuri, A.N., Muthukrishan, S. et al., eds. 2006. The Use of Best Management Practices (BMPs) in Urban Watersheds. Lancaster, PA: DEStech Publications.

Lynch, J.A. & Corbett, E.S. 1990. Evaluation of best management practice for controlling nonpoint pollution from silvicultural operations. Journal of the American Water Resources Association 26(1): 41–52.

Ripa, M.N., Leone, A., Garnier, M. & Lo Porto, A. 2006. Agricultural land use and best management practices to control nonpoint water

pollution. Environmental Management 38(2): 253–66.

Beyond GDP

See: Economic indicators.

See also: Indicators, Gross domestic product (GDP), Measures of economic welfare, Well-being economy, Sustainability.

Biocapacity

A metric that quantifies the renewal rate of ecosystems around the globe. It tracks an ecosystem's inherent potential to renew biomass. This amount can then be compared to human demand on biocapacity, which is called people's ecological footprint. Biocapacity accounting allows researchers to quantify the size of human economies compared to the renewal capacity of the entire planet or any of its regions. Such comparisons are relevant for those studying the biological resource dependence of economies. Note that some portion of the planet's biocapacity is also needed to maintain biodiversity (Wilson 2016). If indeed the biological resources are materially the most limiting factor for the human economy, then mapping the ratio of the ecological footprint to the ecosystem's biocapacity over time becomes foundational for economic considerations.

To make biocapacity operational, it is measured in planetary surface area, which in turn is scaled by its relative biological productivity, ideally in terms of the potential net primary productivity of that area. The measurement unit used is "global hectare," which is a biologically productive hectare with world-average productivity. In most real-life applications, biocapacity estimates are approximated. For instance, national footprint and biocapacity accounts use yield factors and equivalence factors to estimate relative biocapacity of areas. Yield factors describe relative yields among the same area type, while equivalence factors compare productivity across area types. This then allows analysts to scale each hectare to global hectares. This national accounting approach is described in detail in Lin et al. (2018), Wackernagel et al. (2021), and Borucke et al. (2013).

Mathis Wackernagel & David Lin

See also: Ecological footprint, Ecosystem, Biodiversity.

References

Borucke, M., Moore, D., Cranston, G., Gracey, K. et al. 2013. Accounting for demand and supply of the biosphere's regenerative capacity: the national footprint accounts' underlying methodology and framework. Ecological Indicators 24: 518–33.

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Wackernagel, M., Hanscom, L., Jayasinghe, P. et al. 2021. The importance of resource security for poverty eradication. Nature Sustainability 4: 731–38.

Wilson, E.O. 2016. Half-Earth: Our Planet's Fight for Life. New York: Liveright.

Biocentrism

A worldview or ethics that sees intrinsic value to all living things. Biocentrism draws its ethical support from theorists promoting intrinsic value of nature theory. Biocentrism considers humans to be part of the biosphere and seeks to defend all life on Earth (Curry 2011; Washington et al. 2017). "Market biocentrism" is a contested term used by the Future of Conservation survey (https://futureconservation.org/) whose correctness is debated by others such as Kopnina et al. (2018), as there is a confusion between the ethics of biocentrism (that require the market be regulated) and neoliberal ethics where the market is unregulated.

Haydn G. Washington

See also: Ecocentrism, Intrinsic value, Deep ecology.

References

Curry, P. 2011. Ecological Ethics: An Introduction, 2nd edn. Cambridge: Polity Press.

Kopnina, H., Washington, H., Gray, J. & Taylor, B. 2018. The "future of conservation" debate: defending ecocentrism and the nature needs half movement. Biological Conservation 217: 140–48.

Washington, H., Taylor, B., Kopnina, H. et al. 2017. Why ecocentrism is the key pathway to sustainability. Ecological Citizen 1: 35–41.

Biocultural heritage

A concept that originated in the Declaration of Belém (1988) from the First International Congress of Ethnobiology, held in Belém, Brazil. While the term "biocultural" was not in the Declaration, it noted: "That there is an inextricable link between cultural and biological diversity." This concept extends to include the creation and maintenance of traditional landscapes and the ecological systems within them (Agnoletti & Rotherham 2015; Bridgewater & Rotherham 2019; Merçon et al. 2019).

The Convention on Biological Diversity (CBD) integrated biocultural perspectives into its Strategic Plan for Biodiversity 2011–2020, within which biocultural heritage was seen as a key promoter of resilience. In 2018, through Decision 14/13 of its Conference of the Parties in 2018 (CBD 2018) presented the following two definitions: "Biocultural diversity is considered as biological diversity and cultural diversity and the links between them," and "Biocultural heritage reflects the holistic approach of many indigenous peoples and local communities." This holistic and collective conceptual approach also recognizes knowledge as "heritage," thereby reflecting its custodial and intergenerational character. The cultural landscapes inscribed under the World Heritage Convention are examples of biocultural heritage. Biocultural assets and heritage therefore result from interactions and feedbacks between people and nature at a given time and place.

Peter B. Bridgewater

See also: Biodiversity, Resilience, Cultural values, Landscape.

References

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Declaration of Belém. 1988. The Declaration of Belem. http://www.ethnobiology.net/wp-content/uploads/Decl-Belem-Eng-from-Posey.pdf.

Merçon, J., Vetter, S., Tengö, M. et al. 2019. From local landscapes to international policy: contributions of the biocultural paradigm to global sustainability. Global Sustainability 2: e7.

Biodiversity

Ecology:

a. "The variety of life on Earth and the natural patterns it forms" (Secretariat of the Convention on Biological Diversity 2000, p. 2).
b. "[An] umbrella term used to describe the number, variety, and variability of living organisms in a given assemblage. Biodiversity therefore embraces the whole of 'Life on Earth'." The variety may be described in terms of genes, species, and ecosystems (Pearce & Moran 1994, p. 3). A widely quoted variant of that version is: "[A]ll hereditarily based variation at all levels of organization, from the genes within a single local population or species, to the species composing all or part of a local community, and finally to the communities themselves that compose the living parts of the multifarious ecosystems of the world" (Wilson 1996, p. 1).
c. Biological diversity reflected along several dimensions, including taxonomic diversity, phylogenetic diversity, genetic diversity, functional diversity, spatial or temporal diversity, interaction diversity, and landscape diversity (Naeem et al. 2012, p. 1403).

Economics: economists treat biodiversity as a stock that is part of natural capital and have modeled it as a public good, a club good, an open access good, and a common property good. A point of confusion sometimes arises when the flow of services from the stock is mislabeled as biodiversity.

David W. Martin

See also: Biodiversity conservation, Biodiversity indices, Biodiversity finance, Natural capital, Public goods, Common property resources, Open access.

References

Naeem, S., Duffy, J.E. & Zavaleta, E. 2012. The functions of biological diversity in an age of extinction. Science 336(6087): 1401–6.

Pearce, D. & Moran, D. 1994. The Economic Value of Biodiversity. London: International Union for the Conservation of Nature and Earthscan Publications.

Secretariat of the Convention on Biological Diversity. 2000. Sustaining Life on Earth: How the Convention on Biological Diversity Promotes Nature and Human Well-being. Montreal: Secretariat of the Convention on Biological Diversity.

Wilson, E.O. 1996. "Introduction," pp. 1–3 in Biodiversity II: Understanding and Protecting Our Biological Resources. M.L. Reaka-Kudla, D.E. Wilson & E.O. Wilson, eds. Washington, DC: John Henry Press.

Biodiversity conservation

Preventing losses to the stock of biodiversity from such direct anthropogenic causes as species extermination, habitat modification or conversion, and introduction of invasive species; and/or due to such indirect anthropogenic causes as the cascading effects from hunting a predator or prey species, pollution effects distant from its origin, and climate change. The following two definitions are based upon the Convention on Biological Diversity (Secretariat of the Convention on Biological Diversity 2006):

a. "*ex-situ* biodiversity conservation" protects biodiversity elements outside of their natural habitats.
b. "*in-situ* biodiversity conservation" protects biodiversity elements inside their natural habitats or, for domesticated or cultivated species, in the surroundings where they gained their distinctive character.

David W. Martin

Further reading

Myers et al. 2000; Sodhi & Ehrlich 2010; Pearce & Moran 1994; Weitzman 1992, 1998; Society for Conservation Biology 2019; International Union for Conservation of Nature 2016.

See also: Biodiversity, Biodiversity indices, Biodiversity finance, Biodiversity finance solution.

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International Union for Conservation of Nature. 2016. Conservation Tools. https://www.iucn.org/resources/conservation-tools.

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Biodiversity expenditure

Any expenditure whose purpose is to have a positive impact or to reduce or eliminate pressures on biodiversity. Biodiversity expenditures include "direct" expenditures that have biodiversity as their principal purpose, or *causa finalis*, as well as "indirect" expenditures that have biodiversity as their secondary or joint purpose.

Increasingly, biodiversity expenditures are more appropriately considered "investments." Distinct from a cost center (or "consumption"), there is an expectation that investment in biodiversity today will result in returns to human well-being in the future. A line-item categorization scheme and tagging exercise can identify and apportion biodiversity budget expenditures, and can be institutionalized for mainstreaming biodiversity expenditures into public and private sector budgeting systems. They generally align with categories from the United Nations System of Environmental-Economic Accounting (SEEA), Classification of Environmental Protection Activities (CEPA) and Classification of Resource Management Activities (CReMA), but they are not fully percent-commensurable, because of the inclusion of indirect or secondary expenditures in biodiversity finance and not in the SEEA-based budgeting approaches (United Nations et al. 2021).

Andrew F. Seidl

Further reading

Arlaud et al. 2018a, 2018b; European Communities 2009; UNSD 2014.

See also: Biodiversity conservation, Biodiversity finance, System of National Accounts (SNA), Restoring natural capital (RNC), Investment.

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Biodiversity finance

The practice of raising and managing capital and using financial and economic incentives to support sustainable biodiversity management. It includes private and public financial resources used to conserve biodiversity, investments in commercial activities that produce positive biodiversity outcomes, and the value of the transactions in biodiversity-related markets such as habitat banking. It helps to leverage and effectively manage economic incentives, policies, and capital to achieve the long-term well-being of nature and society (Arlaud et al. 2018a).

Andrew F. Seidl

Further reading

Arlaud et al. 2018b; Tobin-de la Puente & Mitchell 2021; UNDP 2020.

See also: Biodiversity conservation, Biodiversity finance solution, Conservation finance, Environmental finance.

References

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UNDP (United Nations Development Programme). 2020. Moving Mountains: Unlocking Private

Capital for Biodiversity and Ecosystems. UNDP: New York.

Biodiversity finance solution

An integrated approach to solve a specific biodiversity investment problem or challenge by the context-specific use of finance and economic instruments. It is built on a combination of elements that includes one or more finance instruments, financing sources, lead agent or intermediaries, beneficiaries or principal stakeholders, and the desired finance result. A desired biodiversity finance result can generate new sources of revenue, avoid future expenditures, realign existing expenditures, and/or improve delivery of biodiversity outcomes (Arlaud et al. 2018a).

ANDREW F. SEIDL

Further reading

Arlaud et al. 2018b; GIZ 2018; Tobin-de la Puente & Mitchell 2021; UNDP 2020; Deutz et al. 2020; Dasgupta 2021.

See also: Biodiversity conservation, Biodiversity finance, Biodiversity expenditure.

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UNDP (United Nations Development Programme). 2020. Moving Mountains: Unlocking Private Capital for Biodiversity and Ecosystems. UNDP: New York.

Biodiversity indices

Quantitative measures used to estimate biological diversity. Numerous indices have been developed to quantify and compare biodiversity (in all its forms and levels of organization) across different temporal and spatial scales. Biodiversity indices vary greatly in their theoretical foundation, performance, and complexity, but most of them combine the number of different units (for example, species) and their relative abundance within an area or community. For example, the Shannon diversity index—one of the most widely used indices—increases as the number of species and the number of individuals per species increases in an assemblage.

Even though ecologists have largely focused on quantifying biodiversity at the species level, there has been growing interest in assessing other dimensions of biodiversity (for example, functional diversity, phylogenetic diversity) during the last few decades. This is an active research area, with new indices being developed and ongoing debate on which are more appropriate and informative in different contexts.

Biodiversity indices are valuable tools for environmental monitoring and conservation, as they help to estimate the stability and overall health of an ecosystem. Additionally, using various indices to evaluate the multiple dimensions of biodiversity can provide a comprehensive understanding of how biodiversity influences ecosystem function and the provision of ecosystem services.

AURA M. ALONSO-RODRÍGUEZ

Further reading

Fath 2018; Naeem et al. 2016; Morris et al. 2014; Gotelli & Ellison 2013.

See also: Biodiversity, Biodiversity conservation, Indicators, Ecological indicators, Conservation, Ecosystem, Ecosystem health, Ecosystem services.

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Bioeconomic modeling

The use of mathematical and statistical techniques to maximize an economic objective function subject to biological, economic, and technical constraints, typically with the goal of determining optimal levels of stock and harvest. The classic work was done on fisheries and forest management by Colin Clark and Geoffrey Allen (e.g., Clark 1974, 1985; Allen et al. 1984). Given the complexity of ecosystem functioning, their depiction of ecological systems is inevitably simplistic, which has led to criticism (Van der Ploeg et al. 1987). However, since complex analytical models quickly become intractable, restricting the interaction with the environment to a few equations is an appealing feature.

Interest in non-linearities, critical thresholds, and ecosystem stability has created new opportunities for bioeconomic modeling from an ecological perspective (Perrings & Pearce 1994; Perrings 1991). Further modifications of the basic bioeconomic model emphasize an integrated modeling approach (Gilliland et al. 2020; Castro et al. 2018), and the integration of stochastic elements (Costello et al. 2001; Johnston & Sutinen 1996). Bioeconomic models can be useful for analyzing changes in natural resource management policies (for example, land use) or estimating the welfare effects of changes in environmental quality (environmental valuation).

Duncan J. Knowler

Further reading

Clark 1990; Knowler 2002.

See also: Bioeconomics, Biophysical economics, Fisheries management, Forest conservation, Population dynamics, Ecological-economic models, Multi-scale integrated analysis of societal and ecosystem metabolism (MuSIASEM), Environmental valuation.

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Perrings, C.A. & Pearce, D.W. 1994. Threshold effects and incentives for the conservation

of biodiversity. Environment and Resource Economics 4: 13–28.
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Bioeconomics

The integration of economics with the biophysical reality that humans are a biological species shaped by social institutions, to provide a better understanding of the dependence of economic processes on the availability of low-entropy energy and matter. The sustainability of such processes is ultimately dictated by the viability of technologies to support their resource flows and sustaining functions on renewable sources over time (Gowdy & Mesner 1998; Giampietro 2019). The term was first used in the early 20th century by T.I. Baranoff, a Russian marine biologist, although he made little explicit reference to economic factors (Gordon 1954, p. 125).

Bioeconomics was developed by Nicholas Georgescu-Roegen (1977), whose life's work (1971, 1986, 1993) served as the foundation to the subsequent development of biophysical and ecological economics (Melgar-Melgar & Hall 2020). In Georgescu-Roegen's (1977, p. 361) own words, bioeconomics "is intended to make us bear in mind continuously the biological origin of the economic process and thus spotlight the problem of [humans'] existence with a limited store of accessible resources, unevenly located and unequally appropriated." Moreover, Georgescu-Roegen (1979) emphasized that (bio)economics is fundamentally about qualitative evolutionary changes dependent of biophysical and social realities that cannot be explained by mathematical tautologies. Today, the qualitative changes of unsustainable economic processes based on consuming finite fossil fuel stocks require societies to transition to renewable flows of energy to get ahead of resource depletion and address climate change.

Rigo E.M. Melgar

See also: Bioeconomy, Biophysical economics, Biophysical constraints on human economic activity, Bioeconomic modeling, Evolutionary analysis, Evolutionary economics.

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Melgar-Melgar, R.E. & Hall, C.A. 2020. Why ecological economics needs to return to its roots: the biophysical foundation of socio-economic systems. Ecological Economics 169: 106567.

Bioeconomy

The administration of the living household. The bioeconomy encompasses all the actions to ensure the use (production, consumption, exchange, distribution of goods and services) and stewardship of the Earth (the living household of the world). The terms "bio" and "economy" were merged for the first time in 1918 by the Russian marine biologist T.I. Baranoff (Gordon 1954).

There are more approaches to define what bioeconomy is:

a. In Georgescu-Roegen's approach the bioeconomy "make us bear in mind continuously the biological origin of the economic process and thus spotlight the problem of mankind's existence with a limited store of accessible resources, unevenly located and unequally appropriated" (Georgescu-Roegen 1977, p. 361).

b. The Organisation for Economic Co-operation and Development (OECD) approach promotes the wide application of biotechnology to generate the bioeconomy seen as an economic sector (Arundel & Sawaya 2009; Diakosavvas & Frezal 2019).
c. For the European Commission the bioeconomy is based on biorefining, "an economy using biological resources from the land and sea, as well as waste, as inputs to food and feed, industrial and energy production. It also covers the use of bio-based processes for sustainable industries" (EC 2012). The aim is to replace the use of fossil fuels with biomass, but it is not clear that it is ecologically sustainable (Vivien et al. 2019).

Raluca-Ioana Iorgulescu

Further reading

Mayumi 2001; Giampietro 2019.

See also: Bioeconomics, Bioeconomic modeling, Biophysical economics.

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Vivien, F.-D., Nieddu, M., Befort, N. et al. 2019. The hijacking of the bioeconomy. Ecological Economics 159: 189–97.

Bioenergy

Energy produced from renewable sources of biological materials called biomass, including traditional sources such as wood and animal wastes, and modern technologies that produce liquid fuel from bagasse and other plants, anaerobic digestion of residues, and others. Ethanol, methanol, biodiesel, and hydrogen are the most produced biofuels from biomass. Bioenergy can be used to produce transportation fuels, heat, electricity, and other products. Expansion of bioenergy is sometimes cited to be one of the key paths to becoming carbon neutral, thereby both mitigating and adapting to climate change, but some forms of bioenergy have been strongly criticized as contributing to ecological degradation and forest loss.

Valerie A. Luzadis

Further reading

Dahiya 2015; Solomon 2010; International Renewable Energy Agency 2021.

See also: Biofuel, Biomass, Renewable energy.

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International Renewable Energy Agency. 2021. Bioenergy. https://www.irena.org/bioenergy.
Solomon, B.D. 2010. Biofuels and sustainability. Annals of the New York Academy of Sciences 1185: 119–34.

Bioethics

The interdisciplinary study of ethical perspectives on science and technology in medicine, the life sciences, and health and science policy. Areas of focus include: medical research, clinical health care practice, public health, and health law, policy, politics, and economics. The influence of cultural and institutional systems on health is also addressed. The term "bioethics" was coined by Van Rensselaer Potter (1971). Bioethics brings concepts and logics of reasoning drawn from philosophy and the humanities into the discourse of fields that are mainly positivistic and empirical in orientation.

Traditional medical ethics is centuries old. Contemporary bioethics is largely devoted to the application of theories, frameworks, and principles developed in moral philosophy (Beauchamp & Childress 2013).

The main overlap between bioethics and ecological economics comes in health policy and environmental public health. Ecological economics, compared with other mainstream approaches, has been more receptive to explicitly normative and philosophical perspectives coming from bioethics. In the 1970s, the purview of bioethics included humanity's ethical responsibilities regarding ecosystems and biodiversity on a planetary scale. Over time, however, that inquiry was taken over by environmental ethics, which arose out of the environmental social movements of the time. Today attention in bioethics is returning to the interconnections between human health, ecological resilience, and climate change (Macpherson 2016). Challenges to an anthropocentric focus in both moral philosophy and economics may increasingly be generated by the fields of ecological economics and bioethics working in collaboration (Brown & Timmerman 2015).

Bruce Jennings

Further reading

Callahan 2012; Fox et al. 2008; Jonsen 1998; Mackenzie & Stoljar 2000; Toulmin 1982.

See also: Environmental ethics, Public health, Environmental health.

References

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Mackenzie, C. & Stoljar, N., eds. 2000. Relational Autonomy: Feminist Perspectives on Autonomy, Agency, and the Social Self. New York: Oxford University Press.

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Toulmin, S. 1982. How medicine saved the life of ethics. Perspectives in Biology and Medicine 25(4): 736–50.

Biofuel

Any biogenic resource used by people as a source of energy, such as: firewood, charcoal, straw, grasses, tallow, or dung; food crops such as maize, wheat, sugar beet and sugarcane; and vegetable oils derived from soybeans, rapeseed, palm trees, and used cooking oils. Biofuels are not always produced or used sustainably (Solomon 2010; Efroymson et al. 2013).

Barry D. Solomon

Further reading

Fargione et al. 2010; Giampietro & Mayumi 2009; Solomon & Johnson 2009.

See also: Bioenergy, Biomass.

References

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Solomon, B. 2010. Biofuels and sustainability. Annals of the New York Academy of Sciences 1185: 119–34.

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Biogeography

Geography:

a. The original meaning is the description of biota on or below the Earth's surface.
b. Today, biogeography is the analysis and explanation of spatial patterns of plant and animal distributions on the Earth's surface and within Earth's subsurface today and in the past. Biogeographers seek to answer the following questions: (1) Why are there so many living things? (2) Why are they distributed in the way they are? (3) Have they occupied their current distribution patterns for very long? (4) How is the organism adapted to the conditions of life in the area they exist within, and why does the organism not exist in an adjacent area; and what factors (be they biological or environmental) prevent the species from doing so? (5) Is human activity and humans use of space and the increasing lack of space for other species affecting these biogeographic patterns?

Economics: today, it is increasingly understood that biogeographic patterns and processes and geographic issues of scale and boundaries impact resource management, development, environmental policymaking, and a whole host of other components that shape the human–environment mosaics that pattern the globe through the biogeographic variation in ecological services.

MARK R. WELFORD

Further reading

Riddle et al. 2008; Welford & Yarbrough 2020; MacArthur & Wilson 1967.

See also: Geography, Resource management, Ecosystem management, Ecosystem services.

References

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Welford, M.R. & Yarbrough, R. 2020. Human–Environment Interactions: An Introduction. London: Palgrave Macmillan.

Biological control

A method of controlling pests and invasive species, including insects, weeds, and pathogens, using other living organisms. Natural enemies of pests, also known as biological control agents, include predators, parasitoids, and disease organisms. There are three basic strategies of biological control: (1) the intentional introduction of an exotic natural enemy for permanent establishment and long-term pest control (classical biological control); (2) the intentional release of a natural enemy to increase its population and temporary enhance pest control (augmentation biological control); and (3) the modification of the environment or practices to protect and enhance natural enemies (conservation biological control).

CARLOS VALENTE

Further reading

Eilenberg et al. 2001.

See also: Invasive species, Integrated pest management (IPM).

Reference

Eilenberg, J., Hajek, A. & Lomer, C. 2001. Suggestions for unifying the terminology in biological control. BioControl 46: 387–400.

Biomass

Ecology: the total mass, weight, or quantity of living plant or animal organisms in a specific area, habitat, or region.

Energy: plant or animal material used to produce heat, liquid fuel, or electricity. Examples include dedicated food crops (maize, wheat, sugarcane, sugar beet, and so on), wood, forestry, and food crop resi-

dues, purpose-grown grasses, municipal and industrial solid wastes, landfill gas, algae, seaweed, animal wastes, bedding materials, and by-products such as fats, oils, greases, and manure.

BARRY D. SOLOMON

Further reading

Krausmann et al. 2008; Erb et al. 2009; Gerbens-Leenes et al. 2009.

See also: Bioenergy, Biofuel, Biotic resources.

References

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Krausmann, F., Erb, K.H., Gingrich, S. et al. 2008. Global patterns of socioeconomic biomass flows in the year 2000: a comprehensive assessment of supply, consumption and constraints. Ecological Economics 65(3): 471–87.

Biome

A large-scale biogeographical community of plants and animals that has adapted to a specific climate. Biomes can contain multiple habitats. The term "biome" was first used in 1916 by the botanist Frederic Clements. Five major categories of biomes exist: forest, grassland, tundra, desert, and aquatic. Several ecosystems form a biome, which may span more than one continent. Biomes are the most basic units that ecologists use to describe global patterns of ecosystem form, process, and biodiversity (Ellis & Ramankutty 2008).

BARRY D. SOLOMON

Further reading

Clements 1917.

See also: Ecosystem, Biogeography, Biodiversity.

References

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Ellis, E.C. & Ramankutty, N. 2008. Putting people in the map: anthropogenic biomes of the world. Frontiers in Ecology and the Environment 6(8): 439–47.

Biophysical constraints on human economic activity

Well-being depends on the ability of humanity to sustainably manage its complex socio-economic systems within biophysical constraints by: (1) harnessing surplus low-entropy energy and resource inputs to produce goods and services; (2) maintaining well-functioning ecosystems; and (3) avoiding overshooting natural sinks with the high-entropy waste outputs that economic processes and consumption generate (Georgescu-Roegen 1993; Wackernagel & Rees 1998). These quantitative and qualitative constraints imposed by the laws of thermodynamics mean that a sustainable economy cannot extract renewable resources faster than they regenerate, or rely on the extraction of non-renewable energy stocks (and other resources) at a rate faster than we are able to create renewable substitutes, or emit wastes faster than they can be absorbed. Consequently, the biophysical embeddedness of socio-economic systems requires society to pay close attention to its population growth rate, and the sources, rates, and sinks of energy and resource consumption, to avoid rapid depletion and irreversibly crossing our planetary boundaries (Sorrell et al. 2010; Steffen et al. 2015).

The modern reliance of socio-economic systems on finite fossil fuels has created an ephemeral and unconstrained psychological reality that perpetuates an unsustainable socially constructed dualism between humans and nature, fostering our endless pursuit of financial maximization and (un) economic growth (Hall et al. 2003; Daly 2014). Understanding the biophysical foundation of socio-economic systems can help us to overcome this dualism by providing humans with an idea of the sustainable

scale at which human economic activity can operate to justly distribute and efficiently allocate resources within biophysical and social constraints (Melgar-Melgar & Hall 2020). Ultimately, to protect global ecosystems and to avoid a potential collapse of civilization from depletion and runaway climate change, humanity not only needs to transition to a low-carbon economy, but also needs to biophysically understand and socially address the root causes of unsustainability: population growth, overconsumption, affluence, inequality, and (un)economic growth (O'Sullivan 2020; Weidmann et al. 2020; Oswald et al. 2020).

RIGO E.M. MELGAR

Further reading

Odum 1973; Ayres 2016; Hall & Klitgaard 2018.

See also: Embeddedness, Classical thermodynamics, Fossil fuels, Sources, Optimal scale of the macroeconomy, Sinks, Overshoot, Analytical dualisms, Uneconomic growth, Affluence, Collapse.

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Biophysical economics

The study of how socio-economic systems procure and use energy and other resources to produce, consume, and exchange goods and services while generating wastes and environmental impacts. Biophysical economics (BPE) examines economic questions starting from an energy and materials stocks-flows perspective, using the natural and social sciences to understand the socio-ecological implications of humanity's consumption of resources. It emphasizes that wealth is derived mostly from transformations of nature using energy (Hall & Klitgaard 2018).

Biophysical concepts influenced the early development of ecological economics by provided the foundation needed for a paradigm shift in economic thought so that the laws of thermodynamics and conservation of energy and matter were considered and respected (Georgescu-Roegen 1971; Odum 1971 [2007]; Daly 1968, 1977). A BPE perspective can help to address the root causes of ecosystem degradation and unsustainability, which have been primarily driven since the Industrial Revolution by the dependence of economic growth on finite stocks of fossil fuels (Melgar-Melgar & Hall 2020). This perspective understands that it was only the vast use of low-entropy energy flows from fossil fuels that have provided humanity with unprecedented well-being (although unequally between the global North and South and at the expense of altering the biosphere) (Hagens 2020).

Contemporary societies are attempting an energy transition to low-carbon energy resources due to concerns about depletion, climate change, and planetary boundaries (Capellán-Pérez et al. 2014; Steffen et al. 2015). The BPE perspective can help to address this transition, which will require massive energy and material investments (Capellán-Pérez et al. 2019). BPE thinkers argue that we need to stabilize and in time reduce (un)economic and population growth to levels that the biosphere can sustain (Daly 2015). However, they also believe that the lack of a basic understanding of what energy is (the ability to do work) by the public, decision-makers, and some economists not only perpetuates a false dualism between humans and nature, but makes it difficult to manage natural resources sustainably.

Rigo E.M. Melgar & Charles A.S. Hall

Further reading

Hall et al. 2001.

See also: Bioeconomics, Biophysical constraints on human economic activity, Classical thermodynamics, Ecological macroeconomics.

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Steffen, W., Richardson, K., Rockström, J. et al. 2015. Planetary boundaries: guiding human development on a changing planet. Science 347(6223): 1259855.

Biophysical equilibrium

A level of economic activity that maintains stocks and flows of natural resources. A necessary condition of Herman Daly's "steady state economy" (Daly 1977). Careful management of renewable resources fits this concept well, but drawdown of non-renewable resources requires substitution of similar services over time. This concept focuses on the management and use of natural resources, while Daly's larger vision includes an equitable reallocation of the benefits of resource use.

Brent M. Haddad

Further reading

O'Neill 2015.

See also: Biophysical economics, Steady state economy, Sustainability.

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Bioregionalism

A territorial and geographical classification founded on the concept of the bioregion, from *bios* (life, in Greek) and region (*regere*, to govern, in Latin). The latter is a geographical territory, relatively homogeneous in geomorphological, hydrological, floral, and faunal dimensions, where the rules of nature should direct those of humans, and that humans are not the owner nor the sole master of the house. With this characterization, it is an ethical, ideological, and political proposition, which Peter Berg and Raymond Dasmann advanced in the 1970s as a way to renew our citizenship on Earth through a lifestyle that promotes the needs and right for living creatures to a dignified and full life (Berg & Dasmann 2014). A "bioregion is as much a geographic territory as it is a territory of our consciousness" as Peter Berg used to say. Bioregions are the natural regions of the Earth, each of which shares within it the characteristics outlined above, and as such can support a large and complex community of living beings, including towns and cities of humans.

Aurelio Angelini

Further reading

Berg 1978.

See also: Biogeography, Regional environmental planning, Regional science.

References

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Bioremediation

The harnessing of the natural process of biodegradation by using selected microbes to consume and reduce land and water pollution. Can be effective with oil spills, landfill pollution, riverbeds, and other degradable wastes. Some microbes, such as mercury-resistant bacteria, can transform toxic forms of pollutants to non-toxic forms. It is a slow process but not or minimally harmful to underlying ecosystems since the microbes used are naturally occurring. Risks with bioremediation include incomplete reduction of the pollutant and possible environmental mobilization of by-products of the degradation process. Economic issues arise related to cost, timing, duration, and completeness of environmental restoration and remediation, and bargaining over liability for damages.

Brent M. Haddad

Further reading

Bluffstone 2008; Pushkar et al. 2019.

See also: Pollution, Pollution abatement.

References

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Biosecurity

Ecology: activities that reduce the risk of transmitting pests, diseases, and harmful organisms. Biosecurity activities reduce entry (through border controls), spread (through eradication or threat management programs) and establishment of exotic biosecurity threats that would otherwise degrade ecosystems, reduce agricultural productivity and impact on human health.

Economics: a class of risk that is uninsurable (because of systematic risk) in the case of pandemics, losses arising from access to markets, and productivity losses caused by highly transmissible pests and diseases. There appears to be no theoretical barrier (from an actuarial perspective) to the creation of risk

markets offering insurance against the cost of responding to the entry of biosecurity threats.

GARY C. STONEHAM

Further reading

Stoneham et al. 2021.

See also: Alien species, Exotic species, Risk, Risk assessment, Risk premium, Natural insurance, Insurance value.

Reference

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Biosphere

The life-supporting region or zone of the Earth's surface and its atmosphere, which includes all ecosystems. The term was first used by Austrian geologist Eduard Suess in 1875 (Hutchinson 1970). Also called the ecosphere. The biosphere consists of the lithosphere (land, which is the rocky crust of the planet and is sometimes also called the geosphere), hydrosphere (water), and the atmosphere (air), and includes all biotic as well as abiotic resources. The biosphere is an open system with respect to solar and heat energy, but a virtually closed system with respect to matter.

BARRY D. SOLOMON

See also: Ecosystem, Biotic resources, Abiotic resources, Open system, Closed system.

Reference

Hutchinson, G.E. 1970. The biosphere. Scientific American 223(3): 44–53.

Biotic potential

The hypothetical maximum population growth of a species before biotic and abiotic conditions in the environment constrain it. It is a combination of maximum reproductive potential and maximum survival potential. If an accurate biotic potential figure can be identified, the effects of biotic and abiotic inhibitors, or limiting factors, on population growth can be expressed in quantitative terms. When pollution, land use change, or other human-caused factors are limiting population growth, knowledge of biotic potential can help to evaluate the impacts.

BRENT M. HADDAD

Further reading

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See also: Endangered species, Indicator species, Threatened species value, Biotic resources.

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Biotic resources

Ecology: living and once-living species that provide food and shelter to sustain other species and those that are integral to some ecosystem services.

Economics: living goods by which products can be derived to sustain human life and development, and which have a monetary value. Includes crops, timber, and animals such as fisheries. Derived materials include fuel, food, textiles, and medicine. Can also include forests and megafauna, whereby intrinsic and ecotourism values can be derived.

CHARLIE M. CHESNEY

Further reading

Perrings 1994.

See also: Abiotic resources, Ecosystem services, Natural capital, Non-renewable resource, Renewable resource.

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Economics Approach to Sustainability. A.M. Jansson, M. Hammer, C. Folke & R. Costanza, eds. Washington, DC: Island Press.

Bootstrap methods

A non-parametric method of inferential statistics that randomly re-samples a single dataset to create many simulated samples. These methods are an alternative to traditional parametric hypothesis testing and were first introduced in statistics by Bradley Efron (1979). Bootstrapping measures accuracy in terms of variance, confidence intervals, hypothesis testing, bias, and standard error of sample estimates. The methods allow for the estimation of the sampling distribution of nearly any statistic using random sampling methods. An advantage of bootstrapping is its simplicity. A wide variety of applications of bootstrapping have been made in ecological economics (e.g., Garza-Gil et al. 2011; Yang et al. 2015; Li et al. 2019).

HEICO WESSELIUS

See also: Multivariate statistical techniques, Frequentist statistics, Scientific method.

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Bottom-up approaches

Approaches in ecological economics that involve placing "people" first. They center their analysis and policy on the goals and dynamics of the communities and their institutions; they focus on local initiatives to implement change. These approaches are generally specific to each social group, incorporating important elements of the cultural and political heritage that defines the way in which communities define and resolve the challenges they face. They are often an integral part of efforts to resolve distributional conflicts among competing world visions. Because of this geographic and cultural specificity, these approaches are often limited to case studies of particular problems.

Bottom-up approaches, however, are central to community efforts to assert their autonomy, their ability to govern themselves democratically. Their significance for ecological economics lies in the power that these approaches offer for building political alliances among social groups to confront common problems or institutions at a regional, national, and international level.

Their relevance is particularly significant in environmental management. The value of local knowledge is paramount for conserving and promoting biodiversity. For this reason, the application of the lessons from traditional farming systems to increase food self-sufficiency have been strengthened by the new-found interest in creating varieties of agroecology suited to local conditions, both environmental and economic. The world's largest social organization, La Via Campesina, with member organizations in 83 countries, brings together more than 200 million people who practice bottom-up approaches to promote food sovereignty, as an alternative to industrial agri-food systems in the international marketplace.

DAVID P. BARKIN

Further reading

Anderson et al. 2020; Blackwell 2012; Charles 2021; Fuente-Carrasco et al. 2019; Rosset et al. 2019; van der Ploeg & Ye 2018.

See also: Autonomous institution, Ecological distribution conflicts, Agroecology, Food self-sufficiency, Biodiversity, Top-down approaches.

References

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van der Ploeg, J.D. & Ye, J., eds. 2018. China's Peasant Agriculture and Rural Society: Changing Paradigms of Farming, 2nd edn. London: Routledge.

Boundary conditions

A mathematical concept that describes what is included, what is excluded, and the assumptions made in ecosystem analysis, systems analysis, and economic modeling (Buenstorf 2000; Coombes et al. 2016). Thus, differences in boundary conditions or rules affect the outcome of the analysis and it is therefore important to describe the boundary conditions of modeling scenarios.

BARRY D. SOLOMON

Further reading

Farrell & Silva-Macher 2017.

See also: Applied systems analysis, Dynamic systems, Dynamic models, Sustainable scale, Scenario, Sensitivity analysis.

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Coombes, P.J., Smit, M. & MacDonald, G. 2016. Resolving boundary conditions in economic analysis of distributed solutions for water cycle management. Australasian Journal of Water Resources 20(1): 11–29.

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Bounded rationality

The term introduced by Herbert Simon in 1955 to represent realistic decision-making rationality as deriving from the relationship between the computational characteristics of the human mind and the informational features of the environment (Simon 1955). Bounded rationality contrasts with the traditional assumption made by neoclassical economics of perfect rationality, or *Homo economicus*. The two main behavioral interpretations are: (1) the limitation of the human mind leads the decision-maker to generate errors and bias with respect to the formal canons of economic rationality, which is studied by behavioral economists; and (2) the decision can be rational or not, based on its cognitive success in problem-solving and in adapting to the environment, which is studied by cognitive economists.

In its ecological meaning, the importance of the structure of the decision-making task characterized by the variables of uncertainty, redundancy, variability, and sample size is highlighted. Based on these characteristics it is preferable, at an adaptive level, to adopt heuristic decision-making procedures based on the "less-is-more" principle, or "satisficing" rather than optimizing decisions.

RICCARDO VIALE

Further reading

Gigerenzer & Selten 2002; Kahneman 2003; Viale 2021.

See also: Homo economicus, Behavioral economics, Satisficing, Heuristic.

References

Gigerenzer, G. & Selten, R. 2002, eds. Bounded Rationality: The Adaptive Toolbox. Cambridge MA: MIT Press.

Kahneman, D. 2003. Maps of bounded rationality: psychology for behavioral economics. American Economic Review 93(5): 1449–75.

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Buddhist economics

a. (From Schumacher 1973) the term was first coined by E.F. Schumacher, who stated that the goal of Buddhist economics is "the maximum of well-being with the minimum of consumption."
b. (From Brown 2017) a holistic model of economics based upon three Buddhist principles: people are altruistic (they care for the well-being of others); the world is interdependent (all beings are interdependent with each other and with nature); and impermanence (everything is constantly changing and dynamic). Happiness does not come from self-centered materialism.
c. (From Payutto 1994) a spiritual approach, where ethical behavior based on Buddhism provides awareness of what is truly harmful and truly beneficial in our economy, and reflects the vital forces of wisdom, compassion, and restraint.

CLAIR BROWN

Further reading

Zsolnai 2008.

See also: Circular economy, Sustainable agriculture, Interconnected, Social equity, Sustainability, Happiness.

References

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Schumacher, E.F. 1973. "Buddhist economics," pp. 56–66 in Small Is Beautiful: Economics as if People Mattered. London: Abacus.

Zsolnai, L. 2008. "Buddhist economic strategy," pp. 279–303 in L. Bouckaert, H. Opdebeeck & L. Zsolnai, eds. Frugality: Rebalancing Material and Spiritual Values in Economic Life. Oxford: Peter Lang Academic Publishers.

Buen vivir

Spanish for "living well," and a worldview in Andean cultures and South America that values the fullness of life in a community with other people and with nature as necessary for true well-being. Ecuador and Bolivia incorporated Buen vivir into their Constitutions in 2008 and 2009 as a set of rights and ethical/moral principles, respectively (Gudynas 2011).

BARRY D. SOLOMON

See also: Happiness, Eudaimonia, Ecozoic, Well-being economy.

Reference

Gudynas, E. 2011. Buen Vivir: today's tomorrow. Development 54(4): 441–7.

Built capital

See: Manufactured capital.

See also: Natural capital, Human capital, Social capital.

Business innovation

Economics: a new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes, and that has been introduced to the market or brought into use by a firm (OECD/Eurostat 2018). It focuses on the factors enabling and generat-

ing new goods and services, how companies use them to gain a competitive position in the market, and the macroeconomic effects of their adoption in different economic sectors.

Management: processes of creativity, novelty, and change in enterprises. It is understood as both an activity (process) and an outcome (Noteboom & Stam 2008). As an activity, the process of innovation typically goes from the generation of an idea, the development of prototypes, testing, and its scalability into real use. As an outcome, it is often classified as a product or service, a process, or an organizational, marketing, or other management methods (Tidd & Bessant 2021; Rogers 2003).

Systems analysis: business innovation is a socially enabled and interactive process (Coenen & Díaz López 2010). Innovation is therefore conditioned by an enabling or hindering ecosystem, consisting of a series of factors that affect the innovation process, for example, relations between actors and networks, legal and institutional framework, availability of funding, and so on (Edquist 2005).

Fernando Díaz López

Further reading

Schumpeter 1934; Kemp et al. 2021.

See also: Sustainable business, Green innovations, Eco-innovation, Green economy.

References

Coenen, L. & Díaz López, F.J. 2010. Comparing systems approaches to innovation and technological change for sustainable and competitive economies: an explorative study into conceptual commonalities, differences and complementarities. Journal of Cleaner Production 18(12): 1149–60.

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Tidd, J. & Bessant, J. 2021. Managing Innovation: Integrating Technological, Market and Organizational Change, 7th edn. Hoboken, NJ: John Wiley & Sons.

C

Capacity building

Refers to the international development policy effort to develop and enhance the skills, abilities, instincts, processes, and resources in developing countries to implement transformative initiatives (UN 2021). Capacity building is reflected in Goal 17 of the United Nations Sustainable Development Goals: "to support national plans to implement all the sustainable development goals, including through North–South, South–South and triangular cooperation" (UN 2017). It involves the development of human, physical, and financial resources in different organizations including the public sector, communities, and non-governmental organizations.

JOAO PAULO BRAGA

See also: Sustainable development, Sustainable Development Goals (SDGs), Development, Non-state actors, Public–private partnerships, Societal transformation, United Nations Development Programme (UNDP).

References

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UN (United Nations). 2021. Capacity-building. https://www.un.org/en/academic-impact/capacity-building.

Cap and trade

An emissions trading program or system that has a limit on the total number of pollution emission credits or allowances that are allocated to firms. The total number of credits or allowances that are emitted in a given year or season may exceed the cap if the program or system allows for banking of emission credits or allowances for use in a later period. The most cost-effective cap and trade programs have a high proportion of the total emission sources included in the program to avoid emissions leakage, and operate at a larger geographic scale (for example, a large state, province, multi-state region, continent, or globally as opposed to an urban region). Non-cap and trade emissions trading programs, and ones that have experienced higher transaction costs and other difficulties, have included emissions reduction credits, offsets, Joint Implementation, and the Clean Development Mechanism (CDM).

BARRY D. SOLOMON

Further reading

Solomon 1995; Shammin & Bullard 2009; Schmalensee & Stavins 2017.

See also: Emissions trading, Carbon trading, Tradable permits, Transaction costs, Clean Development Mechanism (CDM), Individual transferable quotas (ITQs).

References

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Shammin, N.D. & Bullard, C.W. 2009. Impact of cap-and-trade policies for reducing greenhouse gas emissions on U.S. households. Ecological Economics 68(8–9): 2432–8.

Solomon, B.D. 1995. Global CO_2 emissions trading: early lessons from the U.S. Acid Rain Program. Climatic Change 30(1): 75–96.

Capital

a. A stock of produced factors of production that is expected to yield produc-

tive services for a certain period in the future. It entails a costly investment in the present to obtain services in the future and is usually tangible and transferable. Examples include structures, machinery, transport equipment, urban land, and social infrastructures. It is often referred to as produced, manufactured, or built capital. In conventional economics, capital sometimes also includes intangible assets such as intellectual property rights, software, and even financial assets (Piketty 2014).

b. A service yielded each period from produced capital stock as a fund-service resource (Daly & Farley 2011).
c. A broader stock or asset that is expected to yield services beneficial to human well-being over time, and that may not be produced or transferable. Along with produced capital, it includes natural capital, which is not produced; and human capital (that is, a stock of education, knowledge, and skills), which is not transferable and is thus excluded from capital in national accounting. Social capital, which is not easily measurable but arguably important to well-being, is frequently studied especially in ecological economics. Taken together, produced, human, and natural capital is sometimes called (comprehensive or inclusive) wealth.
d. Present discounted value in monetary units of a stream of flows that arise over time in the future.
e. A financial flow or stock, often used in a critical study of capitalism.

RINTARO YAMAGUCHI

Further reading

Dasgupta & Serageldin 2000; Fisher 1906.

See also: Wealth, Capital stock, Natural capital, Human capital, Manufactured capital, Social capital, Fund-service resources.

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Daly, H.E. & Farley, J. 2011. Ecological Economics: Principles and Applications, 2nd edn. Washington, DC: Island Press.
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Fisher, I. 1906. The Nature of Capital and Income. Norwood, MA: Norwood Press.
Piketty, T. 2014. Capital in the Twenty-First Century. Cambridge, MA: Harvard University Press.

Capital accumulation and deaccumulation

a. The process whereby capital is valorized by being invested in the production of commodities. The concept originally derives from *Capital*, Volume 1, where Marx (1976) demonstrates how capital valorization (the generation of "surplus value") derives from labor exploitation. Feminist scholars (e.g., Federici 2020) highlight how gender (alongside race and geographical) hierarchies, as well as unpaid social reproductive or care labor, are taken advantage of by capital for maximizing the rate of exploitation and hence accumulation. The reinvestment of progressively greater portions of surplus value in production, partly as a response to dynamics of competition that lower the profit rate, gives accumulation an expansionary dynamic. As such, it is responsible for the environmentally destructive "growth imperative" of the capitalist mode of production. Hence the centrality, for critics (e.g., Foster 2011), of "deaccumulation," referring to strategies for restraining or reversing capital accumulation and its role as a structuring principle of socio-ecological relations.
b. A host of "extra-economic" processes of appropriation of surplus value and of natural and social assets on the part (or to the benefit) of capital. Expanding on Marx's (1976) discussion of "primitive accumulation," which traces the origins of capitalism in violent historical processes of commons' enclosure in Europe and of resource pillage in the colonies, contemporary scholars use terms such as Harvey's (2003) "accumulation by dispossession" to refer to the continued relevance of these and similar forms of appropriation (for example, privatiza-

tion), as well as cost-shifting, for the viability of the capitalist mode of production.

Diego Andreucci

Further reading

Moore 2015; Chetkovskaya et al. 2019.

See also: Capital, Capitalism, Degrowth.

References

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Federici, S. 2020. Patriarchy of the Wage: Notes on Marx, Gender, and Feminism. San Francisco, CA: PM Press.

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Marx, K. 1976. Capital: A Critique of Political Economy, Volume 1 (B. Fowkes, Trans.). London: Penguin.

Moore, J.W. 2015. Capitalism in the Web of Life: Ecology and the Accumulation of Capital. London: Verso.

Capital formation

Ecological economics: a process that expands the capacity of an economy to provide benefits to society. Employs a broad understanding of capital, including human (skills) natural (biotic and abiotic), governance (enforceable laws and minimal corruption), physical (similar to mainstream economics; see the following), and financial.

Mainstream economics: the investment in and addition of productive capacity to an economy in the form of physical goods and infrastructure, that is, manufactured (built) capital. An alternative to or residual following domestic consumption of goods. Examples include investment in new factories, machines, and physical infrastructure. Can also refer to increased availability of investment funding.

Brent M. Haddad

Further reading

Dominati et al. 2010; Solow 1962.

See also: Capital, Manufactured capital, Natural capital, Human capital, Investment, Capital accumulation and deaccumulation.

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Capitalism

Historically located socio-economic system characterized by the accumulation of capital as its aim. Capitalism is defined by the generalization, combination, and domination of two social relations: the wage relation and the market relation. The wage relation is a particular form of labor organization through a property separation between the producer and the means of production that results in the payment of a wage to the producer in exchange for their labor force. The market relation is a particular organization of production and exchange where production is to be sold against money that gives access to other commodities. Neither the wage relation nor the market relation is specific to capitalism, and both existed before.

What distinguishes capitalism and gives it its historical specificity is its generalization, systematic combination, and domination over other social relations and forms of economic organization. Although this is still debated, capitalism is considered to have emerged between the 16th and 18th centuries in Europe (Brenner 1977; Meiksins Wood 2002; Wallerstein 2011). A dissenting view considers capitalism to have always been in existence under various forms due to accumulation dictated by struggles between states since early Antiquity (Frank 1991). However, Frank does not demonstrate that accumulation for itself was the norm since the Antiquity; moreover, “it is unacceptable to reduce capitalism to a simple inventory of items such as currency, merchants, invest-

ment, and technology, without effectively saying that capitalism is nothing" (Norel 2013, p. 73).

LOUISON CAHEN-FOUROT

See also: Capital, Capital formation, Capital substitution, Capital accumulation and deaccumulation, Economic institutions.

References

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Wallerstein, I. 2011. The Modern World-System I—Capitalist Agriculture and the Origins of the European World-Economy in the Sixteenth Century. Berkeley, CA: University of California Press.

Capital mobility

The degree to which private manufactured (human-made) capital moves freely between countries, seeking more promising investment opportunities. Capital mobility has greatly increased and quickened along with globalization in the last several decades with the advent of rapid telecommunications technologies. High capital mobility can decrease the effectiveness of domestic fiscal policy. In the context of ecological economics, capital mobility may allow firms to depress wages and avoid paying environmental costs, especially when capital moves to developing countries (Schor 2005; Copeland & Taylor 1997; Daly 2013).

BARRY D. SOLOMON

See also: Manufactured capital, Capital stock, Capital theory, Comparative advantage, Globalization, Ecologically unequal exchange.

References

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Daly, H.E. 2013. A further critique of growth economics. Ecological Economics 88: 20–24.
Schor, J.B. 2005. Prices and quantities: unsustainable consumption and the global economy. Ecological Economics 55(3): 309–20.

Capital stock

a. Accumulation of past flows of investment into capital, with past flows of depreciation deducted. This way of calculating capital stock is called the perpetual inventory method (PIM). Consequently, capital stock is equivalent to the total amount of capital at a given point in time. The notion of capital stock stresses its physical and cumulative characteristic, to avoid ambiguity with capital flow (that is, financial flow, typically from/to overseas), or capital goods (that is, investment goods to form capital stock), or capital as a service, or capital value (that is, monetized value of capital).
b. A fund from which capital service is drawn each period. In ecological economics there is sometimes a distinction between stock-flow resources that are used up (matter and energy) and fund-service resources that are worn out (capital, labor, and Ricardian land), in the tradition of Georgescu-Roegen (1971) (Daly & Farley 2011). In this usage, capital stock and capital correspond to fund and service, respectively.
c. Share of corporate capital that has already been issued for equity investors.

RINTARO YAMAGUCHI

See also: Capital, Natural capital, Stocks, Flows, Fund-service resources, Ricardian land.

References

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Georgescu-Roegen, N. 1971. The Entropy Law and the Economic Process. Cambridge, MA: Harvard University Press.

Capital substitution

Neoclassical economics: the substitution between capital and other inputs, usually labor, in production. Capital substitution is measured using the elasticity of substitution, developed by Hicks (1932) and Robinson (1933). It can be constrained by irreversibilities in production conditions and asymmetries in substitutability between factor inputs. Capital substitution and assumptions thereof are used in areas of economic analyses such as economic growth. Zero capital substitution (a fixed proportions technology) in the Harrod–Domar model implies that deviations of economic growth from the natural growth rate result in either rising unemployment or persistent inflation. The assumption that capital substitution is 1:1 (several different input combinations can produce the same output) is central to the conclusions of convergence and the steady state in the neoclassical growth model (Arrow et al. 1961; Sato 1964).

Ecological economics: the substitution between natural capital (natural resources, raw material sources, sinks for wastes) and manufactured and human capital (machines, knowledge, institutional mechanisms) in economic production. While flexible substitution between natural and manufactured/human capital because of knowledge advancements is often assumed by mainstream economists (e.g., Solow 1973), ecological economists emphasize that the relationship between the two types of capital is more one of complementarity than substitutability. This is because the sustenance and expansion of manufactured capital and labor depends on the persistent use of natural capital, which increases entropy in the biophysical system, with implications for sustainability (Tisdell 1997).

SURANJANA NABAR-BHADURI

Further reading

Daly 1994; Molina 2005.

See also: Capital, Capital theory, Manufactured capital, Human capital, Natural capital, Substitutability, Complementarity, Entropy.

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Tisdell, C. 1997. Capital/natural resource substitution: the debate of Georgescu-Roegen (through Daly) with Solow/Stiglitz. Ecological Economics 22(3): 289–91.

Capital theory

Traditionally the study of the possibility of measuring the stock of manufactured capital and the role that capital plays in the economy. This function includes but is not restricted to economic growth, distribution, and business. Measuring the quantity of capital is controversial because capital is a collection of heterogeneous produced means of production. This set is made homogeneous through the estimation of the market value of all capital goods; that is, by multiplying the price of each capital good by its corresponding quantity and then adding those values to come up with the measurement. This measure is flawed because prices of capital goods are affected by the expectations of future profits, which in the neoclassical model can only

be established when the quantity of capital is known. In other words, to estimate the quantity of capital it is necessary to know the quantity of capital, which is tautological. This implies a rupture with the relationship between the quantity of capital and the profit rate. This criticism leads to the conclusion that the distribution variables (wages and profits) must be determined outside the sphere of production, since these remunerations cannot be effectively explained by the marginal productivities of labor and capital (Harcourt 1969).

Despite its fundamental flaws, the neoclassical theory of capital is widely used and accepted. Alternative theories based on the Ricardian–Sraffian tradition measure the quantity of capital by maintaining its heterogenous character. Moreover, in the last several decades capital theory has been extended to include human capital, natural capital, and social capital (e.g., Fix 2018; Kareiva et al. 2011; Lin et al. 2017).

ANDRES F. CANTILLO

Further reading

Robinson 1953; Kregel 1976; Tsoulfidis 2021.

See also: Capital, Manufactured capital, Natural capital, Human capital, Social capital, Capital substitution, Sraffian economics.

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Robinson, J. 1953. The production function and the theory of capital. Review of Economic Studies 21(2): 81–106.

Tsoulfidis, L. 2021. Capital Theory and Political Economy. New York: Routledge.

Carbon capture

A set of technologies that enable the capture of carbon-based, usually carbon dioxide (CO_2) emissions normally associated with fossil fuel combustion, generally for sequestration or use via other processes. It can also be encountered in removing emissions embedded in the industrial production processes, while the term can also apply to capturing CO_2 emissions directly from the air. Carbon capture is often considered alongside a system that transports the captured emissions either for storage or for use in other processes, forming a carbon capture utilization and storage (CCUS) system.

The ecological economics literature includes several studies that explore ways to incentivize the development and deployment of carbon capture (e.g., Bennett & Heidug 2014; von Stechow et al. 2011). There are limited analyses of the wider economy impacts of introducing carbon capture within sectors. While carbon capture does require upfront investment activity/costs, the wider impacts of engaging in the practice are commonly linked to the increased production costs of sectors operating carbon capture equipment, such as thermal power generation (e.g., Li et al. 2017). However, carbon capture involves additional input requirements, particularly capital equipment, not required to produce any sector's primary output. Thus, it is often considered as an end-of-pipe technology where, for example, an appropriate treatment may be to consider additional equipment/machinery requirements in terms of a reduction in capital efficiency within sectors adopting carbon capture (Turner et al. 2021).

KAREN R. TURNER, J. KIM SWALES & ANAT TCHETCHIK

See also: Climate change mitigation, Carbon sequestration.

References

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emission trading scheme in China: a CGE-based analysis. Energy 119: 800–816.
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von Stechow, C., Watson, J. & Praetorius, B. 2011. Policy incentives for carbon capture and storage technologies in Europe: a qualitative multi-criteria analysis. Global Environmental Change 21: 346–57.

Carbon footprint

The total carbon dioxide (CO_2), carbon dioxide and methane, or greenhouse gas emissions of a person, firm, city, region, country, activity, or system over a given period. The non-CO_2 emissions are usually calculated as CO_2-equivalent based on each gas's relevant 100-year global warming potential (Wright et al. 2011). The idea of a carbon footprint was derived from the ecological footprint concept and is usually reported in tons of emissions per year. The measurement of a carbon footprint can be made based on a life-cycle assessment, one of numerous online calculators, among other methods, though there can be large uncertainties involved. Knowledge of carbon footprints can provide a basis for opportunities to reduce greenhouse gas emissions.

Barry D. Solomon

Further reading

Jones & Kammen 2011.

See also: Life-cycle assessment (LCA), Ecological footprint, Water footprint, Carbon intensity, Greenhouse gases, Global warming potential, Climate change mitigation.

References

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Wright, L., Kemp, S. & Williams, I. 2011. "Carbon footprinting": towards a universally accepted definition. Carbon Management 2(1): 61–72.

Carbon intensity

a. The number of grams of carbon dioxide (CO_2) required to produce a megajoule or kilowatt-hour of fuel or electricity, either directly or on a life-cycle basis. Coal is the most carbon-intense fossil fuel, followed by petroleum and natural gas, while nuclear and renewable sources of electricity have the lowest carbon intensity.
b. CO_2 emissions in kilograms or tonnes per monetary unit of gross domestic product (GDP).

Barry D. Solomon

Further reading

Canadell et al. 2007; Jorgenson 2014.

See also: Carbon footprint, Carbon lock-in, Fossil fuels, Renewable energy, Climate change mitigation.

References

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Jorgenson, A.K. 2014. Economic development and the carbon intensity of human well-being. Nature Climate Change 4: 186–9.

Carbon lock-in

A form of technological lock-in, the self-perpetuating inertia created by the dominant role of fossil fuel usage in society, based on long-lived infrastructure lasting many years or decades. The term was coined in 1999 by Gregory Unruh in his doctoral dissertation. Examples of carbon lock-in include coal-fired power plants, cement plants, industrial boilers, large fleets of gasoline and diesel-powered motor vehicles, and poorly insulated high-rise buildings. As a result, existing fossil fuel-intensive systems delay or prevent the transition to low or no-carbon

alternative energy sources, and thereby constrain climate change mitigation options. The result of carbon lock-in is higher levels of greenhouse gas emissions and global warming commitment.

BARRY D. SOLOMON

Further reading

Unruh 1999, 2000, 2002; Unruh & Carrillo-Hermosilla 2006.

See also: Technological lock-in, Carbon intensity, Carbon footprint, Climate change mitigation.

References

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Unruh, G.C. & Carrillo-Hermosilla, J. 2006. Globalizing carbon lock-in. Energy Policy 34(6): 1185–97.

Carbon market

A market policy designed to reduce greenhouse gases emitted into the atmosphere. Relies on the fact that firms have different emission reduction costs. Once a quantitative limit is set for total allowable emissions, lower-cost firms can sell their unneeded emission permits to firms facing higher costs. Some carbon markets also allow for trading of specified greenhouse gases besides carbon dioxide. Firms will have an economic incentive to trade carbon permits unless the transaction costs are too high. The lower-cost firms will receive permits ("credit" or "emission allowance") that have been pre-approved by a certifying authority, abate emissions, and then sell some credits/allowances into the market. As a result, a firm purchasing these in a carbon market need not abate its own emissions as much.

Economists approve of carbon markets because in theory they can reduce greenhouse gas emissions efficiently, and provide incentives, and funding, for investment in lower-emitting technologies. Because a carbon market allows firms with lower abatement costs to exhaust all their emissions reduction options first, before higher-cost firms attempt to reduce emissions, the overall cost to achieve a given emissions target is lower than if all firms were forced to cut emissions by the same amount.

Critics argue that there is a disjunct between the simple theoretical promise of efficiency and the actual, and far more complex, real world. Designing and implementing schemes in the presence of vested interests, corporate power, and even uncertainty and complexity in verifying emission reductions, has sometimes proved challenging.

JUDITH R. MCNEILL

Further reading

Spash 2010; Brohe et al. 2015; Boyce 2018; Bryant 2019.

See also: Carbon trading, Cap and trade, Emissions trading, Greenhouse gases, Tradable permits, Transaction costs.

References

Boyce, J.K. 2018. Carbon pricing: effectiveness and equity. Ecological Economics 150: 52–61.
Brohe, A., Eyre, N. & Howarth, N. 2015. Carbon Markets: An International Business Guide. London: Routledge.
Bryant, G. 2019. Carbon Markets in a Climate-Changing Capitalism. Cambridge: Cambridge University Press.
Spash, C.L. 2010. The brave new world of carbon trading. New Political Economy 15(2): 169–95.

Carbon sequestration

The long-term process of removing, transferring, and storing carbon dioxide (CO_2) from the atmosphere. There are three main categories.

a. Biological: biological carbon sequestration is largely a natural process, as CO_2 naturally cycles through various carbon sinks: the oceans, soils, peatlands, wetlands, grasslands, and forests (for example, through photosynthesis).
b. Geological/industrial: geological carbon sequestration requires carbon capture and storage from industrial facilities such as

coal-fired electric power plants, oil and gas wells, natural gas processing facilities, and steel, cement, hydrogen, and fertilizer production plants. The captured CO_2 is then stored in underground geological formations, rocks, or even the ocean.

c. Technological: technological carbon sequestration involves the use of an advanced and more expensive technology such as direct air capture or enhanced CO_2 mineralization (Lal 2008; Breyer et al. 2019).

Barry D. Solomon

Further reading

Caparrós & Jacquemont 2003; Benítez et al. 2007.

See also: Climate change mitigation, Carbon capture, Sinks, Carbon stock.

References

Benítez, P.C., McCallum, I., Obersteiner, M. & Yamagata, Y. 2007. Global potential for carbon sequestration: geographical distribution, country risk and policy implications. Ecological Economics 60(3): 572–83.

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Caparrós, A. & Jacquemont, F. 2003. Conflicts between biodiversity and carbon sequestration programs: economic and legal implications. Ecological Economics 46(1): 143–57.

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Carbon stock

Ecology: the amount of carbon stored in vegetative biomes including aquatic, grassland, forest, desert, and tundra. It is the carbon found in below-ground and above-ground biomass, soil, dead wood, litters, and other dead biomass. The portion of the carbon stock stored in mangroves, salt tidal marshes, and seagrass meadows within their soil, living biomass above ground (leaves, branches, stems), living biomass below ground (roots), and non-living biomass (for example, litter and dead wood) is referred to as blue carbon (Mcleod et al. 2011). Measured as tonne of elemental carbon (C) or tonne of carbon dioxide (CO_2) (conversion factor: 1 tonne of C is equal to 44/11 or 3.67 tonne of CO_2). Carbon stock can grow (through carbon sequestration) or shrink (through carbon flux) during the natural carbon cycle or due to human activities.

Ecological economics: an indicator of one of the important ecosystem services, namely, climate regulation. As the carbon stock in the biosphere increases—that is, with net annual carbon balance or sequestration—the amount of carbon in the atmosphere declines, resulting in climate regulation. Carbon stock and sequestration are therefore used as proxy indicators of climate regulation ecosystem service provided by ecosystems (Keith et al. 2021; TEEB 2009).

Mahadev G. Bhat

See also: Ecosystem services, Carbon sequestration, Carbon capture, Climate change.

References

Keith, H., Vardon, M., Obst, C. et al. 2021. Evaluating nature-based solutions for climate mitigation and conservation requires comprehensive carbon accounting. Science of the Total Environment 769: 144341.

Mcleod, E., Chmura, G.L., Bouillon, S. et al. 2011. A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO_2. Frontiers in Ecology and the Environment 9(10): 552–60.

TEEB (The Economics of Ecosystems and Biodiversity for National and International Policy Makers). 2009. www.teebweb.org.

Carbon taxes

A form of pollution tax (itself a form of environmental tax), which targets carbon emissions generated by economic agents without necessarily considering the climate damages that they create (externality). Along with carbon markets, they represent the two forms of carbon pricing. With a carbon tax, polluters can decide whether to abate emissions or pay the tax. Thus, carbon taxes account for heterogeneity among polluters and provide continuous incentives to reduce emissions (dynamic efficiency). Econometric studies

suggest that carbon taxes can substantially reduce emissions (e.g., Martin et al. 2014; Andersson 2019).

Many countries have implemented a carbon tax, following the example of Scandinavian countries in the 1990s (World Bank 2021). Carbon taxes may vary along a few key design features. Tax rates can be set according to the concept of social cost of carbon or to reach a policy goal in the most cost-effective way. Most schemes feature a tax escalator: the tax rate starts low and increases over time. Some tax schemes may exempt some sectors or emission sources. Exemptions hurt the scheme's effectiveness. Revenues can be redistributed uniformly to the population (generally making the scheme progressive), earmarked (for instance, to fund further emissions reductions), used to reduce pre-existing distortionary taxes (for instance, on labor), or allocated to the general budget. With a global carbon tax, or a system of harmonized carbon taxes, a global carbon price could in theory be achieved (Hoel 1992; Nordhaus 2015; Carattini et al. 2019).

STEFANO CARATTINI

Further reading

Baranzini et al. 2000.

See also: Carbon market, Carbon trading, Environmental taxes, Pollution taxes, Environmental externalities.

References

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Carbon trading

The exchange of carbon dioxide (CO_2) credits or allowances between companies in a CO_2 or greenhouse gas trading system or market. Forestry and agricultural offsets are also allowed in some cases. Such programs are based on the Coase theorem and have been established to encourage cost-effective mitigation of climate change, and are often an attractive alternative to a carbon tax though the programs can also work in tandem (Haites 2018; Narassimhan et al. 2018).

Usually, carbon trading is part of a cap-and-trade scheme where the total amount of CO_2 or greenhouse gases that can be emitted by all participating companies is limited. If a firm emits less than its emissions allocation or quota in a given year or has extra credits from the Clean Development Mechanism (CDM) program, it can sell excess credits or allowances to another firm whose emission control costs are probably higher or bank the credits. The largest carbon trading program is the European Union Emissions Trading System (EU ETS), which began in 2005. Carbon trading programs have also been established in several United States states and regions, South Korea, Japan, China, Kazakhstan, New Zealand, and Canada.

BARRY D. SOLOMON

See also: Carbon market, Coase theorem, Emissions trading, Cap and trade, Tradable permits, Clean Development Mechanism (CDM), Greenhouse gases, Climate change mitigation, Carbon taxes, Banks.

References

Haites, E. 2018. Carbon taxes and greenhouse gas emissions trading systems: what have we learned? Climate Policy 18(8): 955–66.

Narassimhan, E., Gallagher, K.S., Koester, S. & Alejo, J.R. 2018. Carbon pricing in practice: a review of existing emissions trading systems. Climate Policy 18(8): 967–91.

Carrying capacity

Ecology:

a. Population of a given species that can be supported indefinitely in a region, or on the Earth, without permanently damaging the ecosystem on which it depends. Measured as total population in a region.
b. The maximum rate of resource consumption and waste discharge that can be sustained indefinitely in a given region without progressively impairing the functional integrity and productivity of relevant ecosystems. Measured as a quantity of a resource or waste over time.

Economics: the extent to which a region, or the Earth, can generate material production in the future. Can be measured as throughput or production in a region over a given time. A measure of carrying capacity will change as technologies, preferences, consumption, production, and waste discharge change through time.

BRENT M. HADDAD

Further reading

Arrow et al. 1995; Rees 1992.

See also: Ecosystem, Ecological footprint, Throughput.

References

Arrow, K., Bolin, B., Costanza, R. et al. 1995. Economic growth, carrying capacity, and the environment. Science 268(5210): 520–21.

Rees, W. 1992. Ecological footprints and appropriated carrying capacity: what urban economics leaves out. Environment and Urbanization 4(2): 121–30.

Catchment area

Hydrology: An area in which all water flows to a common endpoint. The endpoint can be a river, lake, wetland, or groundwater basin.

General: a region served by a single service provider, such as a hospital or airport.

BRENT M. HADDAD

Further reading

Turner et al. 2000.

See also: Watershed, Watershed management.

Reference

Turner, R.K., van den Bergh, J.C.J.M., Söderqvist, T. et al. 2000. Ecological-economic analysis of wetlands: scientific integration for management and policy. Ecological Economics 35(1): 7–23.

Chaos theory

A sophisticated mathematical theory that evolved out of catastrophe theory to explain the unpredictability observed in non-linear systems. Chaos theory has had a profound impact on several scientific fields, though it has not been commonly discussed in ecological economics. Like ecological economics, chaos theory was pioneered in the 1960s through the 1990s by a group of transdisciplinary scholars, led by meteorologist Edward Lorenz. Chaos theory establishes that tiny random undetectable variances in initial starting conditions can become increasingly magnified over time, leading to rapidly growing errors in any efforts to predict future outcomes (a phenomenon popularly known as the butterfly effect) (Lorenz 1972). This holds true even in simple deterministic systems, and even when possessing the highest-quality computer models and measuring instruments. Therefore, contrary to the hidden assumption in neoclassical economics that economic agents generally have perfect information even into the future, chaos theory warns us that we cannot (and never will be able to) fully predict system behaviors, changes, or breakdowns (Rosser 1991).

Because the only long-term certainty is surprise, great caution is warranted when interfering with or making predictive decisions about any system (Kay & Schneider 1994). Nevertheless, chaos theoreticians have also discovered that symmetrical patterns, feedbacks, and statistical features do manifest around basins of attraction over time and across systems and scales. By mapping these patterns (for example, graphically through fractals) some useful guiding order can be constituted out of chaos that enriches our

understanding of how complex economic and environmental processes operate.

CONRAD B. STANLEY

Further reading

Gunderson et al. 2002; Kellert 2008; Gribbin 2005.

See also: Surprise, Complexity, Complex systems modeling, Non-linear, Panarchy theory.

References

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Kellert, S.H. 2008. Borrowed Knowledge: Chaos Theory and the Challenge of Learning Across Disciplines. Chicago, IL: University of Chicago Press.

Lorenz, E. 1972, December 29. Predictability: does the flap of a butterfly's wings in Brazil set off a tornado in Texas? Paper presented at the Annual Meeting of the American Association for the Advancement of Science, Washington, DC.

Rosser, J.B. Jr. 1991. From Catastrophe to Chaos: A General Theory of Economic Discontinuities. Boston, MA: Kluwer Academic Publishers.

Choice experiments

Research methods:

a. Survey-based research method used to examine preferences and trade-offs among attributes of hypothetical scenarios. In a class of stated preference non-market valuation methods used to estimate the economic value of particular attributes, along with the contingent valuation method (CVM), measured as willingness to pay.
b. Widely used method to estimate the economic benefits or costs generated by non-market goods and services, such as the values of environmental quality or amenities. Based on Lancaster consumer theory, which suggests that demand for a good can be described by the sum of the characteristics that generate utility for the user (Lancaster 1966).

ROBERT B. RICHARDSON

Further reading

Hanley et al. 1998; Louviere et al. 2000.

See also: Discrete choice models, Contingent valuation method (CVM), Willingness to pay (WTP), Stated preference methods, Non-market value.

References

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Lancaster, K. 1966. A new approach to consumer theory. Journal of Political Economy 74(2): 132–57.

Louviere, J.J., Hensher, D.A. & Swait, J.D. 2000. Stated Choice Methods: Analysis and Applications. Cambridge: Cambridge University Press.

Circular economy

A phrase popularized by the Swiss architect and economist Walter Stahel, based on the idea of tracking materials "from the cradle to the cradle" instead of "from the cradle to the grave." It is a shift of focus: no longer the linear trajectory that leads from resource to waste in industrial societies, but another, circular one, whereby waste becomes the source of another process. Stahel, together with Genevieve Reday-Mulvey, presented in 1976 a report (Stahel & Reday-Mulvey 1981) to the European Economic Community that showed an economic model based on closed circuits and evaluated the favorable impact of this system on job creation, competitiveness economic, resource saving, and waste prevention.

The idea of a circular flow economy was first found in Kenneth Boulding's essay: "spaceship Earth" (Boulding 1966). That title became the slogan of the first Earth Day,

celebrated in New York City on April 22, 1970, after a mobilization of millions of North Americans, but the idea struggled to establish itself. More recently it has become the axis of the green economy, as preached in recent decades by almost all environmental movements with a special emphasis on the role of renewable energy sources in replacing fossil fuels. The basic idea of the circular economy of drawing inspiration from living processes—the waste of one species can become a resource for another, thus generating large trophic cycles—led to the founding of industrial ecology and inspired academic disciplines. A reference to the circular economy is also found in the encyclical letter of Pope Francis "Laudato si" (Pope Francis 2015).

Aurelio Angelini

See also: Green economy, Circularity gap, Industrial ecology, Ecological economics.

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Circular flow model

The cornerstone of simplistic linear conceptions of humans' economic consumption and production as an isolated and closed system (not to be confused with circular economics or the circular economy). Originated by Paul Samuelson in the late 1940s (Raworth 2017).

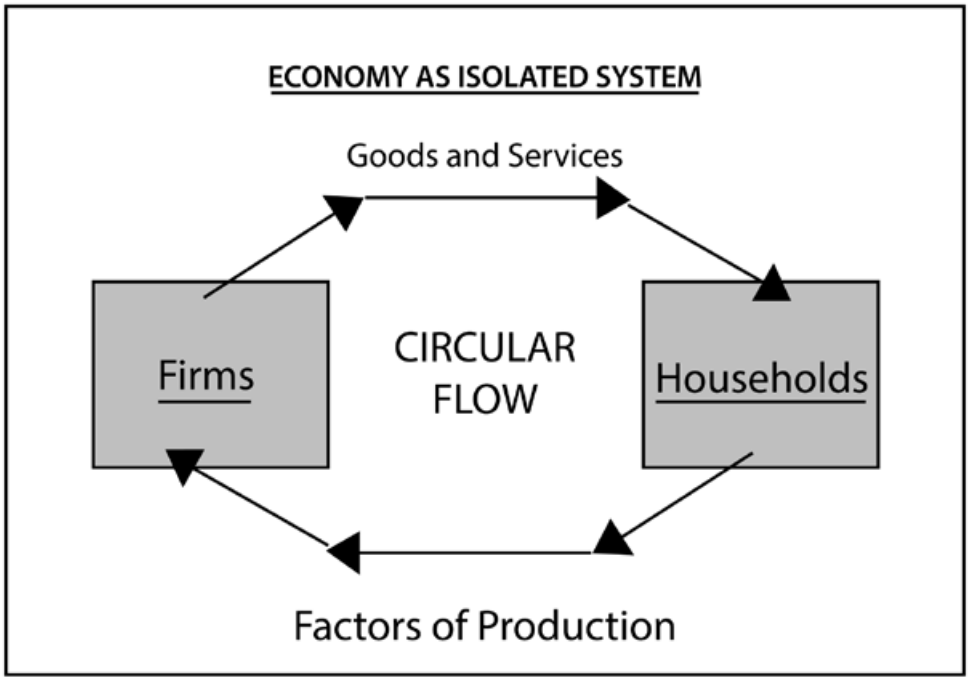

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Figure 1 *A classic circular flow model*

The macroeconomic circular flow model archetype argues that monetized income "flows" between human actors, "households" and "businesses/firms" in two proverbial free markets: a "product market" of goods and services and a "factor/resource market" represented by factors of production. In the basic model, human households consume goods and services produced by businesses in the product market (see Figure 1). Households and businesses own and trade (flow) the monetized factors/resources needed to produce goods and services consumed, for example: human labor, including aptitude and invention; land, including natural resources for materials and energy; and capital, including savings, profits, rents, interest, and employment income. Some versions of the circular flow model add "government" to the list of actors to account for government services, taxes, and employment income.

The circular flow model is often criticized because its simplicity implies apathy towards the complex interdependencies of the socio-economic systems governed by humans with nature. By ignoring the environmental throughput and social impacts and feedbacks of the economic system, the circular flow model imagines a cornucopia for unrestricted human use; a notion that ecological economics soundly rejects (Daly 1985, 1991; Cleveland 1999; Mayumi 2001). The allegory of a circle confers endless continuity and permanence, belied by today's diagnosis of unsustainability created by current patterns of human consumption and production; for example, climate change, social inequality and poverty, unabated pollution and waste, natural resource depletion/exhaustion, and biodiversity and habitat loss.

GILLIAN J. FOSTER

Further reading

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See also: Isolated system, Closed system, Throughput, Circular economy.

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Circularity gap

A critique of the concept and potential for a circular economy promoted by many economists and industrial ecologists. Sometimes also called the circular economy gap, circularity rift, metabolic gap, or metabolic rift. While in the circular economy the geologically produced energy and the materials entering the economy are considered, and waste is very much present, it is assumed that technical change may close the circle. The waste becomes inputs. The energy (dissipated, of course, because of the Second Law of Thermodynamics) is not a problem because it will come from current solar energy (not fossil fuels, which are exhaustible stocks of photosynthesis from the past). The circular supply chain is supposed to rule physically in the economy.

However, the actual degree of the circularity of the current industrial economy is very low and probably decreasing. There is a very large circularity gap or metabolic rift between the "fresh" material input and the recycled material input into the economy. At the global level, the first is about 92 Gt per year and the second about 8 Gt (Haas et al. 2015, 2020). Nicholas Georgescu-Roegen (1971) and other authors have insisted on the fact that the industrial economy is not circular but increasingly entropic.

JOAN MARTÍNEZ-ALIER

Further reading

Martínez-Alier 2022.

See also: Circular economy, Metabolic rift, Entropic dissipation, Classical thermodynamics, Industrial ecology, Biophysical economics.

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Circumfauna

The category of ecological innovation focused on bypassing animal inputs in economic production. The term can also be used to refer to the products and outputs that result from this approach (for example, circumfaunal foods, circumfaunal materials). The term is most associated with the textiles industry (innovations in materials for clothing such as cultured leather made from cells or grown from mycelium), the agriculture industry (alternatives to industrial animal agriculture such as cultured, fermented, and other alternative proteins), as well as the biomedical industry (innovations in research, education, and testing). Circumfauna has been steadily increasing since the beginning of the 21st century, and in the food industry alone the market value of products bypassing animal inputs can expect to "swell to $162 billion in the next decade from $29.4 billion in 2020" (Bloomberg Intelligence 2021).

Due to the steady increase of global populations, incomes, and urbanization, the finite base of resources for livestock production is shrinking, in stark contrast to the growing demand for products that are traditionally produced using animals (FAO 2006). The term "circumfauna" was coined by sustainable innovation expert Joshua Katcher, who calls for an "industrial revolution" as we must "replace animals in the supply chains with something more efficient, sustainable and ethical" (Katcher 2019). In addition to addressing growing demand and dwindling resources, circumfauna innovation is intended to reduce environmental and social impacts associated with farmed animal production, including the following: anthropogenic greenhouse gas emissions, loss of biodiversity, water pollution, irreversible loss of land productivity, antibiotic resistance, and the risk of zoonotic disease epidemics (Specht et al. 2018).

Tracey J. Katof

See also: Ecological justice, Environmental rights, Bioethics, Environmental ethics, Eco-innovation, Wildlife conservation, Agribusiness.

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Citizens' jury

A deliberative democracy process, sometimes used by governments to inform their decision-making, including about environmental policies, programs, or development proposals, through a rigorous and structured community engagement. A citizens' jury is an unconventional process, so it is typically reserved for policy matters that are especially controversial, complex, or problematic for a government. It may also be used experi-

mentally. A government may use it to obtain public legitimacy for a decision that it wants to make.

A citizens' jury is made up of randomly selected, but often representative, members of a defined community. The community will normally be defined by reference to the people likely to be affected by a government decision. Though there is no requirement as to size, a citizens' jury often exceeds 12 people, the common size of a jury in legal trials. The members of a citizens' jury are non-experts, whose role is to offer views on a matter being considered by a government. The jury will hear information that the government has commissioned as part of its own procedures, and the jury may ask questions and request access to expert opinion. The members of the jury are expected to discuss among themselves the evidence and information provided to them and offer a view (not so much a verdict) on the issue that the government has requested it to consider.

A citizens' jury is a more meaningful and empowering form of public participation in environmental matters than many other forms of deliberation, such as consultation or a public inquiry. This is because the jury members have agency owing to their representative status. Ordinarily, the jury members have some control over the matters to be determined; for example, which experts are to be heard, which questions are to be asked, and how to formulate the output and outcome of a jury process.

BRAD S. JESSUP

Further reading

Coote & Lenaghan 1997; Crosby et al. 1986; Kenyon et al. 2003.

See also: Democracy, Deliberative democracy, Deliberative ecological economics, Stakeholder participation, Participatory action research.

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Civil society

A broad term that refers to non-state actors such as non-governmental organizations (NGOs) including environmental activists, community groups, labor unions, indigenous groups, professional associations, charitable and faith-based organizations (Healy et al. 2013; Schoenefeld 2021). It is often referred to as the "civil sector" or "third sector" of society, apart from governments and the for-profit private sector. Civil society organizations work to advance the interests of citizens and the broader public interest outside of government and business, and play an essential role in democratic societies.

BARRY D. SOLOMON

See also: Non-state actors, Bottom-up approaches, Stakeholder, Stakeholder participation, Democracy.

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Classical economics

The school of thought in economics from the late 1700s through the late 1800s, primarily in Great Britain. The leading thinkers of this period included Adam Smith, David Ricardo, Jean-Baptiste Say, Thomas Malthus, John Stuart Mill, and Karl Marx. At the time it was usually called political economy rather than economics. The start of classical economics is regarded by many to be the publication of *The Wealth of Nations* by Adam Smith in 1776, while others credit the Frenchman Francois Quesnay and the physiocrats who promoted agriculture as the sole source of

economic production two decades earlier (Czech 2013).

The main ideas of classical economics were the: importance of capital investment and labor productivity in determining national income and economic growth; scarcity; importance of free market competition and the dangers of monopoly power; division of labor; benefits of laissez-faire ideas and free trade; the economy as self-regulating; that exponential increases in population growth would exceed arithmetical increases in food supply with dire consequences, unless population growth was slowed; comparative advantage; the inevitability of a stationary state economy in the long run; development of value theory; and, according to Marx, the economic exploitation of labor by capital.

BARRY D. SOLOMON

Further reading

Smith 1776 [2018]; Malthus 1798; Ricardo 1817; Say 1821; Mill 1871; Marx 1867.

See also: Political economy, Physiocrats, Laissez-faire economics, Economic growth, Manufactured capital, Malthusian scarcity; Ricardian scarcity, Ricardian land, *Homo economicus*, Comparative advantage, Stationary state, Labor theory of value, Neoclassical economics.

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Classical thermodynamics

During the mid-19th century physics underwent a revolution: classical thermodynamics was founded, which focuses on the description of the states of thermodynamic systems at near equilibrium, using macroscopic, measurable properties. Although energy is one of the most important economic production factors, thermodynamics does not play a key role in neoclassical economics. However, energy consumption is necessary for every production process and has an impact on nature because it creates environmental damage. Its use leads to irreversible loss of fossil fuels. This is the reason why one of the main founders of ecological economics, Nicholas Georgescu-Roegen, focused on thermodynamic considerations in his pioneering book (Georgescu-Roegen 1971).

The first two fundamental laws of classical thermodynamics are: (1) heat energy is always conserved and can be neither created nor destroyed, only transformed as it passes into or out of a system; (2) energy tends to transition from more to less useful forms as entropy in any isolated system always increases. An example of the second law is: heat will by itself always transfer from a hotter to a colder body, like a heated stone giving up its heat to the cooler air surrounding it. These two laws lay the foundation for an understanding that every industrial production process yields joint products, at least one of which is a waste product (Baumgärtner et al. 2006). A practical example is the production of steel by using coke and iron ore. The output is not only steel but also the remains of the manufacturing process, such as carbon dioxide (CO_2), wastewater, dust, and so on.

MALTE M. FABER & MARC FRICK

See also: Entropy, Entropic dissipation, Entropy law, Isolated system, Energy, Fossil fuels, Joint production.

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Clean Development Mechanism (CDM)

Established by Article 12 of the 1997 Kyoto Protocol of the United Nations Framework Convention on Climate Change, the CDM allowed countries with a greenhouse gas emissions reduction or emissions limitation commitment to reduce emissions in developing countries and receive credit for these measures, while promoting sustainable development. CDM projects, subject to public registration and verification processes, including determination of "additionality" of emissions reduction, earned Certified Emission Reduction (CER) credits that were each equivalent to 1 metric ton of carbon dioxide (CO_2) that could be sold and counted toward a country's Kyoto emissions target. Thus, the CDM is a form of emissions trading. The additionality of emissions reductions by developing countries, which were not subject to emissions limitations under the Kyoto Protocol, was difficult to determine and highly contested (Cameo et al. 2016).

The CDM program allowed industrialized countries flexibility in meeting their emissions reduction limitation targets more cost-effectively, and were especially relied upon by Western and Northern European countries. Almost 8000 CDM projects were registered, with China accounting for over half of all CER credits, and the majority registered from 2011 to 2013. The most common CDM projects were based on destroying hydrofluorocarbon-23 (HFC-23) or nitrous oxide (N_2O) gases, with a smaller number based on forestry measures, renewable energy, or energy efficiency technologies.

Barry D. Solomon

Further reading

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See also: Climate change, Climate change mitigation, Greenhouse gases, Emissions trading, Tradable permits, Carbon trading.

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Sutter, C. & Parreño, J.C. 2007. Does the current Clean Development Mechanism (CDM) deliver its sustainable development claim? An analysis of officially registered CDM projects. Climatic Change 84: 75–90.

Climate

The long-term characteristic of weather fluctuations, such as averaged conditions, but also its variability and extremes. Related to climate is the "climate normal," which is defined as a 30-year mean of meteorological variables such as temperature or precipitation. The climate normal characterizes long-term changes of climate if computed over different periods. Climate is the state of the climate system consisting of the atmosphere, the hydrosphere, the lithosphere, the cryosphere, and the biosphere.

Christian L.E. Franzke

Further reading

Marshall & Plumb 2016; Randall 2012; Dessler 2015.

See also: Climate change, Climate regulation, Climate instability, Intergovernmental Panel on Climate Change (IPCC).

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Randall, D. 2012. Atmosphere, Clouds, and Climate. Princeton, NJ: Princeton University Press.

Climate change

A long-term change in global and regional climatic patterns and conditions, including but not limited to planetary warming, sea level rise, drought, and the frequency of extreme weather events. Climate change is compared to the climatic conditions and patterns that existed at the start of the Industrial Revolution as a baseline, and was first detected in the late 20th century by scientists using general circulation models (numerical models of the interactions between the planetary atmosphere, ocean, cryosphere, and land surface). Climate change is largely attributed to the large increase in anthropogenic carbon dioxide, methane, and other greenhouse gas emissions from pre-industrial levels, leading to urgent calls to greatly decrease if not eliminate the use of fossil fuels in the 21st century.

Barry D. Solomon

Further reading

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See also: Climate, Global warming, Climate instability, Climate change mitigation, Greenhouse gases, Anthropogenic.

References

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Climate change adaptation

According to the Intergovernmental Panel on Climate Change (IPCC): the "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (from Parry et al. 2007). The term "climate change adaptation" first came to prominence after the release of a 1995 IPCC report (Watson et al. 1995). A key concept is the adaptive capacity of human and natural systems (Carpenter & Brock 2008). The IPCC further distinguishes between different types of adaptation: anticipatory and reactive, and autonomous and planned. Anticipatory adaptation takes place before (*ex ante*) impacts of climate change are observed. In contrast, reactionary adaptation occurs *ex post*. Autonomous adaptation does not constitute a conscious response to climatic stimuli, and is often triggered by ecological changes in natural systems or unintended human systems. Finally, planned adaptation results from a deliberate policy decision, based on an awareness that conditions have changed or are about to change, and that action is required to return to, maintain, or achieve a desired state.

Adam M. Wellstead

See also: Adaptation, Adaptive capacity, Climate change, Intergovernmental Panel on Climate Change (IPCC), Climate change mitigation.

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Climate change mitigation

Any action that reduces the severity, seriousness, or adverse impacts of climate change. Includes reductions in greenhouse gas emissions by using energy efficiency and renewable energy, nuclear energy, afforestation, reforestation, and large-scale geoengineering of the climate through methods such as ocean iron fertilization or carbon dioxide capture from the air or fossil fuels plus storage, and solar radiation management (Vaughan & Lenton 2011).

BARRY D. SOLOMON

Further reading

Lashof & Tirpak 1990; Jacobson & Delucchi 2011; Hansen et al. 2019.

See also: Climate change, Climate change adaptation, Greenhouse gases, Renewable energy, Energy efficiency, Net zero carbon, Greenhouse gas neutral, REDD (Reducing Emissions from Deforestation and forest Degradation).

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Vaughan, N.E. & Lenton, T.M. 2011. A review of climate geoengineering proposals. Climatic Change 109: 745–90.

Climate instability

The forcing action of global warming to shift the climate from stability to instability (National Research Council 2002). Global warming is primarily due to the increase of atmospheric greenhouse gases, especially carbon dioxide (CO_2). Since 1960 the concentration of atmospheric CO_2 has grown over a 50-year interval as much as it had over 5000 years in previous geoclimatic eras. It is this time contraction factor, 100 times, that measures the forcing action exerted by global warming; a typical threshold effect, that is, beyond a certain value of the "control" parameter, the concentration of CO_2 in the atmosphere, a sudden discontinuity appears, from stability to instability, in the behavior of the climate system.

Loss of stability in climate cycles has had dramatic global impacts: polar ice caps and mountain glaciers are melting at worrying rates, isothermal lines are moving north, drought is invading ever larger areas, extreme weather events are common, an "iceberg" of 5800 km^2 broke off from Antarctica in 2017, and a similar one in 2021. Global warming was denounced by the science academies of the G8 countries, as well as those of China, India and Brazil, as primarily due to the huge use of fossil fuels in human activities. The statement was issued ahead of the G8 Summit in Gleaneagles (2005), which called for "prompt action" from all nations against its risks (National Academies of Sciences, Engineering, and Medicine 2005).

MASSIMO SCALIA

Further reading

Scalia et al. 2018.

See also: Global warming, Climate change, Greenhouse gases, Threshold.

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Climate justice

A framework to address the unequal distribution of costs and burdens of climate change. Countries in the global North are the main beneficiaries of energy-intensive industrial

development that has led to the accumulation of greenhouse gases (GHG) warming the Earth's atmosphere. The wealthiest 1 percent of the world's population contributed more than double the GHG emissions of the poorest half of humanity between 1990 and 2015 (Gore 2020). These inequalities are at the root of climate injustices, though procedural rights and recognition are equally important.

Differences in income and wealth, race, gender, ethnicity, age, and sexual orientation within countries also contribute significantly to climate injustices. Large populations in the global South lack access to safe drinking water, sufficient nutritious food, a reliable source of clean energy, and access to health, sanitation, and education, which contribute to extreme vulnerability. Black, indigenous, people of color, including women, who have suffered historical injustices, lack political power in the status quo. Yet, these frontline communities and the youth have led social mobilization to confront global, national, and local inequalities, and demand a just transition to a climate-robust economic system and ecologically resilient planet.

Climate justice requires an integrated approach, including distributional, procedural, and recognitional justice. Those affected most severely by the ongoing climate crisis need an equal voice in developing and implementing climate policies and responses. Such procedural justice will be effective only if the most marginalized groups, including refugees and stateless people, are recognized as legitimate participants and decision-makers.

PRAKASH KASHWAN

Further reading

Agarwal & Narain 1998; Athanasious & Baer 2002; Kashwan 2021; Newell et al. 2021; Schlosberg & Collins 2014; Sultana 2022.

See also: Greenhouse gases, Justice, North–South relations, Environmental justice, Ecological justice, Distributive justice, Social justice, Intragenerational equity.

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Sultana, F. 2022. Critical climate justice. Geographical Journal 188(1): 118–24.

Climate regulation

A critical type of regulating services, climate regulation refers to a variety of ecosystem services that regulate climate and weather through biogeochemical mechanisms (for example, greenhouse gas control) and biophysical mechanisms (for example, tropical forests). These include the atmospheric chemical composition of carbon dioxide, methane, and other greenhouse gases, and the capacity of terrestrial and marine ecosystems to serve as greenhouse gas sources and sinks; air quality; precipitation; and moderation of temperature and weather patterns.

BARRY D. SOLOMON

Further reading

Anderson-Teixeira et al., 2012.

See also: Regulating services, Climate, Climate change, Greenhouse gases, Sources, Sinks.

Reference

Anderson-Teixeira, K.J., Snyder, P.K., Twine, T.E. et al. 2012. Climate regulation services of natural and agricultural ecoregions of

the Americas. Nature Climate Change 2(3): 177–81.

Closed system

A self-contained system that does not interact with anything outside of it. The Earth or biosphere is a virtually closed system with respect to matter, though it is an open system with respect to solar and heat energy.

BARRY D. SOLOMON

See also: Biosphere, Open system, Isolated system.

Club goods

An economic good that is excludable but non-rivalrous in consumption, at least until congestion occurs (Buchanan 1965; Cornes & Sandler 1996). Examples include private parks, toll roads, public transportation, wireless Internet, cable television, and satellite radio. Some club goods have close to zero marginal costs. Club goods are sometimes also called toll goods, collective goods, or artificially scarce goods.

BARRY D. SOLOMON

See also: Excludability, Excludable good, Non-rival resources, Public goods.

Reference

Buchanan, J.M. 1965. An economic theory of clubs. Economica, New Series 32(125): 1–14.

Cornes, R. & Sandler, T. 1996. The Theory of Externalities, Public Goods, and Club Goods, 2nd edn. Cambridge: Cambridge University Press.

Clustering

The practice of bringing industrial plants together in large, geographically determined groups (clusters) so that they can benefit from, among other things, using common infrastructure and specialized inputs (Porter 2000). The industrial facilities in a cluster are usually in close proximity; however, it is not uncommon for clusters to include isolated industrial units.

In the decarbonization context, for example, clustering is mostly relevant in utilizing integrated energy systems, where for example waste heat from one plant can be used as input for another; or, more recently, in the operation of carbon capture utilization and storage (CCUS) systems. Although the carbon capture element often needs to be tailored to the specific requirements of each industry, clustering can be beneficial on the transport and storage side of the system. Operating as a cluster, industries can benefit from using common, central infrastructure such as large pipelines that will transport the captured carbon to the storage sites. The key perceived benefit of this approach is that it eliminates the need for each industry to build its own transportation network to the storage site, leading to less overall development costs. Furthermore, clustered industries can develop a more integrated approach where decarbonization is not achieved exclusively through carbon capture, but the CCUS system is used as an approach to develop zero or low carbon fuels, which aid the process of reducing carbon emissions (see, e.g., Porthos 2019). Examples of this integrated approach can be seen in the proposals of United Kingdom industrial clusters in Grangemouth, Merseyside, and the Humber/Teesside.

KAREN R. TURNER, J. KIM SWALES & ANTONIOS KATRIS

See also: Industrial economics, Carbon capture, Climate change mitigation.

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Coase theorem

Asserts that if transaction costs are nil and if property rights (that is, rights to pollute or to be protected from pollution) are clearly defined and allocated, then agents will exchange these rights and the result (the level of pollution) will be optimal and independent from the initial allocation of rights. It opposes the traditional welfare economic assumption, in which pollution is viewed as an obstacle to the efficiency of markets since it has no price (it is an "externality").

This proposition was named the "Coase theorem" by George Stigler (1966), after Ronald Coase's seminal paper (Coase 1960). In that article, Coase illustrated it, but provided no general statement nor demonstration; and above all he insisted on the importance of transaction costs that may impede exchanges. The Coase theorem has been subjected to extensive criticism, since most real-world situations involve many parties and transaction costs, unequal market power of potential negotiating partners, and may result in multiple and not necessarily efficient solutions. (It has also been considered tautological, since it suffices to define transaction costs as impeding any mutually advantageous exchange to "prove" efficiency.) The Coase theorem is nevertheless often referred to in order to assert the efficiency of exchanges of ecological or environmental services for money, even without the assumptions of perfect competition. It partly originated the idea of tradable emission permits, and more directly payments for ecosystem services.

ELODIE BERTRAND

Further reading

Mishan 1971; McKelvey & Page 1999.

See also: Property right, Payment for ecosystem services (PES), Emissions trading, Tradable permits, Coasean approach, Externalities.

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Mishan, E.J. 1971. Pangloss on pollution. Swedish Journal of Economics 73(1): 113–20.

Stigler, G.J. 1966. The Theory of Price. New York: Macmillan.

Coasean approach

a. Empirical, case-based approach defended by Ronald H. Coase (1910–2013), who was awarded the Sveriges Riksbank Prize in Economic Sciences in 1991. In opposition to mainstream economics, which he considered too abstract, Coase aimed at building economic theory out of empirical case studies. First, they must make realistic assumptions; in opposition to Milton Friedman's (Friedman 1953) manifesto. Second, they must be used in the design of policies: they allow the analysis of the specific initial circumstances and a comparison of alternative actual institutional arrangements.
b. Bilateral exchange of environmental rights (for example, to pollute or to be protected from pollution) that would reach optimality even in the absence of competitive markets. This approach is named after the Coase theorem, and is supposed to justify, for example, the efficiency of payments for environmental services.
c. In the spirit of Coase (1960), it refers to the necessity of introducing positive transaction costs in the analysis, which may impede the mutually advantageous exchanges referred to in definition b. and make other solutions more desirable. More generally, it refers to policy design by comparison of institutional arrangements rather than by reference to the ideal world of perfect competition.

ELODIE BERTRAND

Further reading

Coase 1982, 1992.

See also: Coase theorem, Competitive market, Transaction costs, Economic institutions, Payment for ecosystem services (PES).

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Cobb–Douglas production function

A relationship between the amounts of inputs and output that assumes a unitary elasticity of substitution between individual factor inputs. The inputs most commonly include labor and capital, in ecological economics often accompanied by energy. A widely used special case of the constant elasticity of substitution production function, the Cobb–Douglas production function, has been criticized by studies showing that the elasticity of substitution between capital and labor is below unity in most countries (Antras 2004; Gechert et al. 2022).

TOMÁS J. HAVRÁNEK

Further reading

Cobb & Douglas 1928; Keen et al. 2019.

See also: Production function.

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Coevolution

Two organisms or systems coevolve when one evolves in relation and in response to the evolution of the other. Evolution, in a general sense, is a process of selective retention of renewable variation. Coevolution may involve biological or social systems, or both. Coevolving entities might include organisms in the biological world, or organizations, institutions, and technologies in the social world. Units of variation and selection might include genes, habits, norms, strategies, products, technologies, institutions, or behaviors.

Biology: Paul Ehlrich and Peter Raven (1964) showed how butterflies and plants evolved in relation to one another.

Ecological economics: Richard Norgaard (1994) introduced coevolution to ecological economic interactions, arguing that technologies, values, forms of organization, knowledge systems, and environments evolve in relation to one another. He showed how pests, pesticides, and the institutions that regulate and control pesticides evolved over time, one in relation to the other. He also revisited development processes in the Amazon as a coevolution between diverse ecological and social systems. Applications of coevolution in ecological economics include the coevolution of water institutions, technologies, and waterscapes in Athens, Greece (Kallis 2010); and the coevolution of tobacco farming practices, organizational forms of farming, and ecosystems in south Brazil (Moreno-Peñaranda & Kallis 2010).

GIORGOS KALLIS

Further reading

Norgaard 2006.

See also: Darwinian theory, Evolutionary analysis, Evolutionary economics, Dynamic systems, Dynamic models, Applied systems analysis, Adaptation, Diversity.

References

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Norgaard, R.B. 2006. Development Betrayed: The End of Progress and a Co-evolutionary Revisioning of the Future. London, UK and New York, USA: Routledge.

Coevolutionary economics

See: Coevolution.

See also: Evolutionary economics, Evolutionary analysis.

Cointegration

A statistical property of some time series variables. Cointegration tests have been developed in econometrics to determine whether there are long-term correlations between several time series data, which can cause spurious regression. Cointegration is commonly used in many branches of economics as well as ecological economics since it was first suggested by Granger (1981), and Engle and Granger (1987, p. 251) who noted:

> If each element of a vector of time series x, first achieves stationarity after differencing, but a linear combination α'xt, is already stationary, the time series xt, are said to be co-integrated with co-integrating vector α. Interpreting α'xt, = 0 as a long run equilibrium, co-integration implies that deviations from equilibrium are stationary, with finite variance, even though the series themselves are non-stationary and have infinite variance.

The most popular cointegration tests in ecological economics are the Engle–Granger, the Johansen (1988), and autoregressive distributed lag (ARDL) tests (Pesaran & Shin 1999; Pesaran et al. 2001).

Melike E. Bildirici

See also: Econometrics, Non-linear cointegration.

References

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Collapse

Anthropology: (from Tainter 1988) the relatively rapid, significant loss of an established level of socio-political complexity in a society. Collapse leads to a loss of: (1) higher degrees of stratification and social differentiation; (2) economic and occupational specialization; (3) centralized control (regulation and integration of diverse economic and political groups by elites); (4) behavioral control and regimentation; (5) investment in monumental architecture, artistic, and literary achievements; (6) information flows within society; (7) sharing, trading, and redistribution of resources; (8) coordination and organization of individuals and groups; and (9) territory integrated within a single political unit.

Geography: (from Butzer & Endfield 2012) societal collapse represents transformation at

a large social or spatial scale, with long-term impacts on combinations of interdependent variables: (1) environmental change and resilience; (2) demography or settlement; (3) socio-economic patterns; (4) political or societal structures; and (5) ideology or cultural memory. The variables encompass energetic structures and flows, but also cultural and psychological dimensions that are grounded in human perceptions, values, and solidarity.

Ecology: (from Bland et al. 2016) ecosystem collapse is the transition beyond a bounded threshold in one or more variables that define the identity of the ecosystem. Collapse involves a transformation of identity, loss of defining features, and/or replacement by a new ecosystem. It occurs when all ecosystem occurrences (or patches) lose defining biotic or abiotic features, and characteristic native biota are no longer sustained. Transitions to collapse may be gradual, sudden, linear, non-linear, deterministic, or highly stochastic. These include regime shifts (Scheffer et al. 2001), but also other types of transitions that may not involve reinforcing feedbacks.

SABIN ROMAN

Further reading

Bland et al. 2018; Tainter 2000.

See also: Complexity theory, Threshold, Resilience, Ecosystem resilience.

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Collective action

The joint action undertaken by a group of people or communities in the pursuit of a common goal, which may not be attainable through unitary action. When individual incentives align with group incentives, as is the case in, for example, coordination games, goal achievement is somewhat trivial, but may be hindered by insufficient information. When individual incentives are at odds with group incentives—when the "Nash equilibrium" strategy dictates defection, but Pareto optimality requires cooperation—groups face a "collective action problem," also known as a "social dilemma." This is the incentive structure surrounding common pool resources, public goods, and prisoner's dilemmas, often resulting in a failure of collective action and, subsequently, in the overexploitation of common resources or the underprovision of public goods.

Economics and political science: focus on the institutions and incentive structures that allow for collective action success. Common strategies entail privatization of resources and delegation of decision-making to a third party (for example, government provision of public goods). In addition to or in lieu of generic mechanisms meant to overcome social dilemmas, communities may devise idiosyncratic institutions to promote collective action (Ostrom 2005). They do so through self-governance, which requires building trust and tailoring attempted solutions to community characteristics and the specific collective problem at hand.

Behavioral economics and social psychology: focus on testing the conditions under which collective action can be successful. Human behavior frequently deviates from expectations derived from the traditional economic model of humans as rational, utility-maximizing actors. Factors shown to be important to collective action success include contribution norms, groupthink,

group cohesion, trust, communication, and intrinsic and social-image motivations.

Jacob S. Bower-Bir & Ursula W. Kreitmair

Further reading

Hardin 2013; Olson 1965; Ostrom et al. 1994.

See also: Common pool resources, Free rider, Nash equilibrium, Prisoner's dilemma, Public goods, Rational behavior, Rational choice, Asymmetric information.

References

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Ostrom, E., Gardner, R. & Walker, J. 1994. Rules, Games, and Common-Pool Resources. Ann Arbor, MI: University of Michigan Press.

Collective choice

The process by which groups of people aggregate individual preferences into social preferences over policies, regulations, and other group actions. Collective choice takes on special importance in social settings that rely on democratic participation or demand weak Pareto optimality, because these constraints make collective choice elusive when selecting amongst more than two alternatives. Supposing different people hold self-consistent albeit different preferences regarding a common public issue, there are no general processes by which they can consistently assemble those preferences into coherent collective preference orderings (Arrow 1963). The results will be socially transitive, Pareto inefficient, or dictatorial (that is, winning proposals endlessly cycle, some participants experience a net loss, or some participants' preferences count more than those of others). Further, the outcome may be manipulated by altering the aggregation mechanism used, or by changing the order in which alternatives are presented. Under certain circumstances, collective decision-making mechanisms may yield transitive results under the constraints, but they are not guaranteed to do so. For most collective choice problems, there is no "common good" or "will of the people."

Political and experimental economics: focus on the institutional arrangements that allow for predictable collective choice outcomes regarding public or common pool resources, especially in scenarios without Nash equilibria. Relevant variables include the number of alternative proposals being considered by decision-makers, the number of dimensions comprising the "policy space" from which decisions can be drawn, the number of participants involved in the decision, and the presence of agenda power and veto power among participants. Formal models heavily inform this work.

Political science: focus on electoral mechanisms commonly used to select leaders and policies in representative democracies, and on candidate and voter behavior in collective choice settings. In addition to incentive structures, significant factors influencing candidate and voter behavior include ideology, cognitive biases, and biological differences.

Social psychology: focus on the cognitive and emotional processes that facilitate or inhibit collective decision-making, and its cognitive and emotional consequences.

Jacob S. Bower-Bir & Ursula W. Kreitmair

Further reading

Bianco et al. 2006; Black 1948; Elster & Hylland 1986; Mueller 2003; Sen 1970.

See also: Collective action, Common pool resources, Preference endogeneity, Preference heterogeneity, Social welfare function, Nash equilibrium.

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Sen, A.K. 1970. Collective choice and individual welfare. Amsterdam: North-Holland.

Collective goods

See: Club goods.

See also: Goods, Public goods, Environmental goods and services, Private goods.

Combined system perspective (CSP)

Initially coined the multiple perspectives approach, a practice developed for studying complex issues or sets of interrelated problems characterized by a high level of uncertainty and controversies (Mitroff & Linstone 1993; Turpin et al. 2009). When possible descriptions and definitions of a situation are diverse, traditional problem-solving approaches attain their limits because they focus on one (micro, meso, or macro) level. Enlarging the scope, the CSP offers a sophisticated framework of analysis to study systems, their dynamics, and their governance options (Ostrom et al. 2007; Berkes et al. 2009). Within social systems, the encapsulation of human decisions in different programs, media, and codes results in uncoordinated system imputations (Luhmann 2012–2013; Alexander & Blum 2016). Their effects can be uncovered with the CSP and the study of the missing link between scaling and governance. Thus, it could improve our understanding of disappointments with environmental policies and their management (Cash et al. 2006) and serve strong sustainability goals.

Being a philosophical or phenomenological approach rather than a practical method, the CSP lacks guidance for its use. To address this challenge, future research can build on practical implementations in the fields of information systems or artificial intelligence. Driver models are categorized from their application: vehicle perspective, driver perspective, and environment/traffic perspective, with traffic situation predictions exemplifying a CSP model. Another illustration combines experience and knowledge in electric mobility and renewable energy with the aim to reduce an organization's carbon footprint.

Véronique C. Blum

Further reading

Plöchl & Edelmann 2007.

See also: Applied systems analysis, Dynamic systems modeling, Complexity theory, Complex systems modeling, Uncertainty, Wicked problems.

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Command-and-control regulation

See: Regulation.

See also: Environmental policy instruments, Regulatory capture.

Command economy

An economy that is coordinated by a state authority rather than by a free market mechanism (Grossman 1963; Ericson 2008). The coordination of economic activities is undertaken through a system of commands, directives, and targets that administer planning, balancing, and rationing of resources and goods, budgetary controls and limits, and price and wage controls (Ericson 2008). Producers in such an economy follow the directives and become non-responsive to prices (Grossman 1963; Kornai 1979). A command economy is often characterized by bureaucracy, production imbalances, shortages, low economic incentives, and overexploitation of natural resources (Ericson 2001; Hartwell et al. 2021; Kornai 1979; Roland 2000).

Examples of command economies include the economy of the former Soviet Union, the United States World War II Administration (1942–1946), the Mormon economic system in Utah in the mid-19th century, and the Inca system in the Andes in the 16th century (Ericson 2008).

OLGA V. POPOVA

See also: Transition economies, Free market.

References

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Roland, G. 2000. Transition and Economics: Politics, Markets, and Firms. Cambridge, MA: MIT Press.

Commensurability

A condition or situation in economics where the value of two or more entities can be compared by a common metric or standard. Strong commensurability occurs when we can give cardinal values to the entities, and conclusively state that one entity, for example, has three times the value of another one. This suggests monism. Weak commensurability occurs when only an ordinal valuation is possible (O'Neill 1993, pp. 102–6).

BARRY D. SOLOMON

See also: Monism, Incommensurable, Incommensurable values.

Reference

O'Neill, J. 1993. Ecology, Policy and Politics: Human Well-being and the Natural World. London: Routledge.

Commodification of nature

When the other-than-human world (that is, the rest of nature) is integrated into a capitalist system as part of the value-creating dynamic of that system through a particular type of property ownership, it becomes commodified. All other values (for example, intrinsic, use) are secondary to its role played in the market economy, and its use and destiny will be dictated by that purpose. The ultimate purpose of commodification is to accommodate the process of capital accumulation.

Commodification necessitates ownership (or possession, as imperialistic conquest demonstrates), but not all ownership implies commodification. For example, when land

in the United States was transferred to individuals in the form of fee-simple ownership it became commodity land. It could then be bought and sold for market purposes. Land may be privately owned that is not commodified. Such would have been the case with feudal land ownership in pre-capitalist Europe, where land could not be bought and sold according to the dictates of the market system (because there was no market for land) even though it was privately owned.

LISI KRALL

Further reading

Krall 2010.

See also: Nature, Human–nature relationships, Use value, Intrinsic value.

References

Krall, L. 2010. Proving Up: Domestication Land in U.S. History. Albany, NY: SUNY Press.

Commodity supply chain

Organizational networks that encompass the whole range of activities in the processes to gather raw materials, transform them into goods, and distribute them to intermediaries and ultimately consumers of the end product. For a given commodity, its supply chain includes all stages of production, trade, and consumption, and therefore links the many different places where the relevant activities occur. Two ideal types of commodity supply chains have been identified due to their different network structure: "producer-driven" chains often exist in capital- and technology-intensive industries; and "buyer-driven" chains occur in labor-intensive, consumer goods industries.

YIXIAN SUN

Further reading

Gereffi & Korzeniewicz 1994; Bair 2005; Lee 2017.

See also: Value chain analysis, Networks.

References

Bair, J. 2005. Global capitalism and commodity chains: looking back, going forward. Competition & Change 9(2): 153–80.

Gereffi, G. & Korzeniewicz, M., eds. 1994. Commodity Chains and Global Capitalism. Westport, CT: Praeger.

Lee, J. 2017. Global Commodity Chains and Global Value Chains, Vol. 1. Oxford: Oxford University Press.

Commodity trade

The exchange, often across national borders, of primary goods, which are raw or partly refined materials whose value reflects the costs of finding, gathering, or harvesting them, and are often traded for processing or incorporation into final goods. Examples include agricultural products (for example, coffee, cocoa, and soy), crude oil, and metals and minerals. Trade in primary goods can take the form of normal changes of goods for money, but also by means of futures contracts.

YIXIAN SUN

Further reading

Daviron & Ponte 2005; Romalis 2004.

See also: Commodity supply chain, Trade liberalization, Globalization, World Trade Organization (WTO).

References

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Romalis, J. 2004. Factor proportions and the structure of commodity trade. American Economic Review 94 (1): 67–97.

Common International Classification of Ecosystem Services (CICES)

A universal system to categorize and describe ecosystem services. CICES was initially developed to support the United Nations (UN) System of Integrated Environmental-Ecosystem Accounts, but since a rapidly growing community of ecosystem services practitioners started using it as a reference to identify which services can be defined as "final," it became an acknowledged classification system for ecosystem services (European Environment Agency 2021). The conceptual basis for CICES is the "cascade model" that is meant to describe the sequence of elements that connect nature to people (Potschin-Young et al. 2018). This pathway starts from ecological structures and processes that generate functional characteristics that in turn provide services, meant as contributing to human activities and human well-being. CICES focuses on services. Services differ from benefits, which in the cascade model are identified with things (tangible or intangible) that people assign a value to. An attempt to combine systems ecology categories (Jørgensen 2012) throughout the cascade model was attempted (La Notte et al. 2017) to insert elements of ecological complexity to the purely linear sequence.

CICES has a hierarchical structure with three main sections: Provisioning services, Regulation and maintenance services, and Cultural services. Each section is further divided into: "divisions," "groups," "classes," and "class types" (Haines-Young & Potschin 2018). Initial versions of CICES have been evolving over time to progress with developments and needs expressed by ecosystem services practitioners in general, and ecosystem services accountants. CICES remains one of the main sources of ecosystem services classification for accounting purposes (UN et al. 2021).

ALESSANDRA LA NOTTE

See also: Ecosystem services, Economic ecosystem accounting, System of National Accounts (SNA), Provisioning services, Regulating services, Maintenance services, Cultural services, Ecology.

References

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United Nations et al. 2021. System of Environmental-Economic Accounting—Ecosystem Accounting (SEEA-EA). White cover publication, pre-edited text subject to official editing. New York. https://seea.un.org/ecosystem-accounting.

Common law

A general system of law deriving exclusively from court decisions (Law 2018). Before the passage of modern environmental protection statutes, common law provided a basis for resolving private environmental disputes, though its effectiveness was extremely limited. Common law is based on precedent from an accumulation of court decisions in specific legal cases throughout history. This body of case law is constantly evolving. The two great virtues claimed for common law elements are that it reflects past wisdom, and it is independent of politics. However, it can be very untidy, leaving judges to wrestle with a bewildering mass of precedents (Kingdom 2003).

In common law countries (for example, England, Wales, Australia, New Zealand, India, United States, and so on) law is no more than a body of past judgments; however, case law is complemented by statutory law. With regard to the environment, it is important to note that common law allows a significant amount of administrative discretion, especially against the background that even where

a formal legal regime exists there is often a very large difference between what the law is and how it is practiced (Fisher et al. 2013).

KEVIN GRECKSCH

See also: Social institutions, Property right.

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Kingdom, J. 2003. Government and Politics in Britain: An Introduction. Cambridge: Polity Press.
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Common patrimony

A way to designate a set of entities, with both material and immaterial dimensions, whose management must be thought of in a perspective integrating both the inheritance of the past and the transmission to future generations, in a long-term perspective. Since the late 1960s, the expression "common patrimony" (or common heritage) has been broadened to encompass a set of holders (humanity, the nation, a community), and reflections on environmental issues have largely contributed to this extension of the perimeter of the notion of patrimony, particularly in international law. The analysis of common patrimony has given rise to various academic works in the fields of history, anthropology, and political economy, notably in France where a group of researchers from the University of Reims have initiated an interdisciplinary research program on this notion.

This patrimonial economics approach insists on the singular character of these patrimonial objects, which standard economics has always tended to consider as capital, or as belonging to situations outside of the market (externalities). Considering common patrimony and the processes of patrimonialization in common seriously requires leaving the sphere of having (including ownership) and moving more towards the sphere of being. This tension, between the market and the non-market, between the material and the immaterial, between the individual and the collective, makes it possible to reveal dynamics linked to identity, territories, and attachment, of which the management of water as a common patrimony is a good example.

OLIVIER PETIT

Further reading

Barrère et al. 2005; Michon et al. 2012; Calvo-Mendieta et al. 2011, 2014, 2017.

See also: Common property resources, Ownership, Capital, Externalities, Water governance, Integrated water resources management (IWRM), Biocultural heritage.

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Calvo-Mendieta, I., Petit, O. & Vivien, F.D. 2017. Common patrimony: a concept to analyze collective natural resource management: the case of water management in France. Ecological Economics 137: 126–32.
Michon, G., Romagny, B., Auclair, L. & Deconchat, M. 2012. Forests as patrimonies? From theory to tangible processes at various scales. Ecology and Society 17(3): 7.

Common pool resources

A potentially divisible natural or human-made resource system that is sufficiently large as to make it costly (but not impossible) to define recognized users and exclude potential beneficiaries from obtaining benefits from its use (Ostrom 1990, p. 30). Common pool resources thus include the air and global atmosphere, the oceans and other (though not all) water bodies, and in some areas forests, fish, and wildlife populations. Such resources either lack formal property rights or may have them but these are too costly to enforce.

Common pool resources have a high degree of subtractability of one person's use from that available to be used by other people, in the sense that "high levels" of consumption can lead to their congestion, degradation, and even destruction (Ostrom et al. 1994, p. 6; Ostrom 2003, pp. 261–2).

BARRY D. SOLOMON

See also: Common property resources, Common property regimes, Commons, the, Tragedy of the commons.

References

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Ostrom, E. 2003. How types of goods and property rights jointly affect collective action. Journal of Theoretical Politics 15(3): 239–70.

Ostrom, E., Gardner, R. & Walker, J. 1994. Rules, Games, and Common-Pool Resources. Ann Arbor, MI: University of Michigan Press.

Common property

See: Common property resources, Commons, the.

See also: Public goods, Private property.

Common property regimes

A property rights arrangement in which a group of resource users share rights and responsibilities towards a resource. Therefore, when a group of individuals and the property rights they share are well defined, common property should be classified as a form of shared private property. An example of a common property regime is a group of farmers cooperating to sustainably use water through the internal rules of water allocation among competing interests.

MARCELLO HERNÁNDEZ-BLANCO

Further reading

Bromley 1992; McKean and Ostrom 1995; McKean 2000; Costanza et al. 2020.

See also: Property right, Property regimes, Property systems, Common pool resources, Open access regimes.

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McKean, M. & Ostrom, E. 1995. Common property regimes in the forest: just a relic from the past. Unasylva 46(1): 3–15.

Common property resources

Access to resources that are commonly held and may or may not be restricted to a particular group or groups of persons. Public lands are a familiar example of common property resources, which are held by government. Other examples include fishing grounds, some pastures, forests, irrigation systems and other waters, and the atmosphere. Resources with unrestricted access are referred to as open access resources or the global commons.

Common property resources that are commonly owned with property rights held by a clearly specified group or groups of people may be thought of as local commons. Unlike open access resources, local commons may be characterized by rights that are exclusive (to the group), enforceable (usually by the group), transferable (usually within the group), and reasonably secure. As a result, these resources can be managed collectively (Ostrom 1990). Management approaches

vary with the local context and can be formal or informal.

NEHA KHANNA

Further reading

Hardin 1968.

See also: Common property, Common property regimes, Open access, Open access regimes, Common pool resources.

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Ostrom, E. 1990. Governing the Commons: The Evolution of Institutions for Collective Action. New York: Cambridge University Press.

Commons, the

a. Land in medieval England and Europe owned by landlords of manors, but where tenants in the community had the right to live, work, and grow food. The United Kingdom eliminated these commons rights and evicted the commoners living in them during the so-called "enclosure movement" using hedges, walls, and fences, though a limited amount of common property land remains today on certain Crown lands. The process of land enclosure took place gradually over several centuries, though it began as early as the 12th century in northern England (Heilbroner & Milberg 2011, Ch. 3). Common lands outside of the United Kingdom also still exist in limited areas in several countries.
b. Natural and cultural resources accessible to all people, and not privately owned, especially air and the global atmosphere, but in some cases also the oceans and other water bodies, forests, and wildlife. These areas and their natural resources are often considered common pool resources.

BARRY D. SOLOMON

Further reading

Berkes et al. 1989.

See also: Tragedy of the commons, Community forestry, Common property, Private property, Common property regimes, Common property resources, Common pool resources.

References

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Community

Social sciences: a network of economic, social, and/or political relationships and interactions, and the geographic areas where they interact. A community can also be virtual, such as scientific communities (among many others), which became more pronounced and widespread during the coronavirus pandemic of 2020–2022.

Ecology: a group or association of multiple species that occurs in the same geographic area at the same time, organized into a trophic structure (food chains and food webs, intraspecies competition for resources, and so on). Common predator–prey relationships are often the object of study, such as wolf–moose or wolf–deer, and fox–rabbit.

BARRY D. SOLOMON

Further reading

Tönnies & Loomis 2002; Shaffer et al. 2004; Vellund & Agrawal 2010.

See also: Local economies, Community currency, Community forestry, Networks, Knowledge networks, Bayesian belief networks, Ecosystem structure and function, Population dynamics.

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Community-based

See: Local economies.

See also: Community, Community currency, Community forestry.

Community currency

A generic term for any non-governmental exchange system that functions as a complement to ordinary money, and which operates at the substate level to serve local socio-economic needs. Four categories are recognized (Seyfang & Longhurst 2013; Collom et al. 2012):

1. "Mutual exchanges," which advertise all member "wants" and "offers" and require a central coordinator to record all transactions either electronically or otherwise. Sometimes called a local exchange trading scheme.
2. "Service credits," which are based on reciprocity of work trading within a group or local area. Often called time banks or time dollars. These first two categories are the most common types of community currency worldwide.
3. "Barter markets," which can be stand-alone, limited site-specific events, informal, irregular, or recurring activities. Bartering predates the monetary system and goes back around 8000 years to Mesopotamian tribespeople who exchanged goods directly following a negotiation (Frankfort 1950). In its simplest form, traditional bartering is any direct trading of goods or services in a market without money.
4. "Local currency," which can involve either printed scrip or electronic transactions. Local complementary currency systems are rare, often short-lived, and only private entities can create them (Collom 2005; Mauldin 2015).

BARRY D. SOLOMON

Further reading

Seyfang & Longhurst 2016.

See also: Money, Monetary policy, Grassroots innovations, Exchange value.

References

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Collom, E., Lasker, J. & Kyriacou, C. 2012. Equal Time, Equal Value: Community Currencies and Time Banking in the U.S. Farnham, UK: Ashgate.

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Mauldin, R.L. 2015. Local currency for community development: policy barriers and support. Journal of Community Practice 23(3–4): 462–76.

Seyfang, G. & Longhurst, N. 2013. Growing green money: mapping community currencies for sustainable development. Ecological Economics 86: 65–77.

Seyfang, G. & Longhurst, N. 2016. What influences the diffusion of grassroots innovations for sustainability? Investigating community currency niches. Technology Analysis and Strategic Management 28(1): 1–23.

Community forestry

Forest management that includes local community benefits and ecological sustainability as its goals, with some, if not all, responsibility for forest management vested in the local community. Sometimes also called social forestry. Three attributes are found in most community forestry programs: (1) residents own and operate the forests; (2) residents are given a meaningful role in decision-making and forest management, including the rules for access and disposition of forest products;

and (3) the first task is forest conservation and restoration (Duinker et al. 1991; Brendler & Carey 1998; Charnley & Poe 2007; McDermott & Schreckenberg 2009). Community forestry programs gained popularity in the 1970s and 1980s and now operate in India, Nepal, Indonesia, the Philippines, Thailand, Cambodia, South Korea, the United States, Canada, Mexico, Guatemala, Honduras, Colombia, Brazil, Peru, Bolivia, and parts of Africa.

BARRY D. SOLOMON

Further reading

Agarwal 2001; Poffenberger 1990.

See also: Forestry, Forest conservation, Forest resources, Urban forestry, Silviculture, Deforestation, Common property resources.

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McDermott, M.H. & Schreckenberg, K. 2009. International Forestry Review 11(2): 157–70.

Poffenberger, M., ed. 1990. Keepers of the Forest: Land Management Alternatives in Southeast Asia. Hartford, CT: Kumarian Press Library of Management for Development.

Comparative advantage

The ability of an economic system to provide greater efficiency (in terms of price–quality ratio) of products sold in international markets (both goods and factors of production) than those of its competitors (other countries). Comparative advantage is achieved through lower relative opportunity cost (lower relative marginal cost) and/or higher quality of goods prior to trade (Bernard et al. 2007; Costinot 2009). David Ricardo developed the classical theory of comparative advantage in 1817 (Ricardo 1817). He concluded that comparative advantage rather than absolute advantage is responsible for much of international trade. Labor productivity plays a key role in achieving comparative advantage and can be increased, in particular, through automation.

An important role in determining comparative advantage is played by product interchangeability, which determines the product boundaries of world markets. It is noteworthy that in the absence of optimality (distorted work) of the institutions of international relations and international trade, comparative advantages do not guarantee the preference of the products of a given economic system over similar products of its competitors. A central role of international organizations such as the World Trade Organization (WTO) and International Monetary Fund (IMF) is to optimize the institutions of international relations and international trade and to guarantee the preference for products with the greatest comparative advantages.

ELENA G. POPKOVA

Further reading

Coniglio et al. 2021; Machado & Trigg 2021; Meoqui 2021.

See also: Commodity trade, Trade liberalization, World Trade Organization (WTO), Classical economics.

References

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the basis of international trade. Journal of the History of Economic Thought 43(3): 433–49.
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Compensability

In a "net zero" context (where emissions generated in any one economy should balance to zero), compensability is the ability of a given economic sector to mitigate its greenhouse gas (GHG) emissions indirectly, by contributing to further emissions mitigation elsewhere, both geographically and in other sectors. Compensability is most relevant for sectors where direct emissions are difficult to reduce using existing technology. To move to net zero such sectors might seek to mitigate their emissions either by supporting additional mitigation in other sectors (e.g., Cabral et al. 2019; Rodriguez et al. 2017), or by supporting the redevelopment and/or protection of forests or the restoration of natural storage sites, such as peatlands.

Alternatively, contributing to the operation of technological solutions such as direct air capture (DAC) are options increasingly considered by sectors such as air transportation, which are heavily dependent on petroleum. The firms of the sector can contribute to the development and/or operation of DAC units (potentially commensurate to tonnes of emissions to be offset), as part of a wider carbon capture and storage system. However, critics question whether compensability delivers the expected emissions reduction (Hyams & Fawcett 2013).

Karen R. Turner, J. Kim Swales & Antonios Katris

See also: Greenhouse gases, Carbon capture, Carbon sequestration, Net zero carbon, Climate change mitigation.

References

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Hyams, K. & Fawcett, T. 2013. The ethics of carbon offsetting. WIREs Climate Change 4: 91–8.
Rodriguez, B.S., Drummond, P. & Ekins, P. 2017. Decarbonizing the EU energy system by 2050: an important role for BECCS. Climate Policy 17: 93–110.

Competitive market

Neoclassical economics: a market that provides the welfare-maximizing outcome for both consumers and society; though the definition of such markets has traditionally been vague (Moore 1906). Normally, competitive markets are assumed to have five common characteristics: (1) many buyers and sellers, which are small relative to the size of the market; as a result, no single producer or consumer can dictate the market price; (2) products or goods are reasonably homogenous or fungible; (3) no barriers to market entry and exit; (4) no transaction costs; and (5) buyers and sellers have access to perfect information about the price of goods or services. A firm in a competitive market tries to maximize profits, while consumers attempt to maximize their utility. In practice, one or more of these market conditions is commonly violated, and as a result perfectly competitive markets are rare.

Barry D. Solomon

Further reading

Kirzner 1997; Benassy 1986.

See also: Neoclassical economics, Free market, Market solution, Non-competitive market, Market failure, Transaction costs.

References

Benassy, J.P. 1986. On competitive market mechanisms. Econometrica 54(1): 95–108.
Kirzner, I.M. 1997. Entrepreneurial discovery and the competitive market process: an Austrian

approach. Journal of Economic Literature 35(1): 60–85.
Moore, H.L. 1906. Paradoxes of competition. Quarterly Journal of Economics 20(20): 211–30.

Complementarity

The concept in economic production, consumption, trade, technology, and infrastructure whereby two (or more) economic factors of production or economic goods strictly depend upon each other. While neoclassical economists emphasize substitutability in production functions, ecological economists emphasize complementarity between factors, especially with respect to natural capital (Kraev 2002).

Two entities are complementary in a given activity if (from Panchamukhi 1983): (1) the activity cannot be performed unless both entities are present; (2) the activity level cannot be maintained when the level of one of the entities changes; and (3) when the activity level increases or decreases, there are corresponding increases or decreases in the two entities. Complementarity exists in degrees, and thus can be perfect (zero substitutability) or imperfect. For example, perfect complements might include maize and water in maize production, or a pair of left and right shoes; while examples of imperfect complements include bird watching and binoculars, coffee and sugar, and waste reduction and recycling (D'Amato et al. 2016).

Barry D. Solomon

See also: Production function, Substitutability, Principle of substitution, Capital substitution, Substitution effects.

References

D'Amato, A., Mancinelli, S. & Zoli, M. 2016. Complementarity vs substitutability in waste management behaviors. Ecological Economics 123: 84–94.
Kraev, E. 2002. Stocks, flows and complementarity: formalizing a basic insight of ecological economics. Ecological Economics 43(2–3): 277–86.
Panchamukhi, V.R. 1983. Complementarity and economic cooperation: a methodological discussion. Foreign Trade Review 42(2): 133–46.

Complexity

Stochastic occurrence of unpredictable and irreversible events emerging from multiple relationships. Complexity arises when a system moves far away from equilibrium conditions by increasing its relationship with other systems via entropy flows (Prigogine 1987). Complexity entails the system's embeddedness in its environment, and therefore the emergence of a higher-order system, whose behavior cannot be inferred from the observation of its original components. The emergence of new systems embedding the original ones constitutes an ordered organization (holarchy) where each level (holon) emerges from the pre-existing ones. If understood as a relational concept (from Rosen 1991), complexity is an all-or-nothing proposition opposite to simplicity; while if expressed as a logical type (from Tainter 1988), complexity allows for comparability, and therefore different degrees of complexity can exist.

Stefano Menegat

Further reading

Allen et al. 2001, 2018.

See also: Complexity theory, Complex systems modeling, Threshold, Limits, Embeddedness, Emergence and emergent properties, System scale and hierarchy.

References

Allen, T.F., Austin, P., Giampietro, M. et al. 2018. Mapping degrees of complexity, complicatedness, and emergent complexity. Ecological Complexity 35: 39–44.
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ma'am": the privilege of science in a Postmodern world. BioScience, 51(6): 475–85.
Prigogine, I. 1987. Exploring complexity. European Journal of Operational Research 30(2): 97–103.
Rosen, R. 1991. Life Itself: A Comprehensive Inquiry into the Nature, Origin, and Fabrication of Life. New York: Columbia University Press.
Tainter, J. 1988. The Collapse of Complex Societies. Cambridge: Cambridge University Press.

Complexity theory

Theory developed to help illuminate the many complex interactions between natural and social systems (Norberg & Cumming 2008). Also called complexity science and non-linear dynamics. The focus is on the heterogeneity of the subsystems of an organization and how parts at a sublevel in a complex system affect emergent behavior and system outcomes (Amagoh 2016; Turner & Baker 2019).

Systems theory, the predecessor to complexity theory, confers centrality to interrelationships: the object separately considered is superseded. Since real phenomena are inseparable, we can only try to get closer to its representation. Interconnectedness, non-linear dynamics, unpredictability, and uncontrollability are key characteristics of complex dynamic systems. Edgar Morin (1977) highlighted transdisciplinarity and complexity. His concept of an order–disorder–organization tetralogical ring based on interactions is fundamental to understand the trend of natural processes. Gregory Bateson (1972, 1979) broadened the field to research on ecological epistemology. Together with the Chilean scientists Humberto Maturana and Francisco Varela (1980), he managed to mend that profound tear that had separated thought from the biological world for several centuries, the "mind" from nature, on a philosophical-cultural level. A separate but vital role has been played by the physicist Fritjof Capra (2005a, 2005b), who has discussed applications of complexity theory ranging from mathematics to non-linear chemical systems, embryology, genetics, morphology, and sustainability.

Aurelio Angelini

See also: Complexity, Complex systems odelling, Dynamic systems, Dynamic systems odelling, Coevolution, Applied systems analysis, Non-linear, Non-linear cointegration, Transdisciplinarity.

References

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Norberg, J. & Cumming, G.S., eds. 2008. Complexity Theory for a Sustainable Future. New York: Columbia University Press.
Turner, J.R. & Baker, R.M. 2019. Complexity theory: an overview with potential applications for the social sciences. Systems 7(1): 4.

Complex systems modeling

Formal representation of the components and relationships characterizing the state and behavior of one or more complex systems. Modeling a complex system entails characterizing and possibly quantifying the systemic interactions occurring across different scales. Systemic interactions are non-linear and include feedback loops, time lags, discontinuities, thresholds, and limits. Scales correspond to levels of organized complexity (hierarchies or holarchies) within which a complex system operates. These include both the system's internal organization in lower-order systems, and the system's external environment composed of higher-order systems embedding it. Modeling complex

systems across multiple scales implies characterizing emergence and unpredictability; two elements that pose rigid limitations to the use of complex systems modeling as a forecasting tool.

Complex systems modeling outcomes range from the production of explanatory models to the analysis of backcasting scenarios. Models of complex systems can be either static or dynamic and can include both algebraic and semantic elements. Examples of modeling techniques include system dynamics to represent a system's causal feedback loops, agent-based modeling to simulate stochastic behaviors and emergent properties, and impredicative loop analyses (from Giampietro et al. 2011) to explore multi-scale relationships in systems for which the direction of causality cannot be established.

STEFANO MENEGAT

Further reading

Proops & Safonov 2004; Costanza et al. 1993; Forrester 1994.

See also: Complexity, Complexity theory, Threshold, Limits, Embeddedness, Emergence and emergent properties, System scale and hierarchy, System dynamics models, Agent-based modeling (ABM).

References

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Forrester, J.W. 1994. System dynamics, systems thinking, and soft OR. System Dynamics Review 10(2–3): 245–56.

Giampietro, M., Mayumi, K. & Sorman, A.H. 2011. The Metabolic Pattern of Societies: Where Economists Fall Short. London: Routledge.

Proops, J.L. & Safonov, P., eds. 2004. Modelling in Ecological Economics. Cheltenham, UK ad Northampton, MA, USA: Edward Elgar Publishing.

Conceptual models

Models that differ from more familiar entities, paradigms, or research programs in the emphasis placed on concepts. In a conceptual model, concepts link to one another through inferential patterns, empirical considerations, and logic (premises and conclusions) to form "logical" wholes (Hoyningen-Huene & Sankey 2001). The concepts that comprise conceptual models are both theoretical and empirical and thus encompass both *a priori* and *a posteriori* aspects.

Like paradigms and research programs, conceptual models create frames through which phenomena in the world can be "seen" and interacted with (and ignored). Conceptual models are ontologically difficult entities: where does one exist exactly? In an individual's mind? In a collective realm? These unresolved ontological questions are perhaps unresolvable. Ontological issues aside, conceptual models allow understanding and communication across and within disciplines.

Conceptual models are not chiefly concerned with classical notions of truth and truth values, nor with certainty in the form of scientific realism and correspondence to a "real" world (Hacking 1985). A conceptual model is a fluid, ever-changing, dynamic entity that is not "falsified" or does not cease to be of interest once further discoveries are made; for those so inclined, phlogiston and phrenology remain valid conceptual models: they fit the criteria of modeling at the core of conceptual models in linking dynamic (that is, changing) concepts and *a priori* and *a posteriori* elements into frames which humans use to understand and learn about the world. That they are scientifically "wrong" does not invalidate their ontological and pragmatic merits.

MICHAEL L.R. BABCOCK

Further reading

Hempel 1952; Harland 1987; Nersessian 2008; Goodman 1978; Hacking 1999.

See also: Paradigm, Incommensurable, Social constructionism, Scientific method, Models and modeling.

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Nersessian, N.J. 2008. Creating Scientific Concepts. Cambridge, MA: MIT Press.

Conceptual pluralism

A term used in many fields of study to refer to different ways of describing and knowing things, different epistemological assumptions, and methodologies for obtaining a complete description of a particular topic. In philosophy of science, epistemological pluralism emerged in opposition to reductionism, monism, and dualism, to highlight that natural or social phenomena cannot be fully explained by a single theory or method. Ecological economics has been built from this epistemological position. This leads to consideration that the understanding of the interdependencies and coevolutions between economic systems and ecological ones, through time and space, cannot be fully captured from one specific epistemic position or one specific school of thought, and needs an interdisciplinary or transdisciplinary approach. Ecological economics assumes that integrating ecological, economic, and sociological analysis helps to create a better picture of these interactions.

However, while this position is shared by most ecological economists, many debates are about the boundaries of such a pluralistic approach regarding the economic schools of thought, especially the neoclassical one. Indeed, ecological economics has been partly developed in opposition to environmental and resource economics, which are founded on a reductionist disciplinary position. Therefore, it may be counterproductive to include environmental or resource economics inside the "pluralist tent of ecological economics." But it is also difficult to justify the exclusion of neoclassical economists from this "tent" when pluralism is considered as a foundation of this field of research.

Harold Levrel

Further reading

Norgaard 1989; Dube 2021.

See also: Pluralism, Interdisciplinary, Transdisciplinary, Epistemology, Epistemological bias, Dogmatism, Monism, Analytical dualisms, Methodological pluralism.

References

Dube, B. 2021. Why cross and mix disciplines and methodologies? Multiple meanings of interdisciplinarity and pluralism in ecological economics. Ecological Economics 179: 106827.
Norgaard, R.B. 1989. The case for methodological pluralism. Ecological Economics 1(1): 37–57.

Congestible good

See: Congestible public good.

See also: Congestion, Public goods.

Congestible public good

Economics: a subcategory of public goods that can be used by some number of people without lowering the benefits enjoyed by other users (that is, these public goods can be non-rival when uncongested). However, as the number of users increases, the benefits to individual users begin to decrease because of crowding or congestion (that is, these public goods become rival). Thus, public goods are typically non-rival and non-excludable, but some may become rival as the number of users approaches the good's capacity constraint (for example, freeways, parks, public golf courses, and so on). Congestible public goods are sometimes also known as impure public goods.

Sonja H. Kolstoe

Further reading

Anas 1988; Brown 1973; Craig 1987; Ding et al. 1999; Leach 2003.

See also: Public goods, Non-rival resources, Congestion, Rivalness, Rival resource.

References

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Craig, S.G. 1987. The impact of congestion on local public good production. Journal of Public Economics 32(3): 331–53.

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Congestion

Economics:

a. Concerning recreation, when there is rivalry in consumption, and there are so many people at a particular site that they detract from the experience (that is, by lowering the utility) to be derived from visiting the site, or by overusing environmental goods at the site (for example, trails, fish stocks, and so on). Congestion has been measured as the fraction of total users visiting a site (Timmins & Murdock 2007), or density of users at a site (Bujosa et al. 2015).
b. Concerning transportation, when there are so many people using a mode of transportation (for example, cars, boats, bicycles, walking) such that the transportation route (for example, street, highway, shipping canal, bike route, and so on) is approaching or at its capacity and each new user slows everyone else's progress. Congestion can also occur in crowded areas where multiple modes may intersect.

Sonja H. Kolstoe

Further reading

Arnott & Inci 2006; Currie & Walker 2011.

See also: Congestible public good, Rivalness, Rival resource, Public goods, Utility, Travel cost method.

References

Arnott, R. & Inci, E. 2006. An integrated model of downtown parking and traffic congestion. Journal of Urban Economics 60(3): 418–42.

Bujosa, A., Riera, A., Hicks, R.L. & McConnell, K.E. 2015. Densities rather than shares: improving the measurement of congestion in recreation demand models. Environmental and Resource Economics 61(2): 127–40.

Currie, J. & Walker, R. 2011. Traffic congestion and infant health: evidence from E-ZPass. American Economic Journal: Applied Economics 3(1): 65–90.

Timmins, C. & Murdock, J. 2007. A revealed preference approach to the measurement of congestion in travel cost models. Journal of Environmental Economics and Management 53(2): 230–49.

Conjoint analysis

A survey method that seeks to identify the value to consumers of separate aspects of a single product. For instance, respondents are shown examples of the same product with somewhat different features and asked to rank them. A statistical analysis then reveals which features are most preferred. For example, Tabi et al. (2014) sought to identify the characteristics of electric utility customers most likely to select a green energy option. In addition to surveying personal characteristics, respondents were asked to rank electricity service packages, some with and some without green energy options. The authors were able to associate the preference for green power with personal attributes of respondents. Conjoint analysis is similar to the contingent valuation method in being a "stated preference" technique.

Brent M. Haddad

Further reading

Stevens et al. 2000; Vander Naald & Cameron 2011.

See also: Contingent valuation method (CVM), Choice experiments, Stated preference methods.

References

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Vander Naald, B. & Cameron, T. 2011. Willingness to pay for other species' well-being. Ecological Economics 70(7): 1325–35.

Connectivity

General and economics: the formal or informal economic, financial, trade, energy, and social linkages and relations between regions, states or provinces, and countries (Calatayud et al. 2016).

Ecology: the degree to which a landscape facilitates or hinders movement of animal and plant species among adjacent patches of resources (Kindlmann & Burel 2008; Reeson et al. 2011; Williams et al. 2012). Greater habitat connectivity is important for promoting healthy and resilient populations and biodiversity, especially with increasing climate change.

BARRY D. SOLOMON

See also: Interconnected, Globalization, Landscape ecology, Biodiversity, Ecosystem services, Ecosystem resilience.

References

Calatayud, A., Palacin, R., Mangan, J. et al. 2016. Understanding connectivity to international markets: a systematic review. Transport Reviews 36(6): 713–36.

Kindlmann, P. & Burel, F. 2008. Connectivity measures: a review. Landscape Ecology 23: 879–90.

Reeson, A.F., Rodriguez, L.C., Whitten, S.M. et al. 2011. Adapting auctions for the provision of ecosystem services at the landscape level. Ecological Economics 70(9): 1621–7.

Williams, K.J., Reeson, A.F., Drielsma, M.J. & Love, J. 2012. Optimised whole-landscape ecological metrics for effective delivery of connectivity-focused conservation incentive payments. Ecological Economics 81: 48–59.

Consensus

General agreement, if not unanimity, about something. In economics, a consensus forecast can be the average result from a series of econometric forecasting models that use different methodologies to forecast the same macroeconomic phenomena.

BARRY D. SOLOMON

Further reading

Ager et al. 2009; Batchelor 2010.

See also: Conventional wisdom, Econometrics, Macroeconomics, Ecological macroeconomics.

References

Ager, P., Kappler, M. & Osterloh, S. 2009. The accuracy and efficiency of the Consensus Forecasts: a further application and extension of the pooled approach. International Journal of Forecasting 25(1): 167–81.

Batchelor, R. 2010. How useful are the forecasts of intergovernmental agencies? The IMF and OECD versus the consensus. Applied Economics 33(2): 225–35.

Consequentialism

Moral philosophy and welfare economics: an ethical theory positing that the moral evaluation of actions should be based solely on their outcomes, not on some inherent properties of the actions themselves (normative consequentialism). An important variety of normative consequentialism is utilitarianism, which postulates that the standard for morally evaluating an action is the utility (pleasure or happiness) of those affected by the action's consequences. Consequentialist theories differ with respect to the set of enti-

ties (such as humans, animals, plants) over which consequences count.

Behavioral science and economics: a behavioral theory which assumes that individuals choose among alternative actions solely based on their outcomes, not on some inherent properties of the actions themselves (positive consequentialism). An important variety of positive consequentialism is rational choice theory, which assumes that individuals choose those actions whose outcomes yield the maximum utility within the set of attainable outcomes.

HEINZ WELSCH

Further reading

Alexander & Moore 2020; Perman et al. 2011; Sinnott-Armstrong 2019.

See also: Behavioral economics, Rational choice, Ecological justice, Deontological, Utility, Utilitarianism.

References

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Perman, R., Ma, Y., Common, M. et al. 2011. "Ethics, economics and the environment," Chapter 3 in Natural Resource and Environmental Economics, 4th edn. London: Pearson Education.

Sinnott-Armstrong, W. 2019. "Consequentialism," in The Stanford Encyclopedia of Philosophy (Summer 2019 edition). E.N. Zalta, ed. https://plato.stanford.edu/archives/sum2019/entries/consequentialism/.

Conservancy

a. An organization established for the acquisition and conservation or preservation of highly ecologically valued lands and their plants, wildlife, and other natural resources. Sometimes also called a land trust. The largest and most successful example is the Nature Conservancy.
b. (In the United Kingdom) a commission or court whose officials regulate navigation and fisheries in rivers, ports, and drainage basins, as well as some areas of land.

BARRY D. SOLOMON

Further reading

Brewer 2003; Groves et al. 2002.

See also: Conservation, Conservation biology, Conservation areas, Preservation.

References

Brewer, R. 2003. Conservancy: The Land Trust Movement in America. Hanover, NH, USA & London, UK: University Press of New England.

Groves, C.R., Jensen, D.B., Valutis, L.L. et al. 2002. Planning for biodiversity conservation. BioScience 52(6): 499–512.

Conservation

A broad term, defined in many ways, often vaguely and controversially.

a. "Actions that are intended to establish, improve, or maintain good relations with nature" (Sandbrook 2015, p. 565). Biological conservation or the conservation of nature. A scientific discipline conducting formal research on and for conservation originated in the late 1970s and is called conservation biology (Soulé 1985). However, the conservation movement in the United States (US) began a century before, in the late 1800s, and was especially associated with Gifford Pinchot, the first head of the US Forest Service, who advocated for the sustainable use of natural resources for the benefit of people (Pinchot 1910). One important question is why to conserve nature, especially whether—or to what degree—to protect nature for its own sake (only), or to safeguard its instrumental value for human well-being (see Büscher & Fletcher 2020 for a detailed analysis of the discussion). Economics frequently applies the total economic value concept to structure the different values of (conserved) nature (see, e.g.,

Kumar 2010), while the interdisciplinary literature incorporates broader ethical approaches to conservation (O'Neill et al. 2008; Chan et al. 2016).

b. The protection and prevention of wasteful use of a resource.
c. Behavior leading to the saving of energy. Conservation has been a fundamental issue in the energy field since the 1970s, where it is largely a behavioral issue (Steg 2008).
d. Behavior leading to the saving of water (Dickerson et al. 1992).

Kurt Jax & Julian Rode

See also: Preservation, Conservation biology, Biodiversity conservation, Conservation areas, Total economic value (TEV), Energy conservation, Energy efficiency, Forest conservation, Wildlife conservation, Soil conservation.

References

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Chan, K.M.A., Balvanera, P., Benessaiah, K. et al. 2016. Why protect nature? Rethinking values and the environment. Proceedings of the National Academy of Sciences of the United States of America 113: 1462–5.

Dickerson, C.A., Thibodeau, R., Aronson, E. & Miller, D. 1992. Using cognitive dissonance to encourage water conservation. Journal of Applied Social Psychology 22(11): 841–54.

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O'Neill, J., Holland, A. & Light, A. 2008. Environmental Values. London: Routledge.

Pinchot, G. 1910. The Fight for Conservation. New York: Doubleday, Page & Company.

Sandbrook, C. 2015. What is conservation? Oryx 49: 565–6.

Soulé, M.E. 1985. What is conservation biology? BioScience 35: 727–34.

Steg, L. 2008. Promoting household energy conservation. Energy Policy 36(12): 4449–53.

Conservation areas

a. A clearly defined area of land or water body that is set aside by a government agency or private party for long-term protection from development to preserve and protect natural ecological features and ecosystem services, biodiversity, habitats, and animal and plant species (some of which may be endangered of threatened), and in some cases cultural values. Specific conservation objectives may range from target species to entire ecosystems and landscapes/seascapes, as well as their associated genetic resources, ecosystem services, and/or cultural values.

   Examples include national parks, fish and wildlife refuges, nature and wildlife reserves, wilderness areas, wild and scenic rivers, and marine protected areas and sanctuaries. While management approaches vary depending on conservation goals, country, and governance type (for example, government, private, local communities), human activities and exploitation of natural resources is generally limited in conservation areas. In some cases, a limited amount of hunting and fishing is permitted in these areas.
b. In the United Kingdom, a conservation area can also refer to land areas of special historical or architectural interest that are worthy of preservation or enhancement. When such a "conservation area" is designated, local planning authorities have greater control over minor developments, demolitions, and tree preservation.

Aura M. Alonso-Rodríguez

Further reading

Watson et al. 2014; UNEP-WCMC & IUCN 2021; Knight et al. 2008; Araújo et al. 2011; Larkham 1993.

See also: Marine protected areas (MPAs), Biodiversity, Ecosystem services, Endangered species, Cultural values.

References

Araújo, M.B., Alagador, D., Cabeza, M. et al. 2011. Climate change threatens European conservation areas. Ecology Letters 14(5): 484–92.

Knight, A.T., Cowling, R.M., Rouget, M. et al. 2008. Knowing but not doing: selecting priority conservation areas and the research–

implementation gap. Conservation Biology 22(3): 610–17.
Larkham, P.J. 1993. Conservation in action: evaluating policy and practice in the United Kingdom. Town Planning Review 64(4): 351–7.
UNEP-WCMC & IUCN. 2021. Protected Planet Report 2020. Cambridge, UK & Gland, Switzerland: UNEP-WCMC and IUCN. https://livereport.protectedplanet.net/.
Watson, J.E., Dudley, N., Segan, D.B. & Hockings, M. 2014. The performance and potential of protected areas. Nature 515(7525): 67–73.

Conservation biology

An applied scientific discipline that addresses the loss of the Earth's biodiversity. It focuses on protecting and/or restoring the diversity of genes, species, and ecosystems, regardless of their economic value. The main goal of conservation biology is to understand the impacts of human activities on biodiversity and to develop practical approaches to prevent species extinctions and maintain the biological functioning of ecosystems. By establishing cross-sector collaborations and expanding from the biological sciences into other disciplines (for example, economics, philosophy, law, politics, education, among others), conservation biology aims to answer research questions that can lead to real-world management decisions, looking to harmonize conservation goals with the needs of local people.

Aura M. Alonso-Rodríguez

Further reading

Kareiva & Marvier 2012; Hunter & Gibbs 2006; Primack 1993; Soulé 1985.

See also: Biodiversity, Biodiversity conservation, Biodiversity indices, Conservation, Wildlife conservation.

References

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Kareiva, P. & Marvier, M. 2012. What is conservation science? BioScience 62(11): 962–9.
Primack, R. 1993. Essentials of Conservation Biology. Sunderland, MA: Sinauer Associates.
Soulé, M.E. 1985. What is conservation biology? BioScience 35(11): 727–34.

Conservation finance

a. Mechanisms and strategies that generate, manage, and deploy financial resources and align incentives to achieve nature conservation outcomes (CFA 2021).
b. The practice of raising and managing capital to support land, water, and natural resource conservation (CFN 2021). Conservation finance practitioners commonly use tools, policies, and mechanisms including payments for ecosystem services (PES), conservation trust funds, debt for nature swaps (DfN), user fees and other types of tourism charges to support marine, coastal, and terrestrial conservation and protection efforts.

Andrew F. Seidl

Further reading

Tobin-de la Puente & Mitchell 2021; Meyers et al. 2020.

See also: Environmental finance, Biodiversity finance, Payment for ecosystem services (PES), Debt-for-nature swap.

References

CFA (Conservation Finance Alliance). 2021. https://www.conservationfinance.info/.
CFN (Conservation Finance Network). 2021. https://www.conservationfinancenetwork.org/.
Meyers, D., Bohorquez, J., Cumming, T. et al. 2020. Conservation Finance: A Framework. Conservation Finance Alliance. https://static1.squarespace.com/static/57e1f17b37c58156a98f1ee4/t/5e8c97ecf33f8960fc2cbda3/1586272239963/Conservation+Finance+Framework.pdf.
Tobin-de la Puente, J. & Mitchell, A.W., eds. 2021. The Little Book of Investing in Nature. Oxford: Global Canopy.

Consumerism

The theory and belief that individual well-being and happiness is highly dependent on the level of personal consumption of goods and services. A consumerist society encourages the purchase of goods and services in greater amounts, including by its economic policies. Criticisms of consumerism have been made since Veblen (1899), and at its extreme can lead to the social disorder or addiction of affluenza, the dogged pursuit of more.

BARRY D. SOLOMON

Further reading

Goodwin et al. 1997; Miles 1988.

See also: Affluenza, Positional goods, Consumption externalities.

References

Goodwin, N.R., Ackerman, F. & Kiron, D., eds. 1997. The Consumer Society. Washington, DC: Island Press.
Miles, S. 1988. Consumerism: As a Way of Life. London: SAGE.
Veblen, T. 1899. The Theory of the Leisure Class. New York: Macmillan.

Consumer sovereignty

Economic hypotheses associated with this term include: (1) "consumption is the sole and end purpose of economic production" (Smith 1776 [1789]); (2) consumers principally determine what is supplied by the market system rather than producers; (3) consumers are the best judges of their own self-interest. The term was originally coined by William Harold Hutt (1936). Together, these hypotheses suggest that a free market system ensures that production satisfies the desires of consumers and therefore can be regarded as an ideal economic system. Nevertheless, these hypotheses need to be qualified. First, the welfare of individuals does not only depend on their consumption of commodities but is also affected, for example, by their satisfaction at work (Tisdell & Hartley 2008, Ch. 5). Second, because of their marketing and advertising, large companies can unfavorably distort consumers' preferences for commodities (Galbraith 1967; Marcuse 1964). Third, consumers may lack sufficient information to make informed choices (Akerlof 1970), which can justify consumer protection and intervention in the market system by governments (Tisdell & Hartley 2008, Ch. 5).

From an ecological and environmental economics point of view, consumer sovereignty can result in unwanted negative environmental spillovers; for example, because of the purchase of products significantly adding to pollution and global warming. Environmentally concerned consumers may also lack sufficient information to discriminate between products based on their ecological and environmental effects. Many governments have restricted consumer sovereignty and personal liberty to reduce the risks of COVID-19 infections (Tisdell 2020).

CLEMENT A. TISDELL

Further reading

Tisdell 2017.

See also: Bounded rationality, Satisficing.

References

Akerlof, G. 1970. The market for lemons: quality and the market mechanism. Quarterly Journal of Economics 84(3): 488–500.
Galbraith, J.K. 1967. The New Industrial State. London: Hamish Hamilton.
Hutt, W.H. 1936. Economists and the Public: A Study of Competition and Opinion. London: Jonathan Cape.
Marcuse, H. 1964. One Dimensional Man. London: Routledge and Kegan Paul.
Smith, A. 1776 (1789). An Inquiry into the Nature and Causes of the Wealth of Nations. New York: Random House.
Tisdell, C.A. 2017. "Consumers' sovereignty," pp. 94–119 in Economics and Environmental Change: The Challenges We Face. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.
Tisdell, C.A. 2020. Economic, social and political issues raised by the COVID-19 pandemic. Economic Analysis and Policy 68: 17–28.
Tisdell, C.A. & Hartley, K. 2008. Microeconomic Policy: A New Perspective. Cheltenham, UK

and Northampton, MA, USA: Edward Elgar Publishing.

Consumer surplus

Economics:

a. (From Dupuit, 1844, 1849) the difference between the price that a consumer is willing to pay and a lesser price that they actually pay (non-tangible).
b. (From Marshall, 1890) a measure of benefit or welfare to consumers, based on a theory of utility and/or marginal utility.
c. The area between a consumer demand function and a lower horizontal line at equilibrium price. The general notion is in some disrepute, partly because of interdependencies among goods and services, and because it is non-measurable.

Ecological economics: the notion of consumer surplus is mainly considered to be inadequate to the needs of ecological economics and is being replaced by, for example, multi-criteria decision analysis/aids.

TERRANCE J. QUINN

Further reading

Chipman & Moore 1980; Munda 2005.

See also: Social welfare function, Benefit–cost analysis (BCA), Hicksian income, Non-market value, Multi-criteria assessment.

References

Chipman, J.S. & Moore, J.C. 1980. Compensating variation, consumer surplus, and welfare. American Review 70(5): 933–49.
Dupuit, J. 1844. De la mesure de l'utilité des travaux publics. Annales des ponts et chaussées 8(2): 332–75.
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Munda, G. 2005. "Multiple criteria decision analysis and sustainable development," pp. 953–86 in Multiple Criteria Decision Analysis: State of the Art Surveys. J. Figueira, S. Greco & M. Ehrgott, eds. New York: Springer.

Consumption externalities

Externalities that occur when there are unpaid social costs or benefits imposed upon others through the consumption of goods. Consumption externalities occur when the market demand curve reflects only the marginal private benefit (MPB), and in the presence of negative (positive) externality in consumption, the marginal social benefit (MSB) lies below (above) the MPB.

Howarth (1996) characterized consumption externalities as the so-called "keeping up with the Joneses" effect. Individual preferences are defined over consumption, leisure, pollution, and economic status. Each person's status increases with their own consumption, but decreases with the average consumption of all individuals. In this case, Howarth showed that policies must satisfy two conditions to support a Pareto-efficient competitive equilibrium: (1) consumption must be taxed to offset the incentive to overconsume in the pursuit of enhanced economic status; (2) pollution must be taxed to account for its external effects on individual welfare.

JOÃO RICARDO FARIA

Further reading

Lin 1976.

See also: Externalities, Environmental externalities, Affluenza, Property right, Transaction costs, Asymmetric information, Positional goods.

References

Howarth, R.B. 1996. Status effects and environmental externalities. Ecological Economics 16(1): 25–34.

Lin, S.A.Y. 1976. Theory and Measurement of Economic Externalities. New York: Academic Press.

Contestation

a. The process or action of disputing, arguing, debating, or objecting to something.
b. A social practice of objecting to norms, which is reactive contestation.
c. A mode of critique through critical engagement in a discourse about norms, which is proactive contestation (Weiner 2014, 2017).

BARRY D. SOLOMON

Further reading

Takeda & Røpke 2010.

See also: Norms, Deliberative democracy, Deliberative ecological economics, Deliberative multi-criteria analysis, Dialectic reasoning, Discursive, Discourse analysis.

References

Takeda, L. & Røpke, I. 2010. Power and contestation in collaborative ecosystem-based management: the case of Haida Gwaii. Ecological Economics 70(2): 178–88.

Wiener, A. 2014. A Theory of Contestation. Heidelberg: Springer.

Wiener, A. 2017. A theory of contestation—a concise summary of its arguments and concepts. Polity 49(1): 107–25.

Contingent valuation method (CVM)

A popular stated preference method in which survey respondents are asked to value a hypothetical change in a natural resource or environmental attribute. While there are many options, the preferred format for the valuation question asks respondents whether they would vote for the hypothetical change at a specified cost in a referendum (Johnston et al. 2017).

RICHARD W. DUNFORD

Further reading

Mitchell & Carson 1989; Hausman 1993; Boyle 2017; McFadden & Train 2017.

See also: Stated preference methods, Choice experiments, Conjoint analysis, Willingness to pay (WTP), Willingness to accept (WTA).

References

Boyle, K.J. 2017. "Contingent valuation in practice," pp. 83–132 in A Primer on Nonmarket Valuation, 2nd edn. P.A. Champ, K.J. Boyle & T.C. Brown, eds. Dordrecht: Springer.

Hausman, J.A., ed. 1993. Contingent Valuation: A Critical Assessment. Amsterdam: North-Holland.

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Mitchell, R.C. & Carson, R.T. 1989. Using Surveys to Value Public Goods: The Contingent Valuation Method. Washington, DC: Resources for the Future.

Contractarian liberalism

A branch of liberal individualism that argues that the legitimate authority of governments comes from a "social contract" in which self-interested individuals consent to being governed in exchange for certain rights and protections. Contract liberalism is a way of escaping a situation in which every person (historically, men) competes with every other to survive, known as the "state of nature," by consenting to surrender certain liberties in exchange for the protection of a sovereign. Notable social contract theorists include Hobbes (Hobbes & Brooke 2017),

Locke (Locke & Laslett 1988), Rousseau (2018), and Rawls (1999).

This tradition in today's context begs the following question: is the government permitted to exploit the environment because the governed consent to their rule, or is the social contract broken because governments are no longer capable of providing protection to the governed? The global environmental movement Extinction Rebellion suggested in its founding declaration that the latter is a helpful way to understand the situation (Extinction Rebellion 2019).

Rupert Read & Joseph Eastoe

See also: Liberal individualism, Liberty, State of nature.

References

Extinction Rebellion. 2019. This is Not a Drill: An Extinction Rebellion Handbook. London: Penguin.

Hobbes, T. & Brooke, C, eds. 2017. Leviathan. Penguin Classics. London: Penguin.

Locke, J. and Laslett, P., eds. 1988. Two Treatises of Government. Cambridge, MA: Harvard University Press.

Rawls, J. 1999. A Theory of Justice, 2nd edn. Cambridge, MA: Belknap Press.

Rosseau, J.S. 2018. The Social Contract. Transl. by G.D.H. Cole. Morrisville, NC: Lulu.com

Conventional economics

See: Neoclassical economics.

See also: Heterodox economics, Behavioral economics.

Conventional energy sources

See: Traditional energy sources.

See also: Fossil fuels, Non-renewable resource, Peak oil supply, Renewable energy.

Conventional wisdom

Widely held ideas and beliefs on a subject that are generally accepted by experts or the public, though conventional wisdom can change over time. For example, conventional wisdom among scientists today is that the climate is changing, and the Earth is warming, and that it is being caused by humans. However, 60 years ago the general belief was that the Earth was cooling. In economics, ecology, and ecological economics, conventional wisdom is reflected in published research in each field, though there may be lack of consensus on many topics. Among these three fields, there is more established conventional wisdom in economics, and the least in ecological economics.

Barry D. Solomon

Further reading

Krugman 1995.

See also: Consensus, Epistemology, Epistemological bias, Induction.

Reference

Krugman, P.A. 1995. Cycles of conventional wisdom on economic development. International Affairs 71(4): 717–32.

Convergence

A process of trend lines or other indicators moving closer together.

Economics: the process whereby the economic performance of income, output, wealth, and development in poorer countries often grows faster than in richer countries over time, with implication for economic equity outcomes.

Biology: when different species evolve to share similar characteristics and traits in response to shared conditions and selective pressures in a biome.

Brent M. Haddad

Further reading

Blampied 2021; Le Pen & Sévi 2010; Camarero et al. 2008.

See also: Divergence, Intragenerational equity, Social equity, Economic inequality, Indicators.

References

Blampied, N. 2021. Economic growth, environmental constraints and convergence: the declining growth premium for developing economies. Ecological Economics 181: 106919.

Camarero, M., Picazo-Tadeo, A. & Tamarit, C. 2008. Is the environmental performance of industrialized countries converging? A "SURE" approach to testing for convergence. Ecological Economics 66(4): 653–61.

Le Pen, Y. & Sévi, B. 2010. On the non-convergence of energy intensities: evidence from a pairwise econometric approach. Ecological Economics 69(3): 641–50.

Coordination problem

The problem in a market system of firms coordinating diverse economic activities in an economic sector, both nationally and globally, without a central coordinating agent or authority (Watson 2005). The challenge is to mesh these decentralized activities together as seamlessly as possible to produce economic value in the marketplace (Friedman 1994). When firms fail to do so this leads to coordination failure, which can help explain economic recessions.

BARRY D. SOLOMON

See also: Microeconomics, Free market, Perfect markets.

References

Friedman, J.W., ed. 1994. Problems of Coordination in Economic Activities. New York: Kluwer Academic Publishers.

Watson, M. 2005. What makes a market economy? Schumpeter, Smith and Walras on the coordination problem. New Political Economy 10(2): 143–61.

Corporate social responsibility

The pro-social and pro-environmental activities that companies undertake to contribute to the betterment of societies, communities, and stakeholders, including efforts to reduce negative company impacts on the natural environment and societies. Linked to understandings that companies' business activities sometime have negative social and ecological consequences, corporate social responsibility (CSR) is an effort to mitigate those negative impacts in positive and constructive ways.

CSR can be differentiated into explicit and implicit activities (Matten & Moon 2008). Explicit CSR is companies' clearly articulated voluntarily taking of responsibility for pro-social and environmental policies and practices that can be either related or unrelated to the company's business practices, and is common in the United States. Implicit CSR is meeting stakeholder and socio-ecological obligations that arise through values, norms, rules, and social expectations. Implicit CSR is evidenced through collective obligations versus individual company responsibilities to serve society's interests, and is common in Europe. Implicit CSR is related to corporate responsibility, in which companies take responsibility for their socio-ecological impacts as part of their business models and activities.

SANDRA WADDOCK

Further reading

Adugelo et al. 2019; Barnett et al. 2020.

See also: Sustainable business, Pro-social behavior, Pro-environmental behavior (PEB), Norms.

References

Agudelo, M.A.L., Jóhannsdóttir, L. & Davídsdóttir, B. 2019. A literature review of the history and evolution of corporate social responsibility. International Journal of Corporate Social Responsibility 4(1): 1–23.

Barnett, M.L., Henriques, I. & Husted, B. 2020. Beyond good intentions: designing CSR initiatives for greater social impact. Journal of Management 46(6): 937–64.

Matten, D. & Moon, J. 2008. "Implicit" and "explicit" CSR: a conceptual framework for a comparative understanding of corporate

social responsibility. Academy of Management Review 33(2): 404–24.

Cost–benefit analysis

See: Benefit–cost analysis (BCA).

See also: Discounting, Social discount rate, Net present value (NPV).

Cost-effectiveness analysis (CEA)

A form of economic analysis that compares the relative costs and outcomes of different courses of action. The main advantage of this method is that it produces as a result a cost–outcome ratio that concentrates on the essential issue: the cost of achieving the desired results, without having to calculate often difficult-to-determine benefits, as in benefit–cost analysis.

Two types of cost-effectiveness analysis (CEA) are most common in ecologic economics:

1. The cost per reduced tonne of carbon dioxide (CO_2) emissions. For example, in Gradus et al. (2017), a CEA of the recycling of Dutch household plastic waste compared with conventional incineration of plastic waste is given. Calculating the costs and revenues leads to an implicit CO_2 abatement price of €178/t of CO_2 in the case of plastics recycling. This is far higher than common alternatives for saving CO_2, such as wind energy (€30/t) or carbon capture and storage in old natural gas fields in the North Sea (€85/t).
2. The cost for improving energy efficiency in kWh. In Tuominena et al. (2015) the measures under consideration in a low investment scenario have a cost of 0.21 USD/kWh for energy saved. For the country under consideration, Egypt, this was more than the market price at that time.

Raymond Gradus

See also: Benefit–cost analysis (BCA).

References

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Tuominena, P., Redaa, F., Dawoud, W. et al. 2015. Economic appraisal of energy efficiency in buildings using cost-effectiveness assessment. Procedia Economics and Finance 21: 422–30.

Coupled human and natural systems

a. A field of science that holistically examines the interactions between human and natural systems, explicitly focusing on cross-scale interactions and feedbacks.
b. A framework used to describe dynamic systems that contain both human and natural components, and interactions between these components.

Laura Schmitt Olabisi

Further reading

Liu et al. 2007; Liu et al. 2021.

See also: Anthropocene, Social-ecological systems, Coupled system dynamics, System dynamics models, System scale and hierarchy.

References

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lution and applications of an integrated framework. Ambio 50: 1778–83.

Coupled system dynamics

Temporal changes of interacting systems possess reciprocated or analogous evolutionary feedbacks and cannot be separately treated as isolated dynamics. Coupled systems can be quantitatively modeled by a system of differential or difference equations. Examples include interactions of fossil fuel consumption and climate change, electricity markets and power systems, voltage responses of coupled spiking neurons, a dynamic game of multiple players, population oscillations in predator–prey ecology, the hydrological system and agriculture, among many others.

Zhengyuan Gao

Further reading

Garfinkel et al. 2017.

See also: Coupled human and natural systems, System dynamics models, Applied systems analysis.

Reference

Garfinkel, A., Shevtsov, J. & Guo, Y. 2017. Modeling Life: The Mathematics of Biological Systems. Cham: Springer.

Creative destruction

a. The process where capitalism is reorganized to be reproduced. A set of processes within capitalism where established structures, social relations, technologies, landscapes, and so on, replace older ones to produce profits and growth, and thereby reproduce capitalism as a social order.
b. The concept first described by German economist Werner Sombart (1913) in 1913 as the "creative spirit of destruction," but which was first popularized by Joseph Schumpeter (1942 [1962]) three decades later. Where Schumpeterians emphasize innovative entrepreneurs and firms who win market shares by introducing new products and technologies, Marxists tend to see creative destruction as a broader expression of capitalism: being a revolutionary mode of production, constantly changing due to competitive laws, needs for profits and growth, and class struggle.
c. A central component in economic crises. It captures the double character of crises: as both tearing down and innovative. We can identify three interconnecting processes: (1) devaluation and destruction of capital; (2) new ways of organizing the economy, new class relations, new technology, and new regulations replacing the old ones; and (3) new investments.
d. Creative destruction is an inherent part of economic crises under capitalism, but not necessary for ecological crises, which is one reason why economic crises are always temporarily solved under capitalism; in contrast to ecological crises (cf. Holgersen 2022).

Ståle Holgersen

Further reading

Harvey 1990; Perez 2002.

See also: Capitalism, Business innovation, Societal transformation.

References

Harvey, D. 1990. The Condition of Postmodernity. Oxford: Blackwell.
Holgersen, S. 2022. Krisernas tid. Ekologi och Ekonomi Under Kapitalismen. Göteborg: Daidalos.
Perez, C. 2002. Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages. Cheltenham, UK

and Northampton, MA, USA: Edward Elgar Publishing.
Schumpeter, J. 1942 [1962]. Capitalism, Socialism, and Democracy. New York: Harper Torchbooks.
Sombart, W. 1913. Krieg und Kapitalismus. München: Duncker & Humblot.

Critical realism

A meta-theoretical perspective in the philosophy of science and social theory that combines transcendental realism and critical naturalism, and which constitutes an alternative to positivism and empiricism. Contemporary critical realism is associated with British philosopher Roy Bhaskar (e.g., 1975), and the perspective has made inroads in several scientific disciplines, including ecological economics (e.g., Spash 2012) and degrowth research (Nesterova 2020).

Detailing a comprehensive ontology (theory of being) according to which reality is deep, differentiated, stratified, and open, and according to which social reality does not exist separate from nature, critical realism sets the overall parameters for scientific inquiry. Critical realism encourages interdisciplinarity and considers it the primary purpose of the sciences to uncover deep structures and other causal mechanisms generating phenomena in the world. With this view, social scientific knowledge that illuminates oppressive or in other respects unjust social structures can serve emancipatory purposes.

HUBERT BUCH-HANSEN

See also: Positivism, Logical positivism, Post-normal science, Critical theory, Deontological, Interdisciplinary.

References

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Nesterova, I. 2020. Degrowth business framework: implications for sustainable development. Journal of Cleaner Production 262: 121382.
Spash, C.L. 2012. New foundations for ecological economics. Ecological Economics 77: 36–47.

Critical theory

A social theory that aims to understand the underlying ideological structure of society with the expressed purpose of being used to critique and change it. Critical theorists believe that all knowledge, even that which is collected through scientific endeavor, cannot be detached from its historical context, and is fundamentally political in nature; it is thus essential to contextualize knowledge as existing within a critical theory. Historically, critical theory is attributed to Karl Marx through his explanation of society as consisting of an economic base and an ideological superstructure (Marx 1859, Preface), and was further developed by the Frankfurt School (Fromm 1992; Horkheimer 1975; Horkheimer & Adorno 2002).

Critical theory has since been adopted by other fields such as sociology, pedagogy, psychology, geography, economics, and linguistics. Other than Marxism, other common critical theories include post-structuralism (for example, Barthes, Derrida, and Foucault), postmodernism (for example, Derrida, Foucault, and Hutcheon), feminism (for example, De Beauvoir, Grier, and Butler), post-capitalism (for example, Drucker, Srnicek, and Williams), and psychoanalytical theory (for example, Freud, Jung, and Adler).

JOSEPH EASTOE

Further reading

Feenberg 2017.

See also: Critical realism, Feminist political ecology, Post-growth, Post-development, Post-capitalist world(s).

References

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Miller & L. Smith-Doerr, eds. Cambridge, MA: MIT Press.
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Horkheimer, M. & Adorno, T.W. 2002. Dialectics of Enlightenment: Philosophical Fragments. Stanford, CA: Stanford University Press.
Marx, K. 1859. A Contribution to the Critique of Political Economy. Berlin: Verlag von Franz Dunder.

Crowdfunding

A form of financial intermediation or "fintech" that operates through an Internet platform matching fund seekers with funders. One can distinguish between donations-based crowdfunding, where the platform acts as collecting agent; and investment-based crowdfunding platforms that match retail investors with opportunities to invest in consumer credit, business loans, company debt, or private equity. As mediators of bilateral transactions between funders and fund seekers, investment crowdfunding platforms do not take on any counterparty risk or act as market makers. In that sense, they offer a layer of financial intermediation that sits between traditional credit institutions such as banks, and the regulated public exchanges and that offers retail investors direct access to investments in projects previously only open to institutional investors or venture capital.

In ecological economics, investment-based crowdfunding has been discussed in the context of new sources of finance for the energy transition, with an additional focus on its potential to democratize investment flows into renewable energy systems and the non-economic motivations feeding into retail investor attitudes when considering renewable energy crowdfunding (e.g., Bergmann et al. 2021).

MATTHIAS KLAES

Further reading

Belleflamme et al. 2015; Bourcet & Bovari 2020.

See also: Environmental finance, Conservation finance, Biodiversity finance, Investment, Renewable energy, Energy transition, Sustainability transition.

References

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Bergmann, A., Burton, B. & Klaes, M. 2021. European perceptions on crowdfunding for renewables: positivity and pragmatism. Ecological Economics 179: 106852.
Bourcet, C. & Bovari, E. 2020. Exploring citizens' decision to crowdfund renewable energy projects: quantitative evidence from France. Energy Economics 88: 104754.

Crowding out

A phenomenon in which one activity pushes aside another, which is perceived as an unintentional and undesirable side-effect.

Neoclassical economics: there is a crowding out effect when increased government involvement in a sector of the market economy substantially affects the remainder of the market, namely decreasing either the supply or the demand side. Two versions are often discussed (from Kenton 2021): (1) increased government spending, such as on social welfare or infrastructure, decreases private spending in these sectors; and (2) an expansionary fiscal policy reduces private sector investment because of increased interest rates. By contrast, "crowding in" means that government spending and borrowing can stimulate private spending (through for example, increased employment).

Behavioral and ecological economics: (from Frey 2001) crowding out refers to a psychological mechanism in which the introduction of external incentives (in particular, money) leads to diminishing intrinsic motivation. Applied to environmental protection: people who protect an environmental good because they think it is inherently valuable, for no other reason but itself, are motivated intrinsically. In contrast, one is extrinsically motivated if one performs an activity to achieve a goal external to that activity. Crowding out occurs when the force of people's intrinsic motivation is lessened because a change in

the choice setting (introduction of a sanction, a financial reward, or regulation) stimulates extrinsic motivation. By contrast, there is "crowding in" if the external incentive contributes to an increased intrinsic motivation.

STIJN NEUTELEERS

Further reading

Goodin 1994; Frey & Jegen 2001; Blanchard 2008; Neuteleers & Engelen 2015; Rode et al. 2015.

See also: Motivation crowding, Incentive compatibility, Behavioral economics, Behavioral ecological economics, Intrinsic value, Monetary policy.

References

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Neuteleers, S. & Engelen, B. 2015. Talking money: how market-based valuation can undermine environmental protection. Ecological Economics 117: 253–60.

Rode, J., Gómez-Baggethun, E. & Krause, T. 2015. Motivation crowding by economic incentives in conservation policy: a review of the empirical evidence. Ecological Economics 117: 27082.

Cultural services

A contested concept intended to characterize the value of ecosystems for the non-material aspects of human well-being; one element of ecosystem services. As initially proposed in the United Nations' 2005 Millennium Ecosystem Assessment (MEA), cultural services (CS) were what remained in the human–ecosystem connection after provisioning (for example, fiber), regulating (for example, climate), and supporting services (for example, photosynthesis) were considered. Like other ecosystem services, CS were seen to involve a flow of instrumental, utilitarian benefits from nature to humans. In addition, culture was understood in the Eurocentric, popular sense of the "refinement of mind, taste, and manners" (OED 2021, §6), so that CS were construed as the outdoor equivalent of going to the opera, attending church, or visiting an art museum (see Millennium Ecosystem Assessment 2005, Box 2.1).

This narrow view of socio-ecological systems left much unrecognized, particularly the role of ecosystems in constituting communities and ways of life. This is exemplified by a comment from a Tlingit (Alaska Native) fisherman: "These lands are vital not only to our subsistence, but also to our sense of being as Tlingit people" (Thornton 2008, p. 3). To accommodate this reality, later interpretations of CS have broadened the understanding of well-being, emphasized the relational as well as instrumental values of nature, and adopted an anthropological sense of culture as a system of meanings through which social life is conducted (Christie et al. 2019; Himes & Muraca 2018; Hirons et al. 2016; Pröpper & Haupts 2014).

ROBERT H. WINTHROP

Further reading

Winthrop 2014.

See also: Ecosystem services, Millennium Ecosystem Assessment, Relational values, Incommensurable values.

References

Christie, M., Martín-López, B., Church, A. et al. 2019. Understanding the diversity of values of "Nature's contributions to people": insights from the IPBES Assessment of Europe and Central Asia. Sustainability Science 14: 1267–82.

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Review of Environment and Resources 41: 545–74.
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Thornton, T.F. 2008. Being and Place among the Tlingit. Seattle, WA: University of Washington Press.
Winthrop, R.H. 2014. The strange case of cultural services: limits of the ecosystem services paradigm. Ecological Economics 108: 208–14.

Cultural values

A set of values and principles, shared by a group. Cultural values can shape what people find meaningful about ecosystems. For example, cultural values can influence the selection of natural sites or species to protect and preserve. Cultural values reflect the importance that people assign to ecosystem services, particularly cultural ecosystem services. Cultural values are intangible and challenging to measure; some scholars (e.g., Kirchhoff 2012) even argue that the ecosystem services framework is poorly suited to characterize them. In general, cultural values are difficult to quantify or monetize. Some researchers suggest that cultural values can be measured through an aggregation of individual values; other scholars posit that cultural values are best articulated through public, group deliberations.

Tatiana G. Marquina

Further reading

Chan et al. 2011; Small et al. 2017; Kenter et al. 2015; Fish et al. 2016.

See also: Culture, Cultural services, Social capital.

References

Chan, K., Goldstein, J., Satterfield, T. et al. 2011. "Cultural services and non-use values," pp. 206–28 in Natural Capital. P. Kareiva, H. Tallis, T.H. Ricketts et al., eds. Oxford: Oxford University Press.
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Kenter, J.O., O'Brien, L., Hockley, N. et al. 2015. What are shared and social values of ecosystems? Ecological Economics 111: 86–99.
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Small, N., Munday, M. & Durance, I. 2017. The challenge of valuing ecosystem services that have no material benefits. Global Environmental Change 44: 57–67.

Culture

Anthropology: set of beliefs, customs, practices, norms, and viewpoints that a group of people shares. Culture shapes how people view the world and what they identify as important. In the ecosystem services context, culture sometimes refers to a set of experiences in the natural environment and cultural values associated with these experiences.

Economics: artistic and intellectual activities undertaken by people, and the products of those activities. Examples of these products, or cultural goods, include films, paintings, concerts, plays, and dance performances.

Tatiana G. Marquina

Further reading

Throsby 2001; Winthrop 2014; MEA 2003; Satterfield et al. 2013.

See also: Norms, Cultural values, Cultural services.

References

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Satterfield, T., Gregory, R., Klain, S. et al. 2013. Culture, intangibles and metrics in environ-

mental management. Journal of Environmental Management 117: 103–14.
Throsby, C.D. 2001. Economics and Culture. Cambridge: Cambridge University Press.
Winthrop, R.H. 2014. The strange case of cultural services: limits of the ecosystem services paradigm. Ecological Economics 108: 208–14.

Cycle

Economics: a repeating sequence of events often involving measures of economic activity. The main economic cycle involves ongoing expansion and contraction of economic activity (periods of "boom and bust"). Conceptually, cycles emphasize mutually reinforcing aspects of economic activity, such as employment levels and consumer spending, and suggest that government policies can influence the length and magnitude of phases of within a cycle.

Ecology: the flow of substances through the Earth, atmosphere, ocean, and organisms, passing through different phases and molecular structures. Cycles essential to life include the water, carbon, oxygen, nitrogen, phosphorus, and sulfur cycles. Cycles form the conceptual bases of models ranging from local to global scales. With respect to biota, cycles describe how substances (for example, carbon) enter, are held by, and leave biomass as part of a larger series of transformations. Ecological cycles help us to recognize the finite nature of Earth's resources, which is an alternative perspective to infinite resource availability.

Brent M. Haddad

Further reading

Ayres 2004.

See also: Recycling, Sustainable recycling, Nutrient cycling, Material cycling, Circular flow model, Life-cycle assessment (LCA).

Reference

Ayres, R.U. 2004. On the life cycle metaphor: where ecology and economics diverge. Ecological Economics 48(4): 425–38.

D

Damage function

The mathematical relationship of the impact pathway between the quantity of emissions and the real economic damages that they cause. Damage functions can be expressed in terms of emission damages, ambient damages, marginal damages, or total damages. For example, the impacts of climate change are increasingly estimated using damage functions. These damage functions relate climatological quantities, such as temperature, sea level height, and precipitation, to economic damages in monetary terms. In climate–economy models damage functions typically translate climate changes into economic damages expressed as a fraction of the gross domestic product (GDP) level or growth rate, or alternatively as biophysical damages such as diminished productivity in the agricultural sector, diminished labor supply and efficiency, and weather extremes.

CHRISTIAN L.E. FRANZKE

Further reading

Krewitt et al. 1999; Nordhaus 1992; Diaz & Moore 2017; Franzke 2021.

See also: Damages, Models and modeling, Climate change, Climate instability, Pollution, Marginal external cost (MEC), Social cost.

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Nordhaus, W.D. 1992. The "DICE" Model: Background and Structure of a Dynamic Integrated Climate–Economy Model of the Economics of Global Warming. Cowles Foundation for Research in Economics. New Haven, CT: Yale University.

Damages

Present value of losses incurred by the public over time from injuries to natural resources caused by oil spills, ship groundings, hazardous substance releases, air pollution, water pollution, climate change, or wildfires. Damages are sometimes equated to the cost of one or more natural resource enhancement projects that provide present-value gains over time equivalent to the present-value losses from the natural resource injuries. In the case of climate change, damages are sometimes converted to a social cost of carbon that can be incorporated into policy responses.

RICHARD W. DUNFORD

Further reading

Israel et al. 2019; Kopp & Smith 1993; Ward & Duffield 1992.

See also: Damage function, Models and modeling, Environmental restoration, Ecological restoration, Restoring natural capital (RNC), Climate change, Climate instability, Pollution, Marginal external cost (MEC), Social cost.

References

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Damage Assessment. Washington, DC: Resources for the Future.
Ward, K.M. & Duffield, J.W. 1992. Natural Resource Damages: Law and Economics. New York: John Wiley & Sons.

Darwinian theory

Refers to English naturalist Charles Darwin's mid-19th-century theory of biological evolution by natural selection, although fellow British naturalist Alfred Russel Wallace independently conceived the theory (Darwin 1859; Darwin & Wallace 1858). Natural selection explains how species successfully adapt to changing environments over time. The theory has four main elements: (1) variation, which refers to individuals of a species having a unique combination of inherited traits, which may increase their chance of survival; (2) inheritance, or the selection for and retention of the useful traits that are passed onto the next generation; (3) overproduction, or the reproduction by an organism of more offspring than can survive; (4) differential survival and reproduction, of individuals possessing traits best suited for the struggle for local resources based on competition for food, water, living space, mates, and so on, over time. This is often called the survival of the fittest. A fifth element is speciation, or creation of a new species, which can occur when multiple and critical variations occur, usually (though not always) over long time periods (Weiner 1995).

Many leading economists since the late 1800s have embraced biological analogies and Darwinism, including Alfred Marshall and Thorstein Veblen, the latter of whom coined the term "evolutionary economics" (Veblen 1898). Increased interest among economists, both mainstream and heterodox, in evolutionary and coevolutionary analysis has occurred since the 1980s (e.g., Nelson & Winter 1985; Norgaard 1984; Boulding 1991).

BARRY D. SOLOMON

See also: Evolutionary economics, Evolutionary analysis, Coevolution, Fitness.

References

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Norgaard, R.B. 1984. Coevolutionary development potential. Land Economics 60(2): 160–73.
Veblen, T.B. 1898. Why is economics not an evolutionary science? Quarterly Journal of Economics 12(3): 373–97.
Weiner, J. 1995. The Beak of the Finch: A Story of Evolution in our Time. New York: Vintage Books.

Debt

Economics: an obligation of one party who has borrowed money or another form of assets to a creditor who has lent money or assets. Debt can be contracted by individuals, in the form of loans or credit cards; and by governments, in the form of bonds, sometimes borrowed from multilateral lending agencies such as the World Bank or International Monetary Fund. Corporations borrow by means of short-term commercial paper and long-term bonds, and by banks themselves, who borrow from central banks such as the Federal Reserve and from corporations in the Federal Funds and Eurodollar markets. Money is also a form of debt, and has been since the inception of money, and continues to be so today. Since the 1980s, debt has exploded, reaching three times national income during the 2008–2009 financial crisis. Bank debt has been the fastest-rising form of any debt category.

Ecology: ecological debts may be owed to poor nations when affluent ones exploit their resources, often for minimum payments. Ecological debt may also be owed to future generations for depleting resources

and for fostering climate change by carbon emissions. Debt becomes a problem when it expands faster than the ability to repay it. Whether wealthy nations can repay their monetary and ecological debts may become problematic when petroleum supplies eventually peak and decline, and climate change becomes overwhelming.

Kent A. Klitgaard

Further reading

Foster & Magdoff 2009, Graeber 2014.

See also: Economic institutions, Money, Ecological debt, Debt-for-nature swap.

Reference

Foster, J.B. & Magdoff, F. 2009. The Great Financial Crisis. New York: Monthly Review Press.
Graeber, D. 2014. Debt: The First 5000 Years. New York: Melville House.

Debt-for-nature swap

An agreement between a creditor and a debtor (usually a developing-country government) in which the creditor cancels (part of) its outstanding (external, hard currency) debt claims in exchange for the debtor's commitment to use the countervalue of the saved debt service obligations to fund specific, earmarked expenditures for environmental purposes, at agreed-upon terms (typically at a discount and in local currency). The agreement is often operationalized via a separate (countervalue) fund structure where the stream of countervalue payments is deposited and which is jointly governed by the debtor, creditor, and in some cases a third party, such as an environmental non-government organization (NGO), which implement the project (and broker such deals). To the extent that the swap is done at terms lower than the claim's market value, it may provide debt relief to the developing-country government at the same time as increasing fiscal resources devoted to environmental issues.

Danny P. Cassimon, Dennis Essers & Martin Prowse

Further reading

Cassimon et al. 2011; Hansen 1989.

See also: Debt, Biodiversity finance, Biodiversity finance solution, Biodiversity conservation, Conservation finance.

References

Cassimon, D., Prowse, M. & Essers, D. 2011. The pitfalls and potential of debt-for-nature swaps: a US–Indonesian case study. Global Environmental Change 21(1): 93–102.
Hansen, S. 1989. Debt for nature swaps: overview and discussion of key issues. Ecological Economics 1(1): 77–93.

Decentralization

Economics:

a. The delegation or devolution of decision-making power from a central authority to regional or local authorities (Bardhan 2002; Pollitt 2007). It takes several forms, including political or administrative, fiscal, territorial, internal or external, and vertical or horizontal decentralization (Pollitt 2007).
b. The opposite of centralization.

Ecology: an approach to environmental policymaking that gives a preference to localized solutions to environmental problems because of better knowledge of specifics by local actors and reduced enforcement costs (Hartwell et al. 2021; Ostrom 2010). Decentralization and interaction of different levels of governance may lead to sustainable environmental outcomes (Hartwell et al. 2021; Newig & Fritsch 2009). Such an approach can be especially effective in governing common-pool resources—for example, forests, lakes, or irrigation systems—when it is difficult to exclude potential users, but the usage also reduces the availability of a resource for others (Hartwell et al. 2021; Ostrom 1990).

Vladimir V. Otrachshenko

See also: Command economy, Governance, Local governance.

References

Bardhan, P. 2002. Decentralization of governance and development. Journal of Economic Perspectives 16(4): 185–205.
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Ostrom, E. 1990. Governing the Commons: The Evolution of Institutions for Collective Action. New York: Cambridge University Press.
Ostrom, E. 2010. Beyond markets and states: polycentric governance of complex economic systems. American Economic Review 100(3): 641–72.
Pollitt, C. 2007. "Decentralization," pp. 371–97 in The Oxford Handbook of Public Management. E. Ferlie, L.E. Lynn Jr & C. Pollitt, eds. Oxford: Oxford University Press.

Decision-oriented optimization models

Models that can build on optimization to support (normative perspective) or simulate observed decision behavior (positive perspective).

a. Normative use of optimization models aims to support decision-makers to achieve their objectives in the best way (Koehler 2007), for example suggesting the best compromise solution under multiple objectives (Ringuest 1992).
b. Optimization to simulate observed decision behavior is less common. However, using optimizing agents has multiple advantages over heuristic (rule-based) decision-making. Advantages include better capacity to address agents' heterogeneity, economic trade-offs, and higher policy relevance (Schreinemachers & Berger 2006). Decision-oriented optimization can also support simulating ecological phenomena, such as explaining the distributions of leaf area index and leaf traits (Flack-Prain et al. 2021).

THOMAS F. KNOKE

Further reading

Romero et al. 1987; Kaya et al. 2016.

See also: Optimization, Decision support systems, Multi-criteria assessment, Deliberative multi-criteria analysis.

References

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Koehler, D.J., ed. 2007. Blackwell Handbook of Judgment and Decision Making. Malden, MA: Blackwell Publishing.
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Romero, C., Amador, F. & Barco, A. 1987. Multiple objectives in agricultural planning: a compromise programming application. American Journal of Agricultural Economics 69(1): 78–86.
Schreinemachers, P. & Berger, T., 2006. Land use decisions in developing countries and their representation in multi-agent systems. Journal of Land Use Science 1(1): 29–44.

Decision support systems

Integrated, computer-based groups of tools for combining data, domain expertise, and user judgment to assist in solving problems. The recognition that the power of computing could be harnessed to aid in reaching decisions originated in the 1950s and 1960s in business management and operations research (Ackoff 1956; Coleman 1956). Following Herbert Simon (1960, p. 2), problem-solving involves three phases: formulating the problem (in Simon's term, intelligence), identifying potential solutions (design), and selecting a solution (choice).

Decision support systems (DSS) can be designed for either semi-structured decisions (where there is agreement on defining the problem, but not the potential solutions) or unstructured decisions (where there is agreement on neither the problem nor

the potential solutions). When applied to coupled socio-environmental systems, DSS typically incorporate a combination of numerical models, a geographic information system, data management, and one or more decision tools (such as optimization, multi-criteria methods, scenario formulation, valuation, Bayesian networks, and rule-based models). The application of decision support to socio-environmental systems entails additional challenges, including bridging epistemologies from varied research traditions; combining quantitative and qualitative methods and data; capturing systemic, non-linear change; and integrating human dimension perspectives (Elsawah et al. 2020).

Robert H. Winthrop

Further reading

French & Geldermann 2005; McIntosh et al. 2011.

See also: Decision-oriented optimization models, Models and modeling, Management science.

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Decommodification

The process by which entities or services become immunized from market dependency. Sometimes also called decommoditization. Commons, co-operatives, state forests, and municipal land are examples of (at times partial) decommodified assets that do not follow the logic of the market (Gerber & Gerber 2017). Decommodification tends to diminish the pressure to generate financial profit; it can give more leeway for communities to manage their resources, and it can allow a new balance between short- and long-term objectives. Ecological economist Karl William Kapp (1950) argued in favor of decommodification: for him, a decommodification of the economy—either partial or wide-ranging—can, if properly done, overcome the incapacity of the market to meet basic human needs for all as well as longer-term ecological sustainability.

Julien-François Gerber

Further reading

Bliss & Egler 2020; Vail 2010.

See also: Commodification of nature, Common property, Private property, Ownership, Commons, the, Market, Community forestry.

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Decoupling economic growth

The delinking of economic growth (measured by gross domestic product, GDP) from resource use and/or environmental impacts. Where resource use or environmental impacts increase with GDP, but at a slower rate, the decoupling is said to be relative. Where they reduce even as GDP increases, then decoupling is said to be absolute. The result of decoupling is using less resources per unit of

economic output, and reducing the environmental impact of any resources that are used or economic activities that are undertaken (UNEP 2011). Decoupling may occur as the result of economic growth itself, because of the implementation of public policies or new technologies (UNEP 2014).

Paul W. Ekins

See also: Resource efficiency, Green growth.

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Deep ecology

A philosophy that regards the environment, human, and non-human species as having certain basic moral rights (and in some interpretations, legal rights) to flourish independently of their economic function (Sessions & Naess 1986; Kopnina et al. 2018). This has implications for addressing environmental problems ranging from climate change (for example, not just compensating various human groups for damage to agricultural and urban centers) to biodiversity (not just preserving species that might be useful for pharmaceutical or tourist industries).

The term was first popularized by the Norwegian environmental philosopher Arne Naess (1973). Sometimes used interchangeably with the terms "ecocentrism," "ecosophy," and "deep green" (as opposed to "shallow green") ecology. Deep ecology differs from traditional notions of environmental sustainability, which tend to be anthropocentric (human-centered). In Naess's philosophy, this anthropocentric care of the environment or "shallow ecology" is primarily concerned with eliminating waste, pollution, and so on, only in cases when human (particularly economic) interests are served. In contrast, deep ecology emphasizes the intrinsic value of nature, environment, and non-human species, and thus proposes a stricter level of protection that reaches beyond utilitarian motives (Drengson & Inoue 1995).

Deep ecology has also at times been referred to as a social and sometimes religious movement that has mystic (or traditional ritualistic) undertones. Building on Naess's definitions, Devall and Sessions (1985) developed a platform of eight organizing principles for the deep ecology social movement. Currently, there are ongoing debates about whether deep ecology principles can be applied at the systems level (ecosystems, habitats, species) or also at the individual level (welfare and rights of individual species), and if so, whether species ranking (hierarchy of importance) should be made.

Helen Kopnina

See also: Ecocentrism, Biocentrism, Ecology, Ecological justice, Ecosystem, Intrinsic value.

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Kopnina, H., Washington, H., Taylor, B. & Piccolo, J.J. 2018. Anthropocentrism: more than just a misunderstood problem. Journal of Agricultural and Environmental Ethics 31(1): 109–27.

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Defensive expenditures

a. Economic activities that defend against damage to the environment caused by economic production. Sometimes also called

averting behavior. Thought of as a cost of production rather than an expenditure on consumption. Can be preventive, restorative, or compensatory in nature. Examples include the costs of air filters to prevent human health damage from air pollution, or the costs of deforestation resulting from timber production.

b. Expenditures aimed at reducing the harm from poor environmental quality. Displaces the consumption of utility-generating goods. Generally used to measure or put bounds on the economic benefits of environmental quality. Has been used in contexts not directly resulting from economic production, such as expenditures on suntan lotion to prevent skin cancer, or defenses against naturally occurring radon. Methods to estimate the value or cost of defensive expenditures are an example of a revealed preference method because they rely on market data and information.

AUSTIN M. WILLIAMS

Further reading

Courant & Porter 1981; Bartik 1988; Leipert 1989; Costanza et al. 1997.

See also: Revealed preference methods, Willingness to pay, Behavioral economics, Behavioral ecological economics.

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Leipert, C. 1989. National income and economic growth: the conceptual side of defensive expenditures. Journal of Economic Issues 23(3): 843–56.

Deforestation

Purposeful conversion of forested land for agriculture, animal grazing, logging, and urbanization. While large parts of Europe and the United States were historically deforested through the 19th century, deforestation has accelerated since the 1960s in the tropical regions of Latin America, Asia, and Africa. The United Nations Food and Agriculture Organization (FAO) estimates that the global rate of deforestation is currently around 10 million hectares per year, down from 16 million hectares per year in the 1990s (FAO 2020). But on a regional basis (as of 2022) deforestation has increased in Africa since 2000, and in Brazil since 2015. Deforestation has significant adverse effects on ecosystems, biodiversity, and climate change through the release of greenhouse gases (Shukla et al. 1990).

The proximate causes of deforestation are land use change including agricultural expansion, timber extraction, and infrastructure development. Underlying causes are complex, and include a variety of socio-economic, political-economic, demographic, and environmental factors (Allen & Barnes 1985; Geist & Lambin 2001).

BARRY D. SOLOMON

Further reading

Kaimowitz & Angelsen 1998; Puyravaud 2003.

See also: Land use change, Biodiversity, Ecosystems, Climate change, Greenhouse gases, Desertification.

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Degradation

See: Environmental degradation.

See also: Pollution, Disturbance, Depletion, Resource depletion, Natural resource depletion.

Degrowth

A process of radical political and economic reorganization leading to drastically reduced resource and energy use and improved quality of life. The degrowth hypothesis is that it is possible to organize a transition and live well under a different (post-capitalist) political-economic system that has a radically smaller resource throughput (Kallis et al. 2018).

Degrowth is a reincarnation of older limits to growth debates. It emerged in France in the 1990s, partly inspired from the translation of works of Nicholas Georgescu-Roegen. Andre Gorz was the first to launch the term in French, back in 1972, and in a debate of the Club of Rome's report. Compared to limits to growth arguments, or steady state economics, the degrowth literature has a stronger emphasis on autonomy, conviviality, and the desirability of collective self-limitation (Kallis 2019), alongside a critique of capitalism as an exploitative system that can only grow or collapse, and that therefore must be battled and changed (Hickel 2020). Degrowth, the argument goes, is necessary because green growth is impossible (Hickel & Kallis 2020), and because continuous growth is a source of global injustices, and of unsustainable extraction and exploitation of people and environments at the world's commodity frontiers (Martínez-Alier 2012).

GIORGOS KALLIS

Further reading

Latouche 2009; Kallis 2018; Kallis et al. 2020.

See also: Decoupling economic growth, Steady state economy, Limits, Limits to growth, Autonomous institution, Post-capitalist world(s), Collapse, Green growth, Agrowth.

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Martínez-Alier, J. 2012. Environmental justice and economic degrowth: an alliance between two movements. Capitalism Nature Socialism 23(1): 51–73.

Deliberative democracy

a. A practice of democracy where deliberation is given a key role, the roots of which can be traced back to Athenian democracy.
b. A governance model where those who will be affected by a decision come together to debate and negotiate on political issues towards formulating policies to be executed. Deliberations can be held in different spaces (formal, such as city councils and informal, such as social media) and in different formats (for example, written or verbal). Unlike formal democracy, where different agents' preferences, values, and interests are aggregated through a voting mechanism, deliberative democracy aims at achieving a negotiated outcome through mutual communication.

Deliberation is advocated in lieu of an aggregation mechanism based on two grounds: (1) the aggregation system is open to manipulation since finding a mechanism to appropriately construct social outcomes from individual positions is technically flawed; and (2) the aggregation mechanism simply rules out the possibility of public reasoning. The extent to which deliberation is successful depends on two requirements: (1) achieving broad consensus on the sides that are to be included in the decision-making process and with what weighting; and (2) ensuring equal recognition and power (economic, social, and political) while also acknowledging reciprocity among participants. Since deliberative democracy emphasizes the process itself, it favors procedural rationality. Ecological economics is inclined to propose deliberative institutions as a governance modality, given that one of its foundational pillars is recognizing both the uncertainty and complexity of the environment, and the multidimensional interdependences at the economics–environment nexus.

Fikret Adaman & Pat Devine

Further reading

Bächtiger et al. 2018; Bessette 1980; Jacobs 1997.

See also: Democracy, Deliberative ecological economics, Procedural rationality, Uncertainty, Complexity.

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Deliberative ecological economics

A combination of ecological economics—a paradigm within the discipline of economics that comprises the laws of thermodynamics and coevolutionary perspectives, while acknowledging the complexity and uncertainty that marks ecological processes—and deliberative mechanisms, where not methods such as voting or individual monetary valuation, but debate and negotiation among agents (be they citizens, associations, production units, groups, organizations, institutions, or nation-states), are advocated to be at the root of legitimate decision-making procedures.

Social interdependency among numerous users of ecosystems and their co-dependency on biophysical processes imply that neither atomistic nor hierarchical and top-down decision-making procedures are adequate to address the broader implications of environmental decisions. Furthermore, decision-making mechanisms are not merely vehicles for expressing values, but they also shape them. Deliberative mechanisms are thus called for where the rationality of the processes relied on in making decisions (procedural rationality) is advanced, rather than the rationality of the decision itself. This general standpoint instigates a critical reading of how market forces function, where the productive capacity structure of an economic system varies solely via profit signals due to the market mechanism's inability to reveal (and incorporate) the likely current and future impacts of private decisions on people and the environment overall. It also casts doubt on the adequacy and desirability of methods such as cost–benefit analysis and individual monetary valuation.

Fikret Adaman & Bengi Akbulut

Further reading

Akbulut & Adaman 2020; Zografos & Howarth 2008, 2010.

See also: Deliberative democracy, Deliberative valuation, Deliberative multi-criteria analysis, Procedural rationality, Paradigm, Coevolution, Uncertainty, Complexity, Atomism, Classical thermodynamics.

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Deliberative multi-criteria analysis

A decision-making approach in which criteria are set to evaluate alternative decisions, and the attributes of each alternative are scored or ranked according to the criteria (see Munda 2004). Multi-criteria analysis recognizes that values relevant in environmental decision-making may be incommensurable and only weakly substitutable (Martinez-Alier et al. 1998). By evaluating multiple criteria an analyst avoids the need to place all impacts into a single numeraire such as a monetary value (Martinez-Alier et al. 1998). In this way, multi-criteria analysis offers an alternative to cost–benefit analysis, which often uses willingness-to-pay surveys and contingent valuation to monetize impacts, including ecological impacts.

Deliberative multi-criteria analysis adds a layer of participation into the multi-criteria analysis process. Analysts engage relevant stakeholders in the process of choosing criteria relevant to a decision, assigning weights to each criterion, and ranking or scoring impacts or decision options with the chosen criteria. Deliberation is based on the idea that "humans make sense of the world through interpersonal communication" (Zografos 2015, p. 76). A deliberative process can lead to the formation of environmental preferences, and to shifts in preferences (van den Bergh et al. 2000). There are four key motivations for including deliberation in a decision-making process (from Zografos 2015): (1) democratic: including more voices and a plurality of values in a decision-making process; (2) substantive: improving decision analysis by including an extended peer community; (3) social learning: learning amongst participants; and (4) instrumental: increasing support for a decision by enhancing trust in the evaluation process.

Brett D. Dolter

See also: Deliberative ecological economics, Deliberative valuation, Multi-criteria assessment, Incommensurable, Incommensurable values.

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Deliberative valuation

A fairly new valuation paradigm based on the principles of deliberative democracy that actively engages citizens and/or stakeholders in decision-making and promotes social learning through reasoned dialogue and deliberation (Raymond et al. 2014). Deliberative valuation methods use a small group of citizens or stakeholders, acting as a focus group or a "citizens' jury." Participants deliberate to reach a consensus about the value of public goods and services such as ecosystem services (Howarth & Wilson 2006). Deliberative valuation could be applied by combining deliberation with monetary (for example, stated preferences) and non-monetary (for example, multi-criteria decision analysis) valuation techniques.

Georgia Mavrommati

Further reading

Kenter et al. 2016; Schaafsma et al. 2018; Gutmann & Thompson 2009.

See also: Stated preference methods, Deliberative multi-criteria analysis, Deliberative democracy, Social learning, Citizens' jury.

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Demand

Economics: the total quantity of goods that a consumer or group of consumers is willing to purchase for a given price at a particular point in time.

Ecology: the quantity of natural resources used to sustain an individual or society.

Biology: the nutrient requirements to perform or sustain a biological function.

Nicholas H. Johnson

Further reading

Mankiw 2021; Wackernagel & Rees 1996; Urry et al. 2021.

See also: Derived demand, Demand management, Ecological footprint, Willingness to pay (WTP).

References

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Wackernagel, M. & Rees, W. 1996. Our Ecological Footprint: Reducing Human Impact on the Earth. Gabriola, Canada: New Society Publishers.

Demand management

Economics: the balancing of customer needs with supply chain capabilities (Croxton et al. 2002).

Utilities: the modification of energy (particularly electricity) or water consumption through consumer education, financial incentives, and technological changes (Strbac 2008; Brooks 2006). Can refer to a reduction of consumption or a shift in the timing of consumption. Sometimes called demand-side management.

Nicholas H. Johnson

See also: Demand, Supply chain management, Energy efficiency, Energy conservation, Integrated water resources management (IWRM).

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Dematerialization

The absolute or relative reduction in the quantity of materials used and/or the quantity of waste generated in the production of a unit of economic output (Wernick et al. 1996; Cleveland & Ruth 1998) over a period

substantially longer than a business cycle (Bernardini & Galli 1993).

Eric Kemp-Benedict

See also: Material flow analysis, Material flow accounts, Material footprint, Material services, Decoupling economic growth, Industrial ecology.

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Democracy

A system of government in which the people exercise political power through elected representatives. In addition to elected legislatures, the executive branch of the state, judiciary, free press, and autonomous civil society are crucial for holding elected representatives and public officials accountable to the public at large. Representation and accountability constitute the cornerstones of a robust democracy (Przeworski et al. 1999). Realization of democratic ideals in a society depends on the quality of governance, that is, the institutions, systems, "rules of the game" and other factors that determine how political and economic interactions are structured and how decisions are made and resources allocated (Grindle 2010, p. 2).

Institutions of democracy and various organs of the state are central to the authoritative allocation of values in a society (Easton 1965). Whether and how the environment and natural resources are valued in a society depend on the policies and institutions meant to govern the environment. Domestic socio-economic inequalities determine how the preferences and interests of different constituencies and interest groups are represented in the policy process, which shapes the use and abuse of environmental and ecological systems (Kashwan 2017). The complex nature of the relationship between socio-economic inequalities and the environment means that institutional checks and balances of democracy are necessary but insufficient to ensure environmental stewardship. The "value-commitments" of political and civic actors and scholars are central to an ecological economics approach, which departs in important ways from the utility-maximizing approaches of political economy and environmental economics (Söderbaum 2004). A deeper understanding of democracy that accounts for institutions of self-governance may open vistas of untapped capabilities and enable individuals to pursue simultaneous improvements in social welfare and environmental stewardship (Ostrom 2010).

Prakash Kashwan

See also: Governance, Environmental governance, Legitimacy, Accountability, Institutions, Civil society, Non-state actors, Economic inequality.

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Söderbaum, F. 2004. Modes of regional governance in Africa: neoliberalism, sovereignty boosting, and shadow networks. Global Governance 10(4): 419–36.

Demographic transition

The evolution of a society from having a relatively stable population with high birth rates and high death rates, through a period of rapid population growth when death rates fall before birth rates, to a new stable condition with low birth rates and low death rates.

After fertility (births per woman) falls below two, population growth continues for several decades (demographic momentum) as age cohorts equalize. The completion of demographic momentum is essential for establishing a sustainable society with low mortality, but many high-fertility countries are barely progressing.

Often claimed to be an automatic process, such that once mortality declines, fertility will inevitably follow (e.g., Dyson 2010), helped along by modernization (urbanization, education, gender equity) (e.g., Moreland 2019). However, there is strong evidence of the opposite causation, such that lower birth rates facilitate gender equity, economic development, and education, by allowing infrastructure creation and productivity gains to overtake the growing needs of the population (O'Sullivan 2017). These scholars argue that without interventions to promote lower birth rates, overpopulation can lead to higher mortality, through war, famine, or diseases of poverty, before fertility falls sufficiently.

Jane N. O'Sullivan

See also: Population dynamics, Population aging, Modernization, Sustainable development.

References

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O'Sullivan, J.N. 2017. The contribution of reduced population growth rate to demographic dividend. Paper presented at the 28th International Population Conference, Cape Town 30 Octover 30–November 3, 2017. https://iussp.confex.com/iussp/ipc2017/meetingapp.cgi/Paper/2521.

Deontological

A normative branch of ethics in which the morality of an action is assessed with regards to a series of *a priori* rules, duties, or obligations rather than in relation to consequences or an understanding of virtue. The rules in question may be held to arise from a variety of sources including a naturalistic understanding of the universe, a particular religion, or a set of personal values.

The most influential deontological ethical theory is associated with Immanuel Kant, who argued that moral action was defined not only by its consonance with duty, but also with respect to individual motives. Kant's pithy expression of the deontological ethic is the famous "categorical imperative": that is, the maxim that moral actions should, in principle, be generalizable as universal laws; that people should never be treated as only as a means but always as an end. This stands in opposition to the consequentialist logic associated with, for instance, the utilitarian theory of Jeremy Bentham, which balances aggregate benefits and harms. It also contrasts with Aristotelian virtue-ethics, which emphasizes the formation of virtuous individuals and natural law. For a deontologist a good person acts in concert with a set of rules or obligations. For a consequentialist, a good person affects positive consequences. For a virtue-ethicist, a good person is defined by the formation of morally positive character traits and personality.

From a sociological perspective, deontological reasoning became dominant from the late 18th century, reflecting the emergence of more complex and diverse societies. From an ecological-economic perspective, it seems likely that a lower-throughput society with a smaller ecological footprint would see a rapprochement between deontological and virtue-ethical perspectives; perhaps along lines suggested by Scruton (2017).

Stephen Quilley

Further reading

Broad 1930; Kant 1964; Beauchamp 1991.

See also: Kantian ethics, Consequentialism, Utilitarianism, Obligation, Duty.

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Depletion

The act of depleting, which is defined as:

a. The emptying of a principal substance.
b. To lessen markedly in quantity, content, power, or value (Dasgupta & Heal 1974).

In natural resource management or ecological economics, the term is often used in its first definition, that is, the emptying of a principal substance. Quotas are used in renewable resource management as a limit on the extraction to prevent depletion, so that the renewable resource can regenerate itself and its use is sustainable. A resource user can in turn deplete these quotas by fully using them. An example of quota depletion in natural resource management is when a fisher is allocated a quota for a fishing year and fishes the quota.

Maartje Oostdijk

Further reading

Lewis 1979; Woods et al. 2015.

See also: Common pool resources, Resource management, Individual transferable quotas (ITQs), Overexploitation, Renewable resource.

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Woods, P.J., Holland, D.S., Marteinsdóttir, G. & Punt, A.E. 2015. How a catch-quota balancing system can go wrong: an evaluation of the species quota transformation provisions in the Icelandic multispecies demersal fishery. ICES Journal of Marine Science 72(5): 1257–77.

Depletion adjusted change of environmental net worth

Economics: an instrumental accounting variable that allows for the presentation of environmental income directly linked with the ecosystem services embedded in total product consumption and changes in environmental assets in the accounting period (Campos et al. 2020a). Ecosystem accounting frameworks provide the records to estimate depletion and changes of environmental net worth. The latter is comprised of environmental net operating margin (net enhancement) and environmental asset gain. An increase in the unit natural resource rent (environmental price) of the product consumed above the individual biological natural growth rate results in a distortion of its threshold endowment. Sustainability cannot be achieved for environmental assets in situations close to or below the critical threshold of the biophysical provisioning stock.

Ecology: it is essential to quantify the physical amounts of an environmental asset at the close of the accounting period. Thus, the "critical" state of the biological endowment of a renewable natural resource is a variable that is external to the economic system and should be established by experts in natural sciences to inform policy decision-makers (Berrens 2001).

Pablo Campos Palacín

Further reading

Campos et al. 2019, 2020b.

See also: Environmental asset gain, Renewable resource, Natural resource rents, Stocks, Safe minimum standard (SMS).

References

Berrens, R. 2001. The safe minimum standard of conservation and endangered species: a review. Environmental Conservation 28: 104–16.

Campos, P., Álvarez, A., Mesa, B. et al. 2020a. Total income and ecosystem service sustainability index: accounting applications to holm oak *dehesa* case study in Andalusia-Spain. Land Use Policy 97: 104692.

Campos, P., Álvarez, A., Oviedo, J.L. et al. 2020b. Environmental incomes: refined standard and extended accounts applied to cork oak open woodlands in Andalusia, Spain. Ecological Indicators 117: 106551.

Campos, P., Caparrós, A., Oviedo, J.L. et al. 2019. Bridging the gap between national and ecosystem accounting application in Andalusian forests, Spain. Ecological Economics 157: 218–36.

Depletion quota

See: Depletion.

See also: Individual transferable quotas (ITQs).

Depreciation

A reduction in the value of an asset over time. Economic depreciation is different from a financial accounting method that allocates the cost of an asset over several years, recognizing that part of a machine or structure is used each year. Accounting for depreciation helps a company's profits by reducing tax liability. The larger concept of economic depreciation recognizes that a physical resource (or human capital) can be used up and not replaced every year.

Most natural resources used in production are depreciating because they are not renewable. Even without the negative externalities caused by extracting oil and gas or using timber, the limited availability of natural resources may constrain human consumption and production. However, markets can mitigate the depreciation if the price rises, incentivizing consumers and producers to substitute the non-renewable resource with a more abundant resource or to recycle.

Teresa Ghilarducci

Further reading

Barbier 2014; Neumayer 2000; Khalil 1996.

See also: Capital, Manufactured capital, Natural capital, Human capital, Environmental asset, Natural assets.

References

Barbier, E. 2014. Economics: account for depreciation of natural capital. Nature 515(7525): 32–33.

Khalil, E.L. 1996. Kenneth Boulding: ecodynamicist or evolutionary economist? Journal of Post Keynesian Economics 19(1): 83–100.

Neumayer, E. 2000. Scarce or abundant? The economics of natural resource availability. Journal of Economic Surveys 14: 307–35.

Depredation

a. A harmful action that results in the taking, damaging, or loss of something, such as natural resources or the environment.
b. Humans or other animals consuming agricultural crops or livestock through plunder.

Barry D. Solomon

Further reading

Muhly & Musiani 2009.

See also: Damages, Environmental degradation, Land degradation.

Reference

Muhly, T.B. & Musiani, M. 2009. Livestock depredation by wolves and the ranching economy in the Northwestern U.S. Ecological Economics 68(8–9): 2439–50.

Derived demand

Economics: the indirect demand for production inputs that is derived from the direct demand for goods and services that they help to produce (Marshall 1890).

Ecological economics: the indirect demand for energy or for environmental resources and services as inputs in the production of recreational activities in a household production function. The derived demand approach estimates the value of unobserved ecological services by incorporating the environmental resources in modeling household preferences and expenditures on observable market good and services. This approach can be found in well-known methods such as the travel cost method and the averting behavior method in non-market valuation.

HONGXING LIU

Further reading

Berndt & Wood 1975; Bockstael & McConnell 1981, 1983; Smith et al. 1983.

See also: Non-market value, Travel cost method, Defensive expenditures, Production function.

References

Berndt, E.R. & Wood, D.O. 1975. Technology, prices, and the derived demand for energy. Review of Economics and Statistics 57(3): 259–68.

Bockstael, N.E. & McConnell, K.E. 1981. Theory and estimation of the household production function for wildlife recreation. Journal of Environmental Economics and Management 8(3): 199–214.

Bockstael, N.E. & McConnell, K.E. 1983. Welfare measurement in the household production framework. American Economic Review 73(4): 806–14.

Marshall, A., 1890. Principles of Economics. London: Macmillan.

Smith, V.K., Desvousges, W.H. & McGivney, M.P. 1983. The opportunity cost of travel time in recreation demand models. Land Economics 59(3): 259–78.

Desertification

Anthropogenic and climate-induced changes and degradations to fertile dryland regions of the world that result in a loss of their biological and economic potential (Thomas 1993). The term is contentious and difficult to measure (there are over 100 definitions), and the relative cause from human and natural factors has been subject to significant debate (Geist 2005; Verón et al. 2006). Causes can include deforestation, drought, climate change, urbanization, overgrazing, overdraft of groundwater, and inappropriate agriculture for the affected area. Global areas most affected by desertification include the Sahel region of Africa, the Gobi Desert region of China, most of Mongolia, several parts of India, West Asia, northeast Brazil, parts of the west and southwest United States, northern Mexico, and the drylands of Argentina and Australia.

BARRY D. SOLOMON

Further reading

Schlessinger et al. 1990; Reynolds et al. 2007.

See also: Deforestation, Land use change, Climate change, Anthropogenic.

References

Geist, H. 2005. The Causes and Progression of Desertification. Aldershot: Ashgate.

Reynolds, J.F., Smith, D.M.F., Kambin, E.F. et al. 2007. Global desertification: building a science for dryland development. Science 316(5826): 847–51.

Schlessinger, W.H., Reynolds, J.F., Cunningham, G.L. et al. 1990. Biological feedbacks in global desertification. Science 247(4946): 1043–8.

Thomas, D.S.G. 1993. Sandstrom in a teacup? Understanding desertification. Geographical Journal 159(3): 318–31.

Verón, S.R., Paruelo, J.M. & Oesterheld, M. 2006. Assessing desertification. Journal of Arid Environments 66(4): 751–63.

Determinism

A metaphysical doctrine that holds that all human actions and events are the direct result of causes other than the free will of people. Thus, determinism argues that all events are directly and completely caused by past events or natural laws (Butts 1986).

Economics: economic determinism is a socio-economic theory attributed to Karl Marx, which argues that economic relationships determine, shape, and define all political, social, and cultural relationships in society (Resnick & Wolff 1982).

Ecological economics: ecological economists reject determinism because it rules out the need for and effectiveness of environmental policy and human actions to improve environmental conditions and promote sustainable development.

Barry D. Solomon

Further reading

Ehrlich 2000; Kerschner & Ehlers 2016.

See also: Economism, Materialism, Human nature, Deterministic.

References

Butts, R.S., ed. 1986. A Primer on Determinism. Dordrecht: D. Reidel Publishing Company.
Ehrlich, P.R. 2000. Human Natures: Genes, Cultures, and the Human Prospect. Washington, DC: Island Press.
Kerschner, C. & Ehlers, M.-H. 2016. A framework of attitudes toward technology in theory and practice. Ecological Economics 126: 139–51.
Resnick, S.A. & Wolff, R.D. 1982. Marxist epistemology: the critique of economic determinism. Social Text 6: 31–72.

Deterministic

General:

a. Relating to a circumstance with a sufficient reason for being as it is, and not otherwise.
b. Relating to an evolutionary series with a known cause and that evolves according to a predetermined law.

Mathematical modeling: relating to a quantitative system without any kind of random components, and thus the relationships being modeled are fixed.

Zhengyuan Gao

Further reading

Uusitalo et al. 2015.

See also: Models and modeling, Analytical models, Hysteresis.

Reference

Uusitalo, L., Lehikoinen, A., Helle, I. & Myrberg, K. 2015. An overview of methods to evaluate uncertainty of deterministic models in decision support. Environmental Modelling and Software 63: 24–31.

Developed country

A sovereign nation-state with a high gross domestic product (GDP) per capita; high level of education, literacy, and health as measured by the Human Development Index (HDI); relatively high level of economic growth and economic security; and an advanced technological infrastructure. Sometimes also called an industrialized country, high-income country, or a more economically developed country (MEDC).

The developed countries are concentrated in Europe and North America, along with Japan, South Korea, Australia, and New Zealand. However, according to the United Nations (UN) there is no established convention for the designation of developed and developing countries in the UN system (UN 2003, 2017). Most developed countries have larger service sectors than industrial sectors in terms of wealth and employment. In recent decades, most developed countries have experienced growing levels of inequality of income and wealth (Cingano 2014; Piketty 2015).

Barry D. Solomon

See also: Economic institutions, Development, Developing country, Development economics, Economic growth, Gross domestic product (GDP), Economic inequality, Human Development Index (HDI).

References

Cingano, F. 2014. Trends in income inequality and its impact on economic growth. OECD Social, Employment and Migration Working Papers. Paris: Organization for the Economic Co-operation and Development.
Piketty, T. 2015. The Economics of Inequality. Translated by A. Goldhammer. Cambridge,

MA, USA & London, UK: Belknap Press of Harvard University Press.
UN. 2003. Millennium Development Indicators: World and Regional Groupings. New York: United Nations Statistical Division.
UN. 2017. Standard Country and Area Codes Classifications (M49): Developed Regions. New York: United Nations Statistical Division.

Developing country

A sovereign nation-state at an early stage of economic development. These countries generally have a low gross domestic product (GDP) per capita, high unemployment rate, low level of economic security, high population growth rate, low levels of education, literacy and health as measured by the Human Development Index (HDI), a dependence on the primary sectors and export of primary commodities, and a less-developed technological and industrial infrastructure compared to developed countries. Sometimes also called a less-developed country, low-income country, or the global South. Countries that fit this description also used to be called the third world.

The developing countries are concentrated in Africa, Latin America, Asia, and the Middle East. However, according to the United Nations (UN) there is no established convention for the designation of developing and developed countries in the UN system (UN 2003, 2017).

BARRY D. SOLOMON

Further reading

Gerber & Raina 2018; Van der Ven et al. 2021.

See also: Economic institutions, Development, Developed country, Development economics, Economic growth, Gross domestic product (GDP), Economic inequality, Human Development Index (HDI), Post-development.

References

Gerber, J.-F. & Raina, R.S. 2018. Post-growth in the Global South: some reflections from India and Bhutan. Ecological Economics 150: 353–8.
UN. 2003. Millennium Development Indicators: World and Regional Groupings. New York: United Nations Statistical Division.
UN. 2017. Standard Country and Area Codes Classifications (M49): Developed Regions. New York: United Nations Statistical Division.
Van der Ven, H., Sun, Y. & Cashore, B. 2021. Sustainable commodity governance and the global south. Ecological Economics 186: 107062.

Development

a. A qualitative change, realization of potential, and evolution toward an improved system, state, or structure, which may or may not involve growth.
b. An increase in the quality of goods and services that are provided by a given throughput in terms of human well-being.

BARRY D. SOLOMON

Further reading

Daly & Farley 2011.

See also: Growth, Economic growth, Economic development, Development economics, Human development, Human Development Index (HDI), Objective well-being, Sustainable development, Throughput.

Reference

Daly, H.E. & Farley, J. 2011. Ecological Economics: Principles and Applications, 2nd edn. Washington, DC: Island Press.

Development economics

The field of economics that treats economic development as a process. By convention it focuses on middle, lower-middle, and low-income countries, but the process involved is common to all countries. It identifies factors affecting economic growth and

structural change and analyzes interventions at micro and macro levels designed to promote the sustainable growth of income and assets. Important topics include: the formation of labor and capital markets; conditions for development based on exploitation of renewable and non-renewable natural resources; the relation between population and economic growth; education and human capital development; institutional change and the reform of property rights; the governance of common pool and common property resources; globalization and trade; foreign direct investment; the relation between economic growth and the distribution of income and assets; and poverty.

Charles A. Perrings

Further reading

De Janvry & Sadoulet 2015.

See also: Economic growth, Sustainable development, Commodity trade, Structural change, Population, Renewable resource, Non-renewable resource, Common pool resources, Income distribution, Capital formation, Labor markets, Human capital, Natural capital.

Reference

De Janvry, A. & Sadoulet, E. 2015. Development Economics: Theory and Practice. London: Routledge.

Dialectic reasoning

Philosophy: from Hegel, a dialectic relation refers to a presumed opposition of ideas that are co-constitutive of the relationship they describe or articulate. Such relations have also been characterized as the "co-constitution and mutual co-production of human experiences, as rooted in socio-cultural phenomena, non-human and biophysical processes and capacities" (Kolinjivadi 2019, p. 33).

Ecological economics:

a. The Marx–Odum dialectic reasoning refers to the ways that capital accumulation historically alienates the labor of human activities from the organic and inorganic natures and biophysical processes that constitute it (Foster & Holleman 2014). The consequence is a metabolic rift of unequal ecological exchange divorcing wage labor and the production of exchange value from its constitutive elements and processes. Marxist dialectics reveal a growing gap between the production of "real wealth," as opposed to "virtual wealth," and the growth of capitalist value relations that dismiss the unified relation of nature and society (for example, human activities and the non-human actors) that define biophysical relationships.
b. Dialectic reasoning in economic production emphasizes how economic activity is ultimately the product of co-constitutive biophysical and socio-cultural relations, whose outcome irreversibly alters these relations in quantitative and qualitative ways (for example, entropy), historically shaping the way phenomena are experienced and take material form.

Vijay K. Kolinjivadi

Further reading

Harvey 1993; Marx 1973 [1857–1858]; Moore 2011.

See also: Ecologically unequal exchange, Metabolic rift, Virtual wealth, Entropy.

References

Foster, J.B. & Holleman, H. 2014. The theory of unequal ecological exchange: a Marx–Odum dialectic. Journal of Peasant Studies 41(2): 199–233.
Harvey, D. 1993. The nature of environment: dialectics of social and environmental change. Socialist Register 29(29): 1–51.
Kolinjivadi, V. 2019. Avoiding dualisms in ecological economics: towards a dialectically-informed understanding of co-produced socionatures. Ecological Economics 163: 32–41.
Marx, K. 1973 [1857–1858]. Grundrisse. London: Penguin.
Moore, J.W. 2011. Transcending the metabolic rift. Journal of Peasant Studies 38(1): 1–46.

Dichotomous choice

A common example of discrete choice modeling that follows a preference elicitation

format that is often used in contingent valuation studies. It is distinguished from the payment card or open-ended formats by its binary answers Yes/No, trying to mimic an actual market and the choice to purchase (or not) a good at a given price. The contingent valuation method (CVM) often uses single-bounded dichotomous choice or double-bounded dichotomous choice. This format, first used by Bishop and Heberlein (1979), has been popularized by the recommendations of the United States National Oceanic and Atmospheric Administration (NOAA) panel (Arrow et al. 1993). The advantage of this format is that it limits strategic behaviors and non-responses and avoids outliers. Furthermore, it imposes a lower cognitive burden on the respondent (Borzykowski et al. 2018).

Nicolas Borzykowski

See also: Discrete choice models, Contingent valuation method (CVM), Willingness to pay (WTP).

References

Arrow, K., Solow, R., Portney, P.R. et al. 1993. Report of the NOAA panel on contingent valuation. Federal Register 58(10): 4601–14.

Bishop, R.C. & Heberlein, T.A. (1979). Measuring values of extramarket goods: are indirect measures biased? American Journal of Agricultural Economics 61(5): 926–30.

Borzykowski, N., Baranzini, A. & Maradan, D. (2018). Scope effects in contingent valuation: does the assumed statistical distribution of WTP matter? Ecological Economics 144: 319–29.

Differential equation

An equation that specifies how one quantity varies with respect to another quantity, called its derivative with respect to the second quantity. When the second quantity is time, the derivative represents the rate of change of the first quantity. In ecological economics, differential equations with respect to time of various system metrics are often used to analyze the dynamics of a system. In application, the set of coupled differential equations cannot typically be solved in closed form and are instead solved numerically by general-purpose computer software such as R or Python, or by application-specific computer software used to study system dynamics. Vensim, for example, provides the numerical solution and a useful visual representation of the system.

Takuro Uehara & Wayne W. Wakeland

Further reading

Derissen et al. 2011; Uehara et al. 2021.

See also: System dynamics models, Quantitative analysis, Models and modeling.

References

Derissen, S., Quaas, M.F. & Baumgärtner, S. 2011. The relationship between resilience and sustainability of ecological-economic systems. Ecological Economics 70(6): 1121–8.

Uehara, T., Nagase, Y. & Wakeland, W. 2021. "System dynamics modeling of ecological economic systems," pp. 285–310 in Feedback Economics: Economic Modeling with System Dynamics. R.Y. Cavana, B.C. Dangerfield, O.V. Pavlov et al., eds. Cham: Springer.

Disaggregation

Dividing a topic or ecological or economic dataset into separate parts. This process can help to identify which parts of the whole are most important or influential in a particular process. Daw et al. (2011) explore the relationship between the provision of ecosystem services and human well-being by disaggregating services (from the single concept of an ecosystem service to multiple individual services) and human well-being (from one general notion of well-being to separate aspects of well-being). They further disaggregate human society into different economic and demographic categories, arguing that the greater the inequalities within a system, the more important it is to disaggregate to better understand the causes and impacts of inequality. By parsing their datasets so finely, they can identify connections and drivers that would not otherwise be apparent.

Brent M. Haddad

Further reading

Gill & Moeller 2018.

See also: Inequality, Economic inequality,

Ecosystem services, Discrete-time models.

References

Daw, T., Brown, K., Rosendo, S. & Pomeroy R. 2011. Applying the ecosystem services concept to poverty alleviation: the need to disaggregate human well-being. Environmental Conservation 38: 370–79.

Gill, B. & Moeller, S. 2018. GHG emissions and the rural–urban divide: a carbon footprint analysis based on the German official income and expenditure survey. Ecological Economics 145: 160–69.

Disaster risk management (DRM)

a. A set of actions, strategies and policies used to reduce the probability of disaster occurring and adverse impacts of hazards. Encompasses prospective risk management, designed to avoid the development of new risks; corrective risk management, designed to address pre-existing disaster risks; and compensatory risk management, aimed at strengthening social resilience when facing risks that cannot be effectively reduced.
b. The process of implementing an institutional framework or a set of actions that aim to achieve DRM.
c. A conceptual framework based on the understanding that disaster risks are socially constructed and inherent to social and economic activities; DRM points out that disaster risk reduction requires a comprehensive strategy, focused on managing the underlying risks of economic development.

Beatriz M. Saes

Further reading

UNISDR 2007, 2015a, 2015b.

See also: Risk, Risk assessment, Resilience, Social constructionism.

References

UNISDR (United Nations Office for Disaster Risk Reduction). 2007. Hyogo Framework for Action 2005–2015: Building Resilience of Nations and Communities to Disasters. Geneva: UNISDR.

UNISDR (United Nations Office for Disaster Risk Reduction). 2015a. Making Development Sustainable: The Future of Disaster Risk Management. Global Assessment Report on Disaster Risk Reduction. Geneva: UNISDR.

UNISDR (United Nations Office for Disaster Risk Reduction). 2015b. Sendai Framework for Disaster Risk Reduction 2015–2030. Geneva: UNISDR.

Discharges

See: Effluent.

See also: Wastewater, Pollutant, Pollution, Polluted, Pollution abatement, Pollution intensity.

Discounting

The practice of incorporating pure time preference in utility functions (or other welfare criteria, such as consumption streams) of economic models involving individual or aggregate intertemporal choices, including benefit–cost analysis. In the latter cases, it is justified by a preference for the welfare of the present generation over that of future ones, as well as uncertainty and changing tastes to account for diminishing expected utilities due to future events (Frederick et al. 2002).

Mathematically represented by a positive discount rate, which is typically equal to the prevailing interest rate and either held constant (exponential discounting) or declining over time (hyperbolic discounting). Ethically grounded criticism of time discounting, especially in the context of the allocation of exhaustible natural resources, is based on its necessarily prescriptive nature (Baum 2009), and the principle of intergenerational equity or fairness and justice between generations, a fundamental notion to the concept of sustainability.

Marco Vianna Franco

Further reading

Franco et al. 2019; Greaves 2017; Heal 2007.

See also: Pure rate of time preference, Exhaustible resource theory, Hotelling model, Hotelling rule, Benefit–cost analysis (BCA).

References

Baum, S.D. 2009. Description, prescription and the choice of discount rates. Ecological Economics 69: 197–205.

Franco, M.P.V., Gaspard, M. & Mueller, T. 2019. Time discounting in Harold Hotelling's approach to natural resource economics: the unsolved ethical question. Ecological Economics 163: 52–60.

Frederick, S., Loewenstein, G. & O'Donoghue, T. 2002. Time discounting and time preference: a critical review. Journal of Economic Literature 40(2): 351–401.

Greaves, H. 2017. Discounting for public policy: a survey. Economics and Philosophy 33(3): 391–439.

Heal, G. 2007. Discounting: a review of the basic economics. University of Chicago Law Review 74(1): 59–77.

Discourse analysis

a. A multidisciplinary field of social sciences aimed at understanding the content, structure, and/or context in which the oral or written expression of, amongst others, systems of ideas, opinions, perceptions, representations, and/or justifications, are made.
b. A set of qualitative, quantitative, or mixed methods used to explore spoken or written speeches. Each method performs a series of procedures (coding, network analysis, hierarchical classification, factor analysis, among others) that enables reducing, selecting, and rearranging complex information contained in textual or verbal data.

Gaël Plumecocq

Further reading

Dryzek 1997; Alexander 2010; Lebart et al. 1998.

See also: Dialectic reasoning.

References

Alexander, R. 2010. Framing Discourse on the Environment. London: Routledge.

Dryzek, J. 1997. The Politics of the Earth: Environmental Discourses. Oxford: Oxford University Press.

Lebart, L., Salem, A. & Berry, L. 1998. "Textual statistics: scope and applications," pp. 5–20 in Exploring Textual Data. Dordrecht: Springer.

Discrete choice models

Models with a specified probability function of choosing one option among a set of finite or countably infinite alternatives. Given the option, the input variables of the function relate to the option's attributes and the decision-maker's preference; the function's output is the probability value assigned to the corresponding option. For example, to quantify a customer's choice of living location, the model specifies a probability of the chosen location in terms of living attributes such as housing prices, available resources, environmental amenities, transportation plans, and the customer's personal living preferences.

Zhengyuan Gao

Further reading

McFadden 1978; Cooper & Millspaugh 1999.

See also: Choice experiments, Dichotomous choice, Models and modeling, Preference heterogeneity.

References

Cooper, A.B. & Millspaugh, J.J. 1999. The application of discrete choice models to wildlife resource selection studies. Ecology 80(2): 566–75.

McFadden, D. 1978. "Modeling the choice of residential location," pp. 75–96 in Spatial Interaction Theory and Planning Models. A. Karlqvist, L. Lundqvist, F. Snickars & J. Weibull, eds. Amsterdam: North-Holland.

Discrete-time models

Models of complex dynamic systems, the state variables of which change only at a countable number of points in time, that is, at fixed (discrete) intervals, as opposed to continuous-time dynamical systems. If the state space is continuous, the model is known as a map, the most common example of which is the one-dimensional logistic map (May 1976). In the logistic map, the state variable grows exponentially until it approaches the carrying capacity of the environment, where it may generate periodic oscillations. For specific values of its relevant parameter, these oscillations turn chaotic via period-doubling cascades. The economists Amit Bhaduri and Donald Harris showed that the seminal Ricardian one-sector growth model, which predicts the long-term decrease of the profit rate due to the gradual exhaustion of natural resources, could be understood as an example of the logistic map (Bhaduri & Harris 1987).

If the state space is discrete, the discrete-time model is a cellular automaton (Wolfram 1983), where the evolution rule assigns a new state to a cell as a function of the old state of this cell and of many of its neighbors (for example, Conway's Game of Life or Schelling's model of urban segregation). If the state space is discrete and the evolution rule is probabilistic (as opposed to deterministic), the model is a Markov chain. Finally, agent-based models, which simulate the actions and interactions of a large set of individual agents under specific decision-making heuristics, and stock-flow consistent macroeconomic models, are also examples of discrete-time models.

Oriol Vallès Codina

Further reading

Schelling 1971; Nikiforos & Zezza 2017; Strogatz 2018.

See also: Dynamic systems, Dynamic models, Complexity, Complex systems modeling, Agent-based modeling (ABM), Stock-flow consistent models.

References

Bhaduri, A. & Harris, D.J. 1987. The complex dynamics of the simple Ricardian system. Quarterly Journal of Economics 102(4): 893–902.

May, R.M. 1976. Simple mathematical models with very complicated dynamics. Nature 261(5560): 459–67.

Nikiforos, M. & Zezza, G. 2017. Stock-flow consistent macroeconomics models: a survey. Journal of Economic Surveys 31(5): 1204–39.

Schelling, T.C. 1971. Dynamic models of segregation. Journal of Mathematical Sociology 1 (2): 143–86.

Strogatz, S.H. 2018. Nonlinear Dynamics and Chaos with Applications to Physics, Biology, Chemistry, and Engineering. Boca Raton, FL: CRC Press.

Wolfram, S. 1983. Statistical mechanics of cellular automata. Reviews of Modern Physics 55(3): 601–44.

Discursive

a. Refers to the different ways in which linguistic devices are employed to produce shared meanings of the environment. Such devices can include any form of communication, including texts, numbers, pictures, graphs, speech, or even gestures used in human interaction. They also include all kinds of social practices of constructing the meanings of phenomena. Discursive representations are based on internally coherent storylines through which actors select, interpret, and organize bits of ecological or other information. Each discourse and storyline rests on a set of assumptions, judgments, and contentions that provide the basic terms for analysis, debates, arguments, and disagreements (Dryzek 1997).
b. Discursive strategies are purposeful attempts aimed to influence or persuade others, or to legitimate certain representation of the reality.

Jari M. Lyytimäki

Further reading

Svarstad et al. 2008.

See also: Discursive ethics, Dialectic reasoning, Narrative.

References

Dryzek, J.S. 1997. The Politics of the Earth: Environmental Discourses. Oxford: Oxford University Press.

Svarstad, H., Petersen, L.K., Rothman, D. et al. 2008. Discursive biases of the environmental research framework DPSIR. Land Use Policy 25(1): 116–25.

Discursive ethics

The argument that awareness and expression of the life-world context (Lebenswelt), in which cultures, social relations, and individuals are formed, is the basis for communicative reason. The term "discursive ethics" has its origins in the Frankfurt School of critical theory. Communicative reason is distinct from predetermined forms of rationality. Reasoned discourse can therefore transcend normative preconditions, and offers a practical advancement to Kant's transcendental ethic. Yet the ethic that emerges as discourse participants bring their life-world contexts to bear does not smack of Kantian acontextual, ahistoric universalization. It offers instead a procedural framework for the expressions of diverse participants freed from conformity and normative constraints.

Discursive ethics can make three key contributions to ecological economics. It offers: (1) an integrated approach to ecosystems valuation that can resolve trade-offs; (2) a contextual framework for considering uncertainty and risk; and (3) a basis for identifying operative valuation biases and conditions for their critical reconstruction. Scholars from various backgrounds have sought to operationalize the ideal of an ethical discourse that must go beyond any expert community and include the diverse voices of those affected by common valuation biases. The contributions of empathetic-, local-, and experiential-knowledge experts thus become critically important and can reshape policies. Discursive ethics thus lays the foundation for stakeholder-based valuation, and participatory action research.

SABINE O'HARA

Further reading

Habermans 1983; Biesecker 1996; Dryzek 1990; O'Hara 1996, 2001.

See also: Discursive, Kantian ethics, Critical theory, Environmental ethics, Bioethics, Environmental valuation, Ecosystem services, Deliberative valuation, Stakeholder analysis, Participatory action research.

References

Biesecker, A. 1996. Power and Discourse: Some Theoretical Remarks and Empirical Observations. Bremer Diskussionspapiere zur Sozialoekonomie. A. Biesecker, W. Elsner, K. Grenzdörffer & H. Heide, eds. Nr. 14, October. Universitaet Bremen, Fachbereich Wirtschaftswissenschaft.

Dryzek, J., 1990. Discursive Democracy: Politics, Policy, and Political Science. Cambridge, UK and New York, USA: Cambridge University Press.

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Dissipation

A physical process of gradually disappearing. One building block of ecological economics is the biophysical understanding that perpetual motion machines are impossible because low-entropy/negentropy (available) energy, when used to do work, irreversibly dissipates into high-entropy (increasingly unavailable) energy in natural and economic processes (Georgescu-Roegen 1971; Amir 1994; Melgar-Melgar & Hall 2020). The qualitative change that energy and matter undergo through dissipation must be taken into consideration in economics to avoid the rapid depletion of finite resources, and overwhelming ecosystems with wastes. However,

while energy dissipation presents serious limits to economic processes, materials can be recycled if enough exergy (useful energy) exists to run such processes (Ayres 1999).

Georgescu-Roegen (1975, p. 353) stated that "the Entropy Law is the most economic in nature of all natural laws," and that the existence of entropic indeterminateness "allows not only for life to acquire an endless spectrum of forms but also for most actions of a living organism to enjoy certain amounts of freedom." For example, while humans can economically plan the consumption rate of natural resources to build complex socio-economic systems, humans cannot avoid using up low-entropy energy and matter indefinitely if the scale of their activities drives the rapid dissipation of resources. Thus, dissipation presents serious long-term limits for economic systems that rely on burning finite fossil fuels to maintain high consumption levels and endless economic growth (Ayres & Warr 2005; Ayres et al. 2013). Consequently, entropic dissipation means that the only available energy source in the long run is solar. Understanding the nature of energy and matter dissipation should lead societies to develop habits of resource conservation and resourcefulness to avoid absolute scarcity and depletion.

RIGO E.M. MELGAR

Further reading

Mirowski 1989.

See also: Entropy, Entropy law, Entropic dissipation, Classical thermodynamics, Renewable resource, Non-renewable resource, Exergy, Relative vs. absolute scarcity, Depletion.

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Dissipative structure

Open systems (systems that exchange energy or matter with their environment) are far away from thermodynamic equilibrium. The term is due to Ilya Prigogine, who received the 1977 Nobel Prize for Chemistry for his work on non-equilibrium thermodynamics. In thermodynamic equilibrium, entropy production is zero and all processes are reversible. Away from equilibrium, entropy production is positive, and processes are irreversible. Sufficiently close to equilibrium, non-equilibrium systems tend to settle down to a steady state of minimum entropy production, which can be described by linear equations. Farther away from equilibrium, entropy production increases, non-linearity prevails, and the system becomes unstable. Fluctuations are no longer damped, but may be amplified and may lead to symmetry breaking. Stable and complex macroscopic structures may come into being: order is created out of chaos.

Thus, open systems may maintain a stable low-entropy state far away from thermodynamic equilibrium. This is only possible if the entropy produced by these systems is compensated by a negative entropy flux, that is, the exportation of entropy to the environment. These orderly macroscopic structures are called dissipative structures because it is the entropic dissipation (or degradation) of energy that maintains them. Well-known examples of dissipative structures are Bénard convection cells and living cells in organ-

isms. Even ecological and economic systems may be interpreted as dissipative structures.

FRITZ SÖLLNER

Further reading

Georgescu-Roegen 2018; Kümmel 2011; Nicolis & Prigogine 1977; Prigogine 1978.

See also: Classical thermodynamics, Entropy, Entropy law, Entropic dissipation.

References

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Kümmel, R. 2011. The Second Law of Economics: Energy, Entropy, and the Origin of Wealth. New York: Springer.

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Prigogine, I. 1978. Time, structure and fluctuations. Science 201(September 1): 777–85.

Distributional effects

The impacts of economic, environmental, and natural resources policies on specified human populations. Distributional analysis is sometimes conducted in benefit–cost analysis. This term has been used, for example, to interrogate how privatization of large public utilities effected equity of distribution of resulting economic costs and benefits. A change in business model to pursue profits has the potential to increase social inequity or even harm.

In the degrowth literature, distributional effects have more to do with environmental impacts of economic activity that are inequitably distributed. Some have observed that industrialized, Northern Hemisphere countries have disproportionately contributed to unstable environmental conditions, because of high throughput, by favoring profits and growth over the environment or social goals. As a result, developing, Southern Hemisphere countries are suffering a greater proportion of climate change impacts even though they contribute less to environmental stress. In the degrowth literature there is a sense that this distribution of environmental "goods" as less available to developing countries in the global South is a case of distributional injustice. Pursuing this idea further, scholars must also account for unequal distributional effects that may result from downscaling an economy.

CAROL J. BOND

Further reading

Andrewoni & Galmarini 2013; Birdsall & Nellis 2003; Aghion et al. 1999.

See also: Distributive justice, Climate justice, Inequity, Intragenerational equity, Income distribution, Benefit–cost analysis (BCA), Degrowth, Environmental goods and services, North–South relations.

References

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Birdsall, N. & Nellis, J. 2003. Winners and losers: assessing the distributional impact of privatization. World Development 31(10): 1617–33.

Distributive justice

Concern with the distribution of environmental "goods" and "harms" in a just or fair way. The question is: who or what is the beneficiary of the just distribution? In neoclassical economics, the distribution of the "goods" or "harms" affects human beings only, raising individual and collective social justice considerations. However, in the degrowth literature, nature, or the Earth, is increasingly viewed as the recipient of distributive justice, raising issues of environmental justice and ecological justice. The reason for this extension is that human life is inextricably intertwined with and wholly dependent upon the environment.

Distributive justice used as a construct to investigate the "goods" and "harms" accruing to the environment, and its various life forms, allows ecological economists to incor-

porate the reality that without a functioning biosphere, human life becomes precarious. Whether humans or the biotic planetary systems are the recipients of distributive justice, human beings are the agents creating consequences for the just distribution of environmental and related social benefits. However, it is important to carefully define the social and environmental "goods" to be distributed. They should be neither conflated nor substituted for one another. A further consideration related to distributive justice comes from the Brundtland Commission statement on sustainability. Care must be taken not to unfairly burden (or shift the environmental "bads") to future generations. However environmental and social goods are distributed, and by whichever mechanism, the focus needs to be on intergenerationally sustainable practices.

Carol J. Bond

Further reading

Dobson 1998; Gabriel & Bond 2018; Kish & Bliss 2020; Pelletier 2010.

See also: Distributional effects, Climate justice, Environmental justice, Ecological justice, Social justice, Sustainable development, Environmental goods and services.

References

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Pelletier, N. 2010. Environmental sustainability as the first principle of distributive justice: towards an ecological communitarian normative foundation for ecological economics. Ecological Economics 69(10): 1887–94.

Disturbance

Ecology: any (relatively) discrete event in time that disrupts ecosystem, community, or population structure and/or function and changes resource availability, substrate, or the physical environment (modified from White & Pickett 1985). These disruptions could originate from endogenous events (within the system) or exogenous events (outside the system); for example: fire, wind, water, volcanoes, storms, and invasive species.

Economics: any disruption to an economic equilibrium, thereby affecting human social and behavioral systems. These disruptions change circumstances under which choices occur, affecting such things as prices (or other financial mechanisms); income; the availability or quality of goods, resources, or substitutes; and risk tolerance. Economic and ecological disturbances could have complex interactions and feedbacks (Figure 2). One notable framework for understanding these phenomena is through the lens of coupled human and natural systems (Liu et al. 2007a, 2007b).

Marla Markowski-Lindsay & Meghan Graham MacLean

Further reading

Turner 1989; Brown et al. 2018; Markowski-Lindsay et al. 2020; Varian 2020.

See also: Endogeneity, Exogenous, Coupled human and natural systems, Preference endogeneity, Utility.

References

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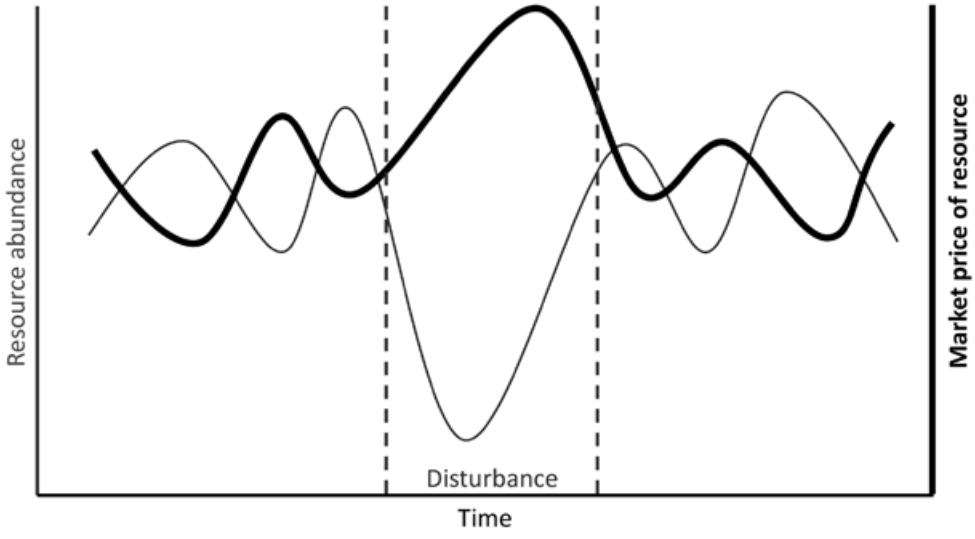

Note: A disturbance event (between dashed vertical lines) can impact both ecosystem structure and/or function and economic activity; the impacts could result in increases or decreases to either system. This figure shows a decrease in resource abundance (a measure of ecosystem structure/ function) and an increase in market price (a measure of economic activity) associated with a disturbance event. One example of this type of disturbance is the introduction of an invasive forest pest. The invasive pest reduces the abundance of a host tree species, and the reduced supply of this forest resource results in an increase in its market price.
Source: Authors.

Figure 2 *Dynamics of a disturbance*

Markowski-Lindsay, M., Borsuk, M.E., Butler, B.J. et al. 2020. Compounding the disturbance: family forest owner reactions to invasive forest insects. Ecological Economics 167: 106461.
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Divergence

A process of trend lines or other indicators deviating or moving apart. Can refer to values, preferences, economic performance of nations, local and regional priorities, and other topics. It is often used to comparatively evaluate changes in environmental and social outcomes over time.

Finance: when the value of an asset no long tracks an underlying related trend or indicator, signaling a buying or selling opportunity on the assumption that the divergence is temporary.

Biology: in evolutionary biology, a process whereby a population of an inbreeding species diverges over time into two or more increasingly dissimilar descendant species.

Brent M. Haddad

Further reading

Kalinowska & Steininger 2009; Wang et al. 2013.

See also: Convergence, Indicators.

References

Kalinowska, D. & Steininger, K. 2009. Distributional impacts of car road pricing:

settlement structures determine divergence across countries. Ecological Economics 68(12): 2890–96.
Wang, I.J., Glor, R.E. & Losos, J.B. 2013. Quantifying the roles of ecology and geography in spatial genetic divergence. Ecology Letters 16(2): 175–82.

Diversity

The variety or variability of something or a condition.

Economics: economic diversity can refer to the degree to which an economy relies on a broad or narrow range of economic sectors and economic activities, for example, primarily oil and gas production, mining, or fishing, versus thousands of products. The latter is a more complex economic system (Dissart 2003).

Ecology:

a. Ecological diversity can refer to resource diversity, habitat diversity, differentiation diversity, as well as species diversity. An important and long-standing research topic in ecology is the relationship between diversity and stability (McCann 2000; Ives & Carpenter 2007).
b. Biodiversity refers to the varieties of life and living organisms at various levels or spatial scales.

BARRY D. SOLOMON

See also: Complexity, Stability, Biodiversity, Ecosystem, Ecosystem functional diversity, Biome, Fitness.

References

Dissart, J.C. 2003. Regional economic diversity and regional economic stability: research results and agenda. International Regional Science Review 26(4): 423–46.
Ives, A.R. & Carpenter, S.R. 2007. Stability and diversity of ecosystems. Science 317(5834): 58–62.
McCann, K.S. 2000. The diversity–stability debate. Nature 405(6783): 228–33.

Dogmatism

Derived from *Dogma Catholicum*, first used in the early Middle Ages to refer to beliefs or principles deemed incontrovertibly true by the Catholic Church. Ecumenical councils continued to issue dogmas over the centuries, often to refute belief systems considered heretical by the Church. The institutional and religious supremacy of the medieval Church meant that dogma became inseparable from absolute veracity; the truest of the true; a truth that was essentially absurd to refute. Dogmatism is the systemic adherence to dogmas. Complex historical changes, including the splintering of the Catholic Church during the Protestant Reformation, the rise of natural philosophy and skepticism during the Enlightenment, and the emergence of atheism from the 19th century onward, undermined not only Catholic dogmas, but the concept of dogma itself.

By the 20th century, dogma and dogmatism were widely viewed as a negative and unhelpful commitment to a set of beliefs. The origins of the concept help to explain its enduring connotation as: (1) a belief, or set of beliefs, that the believer holds uncritically and unreasonably, despite the existence of substantial evidence to undermine the belief(s); and (2) the weaponization of belief to attack, refute, or weaken what are viewed by believers as heresies or non-truths. More recently, dogmatism has come to represent a kind of personality flaw: intellectual laziness and an inability to evolve; uncooperativeness, unreasonableness, and reactive insecurity.

JEREMY L. CARADONNA

Further reading

Rokeach 1954; Spash 2020.

See also: Monism, Pluralism, Conceptual pluralism.

References

Rokeach, M. 1954. The nature and meaning of dogmatism. Psychological Review 61(3): 194–204.

Spash, C.L. 2020. A tale of three paradigms: realising the revolutionary potential of ecological economics. Ecological Economics 169: 106518.

Double dividend

a. A double benefit for the economic system and the environment derived from the implementation of a revenue-neutral tax reform. The double-dividend hypothesis was introduced in the early 1990s by Pearce (1991) and was further developed by Goulder (1995). The first dividend is obtained by the reduction of the environmental damage due to the environmental tax reform (for example, a tax to reduce carbon emissions), while improvements in the efficiency of the tax system from the reduction of distortionary taxes lead to the second dividend.
b. (From Goulder 1995) the revenue-neutral substitution of environmental taxes for ordinary income taxes might offer a double dividend: by not only improving the environment, but also reducing certain costs of the tax system. A weak double dividend claims that returning tax revenues through cuts in distortionary taxes leads to cost savings relative to the case where revenues are returned lump sum. The stronger versions contend that revenue-neutral swaps of environmental taxes for ordinary distortionary taxes involve zero or negative gross costs.

RAFAEL GARAFFA

See also: Pollution taxes, Carbon taxes, Environmental taxes.

References

Goulder, L.H. 1995. Environmental taxation and the double dividend: a reader's guide. International Tax and Public Finance 2(2): 157–83.

Pearce, D. 1991. The role of carbon taxes in adjusting to global warming. Economic Journal 101(47): 938–48.

Doubling time

The length of time that it takes for a population, economy, natural resource consumption or production, money, or any other given quantity to double its value or size at a constant growth rate (Costanza et al. 1997, p. 93). Mathematically, this can be expressed as:

$$T_d = t\frac{\ln(2)}{\ln 1 + r/100}$$

where T_d = doubling time, t = time and r = growth rate.

A rule of thumb to estimate the doubling time in years for a constantly growing quantity is to divide the number 70 by the percentage growth rate. If the rate of doubling is sustained, the number attained at the end of each doubling period will exceed the sum of the corresponding numbers for all previous doublings. Such a growth rate is ultimately unsustainable.

BARRY D. SOLOMON

Further reading

Ehrlich 1968.

See also: Population, Economic growth, Growth rate, Fossil fuels, Peak oil supply.

References

Constanza, R., Cumberland, J.H., Daly, H., Goodland, R. & Norgaard, R.B. 1997. An Introduction to Ecological Economics. Boca Raton, FL: CRC Press.

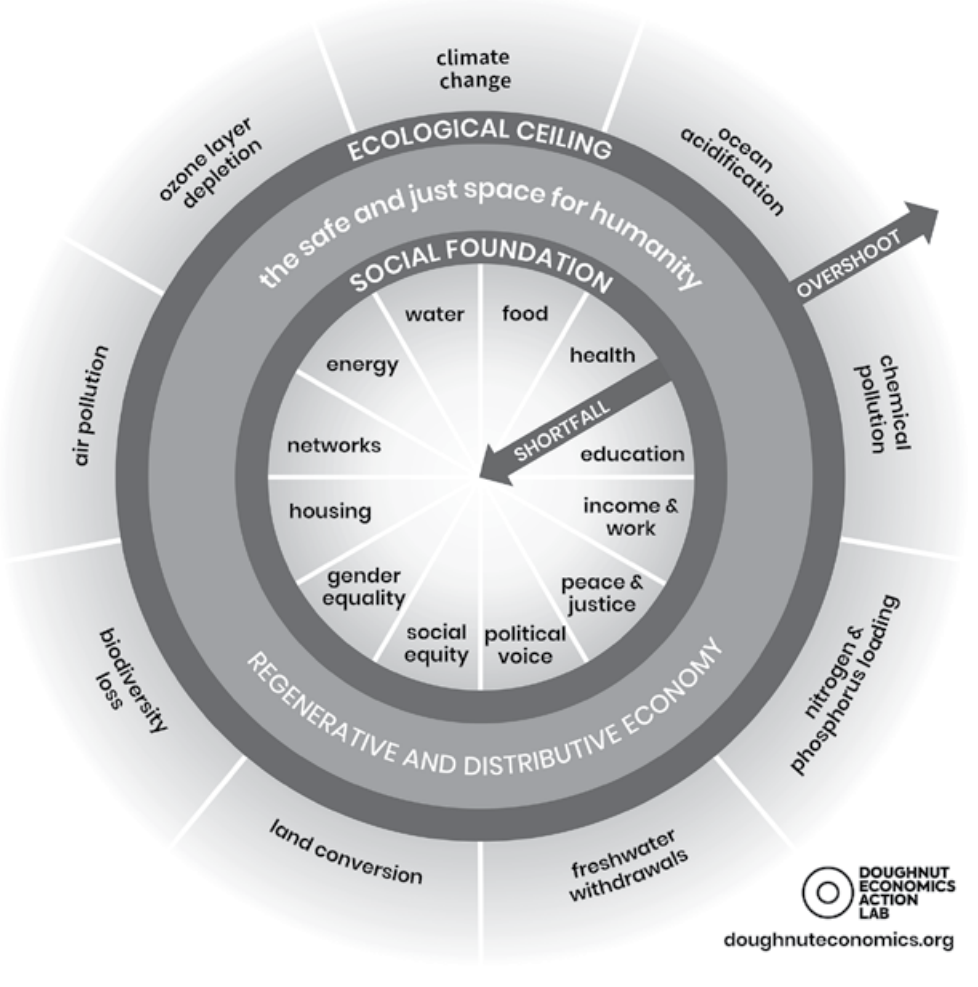
Ehrlich, P.R. 1968. The Population Bomb. San Francisco, CA: Sierra Club/Ballantine Books.

Doughnut economics

Kate Raworth (2017) popularized this term through an innovative "doughnut" diagram of the basic tenets of ecological economics, notably that economic life depends on the biosphere, and social and planetary boundaries should not be overstepped (see Figure 3). Raworth diagnoses a wrong turn in economic theory at the time of John Stuart Mill, when economics was redefined from a goal-oriented discipline to a law-discovering pseudo-science. She finds inspiration among ecological economists and classical economists such as Jean Sismondi. The sustainable economy to which she aspires would be embedded "within society and within nature and powered by the sun."

Gareth Dale

See also: Ecological economics, Classical economics, Planetary health, Carrying capacity, Overshoot.



Source: Doughnut Economics Action Lab, reprinted with permission (Creative Commons).

Figure 3 *The doughnut of social and planetary boundaries*

Reference

Raworth, K. 2017. Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist. London: Random House.

DPSIR (Drivers–Pressures–State–Impact–Response) framework

A heuristic illustrating the mechanisms of (often environmental) impact generation. The Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) uses the same approach but has renamed drivers as "indirect drivers" and pressures as "direct drivers." The heuristic was popularized by the European Environment Agency (EEA) (Smeets & Weterings 1999) and is used by the European Statistical Office, but draws on earlier and less detailed schemes. The best-known are the Organisation for Economic Co-operation and Development's Pressure–State–Response systematique for environmental policy, and United Nations Conference on Sustainable Development's Driving Force–State–Response scheme for sustainable development. The heuristic has been used successfully by the EEA as a tool of the science–policy interface (Hák et al. 2007). It illustrates interactions and underlying mechanisms, and helps understanding of the different stakeholders and the complementarity of curative, mitigating, and preventive measures (see Figure 4).

However, DPSIR is no analytical tool; what is considered a pressure or driver depends on the question analyzed. Hence it is necessary to "anchor" the circle by defining one element based on empirical phenomena and classifying other relevant facts with reference to that anchor. For instance, when analyzing the mechanisms of biodiversity loss, climate change can be either a driver, a pressure, or a result, depending on the research question and the corresponding anchor chosen (Maxim et al. 2009).

Joachim H. Spangenberg

Further reading

Bell & Morse 2018; Redclift & Springett 2015.

See also: Heuristic, Impact assessment, Environmental impact assessment.

References

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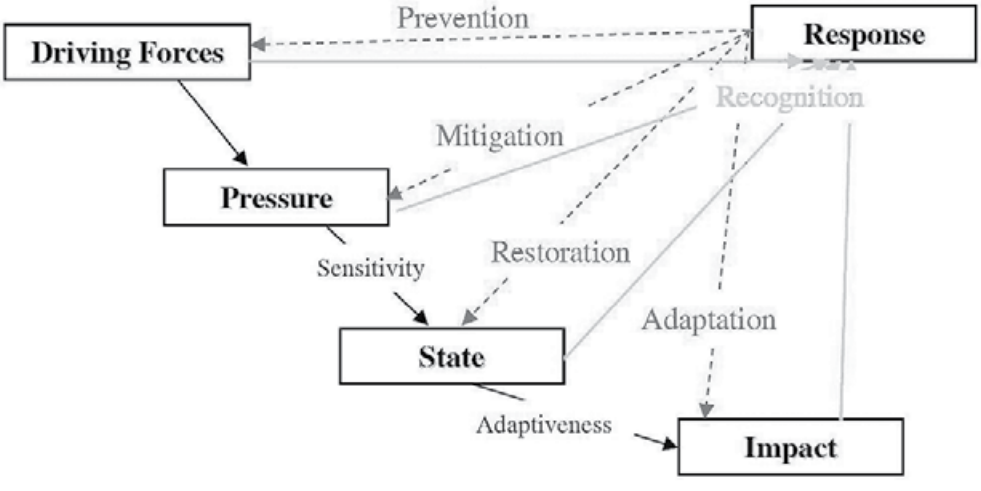
Hák, T., Moldan, B. & Dahl, A.L., eds. 2007. Sustainable Indicators: A Scientific Assessment.



Source: Author.

Figure 4 *The DPSIR conceptual framework*

SCOPE Series Vol. 67. Washington, DC: Island Press.
Maxim, L., Spangenberg, J.H. & O'Connor, M. 2009. An analysis of risks for biodiversity under the DPSIR framework. Ecological Economics 69(1): 12–23.
Redclift, M. & Springett, D., eds. 2015. Routledge International Handbook of Sustainable Development. Abingdon: Routledge.
Smeets, E. & Weterings, R. 1999. Environmental Indicators: Typology and review. EEA Technical Report 25. Copenhagen: European Environment Agency.

Drawdown

Hydrology: a reduction in the level of a water surface. It can refer to lake, well, or groundwater levels. Sustained (multi-year) drawdown can be a sign of mismanagement or overconsumption of water resources, an example of biophysical disequilibrium that can be included in ecological economic models.

General: any reduction in a quantity of something. Often used for financial account balances, but also in reference to natural capital.

Brent M. Haddad

Further reading

Madani & Dinar 2012.

See also: Biophysical equilibrium, Bioeconomic modeling, Groundwater governance, Water governance.

Reference

Madani, K. & Dinar, A. 2012. Non-cooperative institutions for sustainable common pool resource management: application to groundwater. Ecological Economics 74: 34–45.

Duty

Finance: a tax on an imported or exported good. A tariff.

General and philosophy: a commitment or legal or moral obligation. Immanuel Kant argues that a duty to uphold moral law should guide personal conduct and will lead to a better society. This is a procedural (deontological) approach to social organization in which the motivation itself renders an action good. It contrasts strongly with the ends-based (teleological) approach of utilitarianism, which lies at the moral core of mainstream economics.

In mainstream economics, a good outcome is determined by whether it improves one's well-being. If the end is achieved—well-being improved—then the act is good. The worthiness of duty (for example, to tell the truth; to act virtuously; to not murder) provides a challenge to a society based on individual preference satisfaction. The ubiquitous tool of benefit–cost analysis, rooted in utilitarian measures of well-being, does not easily accommodate duty as a reason for allocation of resources. Duty is of interest to ecological economists because preservation of nature is not easily incorporated into utilitarian cost–benefit analysis, but makes sense as an expression of one's duty to others.

Brent M. Haddad

Further reading

Rohlf 2020; Haddad & Howarth 2006; Gelso & Peterson 2005.

See also: Tariff, Kantian ethics, Deontological, Teleology, Utilitarianism, Lexicographic preferences.

References

Gelso, B. & Peterson, J. 2005. The influence of ethical attitudes on the demand for environmental recreation: incorporating lexicographic preferences. Ecological Economics 53(1): 35–45.
Haddad, B. & Howarth, R. 2006. "Protest bids, commensurability, and substitution: contingent valuation and ecological economics," pp. 133–51 in Handbook on Contingent Valuation, A. Alberini & J.R. Kahn, eds. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.
Rohlf, M. 2020. "Immanuel Kant," The Stanford Encyclopedia of Philosophy, Fall 2020 edn. E.N. Zalta, ed. https://plato.stanford.edu/archives/fall2020/entries/kant/.

Dynamic models

Analytical or computational representations of systems that include changes in time (dynamics). Some important classes of dynamic models include: (1) simulation models, which represent outcomes of systems based on dynamic environmental and management inputs (for example, biophysical models; see Bellocchi et al. 2011); and (2) forward-looking models, where a decision-making process is represented that accounts for expected future external changes (an open-loop model) or expected future consequences of present and future decisions (a closed-loop model) (Kamien & Schwartz 2012). Forward-looking models are typically relevant when studying learning, repeated games, or optimal bioeconomic management. Dynamic models are often modeled using differential or difference equations, with forward-looking models generally solved using calculus of variation, optimal control theory, or dynamic programming.

James A. Rising

See also: Biophysical economics, Bioeconomic modeling, System dynamics models, Differential equation, Dynamic systems.

References

Bellocchi, G., Rivington, M., Donatelli, M. & Matthews, K. 2011. Validation of biophysical models: issues and methodologies. Agronomy for Sustainable Development 30(1): 109–30.

Kamien, M.I. & Schwartz, N.L. 2012. Dynamic Optimization: The Calculus of Variations and Optimal Control in Economics and Management, 2nd edn. Mineola, NY: Dover Publications.

Dynamic systems

Economies and ecosystems are dynamic and non-linear systems. Dynamic systems typically exhibit changes in spatio-temporal phenomena. An early example of a model of a dynamic biological system is the Lotka–Volterra model of oscillating predator–prey populations (Volterra 1926). This model was aspatial in that it only described changes through time to the population of foxes and rabbits in a system. Dynamic systems involve feedbacks between elements of the model. In a predator–prey model the predators can diminish the population of prey, which "feeds back" to cause a subsequent declining predator population. In Earth system models (which are also dynamic systems), melting icecaps can change the Earth's albedo, which changes the nature and magnitude of incoming solar radiation that is absorbed by the Earth. This in turn can raise the temperature of the surface of the Earth, accelerating ice melt in positive feedback.

Understanding dynamic systems is a challenging exercise in understanding how different elements of a system interact with one another. Typically, these interactions are characterized as positive or negative feedbacks, but that can be an oversimplification. Another famous aspatial model of an ecological-economic system is the famous World3 model used for the *Limits to Growth* report of the Club of Rome (Meadows et al. 1972). World3 was represented as a system of "stocks" and "flows" of resources for the entire world in the STELLA visual programming language. The model captured interactions between five variables: population, food production, industrialization, pollution, and consumption of non-renewable resources. World3 is a model of a dynamic system that projected declining resources with growing then falling population, food production, and pollution. Follow-up studies comparing the projections of *Limits to Growth* to empirical observations have demonstrated that the "standard-run" scenario (or "business as usual") closely matches the changes to the five variables that have taken place since 1972 (Turner 2008).

Paul C. Sutton

See also: Limits to growth, Population dynamics, Coupled system dynamics, Dynamic models, System dynamics models, Spatial dynamics, Temporal dynamics, Stocks, Flows.

References

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Predicament of Mankind. New York: Universe Books.
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Dynamic systems modeling

See: System dynamics models.

See also: Dynamic models, Dynamic systems, Limits to growth.

E

Easement

a. The right to cross or otherwise use and/or enter the real property of another person, organization, or business. Historically, four general types of easements were recognized under common law: (1) right-of-way; (2) easements for excavations; (3) easements for light/sun and air; and (4) easements for artificial waterways. In recent decades, many additional types of easements have been recognized by courts.
b. A conservation or historic preservation easement vests a voluntary power in a government organization or a conservancy/land trust to constrain land use on a specified land area to protect its conservation and/or environmental values by not using, developing, or subdividing the land (or building) while retaining its private ownership. The use of conservation easements is generally assumed, based on economic theory, to reduce land prices despite conflicting empirical evidence (Nickerson & Lynch 2001; Lynch et al. 2007; Anderson & Weinhold 2008).

BARRY D. SOLOMON

Further reading

Curran et al. 2016.

See also: Common law, Land use designations, Conservation, Preservation, Conservancy, Trust, Public trust doctrine.

References

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Easterlin paradox

The contradiction between two empirical income–happiness relationships. Countries that have higher gross domestic product (GDP) per capita are on average happier, but over time, countries with greater GDP per capita growth do not experience greater increases in happiness. This evidence applies to countries around the world, including the less developed. The measures of happiness are obtained using survey questions regarding individuals' evaluations of their lives as a whole and considered to be both reliable and valid (OECD 2013).

Richard Easterlin first discovered the relationships in 1974 (Easterlin 1974). Later, he and colleagues clarified that the trends of GDP per capita and happiness are unrelated, while short-run fluctuations are positively related, for example, during recessions (Easterlin et al. 2010). The paradox does not imply that happiness trends are flat, contrary to what some studies have suggested (e.g., Clark et al. 2008). The paradox implies that growth-oriented goals will not have lasting improvements on happiness. Consequently, it has received a lot of criticism (e.g., Stevenson & Wolfers 2008) but is also referenced in

critiques of economic development (e.g., Schneider et al. 2010).

The principal explanation of both the cross-sectional and time-series evidence comes from individuals' tendency to compare with references (based on their peers and past experience) (Tversky & Kahneman 1991; Clark et al. 2008). Further contributions address criticisms and both add to and explain the evidence (Easterlin 1995, 2017; Easterlin & O'Connor 2021).

KELSEY J. O'CONNOR

Further reading

Bartolini & Sarracino 2014.

See also: Happiness, Utility, Consumption externalities, Subjective well-being, Economic development, Post-development, Social capital.

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Schneider, F., Kallis, G. & Martínez-Alier, J. 2010. Crisis or opportunity? Economic degrowth for social equity and ecological sustainability. Introduction to this special issue. Journal of Cleaner Production 18(6): 511–18.

Stevenson, B. & Wolfers, J. 2008. Economic growth and subjective well-being: reassessing the Easterlin paradox. Brookings Papers on Economic Activity 39(1): 1–87.

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Ecocentrism

A worldview focused on a nature-centered system of values that accepts that humanity is part of nature and must treat it with responsibility and respect. Ecocentrism finds inherent (intrinsic) value in all of nature. It takes a much wider view of the world than does anthropocentrism, which sees individual humans and the human species as more valuable than all other organisms. Ecocentrism is the broadest of worldviews, but there are related worldviews (that have been called intermediate varieties). Ecocentrism goes beyond biocentrism (ethics that sees inherent value to all living things) by including environmental systems as wholes, and their geodiversity. It also goes beyond zoocentrism (seeing value in animals) on account of explicitly including flora and the ecological contexts for organisms.

HAYDN G. WASHINGTON

Further reading

Kopnina et al. 2018; Washington et al. 2017, 2022; Curry 2011.

See also: Biocentrism, Deep ecology, Intrinsic value, Environmental ethics, Bioethics, Environmental rights.

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half movement. Biological Conservation 217: 140–48.
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Ecocide

Deliberate and negligent, wanton, or unlawful acts committed with knowledge that there is a substantial likelihood of severe and widespread or long-term damage to the natural environment. At least ten countries have codified ecocide as a crime within their borders during peacetime, including many former republics of the Soviet Union.

Prakash Kashwan

Further reading

Churchill 2002; Higgins 2012; Higgins et al. 2013; Brisman & South 2014; Dunlap 2021.

See also: Environmental rights, Indigenous rights, Human rights, Ecological justice, Environmental justice, Ecocentrism.

References

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Higgins, P., Short, D. & South, N. 2013. Protecting the planet: a proposal for a law of ecocide. Crime, Law and Social Change 59: 251–66.

Eco-design

From Ian McHarg (1969) and adapted by Pioch and Souche (2021): designing sustainable infrastructure development projects with precise/specific technical and ecological functions, which generate socio-ecological co-benefits, without generating additional costs in the long term. According to Bergen et al. (2001), the design of development projects must integrate the issues of human societies in an ecological approach, for a mutual human–nature benefit, following three steps that ratify its application: (1) design in accordance with ecological principles; (2) design adapted to the environmental specificity of each site; and (3) maintain the functional requirements of the structures, regardless of environmental requirements.

Sylvain Pioch

See also: Sustainable design, Eco-innovation, Eco-efficiency, Industrial ecology, Sustainable business, Circular economy, Sustainable recycling, Sustainable consumption.

References

Bergen, S.D., Bolton, S.M. & Fridley, J.L. 2001. Design principles for ecological engineering. Ecological Engineering 18(2): 201–10.
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Pioch, S. & Souche, J.C. 2021. Eco-Design of Marine Infrastructures: Towards Ecologically-Informed Coastal and Ocean Development. New York: Wiley.

Eco-efficiency

a. A ratio between an economic output (numerator) and a natural resource (for example, copper, tungsten), as an ecological or environmental input (denominator). A greater extent of eco-efficiency occurs when this ratio increases. Eco-efficiency was coined and popularized by the World Business Council for Sustainable Development (WBCSD) in the early 1990s but is now commonly and frequently referred to in domains such as

ecological economics, industrial ecology, and other areas of sustainability.
b. A maxim that refers to a more prudent use of natural resources.

Andrea S. Thorpe

Further reading

DeSimone & Popoff 2000.

See also: Eco-design, Rebound effect, Jevons paradox, Circular economy.

Reference

DeSimone, L.D. & Popoff, F. 2000. Eco-Efficiency: The Business Link to Sustainable Development. Boston, MA: MIT Press.

Ecofeminism

The term, short for "ecological feminism," was coined in the 1970s by Francoise D'Eaubonne (D'Eaubonne 1974). It has two main interconnected sets of meanings or applications.

Political activism: the linking of environmental and other political emancipatory causes to "radical" action, as famously seen in the 1980s Greenham Common anti-nuclear protests, where women were seen as having an innate connection to life and nature and, by extension, the survival of the planet. (Male) patriarchy was blamed for environmental as well as socio-economic injustices.

Academic (social, political, and environmental) sustainability discourses: the extension of this activist perspective to a general anti-exploitation stance that is seen as "anti-masculinist" insofar as "masculinism" refers to capitalist, exploitative, competitive, hegemonic: against the natural world as well as marginalized social groups. Sustainability is seen as a central moral political issue, in which ecology, feminism, socialism, and indigenous politics and globalism are brought together (Salleh 1997, p. 103). The guiding principle of responsibility for our physical environment via the use of fewer resources is matched by that of social responsibility, for equal sharing of those resources (Findlow 2019). "Internationalism" is conceived as a commitment to the common good, for people in other societies as well as to future populations (Lister 1997).

Sally Findlow

See also: Feminist ecological economics, Feminist political ecology, Social equity, Ecology, Environmentalism.

References

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Salleh, A. 1997. Ecofeminism as Politics: Nature, Marx and the Postmodern. London: Zed Books.

Ecohealth

A concept that combines ecosystem health and public health as intertwined objectives, with an emphasis on ecological restoration and allied activities (for example, agroforestry, urban greening, and so on). The science, practice, and policy of ecological restoration undertaken with an ecohealth approach considers its implications for human health. Likewise, public health interventions designed with an ecohealth perspective consider the role of ecosystem health in impacting human health.

This framework differs from planetary health and "one health" in that it is grounded in place-based ecological restoration. The "ecohealth hypothesis" states that the restoration and rehabilitation of a degraded ecosystem will have significant health benefits for people who interact with that ecosystem, in present and future generations.

Laura Orlando, James C. Aronson, Adam T. Cross & Neva R. Goodwin

Further reading

Breed et al. 2020; Cross et al. 2019.

See also: Ecosystem health, Environmental health, Human health, Public health, One health, Planetary health, Ecological restoration, Well-being economy.

References

Breed, M.F., Cross, A.T., Wallace, K. et al. 2020. Ecosystem restoration: a public health intervention. EcoHealth 18: 269–71.

Cross, A.T., Nevill, P.G., Dixon, K.W. & Aronson, J. 2019. Time for a paradigm shift towards a restorative culture. Restoration Ecology 27(5): 924–8.

Eco-innovation

An improvement in environmental performance of products and processes, reducing the environmental impact caused by consumption and production activities, whether the main motivation for its development or deployment is environmental or not (Carrillo-Hermosilla et al. 2009, 2010). One of the first appearances of the concept of eco-innovation in the literature is in the book by Fussler and James (1996). Rennings (2000) first introduced the term "eco-innovation," addressing explicitly three kinds of changes towards sustainable development: technological, social, and institutional innovation.

As stressed by the OECD (2009), eco-innovation may be environmentally motivated, but may also occur as a side-effect of other goals, such as reducing production costs. From the social point of view, it does not matter very much if the initial motivation for the uptake of eco-innovation is purely an environmental one. It is more difficult to verify an environmental motivation than an environmental result, although the latter may also prove challenging. While it is mainly environmental impacts that define eco-innovation, economic and social impacts play a crucial role in its development and application, and hence determine its diffusion path and contribution to competitiveness and overall sustainability.

Javier Carrillo-Hermosilla

See also: Green innovations, Grassroots innovations, Business innovation, Sustainable business, Circumfauna.

References

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Rennings, K. 2000. Redefining innovation: eco-innovation research and the contribution from ecological economics. Ecological Economics 32(2): 319–32.

Eco-labeling

Eco-labels (n. eco-label; v. eco-labeling) are a form of environmental performance disclosure that can help consumers, including institutional purchasers, to easily identify products or services that are deemed environmentally preferable based on independently developed criteria and certified by accredited bodies. Eco-labels are typically developed and operated by non-governmental environmental organizations or multi-stakeholder consortia (for example, Forest Stewardship Council), and remain voluntary, relying on consumer awareness for market transformation. However, they can also be government-run and made mandatory (for example, the United States Energy Guide), which can help to increase their effectiveness. Due to the proliferation of "greenwashing" claims and labels, only "third-party" eco-labels should be considered credible.

The International Organization for Standardization (ISO) classifies eco-labels into Type I: multi-attribute "Seal of Approval" based on life-cycle assessment (for example, German Blue Angel); Type II: single-attribute claim certification (for example, "CFC-free," "Dolphin-safe"); and Type III: detailed "Report Card" type disclosures (for example, Environmental Product Declaration) (see ISO 2019).

Abhijit Banerjee

Further reading

Teisl 2007; Bostrom & Klintman 2011; Mason 2013; Carlson & Palmer 2016; van der Ven 2019.

See also: Greenwashing, Sustainability, Sustainable business.

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van der Ven, H. 2019. Beyond Greenwash: Explaining Credibility in Transnational Eco-labeling. New York: Oxford University Press.

Ecological anthropology

Developed in the 1960s as a response to cultural ecology (notably established by Julian Steward), an anthropology that looks at human beings as ecological populations. It often focuses upon a single ecosystem and the ways it constrains and determines the subsistence patterns of a usually small human population, and therefore their cultural development. It sees the complexity of a culture—its technology, social forms, work organization, beliefs, practices, and lifeways—as borne of the need to adapt to, alter, and maintain a human population's habitat. Drawing upon methods, concepts, and terminology from ecology, systems theory, and economics, among others, its assessment of the environment is largely biophysical. Its lens can be applied to a variety of human–environment arrangements, from forager societies both past and present, through the archeology of earlier agricultural societies, to contemporary environmental crises.

Although environmental anthropology and ecological anthropology are sometimes used interchangeably, the former's approach is broader, and in some ways is a response to criticisms levied against the latter for being overly reductionist and deterministic, as well as often oversimplifying in its overreliance on the concept of static equilibrium. Further, it maintains an ontological distinction between humans and the environment that has been more broadly critiqued. These criticisms continue to be reckoned with as the scholarship grows, moving in a more processual direction, which sees human–nature interactions as contingent. In so doing it also seeks to give credence to the emic perspective of indigenous epistemologies in conjunction with the predominant scientifically grounded basis of much ecological anthropology.

JOSHUA J. STERLIN

Further reading

Kopnina & Shoreman-Ouimet 2017; Kottack 1999; Gowdy 1998.

See also: Culture, Cultural values, Political ecology, Carrying capacity, Traditional knowledge, Ecosystem.

References

Gowdy, J.M. 1998. Limited Wants, Unlimited Means: A Reader on Hunter-Gatherer Economics and the Environment. Washington, DC: Island Press.

Kopnina, H. & Shoreman-Ouimet, E., eds. 2017. Routledge Handbook of Environmental Anthropology. London: Routledge/Taylor & Francis Group.

Kottack, C.P. 1999. The new ecological anthropology. American Anthropologist 101(1): 23–35.

Ecological citizenship

The status and practice of being a citizen of the environment. Also called environmental citizenship. An ecological citizen is an individual who claims their right to a livable environment and accepts responsibility to act in public and/or private to reduce their impact on other living beings and ecosystems. Actions can include political engagement

such as voting, protests, and lifestyle practices that reduce individual carbon footprint such as cycling and veganism. Academics use the concept to challenge conventional, nation-state-focused meanings of citizenship, whereas governments use it to promote pro-environmental behavior amongst their citizenries. The Government of Canada's Green Plan was the first government document to use the phrase in 1990.

SHERILYN MACGREGOR

Further reading

Cao 2015; MacGregor 2014; Smith 1998.

See also: Sustainable consumption, Pro-environmental behavior (PEB), Environmentalism, Ecocentrism, Carbon footprint.

References

Cao, B. 2015. Environment and Citizenship. London: Routledge.

MacGregor, S. 2014. "Ecological citizenship," pp. 107–32 in The Handbook of Political Citizenship and Social Movements. H.A. van der Heijden, ed. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Smith, M.J. 1998. Ecologism: Towards Ecological Citizenship. Minneapolis, MN: University of Minnesota Press.

Ecological constraints

Ecology:

a. Those environmental characteristics that give shape to a species' physical and social evolution.
b. The biophysical limits to growth of an organism or population, often resulting from inherited (for example, genetic) and/or environmental factors. Frequently measured in terms of physical availability of resources and energy (for example, food) necessary for physical and social reproduction.

Neoclassical economics:

a. Those environmental characteristics with which social processes, functions, and forms must contend and through which they evolve. Sometimes posed as a limit to individual or social activity (for example, limits to economic growth).
b. Ecological constraints are overcome through the price system by substituting "natural capital" with other factors of production, including the application of technology, capital, and labor (Mayumi et al. 1998).

Ecological economics: ecological constraints pose physical limits to individual behaviors and group dynamics that cannot be overcome. Societies do not make the rules governing "external" physical environmental characteristics—the laws of thermodynamics, gravity, the speed of light, and so on—and are therefore inherently constrained. Nevertheless, ecological constraints are internalized and reflected through prevailing power relations. Forms of social organization that unevenly distribute and control access to resources produce "scarcity" that will constrain social and physical potential for less powerful groups and individuals (Kallis 2021).

Political ecology: ecological constraints are necessarily tied to social conflicts over ways of relating to and valuing nature (Brand et al. 2021). Social conflicts shape how environmental benefits and burdens are distributed, and therefore pose new constraints and opportunities to groups as they adapt to changing environmental circumstances.

JEFFREY S. ALTHOUSE

See also: Scarcity, Resource scarcity, Relative vs. absolute scarcity, Limits, Limits to growth, Principle of substitution, Substitutability, Planetary health.

References

Brand, U., Muraca, B., Pineault, E. et al. 2021. From planetary to societal boundaries: an argument for collectively defined self-limitation. Sustainability: Science, Practice and Policy 17(1): 305–15

Kallis, G. 2021. Limits, ecomodernism and growth. Political Geography 87: 102367.

Mayumi, K., Giampietro, M. & Gowdy, J.M. 1998. Georgescu-Roegen/Daly versus Solow/

Stiglitz revisited. Ecological Economics 27: 115–17.

Ecological debt

The cumulative sum of environmental injustices where resource extraction and/or pollution have burdened the people and environments of one geographical area while enriching the people of another one, often the global South versus global North. The debt has two parts: underpaid and/or unequal net flows of natural resources such as minerals, fuels, biomass, and genetic information (referred to as ecologically unequal exchange); and overuse of ecological services such as absorption capacity (of, for example, carbon dioxide) above the equitable rights of the appropriators (Martinez-Alier 2002; Paredis et al. 2008).

Ecological debt is a historical concept and has accrued through periods of colonialism, imperialism, and uneven terms of trade. It was first developed within grassroots organizations partly as a response to the financial debt crisis of the 1980s and 1990s, when developing countries were put under economic restraints ("structural adjustment programs") by multilateral financial creditors. Ecological debt thus became a policy tool for "reversing the arrow of arrears" (Warlenius et al. 2015). Attempts to quantify ecological debts have been made with both monetary and biophysical metrics. Local applications also exist, where intergenerational aspects are emphasized over geographical ones.

Rikard H. Warlenius

See also: Debt, Ecologically unequal exchange, Environmental accounting, Natural resource accounting, North–South relations, Environmental justice.

References

Martinez-Alier, J. 2002. The Environmentalism of the Poor: A Study of Ecological Conflicts and Valuation. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Paredis, E., Goeminne, G., Vanhove, W. et al. 2008. The Concept of Ecological Debt: Its Meaning and Applicability in International Policy. Cambridge, MA: Academia Press.

Warlenius, R., Pierce, G. & Ramasar, V. 2015. Reversing the arrow of arrears: the concept of "ecological debt" and its value for environmental justice. Global Environmental Change 30: 21–30.

Ecological distribution conflicts

Social conflicts over the unfair and uneven distribution of environmental burdens or environmental benefits across different social groups and actors. Environmental burdens include, among others, adverse exposure to contaminated water, air and soil, toxic waste, climate change impacts, or the risk thereof. Environmental benefits include, among others, enjoying a healthy environment, access to land, water, forests and natural resources in general, biocultural diversity, and other benefits and values derived from cultural environments, such as sacred places and landscapes.

The term "ecological distribution conflict" was first proposed in 1996 by Joan Martínez-Alier and Martin O'Connor to highlight differences with "economic distribution conflicts" arising over salaries, prices, profits, or rents (Martínez-Alier & O'Connor 1996). Ecological distribution conflicts cannot necessarily be resolved through economic measures, such as monetary compensation, or correct price schemes, but are conflicts over incommensurable values that different social groups associate with the environment. The term is often used interchangeably with environmental, socio-environmental, or ecological conflicts.

Arnim Scheidel

Further reading

Walter 2009; Scheidel et al. 2018.

See also: Environmental justice, Environmentalism, Violence in environmental conflict, Inequity, Inequality, Distributional effects, Incommensurable values.

References

Martínez-Alier, J. & O'Connor, M. 1996. "Ecological and economic distribution conflicts," pp. 153–83 in Getting Down to Earth: Practical Applications of Ecological Economics. R. Costanza, J. Martínez-Alier and O. Segura, eds. Washington, DC: Island Press.

Scheidel, A., Temper, L., Demaria, F. & Martínez-Alier, J. 2018. Ecological distribution conflicts as forces for sustainability: an overview and conceptual framework. Sustainability Science 13(3): 585–98.

Walter, M., 2009. Conflictos ambientales, socio-ambientales, ecológico distributivos, de contenido ambiental … Reflexionando sobre enfoques y definiciones. [Environmental conflicts, socio-environmental conflicts, ecological distribution conflicts, conflicts over environmental concerns … Reflecting about different approaches and definitions]. Boletín ECOS del Centro de Investigación para la Paz (6): 2–9.

Ecological-economic models

See: Bioeconomic modeling.

See also: Biophysical economics, Coupled human and natural systems, Models and modeling.

Ecological economics

The view that the macroeconomy is a subsystem of the ecosphere that is sustained by a metabolic throughput of matter-energy, beginning with depletion of the finite ecosphere's low entropy resources and ending with its pollution by resulting high-entropy wastes (Daly & Farley 2011). The economy recycles materials to varying extents; energy cannot be recycled. The containing ecosphere is materially closed and its biogeochemical cycles, powered by the Sun, recirculate materials.

Ecological economists ask: how big is the economic subsystem relative to the total ecosphere? How big could it be without destroying the life-sustaining functions of the ecosphere? And how big should it be to maximize cumulative lives supported over time at a good (not luxurious) level of welfare? These questions are not asked in neoclassical economics. Ecological economics focuses, first, on the scale of the economy relative to the ecosphere (is it sustainable?); second, on the distribution of resources among people (is it just?); and third, on the allocation of resources among alternative uses (is it efficient?). Logically the scale and distribution questions must first be socially decided before the individualistic competitive market can determine a Pareto-efficient allocation. And even then, market allocation is restricted to rival and excludable goods. Neoclassical economics focuses overwhelmingly on efficient allocation, with only secondary attention to just distribution, and no recognition of sustainable scale. Even its central concept of Pareto efficiency assumes a given scale and given distribution that remain unspecified.

HERMAN E. DALY

See also: Bioeconomics, Biophysical economics, Biophysical constraints on human economic activity, Optimal scale of the macroeconomy, Neoclassical economics.

Reference

Daly, H.E. & Farley, J. 2011. Ecological Economics: Principles and Applications, 2nd edn. Washington, DC: Island Press.

Ecological fiscal transfers (EFT)

Transfers of public revenue between governments within a country based on ecological indicators. First defined in Ring (2008), EFT are intergovernmental fiscal transfers for ecological public functions at different levels of government, which encompass both nature conservation and abatement of environmental pollution. EFT may transfer revenue vertically from higher-level to lower-level governments or horizontally between governments at the same level. EFT may be "general-purpose" transfers to subnational government budgets that can be spent on any priority of recipient jurisdictions, whether ecological or non-ecological. Or they may be "specific-purpose" transfers earmarked for a particular ecological use, for example, reforestation or water treatment.

EFT can be established by modifying existing intergovernmental fiscal relations, that is, institutional channels of regular financial flows between different levels of government. This can make EFT institutionally easier to implement than policy instruments or programs that require approving new, additional, annual budget outlays. EFT can compensate subnational governments for the management costs of conserving ecosystems and the opportunity costs of forgone tax receipts from revenue-generating activities. In principle, EFT can also incentivize subnational governments to provide greater ecological conservation. In this way, EFT are an instrument for financing ecological conservation, alongside complementary mechanisms such as payments for ecosystem services, reducing emissions from deforestation and forest degradation (REDD+), and finance for protected areas.

IRENE RING & JONAH BUSCH

Further reading

Busch et al. 2021.

See also: Biodiversity finance, Biodiversity finance solution, Biodiversity expenditure, Indicators, Ecological indicators, REDD (Reducing Emissions from Deforestation and forest Degradation), Deforestation, Payment for ecosystem services (PES), Environmental policy instruments.

References

Busch, J., Ring, I., Akullo, M., Amarjargal, O. et al. 2021. A global review of ecological fiscal transfers. Nature Sustainability 4(9): 756–65.

Ring, I. 2008. Integrating local ecological services into intergovernmental fiscal transfers: the case of the ecological ICMS in Brazil. Land Use Policy 25(4): 485–97.

Ecological footprint

A metric of human demand on ecosystems; that is, the planet's biocapacity. Based on the 1994 doctoral dissertation of Mathis Wackernagel, when he worked with his supervisor William Rees to develop the concept. It tracks how much mutually exclusive, biologically productive area is necessary to renew people's demand for nature's products and services (Borucke et al. 2013; Lin et al. 2018; Wackernagel et al. 2019, 2021). The demands on nature that compete for biocapacity include: (1) food, fiber, timber; (2) space for roads and structures; (3) energy production (from hydropower to biomass); and (4) waste absorption, including carbon dioxide (CO_2) from fossil fuels and cement production. The measurement unit used is the "global hectare," which is a biologically productive hectare with world-average productivity. The carbon footprint is an integral part of the ecological footprint. In ecological footprint accounts, carbon emissions are expressed in global hectares or tonnes per year. The water footprint, in contrast, inspired by the ecological footprint, tracks embodied (virtual) water. Water use in the ecological footprint context is measured in terms of its embodied biocapacity.

While applicable at any scale, the most prominent accounts are the National Footprint and Biocapacity Accounts, based on United Nations statistics. They are now independently produced annually by the Footprint Data Foundation, in collaboration with York University, Toronto. Results for 2017 show that human demand exceeded the planet's regeneration by at least 73 percent (York University et al. 2021). For subglobal ecological footprint calculations, one needs to distinguish between the consumption footprint versus the production footprint. The difference between the two is the footprint of net imports. Ecological footprint accounting—that is, mapping overall demand against overall regeneration—is used by those who believe that regeneration is the materially most limiting factor for the human economy. They argue that biological regeneration is also the most constraining physical factor for fossil fuel use, since the biosphere's ability to cope with the carbon dioxide (CO_2) emissions is even more limited than the reserves underground.

MATHIS WACKERNAGEL & DAVID LIN

See also: Biocapacity, Carbon footprint, Water footprint, Virtual water, Sustainability metrics, Waste absorption capacity, Overshoot.

References

Borucke, M., Moore, D., Cranston, G. et al. 2013. Accounting for demand and supply of the biosphere's regenerative capacity: the National Footprint Accounts' underlying methodology

and framework. Ecological Indicators 24: 518–33.
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Wackernagel, M., Hanscom, L., Jayasinghe, P. et al. 2021. The importance of resource security for poverty eradication. Nature Sustainability 4: 731–8.
Wackernagel, M., Lin, D., Evans, M. et al. 2019. Defying the footprint oracle: implications of country resource trends. Sustainability 11(7): 2164.
York University Ecological Footprint Initiative & Global Footprint Network. National Footprint and Biocapacity Accounts, 2021 edition. Produced for the Footprint Data Foundation and distributed by Global Footprint Network. https://data.footprintnetwork.org.

Ecological indicators

Biological assemblages or taxa that by virtue of their presence or condition, or their absence, indicate something about the local ecosystem or environment; for example, it is healthy, resilient, diverse, and so on. Similarly, ecological indicator species are those species that by their presence, absence, population, population density, dispersion, reproductive success, and so on, tell us something about the state or condition of the local ecosystem or environment.

Barry D. Solomon

Further reading

Niemi & McDonald 2004.

See also: Indicators, Indicator species, Biodiversity indices, Environmental indicators, Resilience, Ecosystem functional diversity, Ecosystem resilience.

Reference

Niemi, G.J. & McDonald, M.E. 2004. Application of ecological indicators. Annual Review of Ecology, Evolution, and Systematics 35: 89–111.

Ecological inequality

Any situation in which a particular group (or groups) of people is disproportionately affected by pollution, resource depletion, or some other form of environmental degradation. For example, ecological inequality is present when mercury tailings from mining cause adverse health effects on the local population rather than the mining interest. Since ecological inequality in most cases adversely impacts the poor, it is often associated with environmental discrimination or environmental racism.

Mariano Torras

Further reading

Boyce 1994; Torras 2005; Castillo-Gallardo 2016; Bourg 2020; Bullard 1990.

See also: Ecologically unequal exchange, Environmental justice, Environmental degradation, Resource depletion, Natural resource depletion.

References

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Boyce, J.K. 1994. Inequality as a Cause of Environmental Degradation. Ecological Economics 11(3): 169–78.
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Torras, M. 2005. Ecological inequality in assessing well-being: some applications. Policy Sciences 38(4): 205–24.

Ecological justice

A combination of perspectives and procedures that provides fair, equitable, and ethical treatment of the non-human world. Sometimes also called ecojustice. Ecological justice or ecojustice is distinct from "environmental justice," which is justice for people regarding environmental issues (Washington et al. 2018).

Ecological justice is distinct from and more inclusive than environmental justice, and is concerned with other species independently of their instrumental value for humans. It is associated with "biospheric altruism" and extends concern beyond human beings (Shoreman-Ouimet & Kopnina 2016). Naess (1973) refers to ecological justice as justice between the human and non-human species. However, Washington et al. (2018) considers its simplest definition: that is, justice for non-human nature. "Distributive justice" has also been applied to the non-human world (Baxter 2005). "Bio-portionality" a related term, which "would seek not merely viable but optimal populations of all species" (Mathews 2016).

HAYDN G. WASHINGTON

See also: Justice, Environmental justice, Ecocentrism, Distributive justice.

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Mathews, F. 2016. From biodiversity-based conservation to an ethic of bio-proportionality. Biological Conservation 200: 140–48.
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Shoreman-Ouimet, E. & Kopnina, H. 2016. Culture and Conservation: Beyond Anthropocentrism. New York: Routledge.
Washington, H., Chapron, G., Kopnina, H. et al. 2018. Foregrounding ecojustice in conservation. Biological Conservation 228: 367–74.

Ecological limits

In the early 1970s the Western ideology of infinite growth integral to classical, Marxist, neoclassical, and neoliberal economic theory was challenged by the *Limits to Growth* report and systems ecologists, who warned of the potential failure of the biosphere's regenerative capacity to support complex life should exponential "growth" continue to deplete resources and damage ecosystems (Meadows et al. 1972). More recently these ecological limits have been described as "planetary boundaries," including loss of biodiversity and ecosystem integrity, global heating and ocean acidification, disruption of the carbon, nitrogen and phosphorus cycles, and accumulation of novel artificial substances (for example, plastics, synthetic chemicals).

JEREMY WALKER

Further reading

Vernadsky [1926] 1998; Lovelock & Margulis 1974; Rockström et al. 2009.

See also: Limits, Limits to growth, Biosphere, Planetary health, Gaia hypothesis, Ecological footprint.

References

Lovelock, J.E. & Margulis, L. 1974. Atmospheric homeostasis by and for the biosphere: the Gaia hypothesis. Tellus 26(1–2): 2–10.
Meadows, D., Meadows, D., Randers, J. & Behrens, W. 1972. The Limits to Growth. New York: Universe Books.
Rockström, J., Steffen, W., Noone, K. et al. 2009. A safe operating space for humanity. Nature 461(7263): 472–5.
Vernadsky, V. [1926] 1998. The Biosphere (trans. D. Langmuir). New York: Copernicus.

Ecological macroeconomics

a. Before the financial crisis of 2007–2008, this term was seldom used. It typically referred to studies on the biophysical scale of the economy, where the economy is conceptualized as a metabolic organism, and the social metabolism is measured in terms of energy, materials, land use, and so on. These measures are used, for instance, in the debates on the relationship between economic growth and environmental impacts, and the possibilities for decoupling.
b. After the financial crisis of 2007–2008, the use of the term increased considerably. In addition to the continued interest in measuring social metabolism, ecological macroeconomics developed as a new research program, focusing on the relationships between three major crises: (1) environmental challenges (in particular,

climate change and biodiversity loss); (2) large inequalities within and between nations; and (3) macroeconomic instability, related to finance. The research explores the possibilities for coping with all three crises at the same time, and provides suggestions for policies. The development of such research implies increased cooperation between ecological economics and post-Keynesian economics.

Inge Røpke

Further reading

Harris 2009; Rezai & Stagl 2016.

See also: Macroeconomics, Economic growth, Degrowth, Decoupling economic growth, Steady state, Social metabolism, Biophysical constraints on human economic activity, Ecological footprint, Human appropriation of net primary production (HANPP), Material flow analysis, Post-Keynesian economics.

References

Harris, J.M. 2009. Ecological macroeconomics: consumption, investment, and climate change. Real-World Economics Review 50: 34–48.

Rezai, A. & Stagl, S. 2016. Ecological macroeconomics: introduction and review. Ecological Economics 121: 181–5.

Ecological perturbation

Displacement of ecological variables away from their prior or typical state (Rykiel 1985), as the direct consequence of processes that are not part of the ecosystem's description: events that originate externally (for example, human action), at larger scales (for example, geophysical events), or at smaller scales (for example, physiological changes).

The ecosystem's subsequent response to the perturbation encompasses all impacts mediated by processes that are part of the ecosystem's description, such as population dynamics, species interactions, and resource flows (Yodzis 1988). For example, an organism-level perturbation can induce a response in the organism's mortality; in turn, this change in mortality can be seen as a perturbation at the population level, inducing a response in species abundance.

Typical ecological perturbations include changes in species abundance or resource availability (for example, due to human inputs or extraction, fires, invasions), and changes in ecological parameters such as growth and mortality, species interactions, rates of uptake or decomposition (for example, due to climate change, disease).

Matthieu Barbier

See also: Perturbation, Disturbance, Stressors, Stability, Spatial dynamics.

References

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Yodzis, P. 1988. The indeterminacy of ecological interactions as perceived through perturbation experiments. Ecology 69(2): 508–15.

Ecological resilience

See: Resilience.

See also: Ecosystem resilience.

Ecological restoration

The process in which people assist the recovery of an impaired ecological system that has been degraded, damaged, or destroyed (Society for Ecological Restoration 2004). It includes a range of activities that have the goal of achieving or supporting substantial ecosystem recovery compared to the baseline condition of degradation and with reference to a collectively agreed-upon model of a healthier ecological system (Clewell & Aronson 2013; Gann et al. 2019). Ecological restoration may be undertaken in any type of ecosystem—terrestrial, aquatic, or oceanic—and in any type of land-use regime, including agricultural and urban.

Examples of ecological investment and restoration activities include: removing invasive plant and animal species; identifying, growing, or collecting specimens (for

example, seeds or wildlings) and using them for the reintroduction or enrichment of populations of native species; improving soil health; removing dams and repairing river channels by re-establishing native riparian vegetation; rehabilitating post-mining sites.

James C. Aronson, Adam T. Cross, Neva R. Goodwin & Laura Orlando

See also: Ecology, Restoration ecology, Environmental restoration, Investment.

References

Clewell, A.F. & Aronson, J.C. 2013. Ecological Restoration: Principles, Values, and Structure of an Emerging Profession, 2nd edn. Washington, DC: Island Press.

Gann, G.D., McDonald, T., Walder, B., Aronson, J. et al. 2019. International principles and standards for the practice of ecological restoration, 2nd edn. Restoration Ecology 27(S1): S1–S46.

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Ecological science

See: Ecology.

See also: Ecological succession, Ecological perturbation, Ecological footprint, Ecological limits, Ecological indicators, Ecological restoration.

Ecological succession

The process of change in the structure of plants and animals in an ecological community following a natural or anthropogenic disturbance or perturbation, which can take place over widely varying timescales. It was one of the first theories advanced in ecology. While ideas of ecological succession were proposed in the 18th and 19th centuries, the first formal conception was by Henry Chandler Cowles in his studies of vegetation development on the Indiana Dunes on the shore of Lake Michigan in the United States (Cowles 1899; Egerton 2015).

The course of an ecological succession can be determined by site conditions, perturbations, species interactions, and stochastic factors (for example, weather, availability of seeds, colonists, and so on). Ecological succession is often divided into "primary" (newly exposed lifeless, rocky, or sandy areas, lava flows, or glacial tills are colonized for the first time) and "secondary" (previously occupied communities are disturbed or removed and recolonized, without destroying the soil).

Barry D. Solomon

Further reading

Luken 1990; Pielou 1966; Chang & Turner 2019.

See also: Disturbance, Perturbation, Ecological perturbation, Ecosystem structure and function, Anthropogenic.

References

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Cowles, H.C. 1899. The ecological relations of the vegetation on the sand dunes of Lake Michigan. Part I—geographical relations of the dune floras. Botanical Gazette 27(2): 95–117.

Egerton, F.N. 2015. History of ecological sciences, part 54: succession, community, and continuum. Bulletin of the Ecological Society of America 96: 426–74.

Luken, J.O. 1990. Directing Ecological Succession. London & New York: Chapman & Hall.

Pielou, E.C. 1966. Species-diversity and pattern-diversity in the study of ecological succession. Journal of Theoretical Biology 10(2): 370–83.

Ecologically unequal exchange

Posits that "Northern" consumption and capital accumulation, to a large extent, is based on "Southern" environmental degradation and extraction. The environmental space for the poor deteriorates, and at the same time the rich can buy release from global ecosystems' destruction. Ecologically unequal

exchange has been measured, appraised, and explained from three different perspectives:

1. Disjunctive ecological exchange: does a country or region that specializes in the exports of natural resources tend to suffer from distorted economic development in comparison to a country that specializes in the exports of manufactured goods and services?
2. Non-equivalent ecological exchange: various measures of the ecological contents of exports and imports. Is a country or region a net importer or exporter of an environmentally relevant aggregate, such as energy, material mass, land use or pollution?
3. Ecologically unsustainable trade: exchange is ecologically unsustainable if it hurts the ecological sustainability locally or nationally. Trade can be unsustainable for both partners involved, and even threaten the global social and ecological system.

Jan Otto Andersson

Further reading

Bunker 1990; Rice 2007; Hornborg & Jorgenson 2010; Jorgenson 2016; Andersson 2021.

See also: Ecological debt, Ecological distribution conflicts, World Trade Organization (WTO), North–South relations.

References

Andersson, J.O. 2021. "Ecological unequal exchange," in The Palgrave Encyclopedia of Imperialism and Anti-Imperialism. I. Ness & Z. Cope, eds. Cham: Palgrave Macmillan.

Bunker, S.G. 1990. Underdeveloping the Amazon: Extraction, Unequal Exchange, and the Failure of the Modern State. Chicago, IL: University of Chicago Press.

Hornborg, A. & Jorgenson, A.K., eds. 2010. International Trade and Environmental Justice: Toward a Global Political Ecology. Hauppauge, NY: Nova Science Publishers.

Jorgenson, A.K. 2016. Environment, development, and ecologically unequal exchange. Sustainability 8(3): 227.

Rice, J. 2007. Ecological unequal exchange: International trade and uneven utilization of environmental space in the world system. Social Forces 85(3): 1369–92.

Ecology

Sometimes also called ecological science, ecology is the branch of biology that involves the scientific study of the relationships between living organisms (including humans) and their organic and inorganic environments, as well as their distribution. The term was coined in 1866 by the German zoologist and follower of Charles Darwin, Ernst Haeckel, and is derived from the Greek terms *oikos* for "house or dwelling place" and *logos* for "the study of" (Egerton 2013). Ecology can be studied at several levels or spatial scales: the individual, population, community, ecosystem, and biosphere.

Barry D. Solomon

Further reading

Odom & Barrett 2005.

See also: Conservation biology, Ecosystem, *Oikos*, Biogeography, Biosphere, Social ecology, Human ecology.

References

Egerton, F.N. 2013. History of ecological sciences, part 47: Ernst Haeckel's ecology. Bulletin of the Ecological Society of America 94(3): 222–44.

Odom, E.P., & Barrett, G.W. 2005. Fundamentals of Ecology, 5th edn. Belmont, CA: Thomas Brooks/Cole.

Econometrics

a. The application of statistics and mathematical forecasting models within an economic context. The observed measures used to verify these models will be time series or cross-sectional data.
b. Statistical analysis using multivariate inferences to test hypotheses, develop theories, and draw conclusions about

casualties and the relative impact factors have in economic systems.

Garry J. Claridge

Further reading

Wooldridge 2019.

See also: Multivariate statistical techniques, Quantitative analysis, Models and modeling, Discrete-time models.

Reference

Wooldridge, J.M. 2019. Introductory Econometrics: A Modern Approach, 7th edn. Boston, MA: Cengage Learning.

Economic development

The process under which sustained economic growth occurs in a manner so that economic well-being and the quality of life of a nation, region, or local community are improved. That is, economic development expands employment opportunities for people, enhances standards of living for all, improves human capabilities through promotion of health and education, and is environmentally sustainable. Economic development also promotes greater equality of incomes and wealth, and it is inclusive of all socio-economic groups, particularly the lagging groups.

Economic growth is a means to reach the end; that is, economic development. Whether economic growth leads to economic development or not depends on the nature and composition of economic growth. Economic development is environmentally sustainable when the economic growth considers the full cost of the depreciation of natural resources.

Indira Hirway

Further reading

Ranis & Fei 1961; Schumpeter & Backhaus 2003.

See also: Development, Economic growth, Human development, Human Development Index (HDI), Happiness, Sustainability.

References

Ranis, G. & Fei, J.C.H. 1961. A theory of economic development. American Economic Review 51(4): 533–65.

Schumpeter, J. & Backhaus, U. 2003. "The theory of economic development," pp. 61–116 in Joseph Alois Schumpeter: Entrepreneurship, Style and Vision. J. Backhaus, ed. Boston, MA: Springer.

Economic ecosystem accounting

Economics:

a. An extension of the standard System of National Accounts (SNA) economic activities that explicitly incorporate the ecosystem as a production factor subject to ownership of non-financial corporations and the government in the ecosystem accounts (Campos et al. 2019). These are valued by transaction prices observed in formal markets and/or in simulated markets for consumed products without market prices. The latter are valued by the revealed and/or stated marginal willingness to pay of the final consumers. Its ultimate purpose is to estimate explicitly and spatially environmental income, conditional on its theoretical consistency with total income of nature-basis economic activities.
   Given the residual nature of environmental income, it is a precondition to have measured total income of individual economic activities first. The purpose of this is to explicitly measure environmental incomes in a manner consistent with total incomes. Economic ecosystem services, the destructions of environmental assets, opening and closing period environmental assets, and environmental incomes, are valued by the same criteria as the System of Environmental–Economic Accounting—Ecosystem Accounting (SEEA-EA) and Agroforestry Accounting System (AAS) economic ecosystems accounting methods.
b. (From UNSD 2021) the SEEA-EA is a statistical framework created by the United Nations to measure the biophys-

ical extent and condition of ecosystem habitats and landscapes, as well as the economic ecosystem services and the changes in environmental assets that they provide.

Pablo Campos Palacín

Further reading

Campos & Caparrós 2006; Campos et al. 2008; Stone 1984.

See also: Environmental income, Total income, System of National Accounts (SNA), Systems-oriented simulation models, Revealed preference methods, Stated preference methods, Ecosystem services.

References

Campos, P. & Caparrós, A. 2006. Social and private total Hicksian incomes of multiple use forests in Spain. Ecological Economics 57: 545–57.

Campos, P., Caparrós, A., Oviedo, J.L. et al. 2019. Bridging the gap between national and ecosystem accounting application in Andalusian forests, Spain. Ecological Economics 157: 218–36.

Campos, P., Daly-Hassen, H., Oviedo, J.L. et al. 2008. Accounting for single and aggregated forest incomes: application to public cork oak forests in Jerez (Spain) and Iteimia (Tunisia). Ecological Economics 65: 76–86.

Stone, R. 1984. The accounts of society. Nobel Memorial Lecture, December 8, 1984. https://www.nobelprize.org/uploads/2018/06/stone-lecture.pdf.

UNSD. 2021. System of Environmental–Economic Accounting—Ecosystem Accounting, final draft, version 5. New York: United Nations, Statistical Division. https://unstats.un.org/unsd/statcom/52nd-session/documents/BG-3f-SEEA-EA_Final_draft-E.pdf.

Economic efficiency

In standard economics, an allocation of resources that maximizes net social benefits. Perfectly competitive markets in the absence of externalities are considered to be efficient. In the broader perspective of ecological economics, the assertion that net social benefits are maximized in efficient markets is questionable, since only those costs and benefits that are reflected in markets are considered. This approach may omit significant social and ecological factors, as well as generational considerations. For example, "efficient" exploitation of resources may damage ecosystems in ways that are not reflected in markets, as well as deplete essential resources for future generations. In addition, considerations of economic efficiency may not be fully separable from issues of equity, since an "efficient" market outcome necessarily reflects the current distribution of income and purchasing power, regardless of how equitable or inequitable this distribution may be.

Jonathan M. Harris

Further reading

Liscow 2018; Harris & Roach 2022, Chapters 3 and 9.

See also: Efficiency-based arguments, Pareto optimality, Equity, Externalities.

References

Harris, J.M. & Roach, B. 2022. Environmental and Natural Resource Economics: A Contemporary Approach, 5th edn. New York: Routledge.

Liscow, Z. 2018. Is efficiency biased? University of Chicago Law Review 85(7): 1649–1718.

Economic growth

Economics: growth in the output of an economy. Usually measured as an ongoing increase in inflation-adjusted gross domestic product (GDP), or gross domestic product per person.

Ecological economics:

a. An increase in the physical scale of an economy. An increase in scale can mean growth in the throughput of materials and energy measured in physical units.
b. The accumulation of materials in infrastructure, buildings, and equipment, again measured in physical units.
c. Growth in either of the first two measures (GDP or scale) where the benefits of further growth exceed the costs. The difference here is that "economic" is understood as an adjective describing growth,

rather than a noun referring to what is growing. That economic growth (in the first sense, an increase in GDP) may be uneconomic, especially in advanced economies, is emphasized in ecological economics.

PETER A. VICTOR

Further reading

Daly 1996; Victor 2019; Jackson 2021; Roser 2021; World Bank n.d.

See also: Growth, Growth theory, Growth fallacies, Degrowth, Limits to growth, Economic development, Gross domestic product (GDP), Uneconomic growth, Decoupling economic growth, Throughput.

References

Daly, H.E. 1996. Beyond Growth. Boston, MA: Beacon Press.
Jackson, T. 2021. Post Growth: Life after Capitalism. Cambridge: Polity Press.
Roser, M. 2021. What is economic growth? And why is it so important? Our World in Data. May 13. https://ourworldindata.org/what-is-economic-growth.
Victor, P.A. 2019. Managing Without Growth: Slower by Design, not Disaster, 2nd edn. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.
World Bank. n.d. Economy. https://datatopics.worldbank.org/world-development-indicators/themes/economy.html.

Economic imperialism

Epistemology: the tendency of economists to read all social, political, and natural phenomena through their own frameworks. By extension, the overflow of economics onto other disciplines in the social or natural sciences. In environmental matters, examples include the description of nature as a set of financial assets, the interpretation of ecosystem interactions as transactions, the translation of fossil fuel exhaustion into an intertemporal allocation problem to be optimized. Relates to the commodification processes of nature.

Economic history: forced implementation of an economic system in certain regions of the world, for example, the worldwide development of Western capitalism during colonization. In the environmental sector, the obligation to adopt specific management regimes for natural resources, for example, through the dictates of the World Bank or the International Monetary Fund, possibly leading to the empowerment of foreign actors. Examples include the energy-oriented view of industrialism projected onto colonized countries in the 19th century, and today's phenomenon of land grabbing, especially in the global South.

ANTOINE A.G. MISSEMER

Further reading

Mäki 2013; Daggett 2019.

See also: Commodification of nature, Interdisciplinary, World Bank, North–South relations.

References

Daggett, C.N. 2019. The Birth of Energy: Fossil Fuels, Thermodynamics, and the Politics of Work. Durham, NC: Duke University Press.
Mäki, U. 2013. Scientific imperialism: difficulties in definition, identification, and assessment. International Studies in the Philosophy of Science 27(3): 325–39.

Economic incentives

See: Market mechanisms.

See also: Environmental policy instruments.

Economic indicators

Economics:

a. Quantitative variables or statistics that are used to measure current economic conditions and/or forecast trends, usually at a macroeconomic scale, which can provide a broader qualitative index, gauge, or barometer of the state or trend of an economy. Examples are the gross domestic product (GDP), the unemployment rate, the inflation rate (for example, consumer price index), and the Gini index

of income inequality (The Economist 2010). The indicator can measure the level and the change (for example, GDP and GDP growth rate).
Some indicators can be expressed in total and per capita terms (for example, GDP and GDP per capita). The long-term focus on traditional economic indicators, especially GDP, has recently led to the Beyond GDP movement that promotes indicators measuring current well-being and the conditions for future well-being (that is, sustainability). When these indicators are conceptualized in economic terms (such as the adjusted net saving), they can be considered economic indicators.

b. "Leading" economic indicators are used to help predict or forecast changes in business cycles or other specific economic variables of interest. Examples include the stock market (for example, Dow Jones Industrial Average), consumer spending, home sales, home building, the (United States) Treasury Yield curve, durable goods orders, and industrial production.

Miroslav Syrovátka

Further reading

Stiglitz et al. 2009.

See also: Indicators, Gross domestic product (GDP), Measures of economic welfare, Adjusted net saving (ANS), Well-being economy, Sustainability.

References

Stiglitz, J.E., Sen, A. & Fitoussi, J.-P. 2009. Report by the Commission on the Measurement of Economic Performance and Social Progress. Paris: French Commission on the Measurement of Economic and Social Progress. https://ec.europa.eu/eurostat/documents/8131721/8131772/Stiglitz-Sen-Fitoussi-Commission-report.pdf.

The Economist. 2010. Guide to Economic Indicators: Making Sense of Economics, 6th edition. New York: Bloomberg Press.

Economic inequality

Unevenness in the distribution of economic resources, namely income and/or wealth, among individuals or households in a society or population. In general, there is greater wealth inequality than income inequality (Keeley 2015). Commonly used measures of economic inequality include the Gini index, and the concentration of income or wealth at the top of the distribution, such as the percentage of wealth or income in the highest decile (Kus 2016). Research in ecological economics suggests that higher levels of economic inequality are associated with greater environmental demands and degradation (Berthe & Elie 2015; Boyce 1994).

Kyle W. Knight

Further reading

Cushing et al. 2015; Piketty 2014.

See also: Inequality, Income distribution, Gini index.

References

Berthe, A. & Elie, L. 2015. Mechanisms explaining the impact of economic inequality on environmental deterioration. Ecological Economics 116: 191–200.

Boyce, J.K. 1994. Inequality as a cause of environmental degradation. Ecological Economics 11(3): 169–78.

Cushing, L., Morello-Frosch, R., Wander, M. & Pastor, M. 2015. The haves, the have-nots, and the health of everyone: the relationship between social inequality and environmental quality. Annual Review of Public Health 36: 193–209.

Keeley, B. 2015. Income Inequality: The Gap between Rich and Poor. Paris: OECD Publishing.

Kus, B. 2016. Wealth inequality: historical trends and cross-national differences. Social Compass 10(6): 518–29.

Piketty, T. 2014. Capital in the Twenty-First Century. Cambridge, MA: Harvard University Press.

Economic institutions

Organizations that write and enforce the rules by which an economy operates, as well as the rules themselves. Economic institutions may include markets, in which goods and services are bought and sold, and non-governmental institutions that provide relief and research, governments of various nations, as well as

international organizations such as the United Nations and multilateral lending agencies such as the World Bank and International Monetary Fund. A legal system that rules upon the limits to governmental and corporate actions is an economic institution, as are labor unions and employers' associations.

Economic institutions also act to maintain the hegemony of dominant powers, such as the way the World Bank and International Monetary Fund extend loans and manage the debts of various nations. Economic institutions may be democratic, or they may be dictatorial, and are subject to change when the underlying economy changes. Institutions may also break down, leading to periods of conflict and economic stagnation.

Kent A. Klitgaard

Further reading

Acemoglu & Robinson 2013; Kuttner 1991; Payer 1982.

See also: Institutional economics, New institutional economics, World Bank.

References

Acemoglu, D. & Robinson, J.A. 2013. Why Nations Fail. New York: Random House.
Kuttner, R. 1991. The End of Laissez Faire. New York: Alfred A. Knopf.
Payer, C. 1982. The World Bank: A Critical Analysis. New York: Monthly Review Press.

Economic resilience

Rebounding from shocks in an economically efficient manner. It adapts basic resilience principles from the work of ecologists Holling (1973) and Pimm (1984). Static economic resilience is the efficient use of remaining resources at a given point in time (Rose 2007, 2017). It refers to the core economic concept of coping with resource scarcity, which is exacerbated under disaster conditions.

Dynamic economic resilience is the efficient use of resources over time for investment in repair and reconstruction (Rose 2007, 2009). Investment is a time-related phenomenon: the act of setting aside resources that could potentially be used for current consumption to re-establish productivity in the future.

The definitions are typically measured as the flow of goods and services, such as gross output (sales revenue), gross domestic product (GDP), or broader measures of economic welfare (well-being), as opposed to property damage. Economic resilience is applicable at all scales and is typically implemented using various resilience tactics to cope with input disruptions: micro (individual firm or household: conservation, input substitution, use of inventories), meso (sector and market: price signals, resource pooling) and macro (economy-wide: fiscal and monetary policy, diversification). Some of these tactics are inherent—intrinsic in the workings of the entity or system—or adaptive, involving improvisation after the disaster has struck. Overall, economic resilience is a process, whereby resilience capacity can be enhanced prior to the shock, but the tactics are not implemented until after the disaster strikes.

Adam Z. Rose

Further reading

Rose 2017.

See also: Resilience, Ecosystem resilience, Urban resilience, Rural resilience.

References

Holling, C. 1973. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics 4: 1–23.
Pimm, S.L. 1984. The complexity and stability of ecosystems. Nature 307(26): 321–6.
Rose, A. 2007. Economic resilience to natural and man-made disasters: multidisciplinary origins and contextual dimensions. Environmental Hazards 7(4): 383–95.
Rose, A. 2009. Economic Resilience to Disasters. Community and Regional Resilience Institute Report No. 8, Oak Ridge National Laboratory, Oak Ridge, TN.
Rose, A. 2017. "Benefit–cost analysis of economic resilience actions," in Oxford Research Encyclopedia of Natural Hazard Science. S. Cutter, ed. New York: Oxford University Press. https://oxfordre.com/naturalhazardscience/view/10.1093/acrefore/9780199389407.001.0001/acrefore-9780199389407-e-69.

Economics

A broad area of research concerned with the use and allocation of scarce resources. Resources can be any needed input, such as natural and biological resources, human labor, and intellectual property. Research topics range from national wealth effects of trade to individual choice to the organization and impacts of production, and beyond. Economics has dozens of well-defined subfields, the largest being microeconomics and macroeconomics, with new ones emerging regularly, such as ecological economics. Economics is one of the most quantitative of the social sciences, due in part to assumptions about the rationality of decision-makers, clear definitions of what constitutes socially optimal exchange outcomes, and the importance of marginal analysis (evaluating the costs and benefits of the next increment of production and consumption). Economics as a field is useful to policymakers due to its tools that rigorously and comparatively analyze costs, benefits, and other impacts of policy alternatives.

Brent M. Haddad

Further reading

Mankiw 2017; Marshall 1890; Smith 1776 [2008].

See also: Environmental economics, Ecological economics, Macroeconomics, Microeconomics, Rational choice.

References

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Economic throughput

See: Throughput.

See also: Linear throughput, Entropy, Entropy law, Bioeconomics.

Economic valuation techniques

A variety of techniques, usually classified as either revealed preference methods (market-oriented) or stated preference methods (non-market-oriented), to assign an economic value to a good, service, process, or asset. These values are typically monetary but can also include biophysical indicators, indices, or weights. The valuation process depends on people's needs, priorities, or preferences, and the existing capacity to meet these. When goods or services are provided outside market settings, valuation techniques often look at substitute or complementary goods or services obtained in a market setting to approximate values. Behavioral analysis and deliberative methods are also used to estimate values.

Tania Briceno

Further reading

Freeman 2003.

See also: Stated preference methods, Revealed preference methods, Ecosystem service valuation, Non-market value, Environmental valuation, Deliberative valuation.

Reference

Freeman A.M. 2003. The Measurement of Environmental and Resource Values: Theory and Methods, 2nd edn. Washington, DC: Resources for the Future.

Economic welfare

The utility or happiness gained, or needs fulfilled, from obtaining certain goods or services. As a component of human welfare, economic welfare is derived from the acquisition of economic goods and services produced through economic activities. Ecological economists argue that economic welfare is parallel to but not independent of ecological welfare, which can be fulfilled through ecological goods and services produced by ecosystems. All economic goods and services are created from ecological goods and services. Sustainability with high human

welfare requires that both are in balance. The exploitation of ecosystems and the transformation of ecological goods and services to economic goods and services must be constrained to a sustainable level.

Xi Ji

Further reading

Marshall 1890; Pigou 1920; Nordhaus & Tobin 1973; Daly & Cobb 1989; Max-Neef 1995; Jorgenson 2018; Long & Ji 2019; Costanza et al. 1997; Cobb et al. 1995.

See also: Welfare, Measures of economic welfare, Social welfare function, Total human welfare, Objective well-being, Subjective well-being, Utility, Happiness.

References

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Daly, H.E. & Cobb, J.B. 1989. For the Common Good: Redirecting the Economy Toward Community, the Environment, and a Sustainable Future. Boston, MA: Beacon Press.

Jorgenson, D.W. 2018. Production and welfare: progress in economic measurement. Journal of Economic Literature 56(3): 867–919.

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Marshall, A. 1890. Principles of Economics. London: Macmillan.

Max-Neef, M. 1995. Economic growth and quality of life: a threshold hypothesis. Ecological Economics 15(2): 115–18.

Nordhaus, W.D. & Tobin, J. 1973. "Is growth obsolete?," pp. 509–64 in The Measurement of Economic and Social Performance. M. Moss, ed. Cambridge, MA: National Bureau of Economic Research.

Pigou, A.C. 1920. The Economics of Welfare. London: Macmillan.

Economies of scale

Producer theory:

a. (From Stigler 1958) the relationship between the scale of a properly chosen combination of all inputs and the rate of output of the enterprise.
b. (From Silvestre 1987) there are economies of scale if the average cost of producing an output under a given technology is decreasing.

Consumer theory: (from Nelson 1988) in household consumption, economies of scale refer to the decrease of the cost per person of maintaining a given material standard of living as household size rises.

Wenchao Wu

Further reading

Deaton & Paxson 1998.

See also: Microeconomics, Industrial economics, Sustainable scale, Optimal scale of the macroeconomy.

References

Deaton, A. & Paxson, C. 1998. Economies of scale, household size, and the demand for food. Journal of Political Economy 106(5): 897–930.

Nelson, J.A. 1988. Household economies of scale in consumption: theory and evidence. Econometrica 56(6): 1301–14.

Silvestre, J. 1987. "Economies and diseconomies of scale," pp. 80–84 in The New Palgrave Dictionary of Economics. J. Eatwell, M. Milgate & P. Newman, eds. New York: Palgrave Macmillan.

Stigler, G.J. 1958. The economies of scale. Journal of Law and Economics 1: 54–71.

Economism

a. A political theory or belief in the dominant role of economic forces in determining social relations and the functioning of society, rather than political or other institutional factors, culture, nationality, and so on.

b. The belief that the main purpose of a labor union or political organization is to improve the living standards of its members. This belief is thought to have originated in Tsarist Russia in the early 1800s and became influential among moderate Russian Social Democrats in the late 19th century and early 20th century, who advocated for practical labor reforms among industrial workers (Harding 1977). Economism as an ethos has been strongly criticized by many, from Vladimir Lenin in pre-revolutionary Russia (Lenin 1901 [1961]) to Richard Norgaard (2015) in contemporary ecological economics, yet its attraction remains powerful.

BARRY D. SOLOMON

Further reading

Goddard et al. 2019.

See also: Political economy, Living standards, Heterodox economics, Social institutions, Normative assessment of social systems.

References

Goddard, J.J., Kallis, G. & Norgaard, R.B. 2019. Keeping multiple antennae up: coevolutionary foundations for methodological pluralism. Ecological Economics 165: 106420.

Harding, N. 1977. Lenin's Political Thought, Vol. 1. London: Macmillan.

Lenin, V.I. 1901 [1961]. "A talk with defenders of economism," pp. 313–20 in Lenin, Collected Works, Vol. 5. R. Cymbala & D. Walters, transcribers. Moscow: Foreign Works Publishing House.

Norgaard, R.B. 2015. The church of economism and its discontents. Great Transition Initiative. https://greattransition.org/publication/the-church-of-economism-and-its-discontents

Ecosphere

See: Biosphere.

See also: Ecosystem, Biotic resources, Abiotic resources, Open system, Closed system.

Ecosystem

A complex biological community or group of interacting organisms and their physical environment, that is, both biotic and abiotic resources. Ecosystem components can also be divided into autotrophs, heterotrophs, and non-living matter. A collection of different ecosystems that share similar climatic conditions is called a biome. As such, a biome can be thought of as the biotic community of a large-scale ecosystem. While several alternatives have been proposed for classifying ecosystems, Bailey (2009, 2014) developed a popular nested hierarchy system of ecosystem units that he calls "ecoregions," which can be used as a consistent framework for ecological analysis and management at different scales.

BARRY D. SOLOMON

Further reading

Whittaker 1975.

See also: Ecology, Biotic resources, Abiotic resources, Biome, Ecosphere.

References

Bailey, R.G. 2009. Ecosystem Geography: From Ecoregions to Sites, 2nd edn. New York: Springer.

Bailey, R.G. 2014. Ecoregions: The Ecosystem Geography of the Oceans and Continents, 2nd edn. New York: Springer.

Whittaker, R.H. 1975. Communities and Ecosystems, 2nd edn. New York: Macmillan.

Ecosystem approach to management (EAM)

A holistic management method that considers nature, resources, and society (Kern & Söderström 2018). Also referred to as ecosystem-based management (EBM). Both EAM and EBM, along with other similar terms, describe how an ecosystem approach (EA) can be applied concretely to management, to develop an integrated management of resources, focusing on conservation, sustainability, fairness, and equity. As elucidated by the Convention on Biological Diversity

(2000), there are 12 EA principles, all tied to management, including: subsidiarity; taking a long view in decision-making; that all forms of knowledge, including indigenous and local knowledge, be considered; and that all necessary social realms and scientific disciplines be considered. Ecosystems have both intrinsic value and value to humans. Similarly, regarding EBM, Slocombe (1998) expressed the objectives as being: normative, principled, integrative, complex, dynamic, transdisciplinary, applicable, participatory, understandable, and adaptive.

While EBM or EAM, or many of its counterparts, are variably applied, certain concepts, including socio-economic factors and seeing humans as internal to the ecosystem, are usually present (Kern & Söderström 2018). The need for a wide variety of stakeholders is also common. For instance, the United States National Oceanic and Atmospheric Administration (NOAA 2021) stresses that "[p]artners and stakeholders [including government and indigenous communities] are part of the solution" and that the desired goals are attainable when working together. Such management has been developed for several regions, including the Baltic Sea (Kern & Söderström 2018) and the Great Lakes basin (Guthrie et al. 2019).

Gabriel Yahya Haage

See also: Ecosystem management, Adaptive ecosystem management, Ecosystem health, Holisitc approach, Environmental management.

References

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Kern, K. & Söderström, S. 2018. The ecosystem approach to management in the Baltic Sea region: analyzing regional environmental governance from a spatial perspective. Marine Policy 98: 271–7.

NOAA (National Oceanic and Atmospheric Administration). 2021. Ecosystem-based Management. Washington, DC: NOAA. https://ecosystems.noaa.gov/EBM101/WhatisEcosystem-BasedManagement.aspx.

Slocombe, D.S. 1998. Defining goals and criteria for ecosystem-based management. Environmental Management 22(4): 483–93.

Ecosystem assessment

The analysis, measurement, and exploration of an ecosystem to determine its health, risks, connections, and functions. Areas of study include water quality, hydrology, soil health, flora, fauna, geology, and air quality. The term is often associated with the Millennium Ecosystem Assessment, which assessed the impacts of humans on the environment (Millennium Ecosystem Assessment 2005). Typically, assessments of ecosystems are conducted before launching land and infrastructure development projects.

Benjamin C. Collins

Further reading

Beer 2018.

See also: Environmental assessment, Environmental impact assessment, Millennium Ecosystem Assessment.

References

Beer, D.L. 2018. Teaching and learning ecosystem assessment and valuation. Ecological Economics 146: 425–34.

Millennium Ecosystem Assessment. 2005. Ecosystems & Human Well-Being. Washington, DC: Island Press.

Ecosystem-based management

See: Ecosystem approach to management.

See also: Ecosystem management.

Ecosystem functional diversity

The diversity of ecological functions executed by the different species in an ecosystem. This is the diversity of all the activities of plants, animals, and bacteria and their effects on the physical and chemical conditions of their environment (adapted from Tilman et al. 2014). The ecosystem functional diversity is recognized as an essential production factor so that changes in ecosystem functional diversity indirectly affect the production of a marketable good (Daniels et al. 2018).

Changes in ecosystem functional diversity, caused by changes in richness, composition, or abundance, have been shown to result in considerable economic losses for agricultural production systems (Daniels et al. 2017). The main ecosystem properties determining ecosystem functional diversity are: (1) diversity and population parameters, that is, species richness, species composition, or biomass (g/m^3) and functional contribution; (2) consumer–resource interactions, that is, predator–prey interactions; (3) inputs of energy, nutrients, and organic matter; and (4) environmental conditions, that is, water temperature or dissolved nutrient concentrations.

Silvie Daniels

See also: Diversity, Biodiversity, Ecosystem structure and function, Emergence and emergent properties.

References

Daniels, S., Witters, N., Beliën, T. et al. 2017. Monetary valuation of natural predators for biological pest control in pear production. Ecological Economics 134: 160–73.

Daniels, S., Bellmore, J.R., Benjamin, J.R. et al. 2018. Quantification of the indirect use value of functional group diversity based on the ecological role of species in the ecosystem. Ecological Economics 153: 181–94.

Tilman, D., Isbell, F. & Cowles, J.M. 2014. Biodiversity and ecosystem functioning. Annual Review of Ecology, Evolution, and Systematics 45: 471–93.

Ecosystem health

A metaphor intended to emphasize holistic and complex aspects of ecological systems and to encourage application of analogies between ecosystem well-being and organismic health (Costanza et al. 2009). The metaphor is often associated with the work of Aldo Leopold, who experimented with organismic models, and eventually settled on health as the most useful mental model for thinking about ecological systems (Warren 2016). These metaphors are especially important because they explicitly recognize that ecosystems are complex, dynamic systems; their ascendancy marked the end of interpretations of ecosystems as mechanistic and reversible in time. These metaphors signaled a tension between mainstream economists (who came to the field of ecological economics with mainly mechanistic models) and ecologists (who recognize multi-scalar complexity and irreversibility in living systems). These metaphors thus created pressure on ecological economists to enrich their understanding of the structure and functioning of ecosystems, even though they often resort to mechanistic models as acceptable approximations. The reconciliation of these two understandings of the structure and dynamics of ecological systems remains a matter of tension as the field of ecological economics develops (Norton 2015).

Bryan G. Norton

Further reading

Lu et al. 2015; Rapport 1989.

See also: Environmental health, Ecohealth, Ecosystem structure and function, Hierarchy, Ecosystem management, Sustainability.

References

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Environmental Management. Washington, DC: Island Press.
Lu, Y., Wang, R., Zhang, Y. et al. 2015. Ecosystem health toward sustainability. Ecosystem Health and Sustainability 1(1): 1–15.
Norton, B.G. 2015. Sustainable Values, Sustainable Change. Chicago, IL: University of Chicago Press.
Rapport, D.J. 1989. What constitutes ecosystem health? Perspectives in Biology and Medicine 33(1): 120–32.
Warren, J.L. 2016. Aldo Leopold's Odyssey: 10th Anniversary Edition. Washington, DC: Island Press.

Ecosystem management

A holistic approach to natural resource management that promotes the persistence of ecosystems together with individual species, along with long-term sustainability (Christensen et al. 1996; Lackey 1998). Ecosystem management contrasts with a focus on single species protection or maximum sustainable yield of a natural resource such as timber production, and seeks to achieve synergies between animal and plant species in ecosystems and local knowledge and expertise. As such, it attempts to integrate ecological, socio-economic, and organizational knowledge with the participation and priorities of a variety of stakeholder communities (Machlis et al. 1997).

In the United States (US), ecosystem management was first promoted and popularized in the 1990s by the US Forest Service, US Department of the Interior, and the National Oceanic and Atmospheric Administration on public lands and waters (Forest Ecosystem Management Assessment Team 1993; Dell'Apa et al. 2015). Outside the US, it is often called the ecosystem approach to management (EAM), ecosystem-based management, or adaptive ecosystem management.

BARRY D. SOLOMON

See also: Ecosystem approach to management (EAM), Environmental management, Adaptive ecosystem management, Adaptive systems, Resource management, Sustainability, Maximum sustainable yield.

References

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Machlis, G.E., Force, J.E. & Burch, W.R., Jr. 1997. The human ecosystem part I: the human ecosystem as an organizing concept in ecosystem management. Society and Natural Resources 10(4): 347–67.

Ecosystem persistence

The inertia of an ecosystem subject to external changes or fluctuations due to natural or anthropogenic causes. The greater the persistence, the more stable the ecosystem.

BARRY D. SOLOMON

Further reading

Holling 1973; O'Neill 1976; Daufresne & Loreau 2001.

See also: Persistence, Stability, Ecosystem resilience, Resilience.

References

Daufresne, T. & Loreau, M. 2001. Ecological stoichiometry, primary producer–decomposer

interactions, and ecosystem persistence. Ecology 82(11): 3069–82.
Holling, C.S. 1973. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics 4: 1–23.
O'Neill, R.V. 1976. Ecosystem persistence and heterotrophic regulation. Ecology 57(6): 1244–53.

Ecosystem resilience

The inherent capacity of a natural system or habitat to absorb disturbance and/or successfully reorganize while undergoing stress. This capacity for natural renewal depends on properties such as overlapping scales and sources of memory provided through biodiversity. As a domain of study, ecosystem resilience formed the basis for much of the early applied research into resilience. It should not be confused with ecological resilience, a much broader conceptual and philosophical lens used to examine resilience not only in natural systems but also in human systems and the social-ecological systems where both intertwine (Gunderson 2000).

Conrad B. Stanley

Further reading

Scheffer et al. 2001; Walker and Salt 2006.

See also: Resilience, Disturbance, Ecological perturbation, Ecosystem persistence, System scale and hierarchy, Social-ecological systems.

References

Gunderson, L.H. 2000. Ecological resilience—in theory and application. Annual Review of Ecology and Systematics 31: 425–49.
Scheffer, M., Carpenter, S., Foley, J. et al. 2001. Catastrophic shifts in ecosystems. Nature 413: 591–96.
Walker, B. & Salt, D. 2006. Resilience Thinking: Sustaining Ecosystems and People in a Changing World. Washington, DC: Island Press.

Ecosystem services

Ecology: ecosystem services are benefits to humans provided by natural biological processes including photosynthesis; carbon, hydrogen, oxygen, and nutrient (nitrogen and phosphorus) cycling; and the stabilizing functions of biodiverse ecological communities (Holdren & Ehrlich 1974).

Economics: ecosystem services and disservices are the direct and indirect benefits and costs to humans of functioning natural or managed ecosystems. The Millennium Ecosystem Assessment (2005) distinguished four types of ecosystem services: provisioning (consumptive benefits such as foods, fuels, fibers, and pharmaceuticals), cultural (non-consumptive benefits such as recreation, inspiration, aesthetic pleasure, and totemic or spiritual significance), regulating (stabilization, buffering, insurance, or resilience), and supporting (ecosystem processes). Supporting services are now more commonly called maintenance services (Haines-Young & Potschin 2010). Disservices, comprising the costs imposed by pests, pathogens, predators, and competitors, can be classified in similar ways.

Charles A. Perrings

See also: Goods, Services, Provisioning services, Cultural services, Regulating services, Supporting services, Maintenance services, Biodiversity, Economic resilience, Ecosystem resilience.

References

Haines-Young, R. & Potschin, M. 2010. "The links between biodiversity, ecosystem services and human well-being," pp. 110–39 in Ecosystem Ecology: A New Synthesis. D. Raffaelli & C. Frid, eds. Cambridge: Cambridge University Press.
Holdren, J.P. & Ehrlich, P.R. 1974. Human population and the global environment. American Scientist 62: 282–92.
Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: General Synthesis. Washington, DC: Island Press.

Ecosystem services potential (ESP)

A description of what could naturally contribute to the generation of services considering current land use, ecosystem properties, and ecosystem conditions (Burkhard & Maes 2017). In a more ecological meaning, the ESP needs to consider the ecological carrying capacity and resilience. This concept was recently borrowed by a specific stream of applications in ecosystem accounting (La Notte et al. 2019) to describe the ecological side that interacts with the socio-economic side (that is, the ecosystem service demand, or ESD) to generate the ecosystem service actual flow (ESAF).

The main difference between the ESP and the ESAF (or use) is that the former assesses ecosystems' ability to generate services irrespective of ESD, while the latter is the result of the interaction between ESP and ESD. The importance of separately identifying ESP and ESAF enables one to distinguish between ecosystem service effectively used and the opportunities (unused potential) and limits (overuse) of its use. The conceptual scheme that makes use of the ESP, ESD, and ESAF is being applied in a variety of applications in Europe, from the assessment of ecosystems and their services (Maes et al. 2020), to natural capital accounting applications (Vysna et al. 2021).

Alessandra La Notte

See also: Ecosystem services, Economic ecosystem accounting, Ecosystem service valuation, Carrying capacity, Resilience, Ecosystem resilience.

References

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La Notte, A., Vallecillo, S., Marques, A. & Maes, J. 2019. Beyond the economic boundaries to account for ecosystem services. Ecosystem Services 35: 116–29.

Maes, J., Teller, A., Erhard, M., Conde, S. et al. 2020. Mapping and Assessment of Ecosystems and their Services: An EU Ecosystem Assessment. Luxembourg: Publications Office of the European Union.

Vysna, V., Maes, J., Petersen, J.-E. et al. 2021. Accounting for Ecosystems and their Services in the European Union. Final report from Phase II of the INCA project aiming to develop a pilot for an integrated system of ecosystem accounts for the EU. Luxembourg: Publications Office of the European Union.

Ecosystem service valuation

The estimation of a monetary value for a specific benefit obtained by an individual or a population from the natural world. Ecosystem services are the benefits that people obtain from nature such as food, water, pollination, and waste assimilation (MEA 2005). Since many of these services are freely obtained by people outside markets, their economic value is approximated using non-market valuation methodologies. This involves estimating the value that people assign to these services, relative to other goods and services in their consumption bundle, their budget constraints, and the biophysical availability of ecosystem services.

Tania Briceno

Further reading

Costanza et al. 1997; Freeman 2003; McVittie & Hussain 2013.

See also: Environmental valuation, Non-market value.

References

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Freeman, A.M. 2003. The Measurement of Environmental and Resource Values: Theory and Methods, 2nd edn. Washington, DC: Resources for the Future.

McVittie, A. & Hussain, S.S. 2013. The economics of ecosystems and biodiversity valuation database—manual. Sustainable Ecosystems Team, Scotland's Rural College. http://doc.teebweb.org/wp-content/uploads/2014/03/TEEB-Database-and-Valuation-Manual_2013.pdf.

MEA (Millennium Ecosystem Assessment). 2005. Ecosystems and Human Well-being:

A Framework for Assessment. Washington, DC: Island Press.

Ecosystem structure and function

The fundamental description of the system components and properties of all ecosystems. The structure of the system includes both biotic and abiotic components, while the functions include biomass production, energy transfer, nutrient cycling, decomposition, gas and climate regulation, and the water cycle. However, despite the direct relationship between ecosystem structure and functions, the functions are "emergent properties" (that is, understanding the individual system components alone is insufficient to fully understand system behavior) and may not be readily or precisely explained by detailed knowledge of the system components and their structure (Harfoot et al. 2014).

Barry D. Solomon

Further reading

Finn 1976; Grimm et al. 2013; McDonnell & Pickett 1990.

See also: Ecosystem, Ecosystem functional diversity, Ecosystem health, Ecosystem assessment, Biotic resources, Abiotic resources, Species richness, Ecosystem services, Emergence and emergent properties.

References

Finn, J.T. 1976. Measures of ecosystem structure and function derived from analysis of flows. Journal of Theoretical Biology 56(2): 363–80.

Grimm, N.B., Chapin III, F.S., Bierwagen, B. et al. 2013. The impact of climate change on ecosystem structure and function. Frontiers in Ecology and the Environment 11(9): 474–82.

Harfoot, M.B.J., Newbold, T., Tittensor, D.P. et al. 2014. Emergent global patterns of ecosystem structure and function from a mechanistic general ecosystem model. PLOS Biology 12(4): e1001841.

McDonnell, M.J. & Pickett, S.T.A. 1990. Ecosystem structure and function along urban–rural gradients: an unexploited opportunity for ecology. Ecology 71(4): 1232–7.

Ecotourism

a. A form of environmentally responsible tourism that involves travel to relatively undisturbed natural areas with the object of enjoying, admiring, and studying nature (the scenery, wild plants, and animals), as well as any cultural manifestations (both past and present) found in these areas. Ecotourism involves a process that promotes conservation, has a low impact on the environment and on culture, and favors the active and socio-economically beneficial involvement of local communities (Ceballos-Lascurain 1991).

b. Responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and involves interpretation and education. Ecotourism should not be confused with mere nature-based tourism or pseudo-ecotourism, where such responsibility/sustainability dimensions are missing or superficial. Ideally carried out in certified destinations through certified operators, where certification has been performed by independent and accredited third-party organizations based on internationally accepted criteria (International Ecotourism Society 2015).

Abhijit Banerjee

Further reading

Cater & Lowman 1994; Duffy 2002; Honey 2002, 2008.

See also: Conservation, Wildlife conservation, Environment, Sustainable tourism, Culture.

References

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Ceballos-Lascurain, H. 1991. Tourism, ecotourism and protected areas. Parks 2(3): 31–5.
Duffy, R. 2002. A Trip Too Far: Ecotourism, Politics and Exploitation. London: Earthscan.
Honey, M., ed. 2002. Ecotourism and Certification: Setting Standards in Practice, 2nd edn. Washington, DC: Island Press.
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International Ecotourism Society. 2015. What is ecotourism? https://ecotourism.org/what-is-ecotourism/.

Ecozoic

a. An aspirational geological era defined by Thomas Berry and characterized as "mutually-enhancing human–Earth relations" (Berry 1999). Berry was an ordained priest, cultural historian, and self-described "geologian" who developed a vision for the Ecozoic while writing *The Universe Story* with cosmologist Brian Swimme.
b. The Ecozoic imagines the next age of life as a "house of living beings," following from the naming of the Paleozoic (ancient life), Mesozoic (middle life), and Cenozoic (recent life, Earth's current geological era of the last 66 million years). It stands in direct contrast to the image of human domination of the planet signaled by the proposed naming of the Anthropocene, a more recent "age of humans."
c. In the development of ecological economics, the Ecozoic provides a vision for the future focused on enabling harmonious relationships within the human community, and between our species and all life with which we share the Earth, known as "Buen vivir" in Latin America.

JON D. ERICKSON

Further reading

Swimme & Berry 1992; Vargas Roncancio et al. 2019.

See also: Anthropocene, Biocentrism, Ecocentrism, Buen vivir.

References

Berry, T. 1999. The Great Work: Our Way into the Future. New York: Bell Tower.
Swimme, B. & Berry, T. 1992. The Universe Story: From the Primordial Flaring Forth to the Ecozoic Era—A Celebration of the Unfolding of the Cosmos. New York: HarperCollins.
Vargas Roncancio, I., Temper, L., Sterlin, J. et al. 2019. From the Anthropocene to mutual thriving: an agenda for higher education in the Ecozoic. Sustainability 11(12): 3312.

Efficiency

Economics:

a. An economic situation where nobody can be made better off in terms of allocation of goods or resources without someone else being made worse off. More commonly called Pareto efficiency, Pareto optimality, or allocative efficiency. Pareto efficiency assumes competitive markets and will maximize net social benefits.
b. Productive efficiency is a situation where no increase in output of one good can be obtained without a decreased output of another good. When productive efficiency is obtained, the average total costs will be minimized. Productive efficiency also assumes competitive markets and will maximize net social benefits.

Ecology:

a. Ecological efficiency is a measure of the efficiency of energy transfer between trophic levels, which is generally inefficient.
b. Ecological efficiency can also mean the effective capture of low entropy through efficient energy use and recycling of wastes.

Energy:

a. Energy efficiency is a technical measure of the output energy to input energy used in buildings, transportation, and industry.
b. Energy efficiency can imply using less energy to provide the same energy service.

BARRY D. SOLOMON

Further reading

Arrow et al. 1961; Murillo-Zamorano 2004; Kozolovsky 1968; Patterson 1996.

See also: Efficiency-based arguments, Efficiency frontier, Economic efficiency, Competitive market, Pareto optimality, Kaldor–Hicks efficiency criterion, Eco-efficiency, Energy efficiency, Energy conservation, Energy services.

References

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Kozolovsky, D.G. 1968. A critical evaluation of the trophic level concept. I. Ecological efficiencies. Ecology 49(1): 48–60.

Murillo-Zamorano, L.R. 2004. Economic efficiency and frontier techniques. Journal of Economic Surveys 18(1): 33–77.

Patterson, M.G. 1996. What is energy efficiency? Concepts, indicators and methodological issues. Energy Policy 24(5): 377–90.

Efficiency-based arguments

Market-oriented economists commonly argue that environmental problems can be addressed efficiently through markets. This approach supports mechanisms such as a carbon tax or cap-and-trade system to respond to global climate change. A stronger assertion, based on the Coase theorem, is that private negotiations between polluters and victims can yield efficient pollution levels, if property rights are well defined. For example, a community could "buy off" a potential polluter by offering compensation to clean up or shut down production. Alternatively, a polluting industry might be required to pay a fee to operate. This theorem has been subject to extensive critiques. One limitation, acknowledged by Coase, is that most real-world pollution problems involve so many different parties that negotiations are not feasible because of high transaction costs. Another is that supposedly voluntary negotiations may involve an element of coercion based on unequal market power; for example, when a low-income community is persuaded to accept a toxic waste dump out of financial desperation. A more fundamental criticism is that Coasean negotiations are not a market process, but a game-theoretic problem susceptible to multiple, and not necessarily efficient, solutions.

An ecological perspective suggests that the principle of market efficiency is often in conflict with ecological efficiency. Ecological efficiency is based on the effective capture of low entropy through efficient energy use and recycling of wastes. An economic system that places a low price on energy, and no price on environmental damage, will therefore not be efficient in an ecological sense, tending to overuse energy and overproduce wastes. Ecological efficiency suggests that economic activity should be based on minimizing throughput of energy and resources, and maintaining compatibility with natural ecosystems.

JONATHAN M. HARRIS

Further reading

Hahnel & Sheeran 2009; Goodwin 2018; Harris & Roach 2022, Chapters 3 & 9.

See also: Economic efficiency, Coase theorem, Transaction costs, Game theory, Efficiency, Throughput.

References

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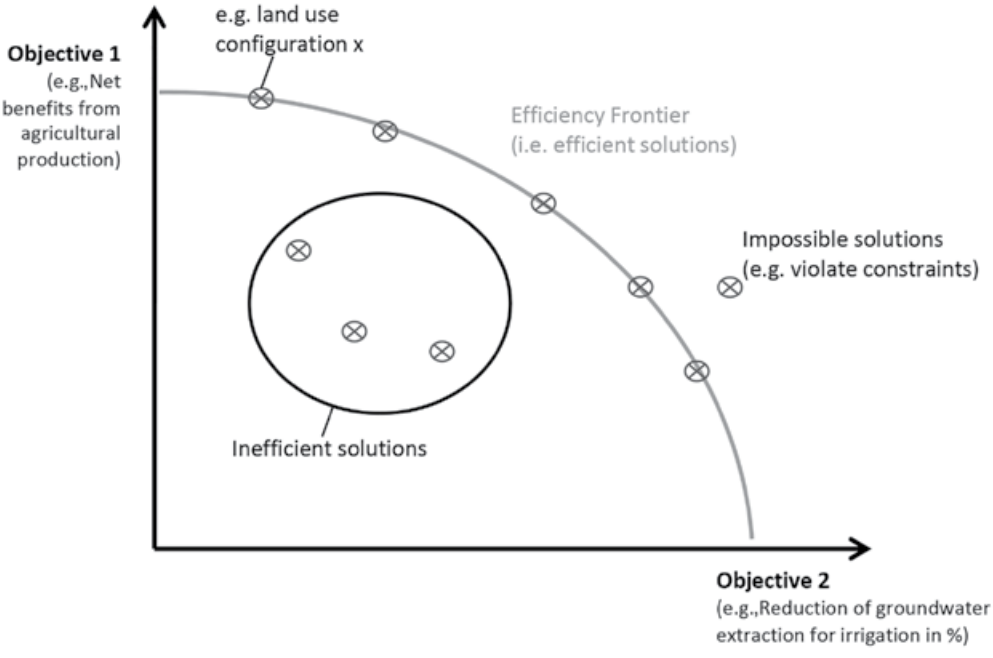

Source: Author.

Figure 5 *An efficiency frontier for land use configurations*

Efficiency frontier

A situation in economics or land use that describes any set of solutions where none of the considered objectives can be improved without deteriorating the performance for any other considered objective. The term "Pareto frontier" is also sometimes used, based on Pareto's definition of efficiency or optimality. For example, the efficiency frontier describes certain land use configurations of a region that correspond to certain levels of, for example, nitrate leaching, topsoil organic carbon stock accumulations, or net benefits from agricultural production (Karner et al. 2021). The frontier, hence, presents solutions; that is, land use configurations, where for example nitrate leaching cannot be declined without declining, for example, topsoil organic carbon stocks. Solutions that do not correspond to a land use configuration from the frontier but lead to, for example, lower levels of topsoil organic carbon stocks accumulation for the same performance of the other objectives, are called inefficient solutions (see Figure 5).

Efficiency frontiers are often computed in land use science (see Kaim et al. 2018 for a review), for instance related to water management (Lautenbach et al. 2013) or maintaining biodiversity (Polasky et al. 2008). However, efficiency frontiers are identified in several other fields, such as production economics (for example, stochastic frontier analysis; Greene 2005), finance (Markowitz 1952), welfare economics (Conesa & Garriga 2008), or energy economics (Yao et al. 2014). The considered objectives depend on the topic and the individual study/research objectives.

Katrin Karner

See also: Efficiency, Pareto optimality, Efficiency-based arguments, Land use planning, Land use change.

References

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reforms. International Economic Review 49(1): 291–318.
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Karner, K., Schmid, E., Schneider, U.A. & Mitter, H. 2021. Computing stochastic Pareto frontiers between economic and environmental goals for a semi-arid agricultural production region in Austria. Ecological Economics 185: 107044.
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Polasky, S., Nelson, E., Camm, J. et al. 2008. Where to put things? Spatial land management to sustain biodiversity and economic returns. Biological Conservation 141: 1505–24.
Yao, W., Zhao, J., Wen, F. et al. 2014. A multi-objective collaborative planning strategy for integrated power distribution and electric vehicle charging Systems. IEEE Transactions on Power Systems 29(4): 1811–21.

Effluent

Pollution from an industrial facility or wastewater treatment plant in the form of gaseous or liquid waste or sewage, typically discharged into a natural body of water such as a river, stream, lake, sea, or ocean.

Barry D. Solomon

Further reading

Jarvie & Solomon 1998; Earnhart 2007.

See also: Wastewater, Pollutant, Pollution, Polluted, Pollution abatement, Pollution intensity, Emissions trading.

References

Earnhart, D. 2007. Regulatory factors shaping environmental performance at publicly-owned treatment plants. Journal of Environmental Economics and Management 48(1): 655–81.
Jarvie, M. & Solomon, B.D. 1998. Point-nonpoint effluent trading in watersheds: a review and critique. Environmental Impact Assessment Review 18(2): 135–57.

Egalitarian

To be drawn from or based on the belief that all people should be treated, or treat each other, as equals. This equality can be conceptualized in a range of manners: equality in power, opportunity, or access to resources, across persons who exist at present, or those who currently exist alongside those who will exist in the future. What constitutes personhood is also constantly evolving and up for debate.

Megan G. Egler

Further reading

Arneson 2013; Dworkin 2000.

See also: Egalitarianism, Social equity, Inequality, Environmental justice, Ecological justice.

References

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Dworkin, R. 2000. Sovereign Virtue: The Theory and Practice of Equality. Cambridge, MA: Harvard University Press.

Egalitarianism

A school of thought within Western political philosophy that favors equality and holds that all beings should be treated as equals. The mainstream understanding of egalitarianism extends only to human people (Dworkin 2000; Arneson 2013). However, egalitarian norms can challenge the anthropocentric justice lens, extending to include non-humans in conceptualizations of who should be considered within the moral framing (Kopnina 2014; Baxter 2005).

Megan G. Egler

Further reading

Holtug & Lippert-Rasmussen 2007.

See also: Egalitarianism, Social equity, Inequality, Environmental justice, Ecological justice.

References

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Kopnina, H. 2014. Environmental justice and biospheric egalitarianism: reflecting on a normative-philosophical view of human–nature relationship. Earth Perspectives 1(1): 8.

Egoistic hedonism

Psychology: (1) ego drives the tendency for humans to focus on the self; (2) ego drives selfishness, in contrast to selflessness (empathy); (3) egoistic hedonism represents an extreme expression of the ego; (4) egoistic hedonism focuses exclusively on the pleasure of the self without regard to the other; (5) egoistic hedonism leads to excesses; (6) hedonism drives addiction unless tempered.

Economics: (1) ego is represented in mainstream (micro)economics in the ego-based pursuit of self(ish)-interest; (2) ego-driven self-interest leads to claiming greed-is-good, some attributing it to Adam Smith (1776 [1789]); (3) ego works to maximize self-interest; (4) an egoistic consumer is represented in one indifference curve, working to maximize self-interest; (5) egoistic hedonism leads to excesses in consumption; (6) heterodox economics, such as in behavioral economic science based (meta)economics (Lynne 2020), and ecological economics, sees the ego-based self-interest as a primal but not the only driver of people; (7) empathy (another indifference curve added to the indifference space, representing the shared-, the other-interest) is the other driver in economic choice; (8) empathy tempered ego leads to maximizing own interest (the actual claim of Smith 1776 [1789], 1759 [1790]), requiring sacrifices in self-interest; (9) environmental, ecological, and sustainability framing sees the ego driving the tragedy of the commons, which can be avoided only with empathy (Brown et al. 2019); (10) ego can result in achieving economic efficiency only if tempered by and balanced with empathy, by balancing self & other interest (Lynne 2020).

Gary D. Lynne

See also: Empathy, Pareto optimality, Utility, Heterodox economics, Behavioral economics.

References

Brown, K., Adger, W.N., Devine-Wright, P. et al. 2019. Empathy, place and identity interactions for sustainability. Global Environmental Change 56: 11–17.

Lynne, G.D. 2020. Metaeconomics: Tempering Excessive Greed. New York: Palgrave Macmillan.

Smith, A. 1759 [1790]. The Theory of Moral Sentiments. Indianapolis, IN: Liberty Fund.

Smith, A. 1776 [1789]. An Inquiry into the Nature and Causes of the Wealth of Nations. New York: Random House.

Embeddedness

Economics: the degree to which economic activities are constrained by non-economic institutions because the economy is immersed in social relations. The term was coined by economic historian Karl Polanyi (Polanyi et al. 1957; Polanyi 1968, 1992). The term has since then been used in other fields. For instance, in social sciences the concept of embeddedness refers to the dependence of a phenomenon on its environment in terms of its institutional, societal, cultural, or cognitive contexts within which a social action takes place and is dependent upon. Boons and Howard-Grenville (2009) describe how the cognitive, cultural, political, and structural mechanisms influence the emergence and operation of the industrial ecology approaches to resource management. Recently, Laurenti et al. (2018) describe the socio-economic embeddedness of the circular economy as the interactions between the socio-economic

systems containing a multitude of actors and the physical resource management system.

Ecology: the degree to which a natural resource manager is rooted in the land by physically living in it, while learning from it in an experiential way (Whiteman & Cooper 2000; Lewis & Townsend 2015).

Jagdeep Singh

See also: Social structures, Circular economy, Industrial ecology.

References

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Polanyi, K.P. 1968. Primitive, Archaic and Modern Economies: Essays of Karl Polanyi. G. Dalton, ed. New York: Doubleday-Anchor.

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Emergence and emergent properties

General: the way in which complex systems and patterns arise, in continuous becoming or formation, out of a multiplicity of relatively simple interactions (Adrienne Maree Brown 2017, citing Nick Obolensky 2014).

Socio-ecological systems:

> a system a made up of a set of parts, C(a), relationships among the parts {r1, … rn}, and the properties both of the parts and of the system: a configuration of parts or component configuration, is always associated with each emergent property, in which emergent property q of a system a is associated with some relation r between components y1 and y2 in C(a). (Trosper 2005)

Social sciences and the humanities: relationships and components that influence and are influenced by structures that may arise independently of human knowledge systems. Feminist traditions, for instance, opt for an open epistemological praxis, which follows how partial, situated knowledges rooted in contestation and deliberation, and grounded in everyday improvisations in response to uncertainty, become integral to understanding how systems change and evolve (Scoones & Stirling 2021).

Vijay K. Kolinjivadi

Further reading

Blitz 1992.

See also: Panarchy theory, Uncertainty, Feminist political ecology.

References

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Brown, A.M. 2017. Emergent Strategy. Stirling, UK: AK Press.

Obolensky, M.N. 2014. Complex Adaptive Leadership: Embracing Paradox and Uncertainty. Aldershot, UK: Gower Publishing.

Scoones, I. & Stirling, A. 2021. The Politics of Uncertainty—Challenges of Transformation. London: Routledge.

Trosper, R. 2005. Emergence unites ecology and society. Ecology and Society 10(1): 14.

Emergy

Ecology: the amount of solar energy (units = energy, such as joules) used directly and indirectly to support an activity or process. Ecologist Howard T. Odum (1995) developed emergy and the methods to calculate it starting in the mid to late 1980s, based on the trophic nature of ecosystems ("all flesh is grass; all grass is sunlight"). Emergy analysts

aptly call it "energy memory," especially because it can span disparate time scales, for example by including the ancient sunlight that produced fossil fuels. It is also used to quantify the sunlight driving the biosphere's assimilation of pollution.

Public policy: Emergy can be used to rank the desirability of projects, businesses, and activities; for example, nuclear versus hydro-based electricity, agriculture, aquaculture, and urban development. Odum and co-workers have forwarded a maximizing principle to guide selection, the "maximum empower principle." Both the method for determining emergy and its usefulness in development decisions are controversial among analysts, and minimally used by policy actors.

Robert A. Herendeen

Further reading

Odum 2007; Brown & Herendeen 1996.

See also: Energy, Energy analysis, Power.

References

Brown, M.T. & Herendeen, R. 1996. Embodied energy analysis and EMERGY analysis: a comparative view. Ecological Economics 19: 219–36.

Odum, H.T. 1995. Environmental Accounting: EMERGY and Environmental Decision Making. New York: John Wiley & Sons.

Odum, H.T. 2007. Environment, Power, and Society for the Twenty-First Century: The Hierarchy of Energy. New York: Columbia University Press.

Eminent domain

A right of a government to take private property by virtue of the superior dominion of the sovereign power over all lands within its jurisdiction. In the United States, under the "Takings Clause" of the Fifth Amendment to the Constitution, the landowner must receive just compensation and the taking must be for a "public use," which has been interpreted to include the broader concept of a "public purpose." States and other governmental entities develop their own due process rules for eminent domain actions (Meidinger 1980).

Traditional eminent domain actions are for roads, bridges, energy transmission, and building government structures such as town halls and capitols. Scenic easements can be obtained through eminent domain. Promoting economic development is considered sufficient "public purpose" to satisfy the constitutional requirement, even if this results in a transfer of condemned property from one private landowner to another. The state may use eminent domain to transfer property outright to a private party, so long as the exercise of the eminent domain power is rationally related to a conceivable public purpose. However, the use of eminent domain may not necessarily increase economic efficiency (Munch 1976).

Patricia A. Gotschalk

Further reading

Epstein 1985.

See also: Land use planning, Private property, Property right, Public goods, Regulatory taking.

References

Epstein, R. 1985. Private Property and the Power of Eminent Domain. Cambridge, MA: Harvard University Press.

Meidinger, E.E. 1980. The "public uses" of eminent domain: history and policy. Environmental Law 11(1): 1–66.

Munch, P. 1976. An economic analysis of eminent domain. Journal of Political Economy 84(3): 473–97.

Emissions

Discharges into the air, typically gases, particles, or radiation, from smokestacks, chimneys, or vents on industrial, commercial, or residential buildings, or tailpipes of motor vehicles.

Barry D. Solomon

See also: Pollutant, Pollution, Pollution abatement, Pollution intensity, Effluent, Emissions trading.

Emissions intensity

See: Pollution intensity.

See also: Emissions, Pollution.

Emissions trading

The exchange of air pollution credits or allowances between companies in an emissions trading system or market, which began in the United States in the 1970s (Gorman & Solomon 2002). Has included sulfur dioxide, nitrogen oxides, leaded gasoline, chlorofluorocarbons, carbon dioxide and greenhouse gases, among other pollutants. The most effective emissions trading programs have used a cap-and-trade system, and have the lowest transaction costs; while others have included emissions offsets, emissions reduction credit trading, Joint Implementation, and the Clean Development Mechanism. Emissions trading is based on the Coase theorem (Coase 1960).

By recognizing that companies have different pollution control costs, this allows them to freely exchange emissions allowances or credits in a manner to minimize total costs for a given level of emissions reduction. However, uncontrolled emissions trading can result in environmental justice problems, and local or regional pollution "hot spots" for non-uniformly mixed pollutant such as nitrogen oxides, sulfur dioxides, or air toxins, in which cases restrictions on trading are called for (Solomon & Lee 2000).

BARRY D. SOLOMON

Further reading

Tietenberg 1985, 1995.

See also: Cap and trade, Coase theorem, Coasean approach, Carbon trading, Tradable permits, Transaction costs, Clean Development Mechanism (CDM), Environmental justice, Hotspots.

References

Coase, R.H. 1960. The problem of social cost. Journal of Law and Economics 3(1): 1–44.

Gorman, H.S. & Solomon, B.D. 2002. The origins and practice of emissions trading. Journal of Policy History 14(3), 293–320.

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Empathy

Psychology:

a. The mindful act of identifying and working to feel the emotions of the other.
b. Walking in the shoes of the other and asking: "How would I wish to be treated?"
c. The starting point to selflessness, in contrast to going toward being selfish (ego).
d. Empathy is sometimes confounded with sympathy and compassion.

Economics:

a. The starting point to an efficient trade, meaning everyone party to the trade in the market can go along with the terms (Smith 1759 [1790], 1776 [1789]).
b. The first step on the path to joining in sympathy with, and, perhaps even having compassion for, the other (the moral sentiments in Smith 1759 [1790]).
c. In behavioral science-based (meta)economics (Lynne 2020), empathy is the starting point on the way to forming a shared (with others) interest.
d. Empathy-based other (internalized yet shared) interest brings ethics back into economic choice.
e. Empathy induces sacrifice in self-interest, with sacrifice essential to achieving economic efficiency.
f. Empathy is formally represented by an overlapping, joint, non-separable set of

iso (indifference or isoquant) curves, one set for ego, the other for empathy.

Environmental, ecological, and sustainability science:

a. Empathy is the essential ingredient to attaining sustainability (Brown et al. 2019.
b. Empathy is essential to avoiding the tragedy of the commons (Lynne 2020).

Philosophy:

a. Empathy is the starting point on the path through empathy–sympathy–compassion.
b. Empathy is the foundation and motivation for ethics (Solomon 2007) and moral sentiments (Smith 1759 [1790]).

Gary D. Lynne

Further reading

Hayes & Lynne 2013; Kirman & Teschl 2010; Singer 2014.

See also: Egoistic hedonism, Pareto optimality, Utility, Heterodox economics, Behavioral economics.

References

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Singer, T. 2014. "Understanding others: brain mechanisms of theory of mind and empathy," pp. 513–30 in Neuroeconomics: Decision Making and the Brain, 2nd edn. P.W. Glimcher, C.F. Camerer, E. Fehr & R.A. Poldrack, eds. San Diego, CA: Academic Press.
Smith, A. 1759 [1790]. The Theory of Moral Sentiments. Indianapolis, IN: Liberty Fund.
Smith, A. 1776 [1789]. An Inquiry into the Nature and Causes of the Wealth of Nations. New York: Random House.
Solomon, R.C. 2007. True to Our Feelings: What Our Emotions Are Really Telling Us. New York: Oxford University Press.

Empiricism

A philosophy of science that posits that acquiring knowledge relies on observation. Observations are made, measured, and compared using statistical methods. Hypotheses are posited and can be falsified by further data gathering and measurement. Ecological economics, with a core tenet being that the economy is nested in a biophysical reality, which itself is subject to the laws of thermodynamics, utilizes empirical methods especially as it frames social processes as occurring within biophysical constraints. Debates continue on the extent to which empiricism can guide studies into human society, if at all.

Social constructivists (an extreme perspective) would argue that empiricism has no place in the study of human society since knowledge emerges from social processes and interactions, not individual empirical observation. Thus, some aspects of ecological economics call for empiricism while others do not. Norgaard (1989) has called for "methodological pluralism," while Spash (2012) advocates for "critical realism," both approaches attempting to orient the field in relationship to empiricism and other ways of knowing, as well as to mainstream economics and other branches of economics.

Brent M. Haddad

Further reading

Ramos-Martin 2003.

See also: Methodological pluralism, Multivariate statistical techniques, Social constructionism, Critical realism.

References

Norgaard, R.B. 1989. The case for methodological pluralism. Ecological Economics 1(1): 37–57.
Ramos-Martin, J. 2003. Empiricism in ecological economics: a perspective from complex systems theory. Ecological Economics 46(3): 387–98.
Spash, C.L. 2012. New foundations for ecological economics. Ecological Economics 77: 36–47.

Empowerment

a. The knowledge and awareness of the process to exercise control and influence over decisions that affect one's own life, through interaction with family members, and their position in social, political, or religious organizations.
b. The process of giving the authority or power to someone to make decisions that affect the individual's life, those of the community members, or beyond when duties are performed in a political, social, or religious role. In an economics context, one can think of empowerment as a broader agency that grants them access to economic resources and therefore empowers them to make decisions that improve their lives and of those around them. For example, the ability of a person to decide to join the work force or a local political/social organization.

KHUSHBU MISHRA

Further reading

Doss 2013; Mishra & Sam 2016; Rappapon 1984; Zimmerman 2000.

See also: Human agency, Autonomous institution.

References

Doss, C. 2013. Intrahousehold bargaining and resource allocation in developing countries. World Bank Research Observer 28(1): 52–78.
Mishra, K. & Sam, A.G. 2016. Does women's land ownership promote their empowerment? Empirical evidence from Nepal. World Development 78: 360–71.
Rappapon, J. 1984. Studies in empowerment. Prevention in Human Services 3(2–3): 1–7.
Zimmerman, M.A. 2000. "Empowerment theory," pp. 43–63 in Handbook of Community Psychology. J. Rappaport & E. Seidman, eds. New York: Springer.

Empty world

A metaphorical device popularized by Herman Daly in the 1980s and 1990s to compare and contrast the economic situation between much earlier times and today. In the empty world, manufactured capital and skilled labor as well as humans were relatively scarce, while natural capital was superabundant (Figure 6). While Daly was always vague about when the empty world period was, it can probably be thought of as times before the Industrial Revolution until the 1970s and 1980s. During the empty world period, lack of concern with overexploitation of natural capital was reasonable. However, this is not the case today where the global ("full world") economy and human population have dramatically grown to current levels, while skilled labor and manufactured capital are abundant, and natural capital is increasingly scarce. While the global economy has grown dramatically the Earth and its ecosystems, which the economy is embedded in, has not changed in size. This change in world outlook, which has not been fully endorsed by neoclassical economics, has stark implications for environmental policy and sustainable development.

BARRY D. SOLOMON

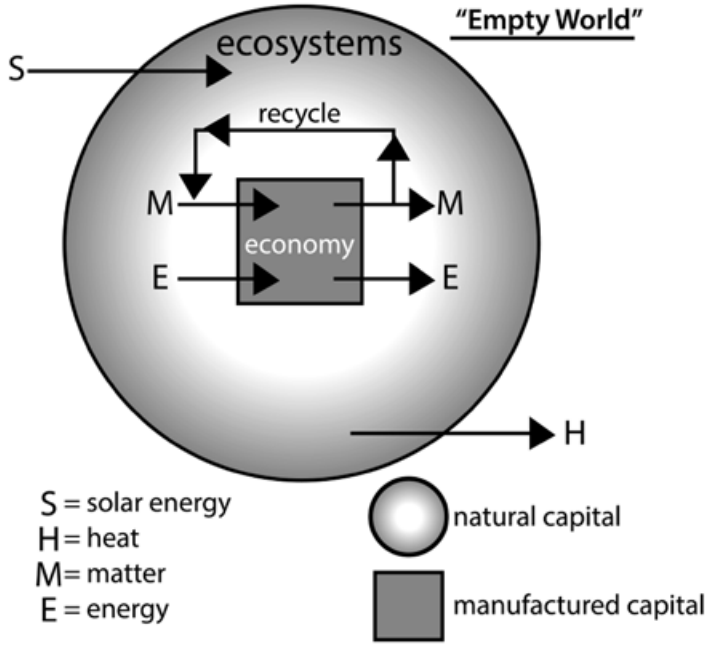
Further reading

Daly 1992, 2005.

See also: Full world, Natural capital, Manufactured capital, Scarcity, Relative vs. absolute scarcity, Sustainable development.

References

Daly, H.E. 1992. "From empty-world economics to full-world economics: recognizing an historical turning point in economic development," pp. 18–26 in Population, Technology and Lifestyle: The Transition to Sustainability.



Source: Jill Gotschalk, reprinted with permission.

Figure 6 *The economy in an empty world*

R. Goodland, H.E. Daly & S. El-Serafy, eds. Washington, DC: Island Press.
Daly, H.E. 2005. Economics in a full world. Scientific American 293(3): 100–107.

Endangered species

Any plant or animal species that is at imminent risk of extinction throughout all or a significant portion of its range because of a decrease in its population and/or loss of critical habitat. A threatened species, in contrast, is one that is not yet endangered but is considered likely to become endangered in the near future in all or a significant portion of its range. A species that becomes extinct in a local area only is considered extirpated in that geographic area.

BARRY D. SOLOMON

Further reading

Czech & Krausman 2001; Kotchen & Reiling 2000; Loomis & White 1996.

See also: Species, Keystone species, Invasive species, Habitat, Habitat fragmentation.

References

Czech, B. & Krausman, P.R. 2001. The Endangered Species Act: History, Conservation, Biology, and Public Policy. Baltimore, MD: Johns Hopkins University Press.
Kotchen, M.J. & Reiling, S.D. 2000. Environmental attitudes, motivations, and contingent valuation of nonuse values: a case study involving endangered species. Ecological Economics 32(1): 93–107.
Loomis, J.B. & White, D.S. 1996. Economic benefits of rare and endangered species: summary and meta-analysis. Ecological Economics 18(3): 197–206.

Endogeneity

Economics: in the context of econometric modeling, a situation where an explanatory variable in the model is correlated with the error term, resulting in a biased coefficient estimate and inferences (Baltagi 2011, p. 7; Louviere et al. 2005, p. 256). Endogeneity results in model misspecification because of the presence of variable values that are fixed and determined outside the model. Thus, when there is endogeneity, ordinary least squares (OLS) estimates are biased and inconsistent (Greene 2018). In applied econometrics, endogeneity usually arises in the context of omitted variables or missing attributes, measurement error, and simultaneity (Guevara 2015). Endogeneity can also be caused by non-random sample selection where the selection is related to dependent variables, either directly or through the error term in the econometric model (Wooldridge 2019).

Can Liu

See also: Econometrics, Preference endogeneity, Endogenous growth model, Exogenous.

References

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Louviere, J., Train, K., Ben-Akiva, M.E. et al. 2005. Recent progress on endogeneity in choice modelling. Marketing Letters 16(3–4): 255–65.

Wooldridge, J.M. 2019. Introductory Econometrics: A Modern Approach, 7th edn. Boston, MA: Cengage Learning.

Endogenous growth model

a. A theoretical model of growth in which the growth rate is determined by the (equilibrium) solution of the model itself (rather than being determined exogenously) and/or in which technical progress is explicitly modeled (rather than taken as exogenously given). Growth models that satisfy only the second condition are referred to as "semi-endogenous" (following Jones 1995).
b. (Following Kaldor 1985) a theoretical model of growth in which the current growth rate is influenced by the past growth rate, so that growth is endogenous to its own history and must be understood as historically contingent.

Mark A. Setterfield

Further reading

Roberts & Setterfield 2007.

See also: Economic growth, Progress, Technological progress.

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Endowment

A quantity of something owned or controlled by a person or group of interests. The term is used to signal that the thing already is present at the beginning of the period of interest, such as fertile soil (Coromaldi et al. 2015), or water resources (Fracasso 2014; Marchiori 2014). It can apply to several types of capital (natural, human, physical, financial).

Modeling studies typically take initial endowments as a given and then explore how the endowments change over time and influence other dynamics in the model. By contrast, the "endowment effect" describes an observed tendency for people to assign greater value to something they already own, compared to the price they would pay to

acquire it. Identified by Kahneman et al. (1991), the endowment effect casts a shadow on the reliability of valuation studies because people can be seen as unreliable estimators of how much they value things when the same item has two different valuations depending on its ownership status.

Brent M. Haddad

See also: Capital, WTP vs. WTA disparity, Factor endowment theory.

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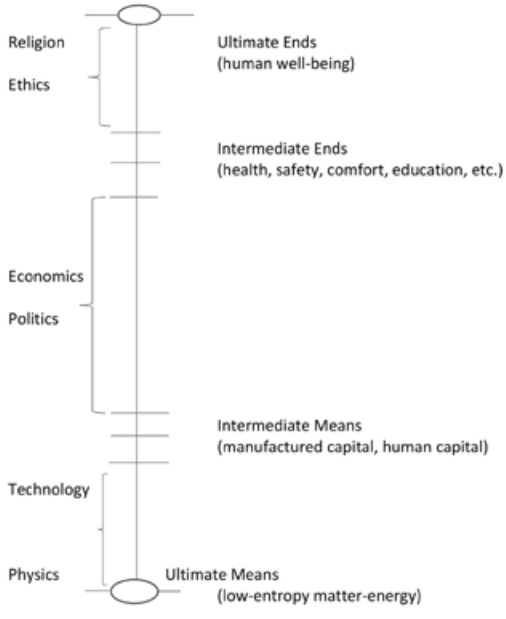
Marchiori, C. 2014. Inequality and the rules in the governance of water resources. Ecological Economics 105: 124–9.

Ends–means spectrum

The full spectrum of useful purposes in the world between ultimate means and ultimate ends, which includes intermediate means and intermediate ends (Daly, 1991; see Figure 7). Mainstream economics focuses on the middle part of the spectrum (between intermediate means and intermediate ends), ignoring the extremes (ultimate means and ultimate ends). This narrow focus prevents mainstream economics from analyzing both biophysical and moral limits to economic growth.

Lina Brand-Correa



Source: Editors.

Figure 7 *The ends–means spectrum in which the economy is embedded*

Further reading

Brand-Correa & Steinberger 2017; O'Neill et al. 2018.

See also: Ultimate ends, Ultimate means.

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O'Neill, D.W., Fanning, A.L., Lamb, W.F. & Steinberger, J.K. 2018. A good life for all within planetary boundaries. Nature Sustainability 1(2): 88–95.

Energy

The ability to do work. Energy exists in many different forms and natural resources. According to the First Law of Thermodynamics, energy can be transformed from one form to another but cannot be created or destroyed.

Economics: a factor of production, which has limited substitutability with manufactured capital and labor.

Ecology: energy from the Sun flows in ecosystems and is transferred between organisms in food webs from producers to consumers.

Barry D. Solomon

Further reading

Hall et al. 1986; Hall & Klitgaard 2018; Odum 1968; Odum 2007.

See also: Primary energy, Secondary energy, Emergy, Exergy, Entropy law.

References

Hall, C.A.S., Cleveland, C.J. & Kaufmann, R. 1986. Energy and Resource Quality: The Ecology of the Economic Process. New York: Wiley-Interscience.

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Energy access

The extent to which a household can afford essential energy services, such as heating, cooling, mobility, and power, necessary to guarantee a decent standard of life (IEA 2020). The inability to access energy is defined as energy poverty (European Commission 2020, pp. 35–41). Energy access is still an unsolved issue for millions of people in both developing countries (IEA 2017, 2019) and developed countries (European Energy Poverty Observatory 2019). It is among the key preconditions for people to fulfill their essential capabilities and social inclusion (Middlemiss et al. 2019). Ensuring access to energy that is affordable, reliable, sustainable, and modern for all is number 7 of the United Nations 2030 Sustainable Development Goals (UN 2015). Energy access is acknowledged as a right in several European documents (Directive 2019/944, pp. 125–99; Charter of Fundamental Rights of the European Union 2012, pp. 391–407; European Pillar of Social Rights 2017).

The progress towards the energy access target is tracked through instruments measuring energy poverty (Nussbaumer et al. 2012). These instruments usually measure the energy costs faced by the households (that is, expenditures), self-reported indoor housing conditions and ability to attain basic needs (that is, consensual approach), and energy services achieved in the home compared to a certain standard (that is, direct measurement) (Thomson et al. 2017). Being multidimensional in nature, energy poverty is also measured with secondary indicators capturing indirectly related aspects, such as housing-related data and energy prices (European Energy Poverty Observatory 2019).

Nives Della Valle

See also: Energy, Energy self-sufficiency.

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UN (United Nations). 2015. Sustainability Development Goal 7. https://sdgs.un.org/goals/goal7.

Energy analysis

Physics: technical analysis of the energy use and flows in structures and buildings. Requires analysis of the physical or chemical processing of materials, and the transfer and conversion of energy in the structure or building. Often conducted to determine the potential for energy savings through efficiency improvements or conservation.

Ecological economics: the process of determining the direct and indirect energy required to allow an economic system to produce a good or service. This technique was developed in the early 1970s (IFIAS 1974). The total energy required to produce a good, service, or entity, direct and indirect, is known as embodied energy, with the indirect energy requirement being especially important. The accounting technique for indirect energy flows is similar to that of input–output (I–O) analysis in economics (Costanza 1980). Energy analysis can also be used to determine the net energy produced by an energy technology, though in practice renewable energy has often been omitted from the analysis. Policy applications of energy analysis have been controversial (Huettner 1976; Herendeen 2004).

BARRY D. SOLOMON

Further reading

Odum & Odum 1983; Brown & Herendeen 1996.

See also: Energy flows, Indirect energy, Energy efficiency, Energy conservation, Input–output (I–O) analysis.

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Energy carriers

Any fuel, substance, or phenomenon that can be used to produce mechanical work or heat, or to operate physical or chemical processes. Energy carriers occupy intermediate steps between primary energy sources and their end use applications, and do not produce energy. Examples include coal, crude oil, natural gas, biomass (including peat, wood, plants, residues, and wastes), dammed water, nuclear energy, wind energy, solar energy, geothermal energy, compressed air, springs, batteries, electricity, capacitors, and hydrogen.

Barry D. Solomon

Further reading

Cleveland & Morris 2013.

See also: Energy, Primary energy, Secondary energy, Fossil fuels, Non-renewable resource, Renewable energy, Exergy, Entropy law.

Reference

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Energy conservation

Any behavior that reduces the consumption of a constrained energy supply to decrease the overall necessity to produce energy. Energy conservation can be achieved in two ways: (1) households or firms can change their consumption of energy services, for example by reducing lighting; (2) they can invest in energy efficiency, for example by buying an energy-efficient washing machine or refrigerator. The purchase of an energy-efficient appliance will eventually lead to energy conservation if the potential energy savings are not fully offset by an increase in the use of the appliance, known as the rebound effect. Energy conservation implies reducing overall energy use. A further example: turning off the air conditioning when leaving a building.

Mark A. Andor, Benjamin Koch & Leonie Matejko

Further reading

Andor & Fels 2018; Andor et al. 2020; Croucher 2011; EIA 2019; Menegaki & Tsani 2018.

See also: Energy efficiency, Rebound effect, Jevons paradox, Conservation.

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Energy economics

a. A subfield of economics that applies its principles, methods, and tools to study the impacts of exploitation, conversion, and use of energy in the society, from its primary forms (for example, hard coal, crude oil) to its end use services (for example, heating, lighting). Energy economics comprises the analysis of the depletion of natural resources and the assessment of energy markets, including environmental, geopolitical, and technological aspects that influence the trade of energy commodities. Energy economists often provide advice as a solution for different applications, measuring the costs and benefits of different policy options, such as regulation and taxation of energy markets.

b. The branch of applied economics that studies, *inter alia*: (1) the economics of energy supply involving exploration, development, production, transportation, storage, transformation, and delivery of energy commodities; (2) the economic logic of energy consumption decisions by various users; (3) energy transactions through alternative market arrangements and their governance; (4) the economic dimension of social and environmental impacts of energy use; and (5) the planning, policy, and performance of the industries, actors, and governance mechanisms (Bhattacharyya 2019; Schwartz 2017).

RAFAEL GARAFFA

See also: Economics, Natural resource economics, Non-renewable resource, Fossil fuels, Renewable resource.

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Energy efficiency

Using less energy to perform the same functions or provide the same energy products or energy services (Patterson 1996). Different from energy conservation, which often involves energy consumption behavioral changes or reduction in the useful output, product, or services from energy use, energy efficiency is usually enabled through technological development or deployment (Jaffe & Stavins 1994). Energy efficiency is one of the most cost-effective ways to lower energy costs, reduce air pollutants and greenhouse gas emissions, and address energy security and independence challenges.

SHAN ZHOU

See also: Energy conservation, Energy services, Energy analysis.

References

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Energy flows

Ecology:

a. The movement of energy across trophic levels of an ecosystem.
b. Vital constituents in the formation, composition, and functioning of socio-ecological systems.

Economics: the movement of energy along supply chains through final consumption.

Ecological and biophysical economics:

a. The extraction of primary energy sources (for example, raw fuels such as coal, natural gas, and renewables), which are transformed into energy carriers or secondary energy (for example, electricity, heat) mapped into usable energy services in a society.
b. Exosomatic energy throughput in societies (Lotka 1956).

Physics: essential energy transfers that sustain the "ability to do work."

Physiology:

a. Prime ingredients sustaining the human body and activities.
b. Endosomatic energy used inside the body in the form of kcal.

Political ecology:

a. The energy expended by people working in politicized environments such as industrial factories as agents for contested political power (e.g., labor resistance movements) over the control of energy (Huber 2017).

b. Flows of vitality within socio-ecological systems beyond resources or commodities (Bennett 2010).

Social anthropology: the nexus between energy (as well as food and water) and life within contemporary culture. (For a conceptual history, see Caygill 2007.)

Spirituality/metaphysics:

a. Unseen forces influencing the human psyche (Fabbo 2020).
b. The movement of spiritual energy related to the sacred.

ALEVGUL H. SORMAN

Further reading

Cleveland 2004; Smil 2017.

See also: Classical thermodynamics, Entropy law, Energy, Commodity supply chain, Commodity trade, Materialism, Complexity, Political ecology, Ecological distribution conflicts, Energy pathways, Energy transition.

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Caygill, H., 2007. Life and energy. Theory, Culture & Society 24(6): 19–27.
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Lotka, A.J. 1956. Elements of Mathematical Biology. New York: Dover Publications.
Smil, V. 2017. Energy: A Beginner's Guide. New York: Simon & Schuster.

Energy intensity

The ratio between total consumption of energy (E) in a particular country and (Y), the gross domestic product (GDP) in the same country: E/Y, that is, the amount of energy needed to produce a unit of national output. Comparisons of energy intensity over time imply the use of an inflation-adjusted (deflated) series of GDP. Energy intensity is also used to estimate energy intensity per economic sector. The level of energy intensity of a country depends directly on: (1) technological efficiency or yield of the energy converters (machines and implements used to produce goods); and (2) structure of the economy (firms and sectors have diverse energy intensities, so total energy intensity depends on their relative shares of the entire energy consumption). Where energy intensity is lower, less energy is required to produce goods and services, and therefore the impact of production on the environment is lower.

On a global scale, energy intensity began to decline from the middle of the 20th century, and especially from the time of the oil crises of the 1970s. Less common than energy intensity is the concept of "energy productivity," or the reverse of energy intensity: that is, the ratio between GDP and total consumption of energy: Y/E. Y/E measures the amount of output produced by a unit of energy.

PAOLO MALANIMA

Further reading

Smil 2017; Metcalf 2008; Miketa 2001; Kander et al. 2017; Malanima 2021.

See also: Energy, Energy efficiency, Gross domestic product (GDP), Productivity.

References

Kander, A., Warde, P., Teives Henriques, S. et al. 2017. International trade and energy intensity during European industrialization, 1870–1935. Ecological Economics 139: 33–44.
Malanima, P. 2021. Energy, productivity and structural growth: the last two centuries. Structural Change and Economic Dynamics 58: 54–65.
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Miketa, A. 2001. Analysis of energy intensity developments in manufacturing sectors in

industrialized and developing countries. Energy Policy 29: 769–75.
Smil, V. 2017. Energy Transitions: Global and National Perspectives, 2nd edn. Santa Barbara, CA: Praeger.

Energy pathways

Biology: refers to different pathways which living systems metabolize resources into energy to do work. For example, the human body can convert nutrients into energy through both aerobic pathways (with oxygen) and anaerobic pathways (without oxygen).

Economics: the social metabolism of energy and matter similarly occurs along various pathways from nature, through the economy, and back to nature as waste. Different pathways—for example, burning stored solar energy in fossil fuels, or living off current energy flows from the Sun—have implications for the availability of energy to grow, maintain, and repair socio-economic systems. Energy transitions, planned or otherwise, follow different energy pathways than the existing energy systems.

JON D. ERICKSON

Further reading

Fischer-Kowalski & Haberl 2007; Pauliuk & Hertwich 2015.

See also: Pathway, Energy, Energy transition, Path dependence, Human appropriation of net primary production (HANPP), Social metabolism.

References

Fischer-Kowalski, M. & Haberl, H., eds. 2007. Socioecological Transitions and Global Change: Trajectories of Social Metabolism and Land Use. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.
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Energy quality

Thermodynamics: the relative potential of a type of energy to do work. In thermodynamics, "work" itself is a rigorously defined term which can reduce to familiar examples: to lift a weight, to accomplish a chemical reaction, to build a house, to extract an ore. Similarly, "energy" is more rigorously called "free energy" or "exergy." An example of the difference: a swimming pool's warm water could contain as much energy as the flame from burning a lump of coal, but only the latter can melt lead. The coal has more exergy per gram than the pool's water. Exergy depends on temperature, height (of a weight), chemical bonds (in a fuel), degree of atomic order (in a magnet), density (that is, concentration), and other variables. Mastering the details is demanding physics.

Economics: the relative ease of accessing, transmitting, transforming, storing, and using an energy type productively and safely. This is the practical and economic parallel of the technical aspect of energy quality given above. For example, electricity is generally considered of higher quality—more flexible, more adaptable—than wood, coal, or oil; and monetary prices usually reflect this. Technology (not to mention politics) affects the evaluation. For example, fracking has made lower-quality oil (previously not economically desirable) now worth extracting.

ROBERT A. HERENDEEN

Further reading

Ayres 1998; Wall 1987; Gillett 2006.

See also: Energy, Exergy, Entropy, Energy analysis.

References

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Wall, G. 1987. Exergy conversion in the Swedish society. Resources and Energy 9(1): 55–73.

Energy return on investment (EROI)

A metric that provides a net energy ratio for any given energy gathering activity. Sometimes called energy return on energy invested (ERoEI). Derived by dividing the energy returned to society over the energy invested to get it (Murphy et al. 2011). A standard application $EROI_{stnd}$ refers to energy directly won from nature, for example, oil at the wellhead, coal at the mine mouth, corn at the farm gate. Other applications have been derived by expanding the system's boundary, including: point of use $EROI_{pou}$; extended $EROI_{ext}$; societal $EROI_{soc}$; ideal $EROI_{ide}$ (Atlason & Unnthorsson 2014); dynamic EROI (Capellán-Pérez et al. 2019); and analogous measures such as energy stored and energy saved on investment (ESOI).

EROI should always be expressed as a ratio; for example, a mean EROI of 20:1 for wind power means that you get ~20 units of electricity in return (before considering storage costs, e.g., Palmer 2017) for every unit of energy invested in manufacturing, installing, maintaining, and decommissioning a wind energy system (Hall et al. 2014). EROI can provide a useful way of thinking about how organisms, ecosystems, and societies must obtain enough surplus energy returned from energy-gathering activities to live, reproduce, and thrive (Hall 2017; Lambert et al. 2014). EROI can help researchers to understand and compare the energy trade-offs, efficiencies (and inefficiencies), and surplus potentials of different fuels and technologies that power, or might power, socio-economic systems (Melgar-Melgar & Hall 2020). Some have criticized EROI estimates as being too variable to be useful for analytic work (Murphy et al. 2016). Alternatively, EROI can provide estimates of a minimum threshold and investments necessary for society to embark on energy transitions (Hall et al. 2009; Sers & Victor 2018).

Charles A.S. Hall & Rigo E.M. Melgar

Further reading

Hall & Klitgaard 2018.

See also: Exergy, Fossil fuels, Renewable energy, Energy analysis, Energy transition.

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protocol for determining the EROI of fuels. Sustainability 3(10): 1888–1907.
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Sers, M.R. & Victor, P.A. 2018. The energy–emissions trap. Ecological Economics 151: 10–21.

Energy revolution

A massive and rapid energy transition to renewable sources and much greater efficiency in the use of energy. In recent decades, what has become the "green economy" (GE) has been proposed to the whole world by environmental movements (Pearce et al. 2016). The GE's core includes equity, replacing all goods with durable and sustainable ones, and promoting the "energy revolution," that is, the growing use of more efficient and renewable energy—the Sun (thermal and photovoltaic panels), wind (onshore and offshore wind generators), biomass, geothermal, and hydroelectric energy, as well as much more efficient energy use—to drastically reduce carbon dioxide emissions from fossil fuels, which are mainly responsible for global warming. To cope with global warming and its increasing dramatic consequences, energy consumption in all sectors—industrial, transport, domestic uses, and electric power—must be converted, abandoning fossil fuels, which still supply almost 80 percent of global energy needs. It is a massive challenge, a true revolution, aimed at keeping the global temperature increase within 1.5°C (Dimitrov 2016). The European Union has already pledged "net zero carbon" by 2050 (Tsiropoulos et al. 2020).

MASSIMO SCALIA

See also: Energy transition, Energy pathways, Renewable energy, Energy efficiency, Energy conservation, Green economy, Global warming, Greenhouse gases, Net zero carbon.

References

Dimitrov, R.S. 2016. The Paris Agreement on climate change: behind closed doors. Global Environmental Politics 16(3): 1–11.
Pearce, D., Markandya, A. & Barbier, E.B. 2016. Blueprint for a Green Economy. London: Routledge.
Tsiropoulos, I., Nijs, W., Tarvydas, D. & Ruiz, P. 2020. Towards Net Zero Emissions in the EU by 2020. Petten, the Netherlands: JRC Technical Reports, European Commission.

Energy self-sufficiency

A condition whereby an economic system (country, state, province, and so on) consumes only its own, or largely its own, primary energy output. Sometimes also called energy independence, energy self-reliance, or energy autarky (Müller et al. 2011). Complete energy self-sufficiency is rare, since the importing and exporting of primary and secondary energy sources is common for economic reasons.

BARRY D. SOLOMON

Further reading

MIT Energy Laboratory Policy Study Group 1974.

See also: Primary energy, Secondary energy, Energy analysis, Commodity trade.

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MIT Energy Laboratory Policy Study Group. 1974. Energy Self-Sufficiency: An Economic Evaluation. Washington, DC: American Enterprise Institute for Public Policy Research.
Müller, M.O., Stämpfli, A., Dold, U. & Hammer, T. 2011. Energy autarky: a conceptual framework for sustainable regional development. Energy Policy 39(10): 5800–810.

Energy services

a. Those functions performed using energy as means to obtain or facilitate desired end services or states (Fell 2017, p. 137). Examples include thermal comfort, mobility, refrigeration.

b. Functions are conceptualized as being independent from actual beneficiaries, while "a service is only a service if a human beneficiary can be identified" (Potschin & Haines-Young 2011, p. 578). For example, no service is attributable to illuminating and heating vacant buildings, although the lighting functions are in place.

There are several contexts in which energy services are characterized or analyzed, including the energy transformation chain (that is, energy conversion from primary energy extraction to final consumption); the role of energy demand and consumption, human needs satisfiers and contributions to well-being; and energy service companies (ESCOs) (Kalt et al. 2019).

KAI WHITING

See also: Services, Ecosystem services, Energy access, Material services, Universal basic services (UBS).

References

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Potschin, M.B. & Haines-Young, R.H. 2011. Ecosystem services: exploring a geographical perspective. Progress in Physical Geography 35(5): 575–94.

Energy transition

A long-term structural change in energy systems, typically in a nation-state (Kuskova et al. 2008; Strunz 2014) or globally.

Economics: a shift in the use of one or more dominant energy sources naturally occurs as technology improves over time and one or more energy sources become more cost-effective than the ones historically relied upon.

Ecology: in the 21st century, many political regimes have promoted a planned energy transition and decarbonization to stay within the Earth's carrying capacity, by requiring or incentivizing greater use of renewable and sustainable energy sources (Foxon 2011). An energy transition does not require the use of a single energy source.

Two research schools have been developed to better understand energy transitions: (1) the Viennese socio-metabolic transitions approach, which takes a long-term perspective; and (2) the Dutch societal transitions management approach, which is decades in scope (Fischer-Kowalski & Rotmans 2009).

BARRY D. SOLOMON

Further reading

Solomon & Krishna 2011.

See also: Climate change, Climate change mitigation, Net zero carbon, Green New Deal.

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Entitlements

a. The right to do or receive something, based on a belief, law, or contract.
b. Specific government-managed benefit payments or services that certain people are entitled to by law; for example, health care benefits, social security benefits, workers' compensation, disability,

paid or unpaid family leave from work, welfare, food assistance, and so on.

c. Real estate entitlements are approvals required for the right to develop land parcels for specific uses.

In ecological economics, entitlements have been explored in the context of access to community forests and other natural resources, that is, "ecological entitlements" (Ruitenbeek 1991, 1996); and as a distributive justice criterion in the context of the degrowth dialogue with respect to the entitlements of nature and society (Gabriel & Bond 2019).

BARRY D. SOLOMON

Further reading

Nussbaum 2003.

See also: Rights, Environmental rights, Obligation, Services, Universal basic services (UBS), Human needs assessment, Matrix of human needs.

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Nussbaum, M. 2003. Capabilities as fundamental entitlements: Sen and social justice. Feminist Economics 9(2–3): 33–59.

Ruitenbeek, H.J. 1991. Indicators of Ecologically Sustainable Development: Towards New Fundamentals. Ottawa: Canadian Environmental Advisory Council.

Ruitenbeek, H.J. 1996. Distribution of ecological entitlements: implications for economic security and population movement. Ecological Economics 17: 49–64.

Entropic dissipation

Carnot's (1824) analysis of the efficiency limits of steam engines showed that it was the irreversible dissipative flow of heat to the cool environment of the motor that resulted in a fraction of the heat being converted to work. Later universalized to all transformations of energy as the Second Law of Thermodynamics, this phenomenon was incorporated into ecological science at the scale of the Earth system by Vladimir Vernadsky in 1924, and into the social sciences by Georgescu-Roegen (1971).

Whilst the foundational importance of solar energy, vegetation, and fire to ecological and economic organization were recognized by Francois Quesnay, since Adam Smith ecology and physics have been excluded from mainstream economic theory. The biosphere and the industrial economy are both "dissipative structures," expanding and maintaining their order by appropriating available energy from their environment and exporting unavailable energy and waste to it. The biosphere, a complex adaptive recycling system, is "sustainable" as long as the photosynthesis-driven carbon cycle maintains a temperature range suitable for life. The industrial economy is unsustainable as long as it burns fuel faster than carbon can be fixed by biogeological processes. What conventional economics terms "production" and "growth" is simultaneously entropic dissipation.

JEREMY WALKER

Further reading

Clausius 1867; Grinevald 1998; Walker 2020; Hornborg 1998; Wicken 1986.

See also: Energy, Dissipation, Entropy, Entropy law, Classical thermodynamics, Physiocrats.

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Hornborg, A. 1998. Towards an ecological theory of unequal exchange: articulating world system theory and ecological economics. Ecological Economics 25(1): 127–36.

Walker, J. 2020. More Heat than Life: The Tangled Roots of Ecology, Energy and Economics. Singapore: Palgrave.

Wicken, J.S. 1986. Evolutionary self-organization and entropic dissipation in biological and

socioeconomic systems. Journal of Social and Biological Structures 9(3): 261–73.

Entropy

An extensive property of a closed, isolated thermodynamic system that represents the unavailability of the system's thermal energy for conversion into useful work. It is also considered a metric of disorder or randomness of the system.

Barry D. Solomon

Further reading

Georgescu-Roegen 1971.

See also: Entropy law, Classical thermodynamics, Entropic dissipation.

Reference

Georgescu-Roegen, N. 1971. The Entropy Law and the Economic Process. Cambridge, MA: Harvard University Press.

Entropy law

The Second Law of Thermodynamics. It states that a physical property of an isolated thermodynamic system is that entropy always increases, as energy transforms from a useful state to a state in which it has a lower capacity to perform work as it is lost to the surroundings. This process is called entropic dissipation. The entropy law has not been accounted for by neoclassical economics and is fundamental to ecological economics.

Barry D. Solomon

Further reading

Georgescu-Roegen 1971.

See also: Entropy, Entropic dissipation, Energy, Classical thermodynamics.

Reference

Georgescu-Roegen, N. 1971. The Entropy Law and the Economic Process. Cambridge, MA: Harvard University Press.

Environment

Ecology: the entire spectrum of biotic and abiotic elements and conditions in the natural world surrounding and affecting an organism. Includes land, soil, water, air, climate, plants, and animals. May be used in a narrow sense: "the harsh Arctic environment is inhospitable to most plant life"; or in a broad sense: "reducing fossil fuel use is crucial for protecting the global environment."

Economics: all the cultural and social conditions that influence the life of an individual, firm, or community; for example: (1) the work environment: the physical, social, cultural, and political conditions in places of employment; (2) the built environment: the physical conditions of factories, offices, homes, schools, and other structures; and (3) the business environment: the internal and external forces and conditions that affect the functioning of businesses, including market conditions and government policies.

Abhijit Banerjee

Further reading

Sachs 2019.

See also: Ecology, Ecosystem, Biotic resources, Abiotic resources.

Reference

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Environmental

(Adjective) relating to the environment.

Abhijit Banerjee

See also: Environment.

Environmental accounting

Also known as green accounting, environmental accounting emerged with the advent of the Brundtland Report of the World Commission on Environment and Development: *Our Common Future* (WCED 1987). After the publication of the Brundtland Report, three main strains of research on this topic began. The first endeavor for environmental accounting culminated with the publication of Rob Gray's seminal work (Gray 1990). A second endeavor reflected a cost–benefit bias concerned with the calculation of resource depletion as measured in the national accounts (entailing the valuation of natural capital and humanity's utilization of natural resources). The third endeavor of environmental accounting takes a business case approach and avows the possibility of combining economic growth with environmental values.

The business case for environmental accounting is challenged by Gray (2010). Some take a deep ecological stance in their view that the business case is little more than corporatist propaganda; glosses over the deep contradictions between humanity and nature; and tends to ignore wider environmental and sociological research. The issue addressed by environmental and social accounting (more generally) is whether the business case for capitalism can solve humanity's conflicting relationship with the natural environment.

GLEN D. LEHMAN

Further reading

Rees & Wackernagel 1996.

See also: Economic ecosystem accounting, Natural resource accounting.

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Rees, W.E. & Wackernagel, M. 1996. Our Ecological Footprint: Reducing Human Impact on the Earth. Gabriola Island, Canada: New Society Publishers.

WCED (World Commission on Environment and Development). 1987. Our Common Future. Oxford: Oxford University Press.

Environmental amenities

Ecology: access to clean air and water, opportunities for recreation, wildlife observation, fishing, hiking, regulation of streamflow, control of erosion, absorption of carbon dioxide, and so on (Freeman et al. 2014). Environmental systems provide a wide variety of amenity services that support human life. Environmental amenities increase individuals' well-being (utility), while environmental disamenities are costly to individuals' well-being.

Environmental economics: the economic value for environmental amenities is the monetary value obtained by relying on either market forces (market valuation techniques) or the use of non-market valuation techniques. Based on the spatial hedonic equilibrium model, different locations present a variety of environmental amenities and disamenities (Rosen 1974). Thus, individuals perceive each location as a bundle of its amenities that bring them different levels of utility. Based on this model, housing and labor markets price differentials are linked to environmental amenities; low wages and high housing prices are associated with a high level of amenities.

MONA AHMADIANI

See also: Amenity, Amenity value, Private amenity value, Utility, Hedonic pricing method.

References

Freeman III, A.M., Herriges, J.A. & Kling, C.L. 2014. The Measurement of Environmental and Resource Values: Theory and Methods, 3rd edn. New York: RFF Press and Routledge.

Rosen, S. 1974. Hedonic prices and implicit markets: product differentiation in pure competition. Journal of Political Economy 82(1): 34–55.

Environmental assessment

The process of systematically evaluating the states, pressures, or impacts relating to some part(s) of, or the whole, natural environment, at a local, national, regional, or global scale, usually resulting in a report. The process may be carried out as an exercise simply to generate knowledge, or to understand the environmental implications of government policy approaches (strategic environmental assessment), or to reveal the likely impacts of a certain policy or project, and how negative impacts can be mitigated (environmental impact assessment). The assessment may include consideration of policies intended to improve the environment, or projections of the implications of the continuation of existing activities or trends, or their alteration (as in UNEP 2019). When used as a tool for planning or decision support, the goal of an environmental assessment is to facilitate sound decision-making about the environment, and often to help achieve or support environmental protection and sustainable development (UNEP 2015).

Paul W. Ekins

See also: Environmental impact assessment.

References

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UNEP (United Nations Environment Programme). 2019. Global Environment Outlook 6. (GEO-6). https://www.unep.org/resources/global-environment-outlook-6.

Environmental asset

Economics: an asset whose value is estimated by the future flows of natural resource rents embedded in the total products that are assumed will be consumed by people directly or indirectly over an infinite time horizon (Campos et al. 2021; UNSD 2021). Since the System of Environmental–Economic Accounting—Ecosystem Accounting (SEEA-EA) and the Agroforestry Accounting System (AAS) methodologies coincide in the concepts and methods of valuation of environmental assets and manufactured fixed capital, the capital account balance sheet does not require any conceptual distinction between these two ecosystem accountings.

Biological and economic sustainability of an environmental asset, in the absence of biological irreversibility, is a situation in which (1) the biophysical quantity is above the critical threshold established by the biological safe minimum standard (Berrens 2001), and (2) there has not been a decrease in the ecosystem total income compared to the previous period in the ecosystem accounting. Consequently, a decrease in the environmental income in the period may be compatible with biological and economic sustainability if the above two mentioned conditions are met.

Pablo Campos Palacín

Further reading

Campos et al. 2020.

See also: Agroforestry Accounting System (AAS), System of Environmental–Economic Accounting—Ecosystem Accounting (SEEA-EA), Capital, Manufactured capital, Natural capital, Natural resource rents, Safe minimum standard (SMS), Total income.

References

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Environmental asset gain

Economics:

a. The change in value of environmental assets adjusted for double counting of natural growth and final product consumption of inventoried provisioning products (for example, woody products and wild game), valued at their environmental prices at the opening of the accounting period. The change in the net present value of products because of discounting and unanticipated changes in physical productivity that are expected to be consumed in the future in successive replicated periods of infinite duration generate the possibility of revaluation of environmental assets. Since the net present value of the ecosystem assets is estimated at accounting period prices, the environmental asset gain does not incorporate nominal price changes. Other changes in the environmental assets may be due to extraordinary destruction and changes in the economic uses of the ecosystem.
b. (From UNSD 2021, para. 12.47):
there is a range of entries [and withdrawals] to record the change in value of ecosystem [environmental] assets including changes in value due to ecosystem enhancement [natural growth], ecosystem degradation [negative change of provisioning ecosystem services], ecosystem conversions, and other changes. These changes in asset values (which may be labeled collectively as capital gains) are accounted for following national accounting treatments as either other changes in volume (e.g., resulting from catastrophic losses) or revaluations.

Pablo Campos Palacín

Further reading

Campos et al. 2020.

See also: Environmental asset, Natural capital, Restoring natural capital (RNC), System of National Accounts (SNA).

References

Campos, P., Álvarez, A., Oviedo, J.L. et al. 2020. Environmental incomes: refined standard and extended accounts applied to cork oak open woodlands in Andalusia, Spain. Ecological Indicators 117: 106551.

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Environmental degradation

A general and broad term for the disturbance and deterioration of environmental quality, which includes the decline in air and water quality due to pollution, topsoil loss and depletion, deforestation, desertification, climate change, stratospheric ozone loss, biodiversity loss and habitat destruction for native species, among others. The causes of environmental degradation can be either natural or anthropogenic, but are mostly the latter.

Barry D. Solomon

Further reading

Boyce 1994; Howard et al. 1991; Li & Reuveny 2006; Ferrer-i-Carbonell & Gowdy 2007; Stern et al. 1996.

See also: Pollution, Biodiversity, Deforestation, Desertification, Climate change, Environmental impact assessment tools, Resource depletion, Natural resource depletion, Environmental quality, Sustainable yield.

References

Boyce, J.K. 1994. Inequality as a cause of environmental degradation. Ecological Economics 11(3): 169–78.

Ferrer-i-Carbonell, A. & Gowdy, J.M. 2007. Environmental degradation and happiness. Ecological Economics 60(3): 509–16.

Howard, P.H., Boethling, R.S., Jarvis, W.F. et al., eds. 1991. Handbook of Environmental Degradation Rates. Boca Raton, FL: CRC Press.

Li, Q. & Reuveny, R. 2006. Democracy and environmental degradation. International Studies Quarterly 50(4): 935–56.

Stern, D., Common, M.S. & Barbier, E.B. 1996. Economic growth and environmental degradation: the environmental Kuznets curve and sustainable development. World Development 24(7): 1151–60.

Environmental economics

A major branch of economics focusing on the economy's uses of and impacts on natural systems as economies grow and develop. Originally developed based on welfare economics. A major focus is pollution impacts and damages that reduce overall welfare outcomes of economic activity. Defined primarily by its subject matter, environmental economics utilizes many assumptions and methods of mainstream economics. Important conceptual contributions include market failures, common goods and public goods, environmental valuation, externalities, and pollution taxes as a corrective mechanism to internalize externalities.

Brent M. Haddad

Further reading

Harris & Roach 2022; Goodstein & Polasky 2020; Tietenberg & Lewis 2018.

See also: Market failure, Externalities, Public goods, Natural resource economics, Pollution taxes, Carbon taxes, Internalizing externalities, Welfare economics, Environmental policy instruments.

References

Goodstein, E. & Polasky, S. 2020. Economics and the Environment, 9th edn. New York: Wiley.

Harris, J.M. & Roach, B. 2022. Environmental and Natural Resource Economics: A Contemporary Approach, 5th edn. New York: Routledge.

Tietenberg, T.H. & Lewis, L. 2018. Environmental and Natural Resource Economics, 11th edn. New York: Routledge.

Environmental ethics

The study of the moral relationships between humans and the natural world. Environmental ethics encompasses questions of values, duties, and justice, both intragenerational and intergenerational. It is in this regard that questions of sustainability are addressed. In an anthropocentrically orientated ethics, justice can be applied exclusively with regard to the consequences for humans, though in environmental ethics all living beings are considered valuable in themselves. Hence, they can be integrated into environmental ethics regardless of their value to humans. This grants non-human organisms certain rights and thus integrates them into the scope of justice.

Until the 1970s, ethics did not explicitly address the human influence on nature. It was Hans Jonas (1976, 1984) who developed the foundations of environmental ethics, which addresses the fact that human behavior has an impact on the environment. Thus, the environment falls within the sphere of human responsibility. Therefore, rules for human actions must be developed, which evaluate and judge these actions ethically with regard to their effects on nature. Responsibility links the effects of an action to its perpetrator, and raises the question of moral and legal consequences. A comprehensive concept of responsibility includes even collective and political responsibility. The latter contains the duty to ensure not only the well-being of a particular person, but also the good state of society.

Malte M. Faber & Marc Frick

Further reading

Rolston 1988; Ott 2020; Washington & Maloney 2020.

See also: Anthropogenic, Ecocentrism, Bioethics, Environmental rights, Justice, Environmental justice, Ecological justice, Environmentalism, Sustainability.

References

Jonas, H. 1976. Responsibility today: the ethics of an endangered future. Social Research 43(1): 77–97.

Jonas, H. 1984. The Imperative of Responsibility: In Search of an Ethics for the Technological Age. Chicago, IL: University of Chicago Press.

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Rolston III, H. 1988. Environmental Ethics: Duties to and Values in the Natural World. Philadelphia, PA: Temple University Press.
Washington, H. & Maloney, M. 2020. The need for ecological ethics in a new ecological economics. Ecological Economics 169: 106478.

Environmental externalities

External environmental effects from a market transaction on third parties who are independent of the transaction, and which result in an unintended loss or gain in welfare. Based on the classic work in welfare economics by Arthur Pigou (1932). Environmental externalities can be from production or consumption, negative or positive.

a. Negative environmental externalities from production include: air pollution from fossil fuel combustion in factories and power plants, air and noise pollution from a construction site, water pollution from sewage treatment plants and effluent discharges, or nutrient runoff from dairy or pig feedlots.
b. Positive environmental externalities from production include: free pollination services from honey beekeeping to surrounding apple, blueberry, cherry, almond, and squash orchards, among other crops.
c. Negative environmental externalities from consumption include: air pollution, traffic congestion, and noise pollution from automobile usage in densely populated urban areas.
d. Positive environmental externalities from consumption include: increased residential property values due to the presence of a nearby public park or green space, or walking or bicycling to work to reduce traffic congestion.

Barry D. Solomon

Further reading

Howarth 1996; Delucchi 2003; Lankoski & Ollikainen 2003.

See also: Externalities, Consumption externalities, Pollution, Welfare economics.

References

Delucchi, M.A. 2000. Environmental externalities of motor-vehicle use in the US. Journal of Transport Economics and Policy 34(2): 135–68.
Howarth, R.B. 1996. Status effects and environmental externalities. Ecological Economics 16(1): 25–34.
Lankoski, J. & Ollikainen, M. 2003. Agri-environmental externalities: a framework for designing targeted policies. European Review of Agricultural Economics 30(1): 51–75.
Pigou, A.C. 1932. The Economics of Welfare, 4th edn. London: Macmillan.

Environmental finance

A market-oriented approach to improving the environment and conservation. Considers the financial implications of environmental change for industries and firms, and the need to transition to a sustainable economy where humanity lives within the boundaries of our Earth system (Linnenluecke et al. 2016). The field tends to be private sector and climate-focused, in contrast to biodiversity and conservation finance, although all three fields work across government, private sector, and civil society. Environmental finance typically includes investments in pollution control/clean technology, emissions trading, water infrastructure, green bonds for infrastructure, climate change mitigation and adaptation. Environmental finance budget categories can be usefully derived from the United Nations System of Environmental–Economic Accounting (SEEA), Classification of Environmental Protection Activities (CEPA), and Classification of Resource Management Activities (CReMA).

Andrew F. Seidl

See also: Biodiversity finance, Conservation finance, System of National Accounts (SNA), Emissions trading, Climate change mitigation, Climate change adaptation.

Reference

Linnenluecke, M.K., Smith, T. & McKnight, B. 2016. Environmental finance: a research

agenda for interdisciplinary finance research. Economic Modelling 59: 124–30.

Environmental goods and services

All goods and services that are produced, designed, and manufactured for either environmental protection or resource management purposes. Environmental protection activities are those activities whose primary purpose is the prevention, reduction, and elimination of pollution and other forms of environmental degradation. These include: protection of the air and climate; waste management; wastewater management; protection and remediation of soil, groundwater, and surface water; noise and vibration abatement; protection of biodiversity and landscapes; protection against radiation; and environmental research and development.

Resource management activities are those activities whose primary purpose is preserving and maintaining the stock of natural resources and thus safeguarding against resource depletion. These include: management of energy and mineral resources; management of timber resources; management of aquatic resources; management of other biological resources; management of water resources; and resource management research and development.

Habtamu Tilahun Kassahun

Further reading

Costanza et al. 1997; OECD 1999; UNSD 2016.

See also: System of National Accounts (SNA), Goods, Services, Ecosystem services.

References

Costanza, R., d'Arge, R., de Groot, R. et al. 1997. The value of the world's ecosystem services and natural capital. Nature 387: 253–60.

OECD. 1999. The Environmental Goods and Services Industry: Manual for Data Collection and Analysis. Paris: Organisation for Economic Co-operation and Development.

UNSD. 2016. System of Environmental Economic Accounting: SEEA Technical Note: Environmental Goods and Services Sector (EGSS). New York: United Nations, Statistical Division. https://seea.un.org/sites/seea.un.org/files/seea_technical_note_-_egss_july_8_2016_draft.pdf.

Environmental governance

A concept used in political ecology and environmental policy to understand the processes that lead to environmental policy decisions and by which the implementation of those decisions takes place or does not take place. Its study implies understanding the regulatory processes, mechanisms, and organizations through which political actors influence environmental actions and outcomes (Lemos & Agarwal 2006). Diverse fields recognize different classifications of environmental governance models. Some of them focus on the social institution that leads the process (state-based, market-based, and so on) (Ostrom 1994). Others focus on the participatory nature of the process (collaborative, top-down, and so on) (Sattler et al. 2016).

For ecological economists, it is the substrate where diverse languages of valuation interact. In the process of defining rights to use and profit from environmental space, some languages (that is, monetary) may prevail over others (that is, biophysical, or qualitative) due to the power relationships involved. Ecological economics recognizes that the choice of valuation methodologies is not just a technical matter but may consolidate power imbalances or contribute to an equitable recognition of the rights of all social actors to the benefits of environmental space (Kallis et al. 2013).

Such imbalances, originating in social vulnerability, gender, ethnicity, and so on, may lead to ecological distributive conflicts. Political ecology has advanced in the understanding of the elements and cycles of ecological distributive conflicts that affect these processes. Along similar lines, recent literature focuses on the impacts of illegal activities (narco-trafficking, protected wildlife trade, and so on) on these governance systems (Wrathall et al. 2020).

Bernardo Aguilar-Gonzalez

Further reading

de Castro et al. 2016; Kemmis & McKinney 2011; Muñoz-Erickson et al. 2007; Ostrom 2015.

See also: Governance, Ecological distributive conflicts, Incommensurable values, Irreducibility of valuation categories.

References

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Kallis, G., Gómez-Baggethum, E. & Zografos, C. 2013. To value or not to value? That is not the question. Ecological Economics 94: 97–105.

Kemmis, D. & McKinney, M. 2011. Collaboration and the ecology of democracy. Sustainable Development Law and Policy 12(1): 46–70.

Lemos, M.C. & Agrawal, A. 2006. Environmental governance. Annual Review of Environment and Resources 31: 297–325.

Muñoz-Ericksson, T., Aguilar-González, B. & Sisk, T. 2007. Linking ecosystem health indicators and collaborative management: a systematic framework to evaluate ecological and social outcomes. Ecology and Society 12(2): 6.

Ostrom, E. 1994. "Institutional analysis, design principles and threats to sustainable community governance and management of commons," pp. 34–50 in Community Management and Common Property of Coastal Fisheries in Asia and the Pacific: Concepts, Methods and Experiences. R.S. Pomeroy, ed. Manila: International Center for Living Aquatic Resources Management.

Ostrom, E. 2015. Governing the Commons. Cambridge: Cambridge University Press.

Sattler, C., Schröter, B., Meyer, A. et al. 2016. Multilevel governance in community-based environmental management: a case study comparison from Latin America. Ecology and Society 21(4): 24.

Wrathall, D., Devine, J., Aguilar-González, B. et al. 2020. The impacts of cocaine-trafficking on conservation governance in Central America. Global Environmental Change 63: 102098.

Environmental health

A branch of public health that studies the impact of environmental factors that affect human health. According to the World Health Organization (WHO 2019), "Environmental health addresses all the physical, chemical, and biological factors external to a person, and all the related factors impacting behaviors. It encompasses the assessment and control of those environmental factors that can potentially affect health." According to the National Environmental Health Association (NEHA 2019), environmental health can be evaluated by: "a) identifying and evaluating environmental sources and hazardous agents and b) limiting human exposures to hazardous physical, chemical, and biological agents in air, water, soil, food, and other environmental media or settings that may adversely affect human health."

Massey University (2019) suggests environmental health measures that include: (1) air quality; (2) drinking water; (3) recreational water; (4) indoor environment; (5) ultraviolet light exposure; (6) hazardous substances; (7) border health; and (8) climate change. Two related terms—ecosystem health and ecohealth—are more comprehensive and integrative.

Prabha Panth

Further reading

Rayner & Lang 2012; Morand & Lajaunie 2018.

See also: Ecosystem health, Ecohealth, Public health, Urbanization, Pollution, Environmental degradation, Sustainable development.

References

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Rayner, G. & Lang, T. 2012. Ecological Public Health: Reshaping the Conditions for Good Health. London: Routledge.

WHO (World Health Organization). 2019. http://www.searo.who.int/topics/environmental_health/en/.

Environmental impact assessment

The evaluation of a proposed policy, plan, program, or development project, such as a construction project by a government agency or private firm, relative to the physical, cultural, or human environment in which it will be carried out. The purpose of an environmental impact assessment (EIA) is to provide decision-makers with technical-scientific assessments of the expected biophysical impacts of the proposed policy, plan, program, or development project, including likely impacts on the quality of the air, noise, water, land, soil, any threatened and endangered species, but also social and economic impacts, impacts on any historical or cultural sites, as well as alternatives to the proposal (including no action). Potential mitigation measures for the negative impacts are also addressed.

The findings of the EIA are compiled into a comprehensive report, called an environmental impact statement (EIS). In this sense the EIA process represents an institutionalization, which began in the United States in the 1970s and spread worldwide, of the growing awareness of the significant impacts of human action on nature. The EIA procedures normally include an interagency and public review of the EIS, and a public hearing for the stakeholders, who represent either the private parties or the interests of the public and nature with respect to potential modifications induced by the policy, plan, program, or development project. Following the hearing, the proponents will determine whether the policy, plan, program, or development project needs revision, and proceed accordingly.

AURELIO ANGELINI

Further reading

Liroff 1976; Caldwell 1999.

See also: Environmental assessment, Institutions.

References

Caldwell, L.K. 1999. The National Environmental Policy Act: An Agenda for the Future. Bloomington, IN: Indiana University Press.

Liroff, R.A. 1976. A National Policy for the Environment: NEPA and its Aftermath. Bloomington, IN: Indiana University Press.

Environmental impact assessment tools

Several analytical models have been used to provide general insight on the environmental impacts of human activities. The classic example is the parsimonious mathematical identity IPAT that emerged from the Paul Ehrlich and John Holdren versus Barry Commoner debate in the early 1970s, where I (environmental impact) = P (human population) * A (affluence) * T (technology). IPAT was inspired by the general but underidentified model POET, developed by Duncan (1964), which connected P (human population) to O (social organization), E (environment) and T (technology).

More recent tools include ImPACT, which disaggregated the T in IPAT into consumption per unit of gross domestic product (C) and impact per unit of consumption (T) (Waggoner & Ausbel 2002); and STIRPAT (stochastic impacts by regression on population, affluence and technology), or more formally $I_i = aP_i^bA_i^cT_i^de_i$ (Dietz & Rosa 1994; York et al. 2003. These authors argued that, among these tools, the STIRPAT model allows for a more precise specification of the sensitivity of environmental impacts to the forces driving them.

BARRY D. SOLOMON

See also: Analytical models, Environmental assessment, Environmental impact assessment.

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ing the driving forces of environmental impact. Ecological Economics 46(3): 351–65.

Environmental income

Economics:

a. The contribution from natural capital to the total income from the economic activities of a national/subnational territory in an accounting period. Signifies the maximum possible consumption of an individual ecosystem product without decreasing its environmental asset consistently integrated into its total income in the accounting period.
   Environmental income is measured by ecosystem accounting as the environmental net operating margin plus the environmental asset gain. By rearranging these two components, it is comprised of economic ecosystem services plus depletion (environmental work in progress used) adjusted change of environmental net worth (CNWead). A positive CNWead shows, simultaneously, an underconsumption of the total product and an enhancement of the environmental asset in the accounting period. The biological sustainability of individual product consumption is guaranteed on the condition that the yield's safe minimum standard is met (Berrens 2001), given the assumption of future stability of all manufactured and environmental factors of production considered.
b. Environmental income is substituted by net value added, in case of a total product function with low or zero labor opportunity cost and manufactured capital used (Sjaastad et al. 2005).
c. Environmental income can refer to wild products extraction from non-cultivated sources: natural forests, other non-forest wildlands such as grasslands, bush, and wetlands, fallow land, but also wild plants and animals harvested from croplands (Angelsen et al. 2014).

Pablo Campos Palacín

Further reading

Krutilla 1967; Cavendish 2002; Campos et al. 2020.

See also: Net value added, Ecosystem services, Total income, Safe minimum standard (SMS).

References

Angelsen, A., Jagger, P., Babigumira, R. et al. 2014. Environmental income and rural livelihoods: a global-comparative analysis. World Development 64: 12–28.

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Krutilla, J.V. 1967. Conservation reconsidered. American Economic Review 57(4): 777–86.

Sjaastad, E., Angelsen, A., Vedeld, P. & Bojö, J. 2005. What is environmental income? Ecological Economics 55: 37–46.

Environmental indicators

A quantitative variable that measures an aspect of the environment, which provides a qualitative gauge or signal of the condition of the environment (for example, healthy or unhealthy, safe or unsafe). The driver–pressure–state–impact–response (DPSIR) framework, which is the European Environment Agency's causal framework for describing the interactions between society and the environment (European Environment Agency n.d.), discerns three levels of interest in this respect: pressure indicators, state indicators, and impact indicators: (1) pressure indicators provide information about anthropogenic activities, such as emission levels or land use; (2) state indicators describe the current (or historic, or predicted) condition of the ambient environment, sometimes relative to environmental quality standards; examples include the atmospheric carbon dioxide (CO_2) concentration, air and water quality, land and

forest quality, and ocean acidity; (3) impact indicators are measures of changes, such as decline of biodiversity or melting of glaciers.

A popular way to benchmark environmental indicators is the planetary boundary framework (Rockström et al. 2009), which includes the quantification of nine environmental indicators—climate change; biodiversity loss (terrestrial and marine); interference with the nitrogen and phosphorus cycles; stratospheric ozone depletion; ocean acidification; global freshwater use; change in land use; chemical pollution; atmospheric aerosol loading—and their critical ("safe") values. The scope of environmental indicators is sometimes broadened to sustainable development indicators. The United Nations Sustainable Development Goals include 231 such indicators (UN n.d.). Efforts also have been undertaken to integrate environmental indicators into the usual economic indicators, such as gross domestic product (Nordhaus & Kokkelenberg 1999).

Reinout Heijungs

See also: DPSIR (Drivers–Pressures–State–Impact–Response) framework, Sustainable development, Sustainable Development Goals (SDGs), Environmental Performance Index (EPI), Anthropogenic, Ecological footprint, Climate change, Land use change, Biodiversity, Planetary health.

References

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Nordhaus, W.D. & Kokkelenberg, E.C. 1999. Nature's Numbers: Expanding the U.S. National Economic Accounts to Include the Environment. Washington, DC: National Academies Press.

Rockström, J., Steffen, W., Noone, K. et al. 2009. A safe operating space for humanity. Nature 461: 472–75.

UN (United Nations). n.d. Sustainable development goals. https://unstats.un.org/sdgs/.

Environmentalism

Refers to an ideological, political, and social movement that fosters environmental protection beliefs and practices. It encompasses mainstream philosophies of ecological-modernization, ecocentrism (protect the environment because of its inherent worth), anthropocentrism (protect the environment for the sake of human well-being), and contemporary perspectives such as environmentalism of the poor, which is premised on conflicts emerging from the unequal distribution of environmental resources resulting from economic growth (Martínez-Alier 2002).

Niharika Tyagi

Further reading

Guha 2000; Guha & Martínez-Alier 1997.

See also: Environment, Environmental, Intrinsic value, Biocentrism, Ecological citizenship, Ecologically unequal exchange, Environmental justice, Ecological justice, Environmental stewardship.

References

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Guha, R. & Martínez-Alier, J. 1997. Varieties of Environmentalism: Essays North and South. London: Earthscan.

Martínez-Alier, J. 2002. The Environmentalism of the Poor: A Study of Ecological Conflicts and Valuation. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Environmental justice

a. The equal distribution of environmental risks, harms, and amenities among social groups of people with varying demographic characteristics, economic resources, political power, and social status (Agyeman et al. 2002);
b. The fair treatment and involvement of all social groups in environmental policy processes, including agenda setting, policy formulation and adoption, policy implementation, and policy evaluation (Bullard 1996). A lack of environmental justice can lead to environmental discrimination and environmental racism against disadvantaged and impoverished communities, though this contention is controversial and contested (Bullard 1993).

Shan Zhou

See also: Justice, Distributive justice, Ecological justice, Climate justice, Social justice.

References

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Bullard, R.D. 1993. "Anatomy of environmental racism and the environmental justice movement," pp. 15–39 in Confronting Environmental Racism: Voices from the Grassroots. R.D. Bullard, ed. Boston, MA: South End Press.

Bullard, R.D. 1996. Environmental justice: it's more than waste facility siting. Social Science Quarterly 77(3): 493–9.

Environmental Kuznets curve (EKC)

An EKC displays an inverted U relationship between an indicator of environmental degradation and per capita gross domestic product. The name refers to the work of Simon Kuznets (1955), who compared income inequality and economic growth with long-term data from the United States, England, and Germany, and inferred a potential inverted U relation between those two variables. The EKC suggesting that environmental quality does not deteriorate steadily with economic growth (Grossman & Krueger 1995) has been observed for some pollutants but not for most others, and therefore remains a hypothesized relationship (Dinda 2004; Stern 2004).

BERTRAND HAMAIDE

Further reading

Shahbaz et al. 2013.

See also: Environmental degradation, Gross domestic product (GDP), Economic growth.

References

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Grossman, G.M. & Krueger, A.B. 1995. Economic growth and the environment. Quarterly Journal of Economics 110(2): 353–77.

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Stern, D.I. 2004. The rise and fall of the environmental Kuznets curve. World Development 32(8): 1419–39.

Environmentally extended input–output analysis (EE-IOA)

A method to assess the environmental consequences of production and consumption activities of a country, region, industry, or product group. When applying environmentally extended input–output analysis (EE-IOA), the input–output table expressed in monetary units is extended with data on environmental pressures or impacts. Examples of environmental extensions are material use, energy use, water use, greenhouse gas emissions, air and water pollution, ecotoxicity, and resource depletion. Environmental extensions are usually represented in physical units (for example, tonnes, m^3, km^2), but can also be expressed in monetary units. In the standard input–output model (also known as the demand-driven "Leontief" model), EE-IOA allocates the environmental pressures or impacts to different categories of final demand, such as consumption by households or governments. EE-IOA thus illustrates the direct and indirect, that is, supply chain-wide, environmental effects caused by final demand for different products.

In recent years, EE-IOA models have moved from covering one or a few countries to data systems that provide global coverage. The key asset of EE-IOA is that it integrates a wide range of economic and environmental data in a consistent sectoral framework, covering a national or the global economy. EE-IOA is widely applied to study the environmental effects along international supply chains and calculate consumption-based indicators (footprints), thus informing about the socio-economic drivers of current environmental problems. Models based on EE-IOA are also used to provide *ex ante* assessments of

the environmental consequences of changes in technologies, lifestyles, or policies.

Stefan Giljum

Further reading

Kitzes 2013; Tukker et al. 2018; Miller & Blair 2009.

See also: Environmental accounting, Natural resource accounting, Input–output (I–O) analysis, Environmental impact assessment tools, Ecological footprint, Material footprint.

References

Kitzes, J. 2013. An introduction to environmentally-extended input–output analysis. Resources 2(4): 489–503.

Miller, R.E. & Blair, P.D. 2009. Input–Output Analysis: Foundations and Extensions, 2nd edn. New York: Cambridge University Press.

Tukker, A., Giljum, S. & Wood, R. 2018. Recent progress in assessment of resource efficiency and environmental impacts embodied in trade. Journal of Industrial Ecology 22(3): 489–501.

Environmental management

Management of the interaction and impacts of human activities on the natural environment (Mitchell 2019). Environmental management concerns knowledge of the structure and function of the natural environment, describing and monitoring changes in the natural environment, and knowledge of how these changes relate to human activities (for example, pollution, harvesting). One may also attempt to predict future changes in the natural environment in relation to human activities.

Environmental management seeks decisions that maximize human benefit or human well-being, without exceeding the critical limits of the natural environment. As such, the concept is anthropocentric and related to sustainable development (Colby 1991; Barrow 2006). In addition, it requires a highly multidisciplinary perspective and involves many stakeholders (Delmas & Toffel 2004; Daley & Kent 2015). Decision-making in environmental management is inherently political as it may favor some groups' interests over others.

Kristine M. Grimsrud

Further reading

Klassen & McLaughlin 1996.

See also: Best management practices (BMPs), Waste management, Pollution abatement, Resource management, Management science, Safe minimum standard (SMS).

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Environmental Performance Index (EPI)

A rating system to rank countries based on 32 performance indicators across 11 issue categories for ecosystem vitality and environmental health (Wendling et al. 2020). The number of performance indicators incorporated into the EPI has grown over time (Esty et al. 2006). First published in 2002, the EPI was developed by Yale University and Columbia University in collaboration with the World Economic Forum and the Joint Research Centre of the European Commission to provide a gauge of how close countries are to meeting established envi-

ronmental policy targets. The top ten ranked countries on the EPI are typically in Northern and Western Europe.

BARRY D. SOLOMON

Further reading

Tyteca 1996; Kumar et al. 2019.

See also: Indicators, Environmental indicators, Ecohealth, Ecosystem health, Environmental health, Sustainable Development Goals (SDGs).

References

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Kumar, S., Giridhar, V. & Sadarangani, P. 2019. A cross-national study of environmental performance and culture: implications of the findings and strategies. Global Business Review 20(4): 1051–68.

Tyteca, D. 1996. On the measurement of the environmental performance of firms—a literature review and a productive efficiency perspective. Journal of Environmental Management 46: 281–308.

Wendling, Z.A., Emerson, J.W., de Sherbinin, A. et al. 2020. 2020 Environmental Performance Index. New Haven, CT: Yale Center for Environmental Law & Policy. epi.yale.edu.

Environmental policy instruments

Any method used by policymakers, for instance in government (but also in international as well as municipal bodies, and so on), to achieve a certain environmental policy objective. Typical objectives are to limit emissions and pollution or to make sure that scarce natural resources are managed sustainably. Clear examples include, but are not limited to, taxes, subsidies, tradable permits, and standards. These instruments can be roughly categorized according to instruments that use markets and economic incentives, create markets, engage the public, change norms, laws or regulations. A non-exhaustive list includes taxes, subsidies, charges, property rights, tradable permits, standards, bans, permits and quotas, zoning, public participation, and information disclosure. Numerous more complex instruments exist such as refunded emission payments, tradable performance standards, bonus malus, border tax adjustment, and so on.

The key feature of market-based instruments is that of achieving economic efficiency when the costs of abatement are heterogeneous. Efficiency means that more environmental benefits can be achieved within the same budget. The choice between policy instruments should take numerous criteria into consideration, in addition to efficiency; also fairness and political feasibility.

THOMAS N. STERNER

Further reading

Sterner & Coria 2012.

See also: Environmental taxes, Pollution taxes, Market mechanisms, Carbon taxes, Emissions trading, Tradable permits, Regulation.

Reference

Sterner, T. & Coria, J. 2012. Policy Instruments for Environmental and Natural Resource Management, 2nd edn. Hoboken, NJ: Taylor & Francis.

Environmental quality

See: Environmental indicators.

See also: Environmental impact assessment, Environmental assessment, Environmental accounting.

Environmental rehabilitation

See: Environmental restoration.

See also: Conservation biology, Ecological restoration, Restoration ecology, Investment.

Environmental restoration

a. A set of actions and investments with the goal to bring an ecosystem, or a subset of an ecosystem, back to a healthy and flourishing state.
b. A term for bringing back a previously degraded site to its pre-development state, or to a state as agreed upon by the land's stakeholders and rightsholders. Sometimes also called environmental rehabilitation, environmental recuperation, or environmental reclamation (the latter especially in the case of mine lands recovery). Actions can include water treatment, soil reclamation, cultural practices, and the reintroduction of native species.

Benjamin C. Collins

Further reading

Allison & Murphy 2017.

See also: Conservation biology, Ecological restoration, Restoration ecology, Investment.

Reference

Allison, S.K. & Murphy, S.D., eds. 2017. Routledge Handbook of Ecological and Environmental Restoration. London: Routledge.

Environmental rights

a. The human belief in the right to a healthy or clean environment.
b. The proclamation and codification of human rights to a healthy or clean environment in national constitutions and laws (Shelton 1991, 2006; Hiskes 2009; Boyd 2011). According to the United Nations Environment Programme, the right to a healthy environment is enshrined in over 100 constitutions (UNEP 2022). Such environmental rights usually include both substantive and procedural rights. In October 2021 the Human Rights Council (a United Nations body) recognized the right to a safe, clean, healthy, and sustainable environment as a human right (UN 2021).

Extending environmental rights to plants and non-human animals is more controversial and less recognized, and intersects with bioethics and environmental ethics. Such legal thinking on natural rights existing in nature goes back to at least Christopher Stone's classic law review article (Stone 1972), and probably much earlier.

Barry D. Solomon

See also: Human rights, Rights, Bioethics, Environmental ethics, Climate justice, Sustainable development.

References

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United Nations Environment Programme. 2022. What are environmental rights? https://www.unep.org/explore-topics/environmental-rights-and-governance/what-we-do/advancing-environmental-rights/what.

Environmental science

The integrated, interdisciplinary study of the natural world, environmental systems, and environmental problem-solving. Normally environmental science is thought to include knowledge from biology, ecology, chemistry, physics, geology, soil science, physical geog-

raphy, and atmospheric sciences, and sometimes the social sciences and engineering. Normally environmental studies programs at universities have greater participation by the social sciences and humanities. Given the nature of the field, environmental scientists often work in multidisciplinary and transdisciplinary, as well as interdisciplinary, collaborations to study pressing issues such as: air and water pollution, waste management, resource depletion, climate change, ocean acidification, loss of biodiversity, deforestation, ecosystem services, sustainable energy, and sustainability, among others.

BARRY D. SOLOMON

Further reading

Miller & Spoolman 2016.

See also: Ecology, Biodiversity, Climate change, Deforestation, Transdisciplinarity, Interdisciplinary, Multidisciplinary, Environmental studies.

Reference

Miller, G.T. & Spoolman, S.E. 2016. Environmental Science, 15th edn. Boston, MA: Cengage Learning.

Environmental stewardship

The responsible use or care for ecological systems or their discrete elements (for example, trees) in a manner that promotes their long-term protection and flourishing, whilst being accountable to the people and communities with an interest in those ecologies. Individuals and groups can practice environmental stewardship in the manner described above. Increasingly, environmental agencies are developing policy that deploys "environmental stewardship" terminology to denote nature conservation and sustainability initiatives that explicitly aim to deliver environmental benefits that are in the wider public good. For example, environmental stewardship programs on private land are often accompanied by payments to the landholder, whereby payment is conceived of as a reward for being a nature conservation "steward" (for example, Environmental Stewardship programs in the United Kingdom).

Environmental stewardship has been criticized as a means for individualizing collective problems and offering a paternalistic characterization of human responsibilities to ecologies. Adjacent concepts describing responsibility for and with non-humans, especially amongst First Nations scholarship, include "custodianship" and "care" (for example, Caring for Country).

BENJAMIN R. COOKE

Further reading

Worrell & Appleby 2000; Bennett et al. 2018; Gill 2013; Cooke & Lane 2015; Mathevet et al. 2018; Neimanis 2015; Watts 2013.

See also: Ecological citizenship.

References

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Worrell, R. & Appleby, M.C. 2000. Stewardship of natural resources: definition, ethical and practical aspects. Journal of Agricultural and Environmental Ethics 12(3): 263–77.

Environmental studies

Everything that is outside our bodies is our environment. The environment may vary in extent from our immediate living space to vast landscapes and the biosphere. Environmental studies focus on how we are influenced by the environment at different scales and how we influence it. Such influences include those of air, water, soil, and all other living organisms. (Daniels & Krishnaswamy 2009). Environment can be broadly classified into three types: the non-living, living, and social. Studies of the three types are sometimes treated as different academic disciplines.

R.J. Ranjit Daniels

See also: Environment, Environmental science, Ecology, Biosphere, Biodiversity.

Reference

Daniels, R.J.R. & Krishnaswamy, J. 2009. Environmental Studies. New Delhi: Wiley India.

Environmental subsidies

Public policy monetary incentives to induce private agents to increase green (environmentally friendly) investment, replacing old polluting practices. According to Parry (1998), environmental subsidies can be of four types: (1) Pigouvian subsidies; (2) indirect subsidies; (3) production-reducing subsidies; and (4) environmentally unfriendly subsidies.

Public policy and economic agents should internalize the costs and benefits associated with the environment, adding non-economic variables to conventional economic decisions. This is the classic problem of an externality, in which market prices are not able to capture negative or positive impacts of certain phenomena. Arthur Pigou (1932) proposed that these externalities should be addressed by tax payments or the implementation of subsidies. An environmentally friendly activity might create positive externalities that are not easily measured by private agents. In this case, Pigou argued that this type of activity should be subsidized. The implication for environmental policy is that governments should implement fiscal or financial instruments to decrease the costs of green activities (see also Acemoglu et al. 2012; Semmler et al. 2021).

Joao Paulo Braga

See also: Subsidies, Environmental policy instruments, Theory of the second best, Externalities, Environmental externalities, Green growth, Green industrial policy, Green trade policy, Trade-related climate policy, Green protectionism.

References

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Parry, I.W. 1998. A second-best analysis of environmental subsidies. International Tax and Public Finance 5(2): 153–70.

Pigou, A.C. 1932. The Economics of Welfare. London: Palgrave Macmillan.

Semmler, W., Braga, J.P., Lichtenberger, A. et al. 2021. Fiscal Policies for a Low-Carbon Economy. Washington, DC: World Bank.

Environmental taxes

Based on the classic work in welfare economics by Arthur Pigou (1920), any tax levied to internalize the social cost and environmental damage caused by environmental and pollution externalities, which is the recommended way to correct such a market failure. In recent decades, environmental taxes have included energy and fuel taxes, transport taxes, pollution taxes (for example, water, air, wastes, noise, ozone-depleting substances, greenhouse gases), and resource taxes (for example, water, land, soil, forests, biodiversity, wildlife, fish stocks).

While the most economically efficient tax level would be based on the environmental damage caused by the taxed activity, this is very difficult to estimate, so in practice environmental taxes are usually set in other ways. Revenues raised from environmental taxes can be used to help balance government budgets, offset other taxes such as on labor, or to increase spending on environmental protection and improvements or other matters. Most of the environmental tax revenues have been from taxes on motor vehicle fuels and transportation and are highest in

Europe, though in many cases tax exemptions have been enacted on competitiveness grounds (Ekins & Speck 1999).

BARRY D. SOLOMON

Further reading

Sterner & Köhlin 2003; Bluffstone 2003; Bashir et al. 2021.

See also: Externalities, Environmental externalities, Market failure, Internalizing externalities, Pollution taxes, Carbon taxes.

References

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Ekins, P. & Speck, S. 1999. Competitiveness and exemptions from environmental taxes in Europe. Environmental and Resource Economics 13: 369–96.

Pigou, A.C. 1920. The Economics of Welfare. London: Macmillan.

Sterner, T. & Köhlin, G. 2003. Environmental taxes in Europe. Public Finance and Management 3(1): 117–42.

Environmental valuation

The estimation of a monetary value for a specific benefit obtained by an individual or a population from the natural world. Since many of these benefits are freely obtained by people outside markets, their economic value is approximated using non-market valuation methodologies. This involves estimating the value that people assign to these benefits, relative to other goods and services in their consumption bundle, their budget constraints, and the biophysical availability of environmental benefits.

TANIA BRICENO

Further reading

Freeman 2003; Costanza et al. 1997.

See also: Ecosystem service valuation, Non-market value, Deliberative valuation.

References

Costanza, R., d'Arge, R., de Groot, R. et al. 1997. The value of the world's ecosystem services and natural capital. Nature 387(6630): 253–60.

Freeman, A.M. 2003. The Measurement of Environmental and Resource Values: Theory and Methods, 2nd edn. Washington, DC: Resources for the Future.

Epistemological bias

Bias that emerges in cases where the same ontological base is taken as data, and in cases of making inferences about the phenomenon in question with different epistemological assumptions. In this sense, the place of value judgments in natural sciences, whose objects are inanimate and whose data are not dependent on human beings, is quite limited. Social sciences, on the other hand, presents a structure in which the data subject to analysis is created by people, together with structures that change in micro and macro dimensions, and the human factor with metaphysical elements, it is relatively difficult to reach a conclusion independent of value judgments. For this reason, different epistemological contexts can be established for the same ontological entity with *a priori* accepted judgments in social sciences.

CENGIZHAN GÜLER

Further reading

Elmessiri 2006; Hammersley & Gomm 1997; Teo 2010.

See also: Epistemology, Deontological.

References

Elmessiri, A.M., ed. 2006. Epistemological Bias in the Physical and Social Sciences. London: International Institute of Islamic Thought.

Hammersley, M. & Gomm, R. 1997. Bias in social research. Sociological Research Online 2(1): 7–19.

Teo, T. 2010. What is epistemological violence in the empirical social sciences? Social and

Personality Psychology Compass 4(5): 295–303.

Epistemology

The branch of philosophy concerned with knowledge. Derived from the Ancient Greek words *episteme* and *logos*. While the *episteme* part of the word can be considered as knowledge and understanding, the *logos* part corresponds to reasoning or causation (Steup 2020). Epistemology constitutes an important part of the philosophy of science. In this context epistemology, which examines the possibility of obtaining scientific knowledge about a phenomenon whose ontological basis is determined, has an important effect on the cumulative progress of the scientific knowledge process.

CENGIZHAN GÜLER

Further reading

Rakova 2006; Conee & Feldman 2004.

See also: Epistemological bias, Methodological pluralism, Scientific method, Deontological.

References

Conee, E. & Feldman, R. 2004. Evidentialism: Essays in Epistemology. Oxford: Clarendon Press.

Rakova, M. 2006. Philosophy of Mind A-Z. Edinburgh: Edinburgh University Press.

Steup, M. 2020 rev. "Epistemology," in Stanford Encyclopedia of Philosophy. E.N. Zalta, ed. https://plato.stanford.edu/entries/epistemology/ .

Equilibrium

In economics, market equilibrium is a situation of trade or exchange between (groups of) economic agents where the quantity supplied equals the quantity demanded in a single market (partial equilibrium) or an entire economy, region, or the world (general equilibrium). The idea of equilibrium is not that it is a desirable state but merely that it is a state of stasis, where there are no forces to change the outcome. It may pertain to goods, services, and production factors. In neoclassical microeconomic welfare theory, a competitive market equilibrium is based on the assumptions of perfect competition. The market clearing price or exchange rate results from a dynamic process of trade or exchange between competing and rationally behaving, utility-maximizing economic agents, given their initial endowments and consumers' fixed given preferences.

The competitive market equilibrium is deemed to be good; precisely, Pareto efficient according to utilitarian ethical principles as illustrated by the set of equilibrium points forming the contract curve in Edgeworth's box (Edgeworth 1881). An equilibrium is called Pareto optimal if additional conditions are met such as compensation of losers by gainers from trade, which assumes value commensurability. Critics deem this theory irrelevant, especially because the original neoclassical microeconomic assumptions are not based on scientific observation (Kaldor 1972). In imperfect markets with market power a Nash equilibrium may occur.

Intertemporal equilibrium:

a. Equilibrium is the result of economic agents basing their decisions on strategies taking the future into account.
b. In Austrian economics the economy is not in equilibrium at any one time, but the interest rate coordinates intertemporal decisions.

WIEPKE W. WISSEMA

See also: Equilibrium model, General equilibrium model, Neoclassical economics, Pareto optimality, Perfect markets, Welfare economics, Austrian School of economics, Nash equilibrium, Utilitarianism.

References

Edgeworth, F.Y. 1881. Mathematical Psychics: An Essay on the Application of Mathematics to the Moral Sciences. London: C.K. Paul & Co.

Kaldor, N. 1972. The irrelevance of equilibrium economics. Economic Journal 82(328): 1237–55.

Equilibrium model

In economics, a mathematical model based on equilibrium theory of a single market (partial equilibrium model) or an entire economy, region, or the world (general equilibrium model) consisting of production and consumption functions, interagent transfers, an objective (utility) function to be optimized, a closure rule, and optional further details. The benchmark equilibrium is based on a social accounting matrix. Equations may have a nested structure with elasticities of substitution between inputs and elasticities of transformation between outputs for each nest. Elasticity values may be econometrically estimated for the specific functional form, taken from other studies, or based on a "guesstimate." After a shock is introduced, a new equilibrium is calculated and compared to the benchmark.

Applied models use data from the real world. Leon Walras (2010) developed the first theoretical equilibrium model in the late 1800s. Existence of a unique equilibrium was proven independently by Arrow and Debreu (1954) and McKenzie (1959), and these authors prepared the ground for modern general equilibrium theory. Bhattacharyya (1996) identifies five modeling traditions. An example of a widely used equilibrium model is GEM-E3 (Capros et al. 1997). Results depend on data, parameter values, model structure, the neoclassical theoretical basis, and the level of disaggregation. Equilibrium models may be comparative static or dynamic. Temporal dynamics have been introduced in different ways (Dellink 2005).

WIEPKE W. WISSEMA

See also: Equilibrium, Neoclassical economics, General equilibrium model, Welfare economics, Econometrics.

References

Arrow, K.J. & Debreu, G. 1954. Existence of an equilibrium for a competitive economy. Econometrica 22(3): 265–90.

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McKenzie, L.W. 1959. On the existence of general equilibrium. Econometrica 27(1): 54–71.

Walras, L. 2010. Éléments d'Économie Politique pure ou Théorie de la Richesse Sociale. Whitefish, MT: Kessinger Publishing.

Equimarginal principle of optimization

The "when to stop" rule. A consumer reaches a utility-maximizing allocation when the marginal benefit per unit of expenditure is equal across all goods and services consumed; if this were not the case, then spending less on a good with lower marginal utility per dollar and more on one with higher marginal utility would increase total utility. A producer reaches a cost-minimizing allocation when the marginal product per unit of expenditure is equal across all factors of production. Conceptually, an economy reaches an optimal scale when the rising marginal costs of economic output equal the diminishing marginal benefits, even if costs and benefits are neither measurable nor commensurable.

While the equimarginal principle is useful for optimization, it tells us nothing about total value: we know that if the utility from the last dollar spent on staple foods equals that of the last dollar spent on bubblegum the consumer has maximized utility for a given budget, but this provides no information on the total value provided by either commodity. Furthermore, marginal analysis is of limited use in the vicinity of ecological, physiological, or social thresholds (that is, tipping points), defined as situations in which a small

change in a system input can drive dramatic, unpredictable, and non-marginal changes to outputs. Human impacts on global ecosystems are currently non-marginal.

JOSHUA C. FARLEY

Further reading

Daly & Farley 2011.

See also: Utility, Utility function, Optimization, Optimal scale of the macroeconomy, Marginal analysis, Tipping point.

Reference

Daly, H.E., & Farley, J.C. 2011. Ecological Economics: Principles and Applications, 2nd edn. Washington, DC: Island Press.

Equitable

Fair, just, or impartial treatment of people.

BARRY D. SOLOMON

Further reading

Leventhal 1980.

See also: Social equity, Inequity, Intragenerational equity, Sustainable development.

Reference

Leventhal, G.S. 1980. "What should be done with equity theory?," pp. 27–55 in Social Exchange. K.J. Gergen, M.S. Greenberg & R.H. Willis, eds. Boston, MA: Springer.

Eudaimonia

The good life, living meaningfully in accordance with moral principles and virtues (Chan et al. 2018). An ethical conceptualization of well-being as human flourishing, prosperity, and blessedness, where people reach their highest potential within their societal context. First recognized by Greek philosophers such as Epicurus and Aristotle, and in the 19th century by John Stuart Mill (Brand-Correa & Steinberger 2017). It is possible to assess eudaimonia based on generally accepted human needs such as health, education, nutrition, income, political participation, and so on (Max-Neef 1991). This approach to well-being is promoted by ecological economics, in contrast with the Hedonic school that considers well-being to focus exclusively on maximizing one's own pleasure and minimizing pain.

BARRY D. SOLOMON

See also: Objective well-being, Subjective well-being, Human needs assessment, Matrix of human needs, Egoistic hedonism, Happiness, Buen vivir.

References

Brand-Correa, L.I. & Steinberger, J.K. 2017. A framework for decoupling human need satisfaction from energy use. Ecological Economics 141: 43–52.

Chan, K.M.A., Gould, R.K. & Pascual, U. 2018. Editorial overview: relational values: what are they, and what's the fuss about? Current Opinion in Environmental Sustainability 35, A1–A7.

Max-Neef, M. 1991. Human Scale Development: Conception, Application and Further Reflections. New York & London: Apex Press.

Eutrophication

The process by which a lake, river, stream, estuary, bay, or other water body gradually becomes overly rich with nutrients, especially nitrogen and phosphorous, leading to excessive growth of plants and algae (for example, phytoplankton, cyanobacteria) and deterioration of water quality (Smith & Schindler 2009). The plants and algae deplete the oxygen content of the water and produce dangerous toxins. Eutrophication can be classified as either natural (especially in lakes) or cultural (anthropogenic). Common causes of eutrophication include fertilizer runoff from lawns, golf courses, and farmlands; fish feeding; and untreated sewage or wastewater disposal. In extreme cases, eutrophication can lead to harmful algae blooms, dead zones, and fish kills.

BARRY D. SOLOMON

See also: Anthropogenic, Soil fertility, Nutrient cycling, Wastewater.

Reference

Smith, V.H. & Schindler, D.W. 2009. Eutrophication science: where do we go from here? Trends in Ecology and Evolution 24(4): 201–7.

Evolutionary analysis

Analysis focused on the population-level changes that result from selection acting on individuals. In evolutionary systems, changes arise because of the interplay of three mechanisms: diversity, innovation, and selection. Diversity of options, genes in biology, or technologies and behaviors in economics, is a prerequisite for selection to act upon, while innovation is a mechanism of diversity generation.

Biology: selection describes a process in which environmental or genetic factors determine which types of organisms thrive better than others, for instance by producing more offspring.

Economics: selection operates on technologies or strategies, where firms adopt new cost-competitive technologies, because of which they diffuse into the economy. The process of selection is often modeled with replicator dynamics. Replicator dynamics offers a tool to study how frequencies of strategies in the population change over time according to their (relative) payoffs, where individual payoffs depend on the strategies of other players.

KAROLINA E. SAFARZYNSKA

Further reading

Hofbauer & Sigmund 1998; Nowak 2006.

See also: Evolutionary economics, Darwinian theory, Coevolution.

References

Hofbauer, J. & Sigmund, K. 1998. Evolution Games and Population Dynamics. Cambridge: Cambridge University Press.

Nowak, M. 2006. Evolutionary Dynamics: Exploring the Equations of Life. Cambridge, MA: Harvard University Press.

Evolutionary economics

A branch of economics that draws upon principles inspired by evolutionary biology, chiefly the process of change caused by variation, selection, and retention. Inquiring systemic change and innovation, Evolutionary economics (EE) is markedly different from much of received economic scholarship that keeps its focus on inquiring about economic operations within a given system. Major theoretical presuppositions of EE include heterogenous and boundedly rational agents and—generally—the rejection of universal and invariable "economic laws."

For the first two decades since its inception as a modern school of thought in the early 1980s, the community largely referenced its position as heterodox, but has since come to increasingly acquire and claim a mainstream position. EE has important roots in Karl Marx's developmental stages, Thorstein Veblen's habits and institutions, and Joseph Schumpeter's creative destruction. Subdivisions include evolutionary growth theory, evolutionary game theory, innovation and life-cycle studies. Notably, EE recognizes the significance of meso-level analysis for bridging the gap between agents/firms (micro), and the overall economy (macro).

GEORG D. BLIND

Further reading

Blind 2016; Dopfer 2012; Nelson & Winter 1982; Ostrom 1990; Schumpeter 1912.

See also: Coevolution, Heterodox economics, Institutional economics, Bounded rationality, Satisficing, Darwinian theory, Creative destruction.

References

Blind, G. 2016. "Behavioural rules: Veblen, Nelson–Winter, Ostrom and beyond," pp. 139–51 in Routledge Handbook of

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Dopfer, K. 2012. The origins of meso economics. Journal of Evolutionary Economics 22: 133–60.
Nelson, R. & Winter, S. 1982. An Evolutionary Theory of Economic Change. Cambridge, MA: Harvard University Press.
Ostrom, E. 1990. Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge: Cambridge University Press.
Schumpeter, J.A. 1912. Theorie der wirtschaftlichen Entwicklung. Leipzig: Duncker & Humblot.

Exchange value

a. According to Karl Marx, the abstract value of a good based on its physical properties and the proportion in which it can be exchanged for other goods, as opposed to its use value (Marx 1867 [1990], p. 128).
b. According to Adam Smith, the power of purchasing other goods, which the possession of an object conveys (Smith 1776 [1960], p. 32).
c. According to David Ricardo, the abstract value of a good based on its scarcity and the human labor embodied in its production (Ricardo 1817 [1951], p. 12).
d. In modern neoclassical economics, the price for which a good is traded in a given market. As such, the distinction between exchange value and use value was abolished.

BARRY D. SOLOMON

See also: Use value, Labor theory of value, Non-consumptive use value, Non-use value, Scarcity value, Intrinsic value, Total economic value (TEV), Classical economics.

References

Marx, K. 1867 [1990]. Capital, Vol. 1. London: Penguin.
Ricardo, D. 1817 [1951]. On the Principles of Political Economy and Taxation. P. Sraffa, ed. with the collaboration of M.H. Dobb. Cambridge: Cambridge University Press.
Smith, A. 1776 [1960]. An Inquiry into the Nature and Causes of the Wealth of Nations, Vol. 1. E. Cannan, ed. London: Methuen.

Excludability

a. The degree to which access to a good, service, or resource can be limited to certain people, for example those who pay to purchase it. Here, excludability is the potential ability to exclude others from benefiting from a given entity. In its original formulation, from economic theory, any good, service, or resource is either excludable, such as food, or non-excludable, such as lighthouses or national defense (Samuelson 1954). Later, excludability was reconceptualized to vary continuously from low to high, rather than discretely as presence or absence, based on the difficulty of excluding potential beneficiaries (Ostrom & Ostrom 1977). This depends not just on the physical characteristics of the entity in question but also on the technological factors; with widespread communications technology, for example, it becomes difficult to exclude people from benefiting from ideas and information.
b. The degree to which access to a good, service, or resource is limited to certain people. In this definition, excludability is the actual ability to exclude others from benefiting from a given entity. It is thus a product of institutions. Human institutions are what keep specified humans from benefiting from existing goods, services, and resources. With enough policing power, nearly anything can be made excludable; even access to sunsets could be restricted by, say, locking non-payers in rooms without west-facing windows. For an entity to be bought and sold in markets, some aspect of it must be excludable, even if only the prestige associated with being the owner of something that is otherwise non-excludable.

SAM C. BLISS

Further reading

Ostrom 2010; Rayamajhee & Paniagua 2021.

See also: Public goods, Private goods, Common pool resources, Club goods, Rivalness, Excludable good, Non-excludable resource, Commons, the.

References

Ostrom, E. 2010. Beyond markets and states: polycentric governance of complex economic systems. American Economic Review 100(3): 641–72.

Ostrom, V. & Ostrom, E. 1977. "Public goods and public choices," pp. 7–49 in Alternatives for Delivering Public Services: Toward Improved Performance. E.S. Savas, ed. Boulder, CO: Westview Press.

Rayamajhee, V. & Paniagua, P. 2021. The Ostroms and the contestable nature of goods: beyond taxonomies and toward institutional polycentricity. Journal of Institutional Economics 17(1): 71–89.

Samuelson, P.A. 1954. The pure theory of public expenditure. Review of Economics and Statistics 36(4): 387–89.

Excludable good

A good, service, or resource that certain people or groups, for example those who do not pay for it, are prevented from accessing. No entities are innately excludable; human institutions must make them so. This can happen via mutual agreements, threats of violence, or, in practice, often mutual agreements backed by threats of violence. For this reason, ecological economists often refer to "excludable resource regimes" rather than using the term "excludable" to describe resources themselves.

SAM C. BLISS

Further reading

Ostrom 2010.

See also: Excludability, Club goods, Private goods.

Reference

Ostrom, E. 2010. Beyond markets and states: polycentric governance of complex economic systems. American Economic Review 100(3): 641–72.

Exergy

The amount of work obtainable when some matter is brought to a state of thermodynamic equilibrium with the common components of the natural surroundings by means of reversible processes, involving interaction only with the above-mentioned components of nature (Szargut et al. 1988). Exergy is the part of energy that can perform work, according to the Second Law of Thermodynamics. Total exergy, measured in joules, is the sum of mechanical (kinetic and potential energies), thermo-mechanical (temperature and pressure based), and chemical exergy components. The term was coined by Zoran Rant (1956), who suggested the term "exergy" should be used to denote "technische Arbeitsfähigkeit—technical available work," based on the Greek words *ex* (external) and *ergos* (work).

PAUL E. BROCKWAY

See also: Energy, Energy efficiency, Classical thermodynamics, Power.

References

Rant, Z. 1956. Exergy, a new word for "technical available work." Forsch Ingenieurweser 22(1): 36–7.

Szargut, J., Morris, D.R. & Steward, F.R. 1988. Exergy Analysis of Thermal, Chemical, and Metallurgical Processes. New York: Hemisphere.

Exhaustible resources

See: Non-renewable resource.

See also: Exhaustible resource theory, Fossil fuels.

Exhaustible resource theory

Addresses the economic implications of the rational allocation over time of the consumption of non-renewable natural resources under the ground such as minerals or fossil fuels. Rational resource allocation over

time is defined by an optimal extraction program resulting from a dynamic problem of social welfare maximization, which implies a choice at any instant between extracting a unit of a resource now and leaving it in the ground for future use. In the classical theory of exhaustible resources (Hotelling 1931), a constrained homogeneous resource stock is viewed as a riskless capital asset, which brings to a resource owner a rent that rewards resource scarcity. According to Hotelling's rule, the marginal resource rent coincides with the opportunity cost of extraction and grows at a rate equal to the real interest rate.

Extensions of the classical theory to cases of heterogeneous natural resources are based on the Herfindahl principle, according to which a lower-cost resource stock will be depleted before extraction will be switched to a higher-cost stock (Herfindahl 1967). Under a modified Hotelling rule, the marginal resource rent falls if extraction switches from low-cost to high-cost resource stocks. Further extensions to cases of heterogeneous resources and consumers use a more general principle of comparative advantage (e.g., Gaudet et al. 2001). The analysis determines an order in which consumers with different efficiencies of resource use switch to a higher-cost stock.

GEORGY TROFIMOV

Further reading

Conrad 2010; Vavilov & Trofimov 2021.

See also: Resource scarcity, Stocks, Hotelling model, Hotelling rule, Resource consumption, Resource depletion, Natural resource depletion.

References

Conrad, J. 2010. Resource Economics, 2nd edn. Cambridge: Cambridge University Press.

Gaudet, G., Moreaux, M. & Salant, S. 2001. Intertemporal depletion of resource sites by spatially distributed users. American Economic Review 91(4): 1149−59.

Herfindahl, O. 1967. "Depletion and economic theory," pp. 63–90 in Extractive Resources and Taxation. M. Gaffney, ed. Madison, WI: University of Wisconsin Press.

Hotelling, H. 1931. The economics of exhaustible resources. Journal of Political Economy 39: 137−75.

Vavilov, A. & Trofimov, G. 2021. Natural Resource Pricing and Rents: An Economic Analysis. Cham: Springer.

Existence value

A class of economic value that reflects the benefit or sense of well-being that people receive from knowing that a special place or environmental resource, or a rare, endangered, or charismatic species, exists. Examples might include the Great Barrier Reef, the Grand Canyon, African lions, and giant pandas. As such, existence value is a type of non-use value, which can include the intrinsic value of nature (Attfield 1998; Davidson 2013). Existence value may exist for people even if they are never able to visit or to experience the special place, environmental resource, or rare, endangered, or charismatic species. A popular technique for estimating existence value is the contingent valuation method as well as the use of benefit transfer (Stevens et al. 1991; Richardson & Loomis 2009).

BARRY D. SOLOMON

Further reading

Walsh et al. 1984.

See also: Non-use value, Intrinsic value, Total economic value (TEV), Contingent valuation method (CVM), Economic valuation techniques, Benefit transfer.

References

Attfield, R. 1998. Existence value and intrinsic value. Ecological Economics 24(2–3): 163–8.

Davidson, M.D. 2013. On the relation between ecosystem services, intrinsic value, existence value and economic valuation. Ecological Economics 95: 171–7.

Richardson, L. & Loomis, J. 2009. The total economic value of threatened, endangered and rare species: an updated meta-analysis. Ecological Economics 68(5): 1535–48.

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life: what do CVM estimates really show? Land Economics 67(4): 390–400.
Walsh, R.G., Loomis, J.B. & Gillman, R.A. 1984. Valuing option, existence, and bequest demands for wilderness. Land Economics 60(1): 14–29.

Exogenous

Economics: a phenomenon and properties that are assumed to originate independently of the socio-economic system they affect. The exogeneity of many phenomena (for example, economic growth, individual preferences) is one of the main subjects of debate between heterodox and orthodox economics.

Economic modeling: variables that are not simulated, but rather imposed to the model. Variables are set as exogenous for simplification purposes within the boundaries of the simulation or following the underlying economic theory.
Ecology: external phenomenon or entities that influence an ecological entity (for example, population, ecosystem); in opposition to the effect of the dynamic subinteractions occurring within that entity (which are endogenous).

ÉTIENNE GUERTIN

Further reading

Mankiw 2003; Harcourt 2006.

See also: Endogeneity.

References

Harcourt, G.C. 2006. The Structure of Post-Keynesian Economics: The Core Contributions of the Pioneers. Cambridge: Cambridge University Press.
Mankiw, G. 2003. Macroeconomics, 3rd edn. New York: Worth Publishers.

Exotic species

See: Alien species.

See also: Species, Invasive species, Endangered species.

Expected utility theory (EUT)

The most common approach in economic theory for assessing risky projects. These normally are defined by states $S_i = (p_i, x_i)$, where p_i is the probability of S_i and x_i the payoff in this state. The expected utility (EU) that the given project has for some agent is: $\sum p_i u(x_i)$ where $u(.)$ is this agent's von Neumann–Morgenstern (vNM) utility function (Osborne & Rubinstein 2020, for details). Making choices among different risky projects, an agent will prefer the one with the highest EU.

From a theoretical viewpoint expected utility theory (EUT) has considerable advantages: according to the vNM representation result EUT can be motivated by assuming rational behavior of agents as expressed by four axioms; the utility function $u(.)$ can be used to describe an agent's risk attitudes, where the standard case is a concave $u(.)$ reflecting risk aversion; many empirically relevant phenomena, such as the working of insurance markets, can be described by EUT in a precise and catchy way. Yet EUT has important drawbacks, too. Real people do not act as rational as assumed for the vNM representation theorem; which, for example, is shown by the venerable Allais and Ellsberg paradoxes. To overcome such anomalies alternatives to EUT, such as Kahneman and Tversky's "prospect theory," have been developed (e.g., Kahneman 2011). EUT moreover has difficulties in handling catastrophic risks; that is, risks with a very negative payoff but small probability. In this case EUT falls into extremes: either negligence of catastrophic events or their absolute dominance in assessment (Buchholz & Schymura 2012). Also, of much importance from the viewpoint of ecological economics is that EUT is not able to handle cases of Knightian uncertainty, where probabilities cannot be not known and states cannot be identified (Kay & King 2020).

WOLFGANG BUCHHOLZ

See also: Risk aversion, Preference heterogeneity, Prospect theory, Uncertainty.

References

Buchholz, W. & Schymura, M. 2012. Expected utility and the tyranny of catastrophic risks. Ecological Economics 77: 234–9.

Kahneman, D. 2011. Thinking, Fast and Slow. New York: Farrar, Straus & Giroux.

Kay, J. & King, M. 2020. Radical Uncertainty: Decision-Making for an Unknowable Future. London: Bridge Street Press.

Osborne, M.J. & Rubinstein, A. 2020. "Preferences under uncertainty," pp. 31–44 in Models in Microeconomic Theory. Cambridge: Open Book Publishers.

Experimental economics

A methodology using procedures implemented by natural sciences to analyze problems related to economic decisions. The motivations identified in the literature for conducting experiments in economics are traditionally identified as the following (Davis & Holt 1993): empirical tests of specific theories (tests of behavioral hypotheses), validation of the robustness of a theory (theory stress test), and a search for empirical regularities in real environments. This method emerged out of the need to overcome the limits of standard observational data, namely the difficulty in identifying causal relationships when a complex system of elements interacts and makes it hard to isolate the elements, which are instead exogenous.

Experimental economics aims to create controlled experiments. A series of rules must be respected for the procedure to be qualified as scientifically designed (Hey 1998; Eber & Willinger 2005; Friedman & Sunder 1994): (1) respect specific rules in the recruitment of the subjects and execution of the experiment; (2) participation of subjects must be adequately motivated: experimental subjects must receive salient remunerations, which should be enough to compensate the effort made to take the decisions; the relationship between the decision and the remuneration must be clearly identified; and (3) the researcher conducting the experiment must not influence the decisions of participants, who should not perceive any hint on how (or which, among a set of possibilities) decisions should be taken. The rigidity of experimental economics procedures aims to guarantee that any researcher can control how data were created and can attempt to replicate the experiment with a different sample of subjects.

Francesca Pancotto

See also: Behavioral economics, Behavioral ecological economics, Scientific method.

References

Davis, D.D. & Holt, C.A. 1993. Experimental economics: methods, problems, and promise. Estudios Económicos 8(2): 179–212.

Eber, N. & Willinger, M. 2005. L'Économie Expérimentale (in French). Paris: Le Decouverte.

Friedman, D. & Sunder, S. 1994. Experimental Methods: A Primer for Economists. Cambridge: Cambridge University Press.

Hey, J.D. 1998. Experimental economics and deception: a comment. Journal of Economic Psychology 19: 397–401.

Experimental ecosystem accounting

Guidelines for economic ecosystem accounting that were proposed by the United Nations Statistical Division in 2013 and pilot tested in seven countries, until the revised statistical framework was formally adopted in March 2021 (Edens & Hein 2013; UNSD 2021).

Pablo Campos Palacín

See also: Economic ecosystem accounting.

References

Edens, B. & Hein, L. 2013. Towards a consistent approach for ecosystem accounting. Ecological Economics 90: 41–52.

UNSD. 2021. System of Environmental–Economic Accounting—Ecosystem Accounting, final draft, version 5. New York: United Nations, Statistical Division. https://unstats.un.org/unsd/statcom/52nd-session/documents/BG-3f-SEEA-EA_Final_draft-E.pdf.

Exploitation

Economics:

a. Making productive use of natural resources or knowledge to profit from or otherwise benefit from it.
b. Selfishly taking advantage of or otherwise treating people or workers unfairly to profit from or otherwise benefit from their work.

Ecology: the act of predators and parasitoids removing individual organisms from the resource population as they consume them, and parasites consuming portions of individual organisms, which reduces the fitness of the affected individuals. Plant and animal species commonly compete with other organisms for resources such as food, nutrients, or water to limit the resources available to other organisms.

BARRY D. SOLOMON

Further reading

Benchekroun & Van Long 2016; Oubraham & Zaccour 2018; Moberg et al. 2019.

See also: Extractivism, Overexploitation, Resources, Common pool resources, Common property resources, Biotic resources, Abiotic resources, Fitness.

References

Benchekroun, H. & Van Long, N. 2016. Status concern and the exploitation of common pool resources. Ecological Economics 125: 70–82.

Moberg, E.A., Pinsky, M.L. & Fenichel, E.P. 2019. Capital investment for optimal exploitation of renewable resource stocks in the age of global change. Ecological Economics 165: 106335.

Oubraham, A. & Zaccour, G. 2018. A survey of applications of viability theory to the sustainable exploitation of renewable resources. Ecological Economics 145: 346–67.

Exponential growth

A growth process that can be represented by an exponential function or curve (Figure 8). Exponential growth takes place when the instantaneous rate of change, or derivative, of the initial quantity is proportional to its initial size. The growth rate does not have to be fast, just steady over time, though the quantity added over time is ever-increasing. The formula for exponential growth is: $X_t = X_0(1+r)^t$, where X_t is the amount of X at time t, X_0 is the initial value of X and r is the growth rate (Klyatis 2020). The growth of the gross domestic product is commonly referred to in percentage terms: for example, 2 percent per year (Lange et al. 2018). Such exponential growth implies an immense growth in absolute terms over time. An economy growing at 2 percent per year doubles approximately every 35 years (Meadows et al. 2004).

The long-term growth rates of human use of energy and mineral resources have been exponential, as have manufactured capital and human capital. Except for human capital, this is unsustainable in the long run. Human population growth has also been exponential, though it has stabilized or even declined in recent decades in some countries. Human population growth has been facilitated by technological change, international trade, and resource substitution; temporary ways to seemingly exceed constraints in natural capital. However, ecological footprint analysis has shown that, due to exponential growth in population and resource use, humans have well overshot the carrying capacity of the environment both globally and in many individual countries (McBain et al. 2017).

STEFFEN LANGE

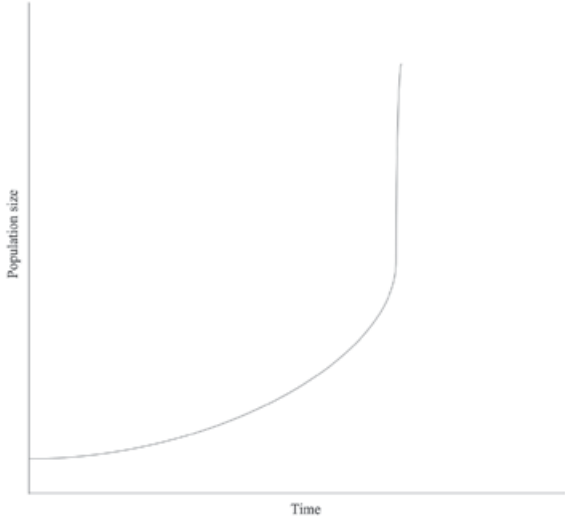
Further reading

Malghan 2021.

See also: Manufactured capital, Natural capital, Human capital, Ecological footprint, Carrying capacity, Overshoot, Logistic growth.

References

Klyatis, L.M. 2020. "Basic negative and positive trends in the development of accelerated testing," pp. 121–72 in Trends in Development of Accelerated Testing of Automotive and



Source: Editors.

Figure 8 *Exponential population growth*

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Malghan, D. 2021. (Un)flatten the curve: a simple model of sink capacity. Ecological Economics 182: 106826.
McBain, B., Lenzen, M., Wackernagel, M. & Albrecht, G. 2017. How long can ecological overshoot last? Global and Planetary Change 155: 13–19.
Meadows, D.H., Randers, J. & Meadows, D.L. 2004. The Limits to Growth: The 30-Year Udpate. White River Junction, VT: Chelsea Green Publishing Co.

Extended producer responsibility

A policy aimed at making the producers and importers of products responsible for the environmental impacts from both use and disposal of their products. The responsibility for disposal may be financial, physical, or a combination thereof. Extended producer responsibility (EPR) shifts the cost of environment-friendly disposal of an end-of-life product from the government to the producer or importer of the product. EPR requires that products be designed for recyclability, encourages design for recycling, and discourages the use of toxic inputs in the products.

YAMINI GUPT

Further reading

OECD 1996; Surak 2011; Gupt & Sahay 2015; Arnaud 2017.

See also: Environmental stewardship, Benefit–cost analysis (BCA), Recycling, Sustainable recycling, Pollution prevention (P2).

References

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in the OECD Area Phase 1 Report. Paris: OECD.
Surak, S.M. 2011. "Extended producer responsibility," in Green Technology: An A-to-Z Guide. D. Mulvaney, ed. Los Angeles, CA: SAGE.

Externalities

The results of actions of an individual or a firm that cause an unintended loss or gain in welfare for other individuals or firms who were not party to the original transaction, and where no compensation for this change in welfare occurs (Stiglitz & Rosengard 2015). The concept originates with Pigou (1932), who described the emergence of "external economies" when marginal social costs diverge from marginal private costs.

Externalities may be positive (welfare-increasing) or negative (welfare-decreasing), and may arise from acts of production or consumption. Examples of positive externalities include: herd immunity via immunization, whereby unvaccinated individuals are protected when other people are immunized; and network externalities, whereby expanding connection to a technology (for example, telecommunications) generates greater benefits and opportunities for all. Examples of negative externalities include loss of amenity due to overcrowding and congestion in cities; and a wide range of environmental impacts such as pollution and ecosystem degradation. Negative environmental externalities with intertemporal effects upon future generations are a central concern of ecological economics, with the internalization of environmental externalities viewed as a necessary but not sufficient condition for sustainability (Bithas 2011).

MARTIN C. HENSHER

See also: Environmental externalities, Consumption externalities, Internalizing externalities, Market failure.

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Stiglitz, J.E. & Rosengard, J. 2015. "Externalities and the environment," pp. 129–62 in Economics of the Public Sector, 4th edn. New York: W.W. Norton & Co.

Extractivism

a. A mode of extraction of natural resources (typically minerals, hydrocarbons, and agro-industrial commodities), characterized by high intensity (large volumes of materials extracted) and geared toward export to industrial centers, with little or no processing (Gudynas 2021). This meaning of the term was first popularized by Latin American political ecologists in relation to the resource export boom that started in the region at the turn of the 20th century, to denounce its negative impacts on ecologies and communities at the point of extraction (disproportionately affecting women and indigenous or racialized groups).
b. An extraction-based "mode of development" primarily adopted by (or imposed upon) resource-rich countries in the "global South," often coupled with the redistribution of extractive rents as a central hegemonic strategy (Brand et al. 2016). This mode of development reflects a neocolonial and neo-imperial global division of labor between industrial "centers" and primary exporting "peripheries," resulting in unequal ecological and value exchange to the detriment of the latter (Vela-Almeida 2020).
c. An extractive mode of appropriation of (surplus) value produced elsewhere, typically associated with the operations of financial and rentier capitalism (Gago & Mezzadra 2017).
d. The sustainable productive practices of rubber tappers (*seringueiros*) and other small-scale collectors in the Brazilian Amazon, called collectively *extractivistas*; their struggles for the defense of such practices against the advance of mining, agro-industrial, and cattle-ranching fron-

tiers gained international visibility in the late 1980s, following the assassination of unionist and environmental defender Chico Mendes (Barca & Milanez 2021).

Diego Andreucci

Further reading

Arboleda 2020; Svampa 2019.

See also: Capital accumulation and deaccumulation, Environmental governance, Ecologically unequal, Ecological debt.

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Barca, S. & Milanez, F. 2021. "Labouring the commons: Amazonia's 'extractive reserves' and the legacy of Chico Mendes," pp. 319–38 in The Palgrave Handbook of Environmental Labour Studies. N. Räthzel, D. Stevis & D. Uzzell, eds. Cham: Springer.

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Svampa, M. 2019. Neo-Extractivism in Latin America: Socio-Environmental Conflicts, the Territorial Turn, and New Political Narratives. Cambridge: Cambridge University Press.

Vela-Almeida, D. 2020. Seeing like the people: a history of territory and resistance in the southern Ecuadorian Amazon. Journal of Political Ecology 27: 1110–27.

Extrapolation

Logic: a procedure that assumes future outcomes or developments continue to follow a previous trend.

Statistics: to assign values to extend a series assuming continuation of a similar pattern.

Mathematical modeling: major methodological issue for adequacy of model scenario and prediction in Earth system science, climate science, and economic approaches to abatement, climate change mitigation, and adaptation. Invokes problems of linearity, feedback, tipping points, complexity, measurement of risk, and the difference between quantitative probability and more fundamental uncertainty.

Josh Moos & Jamie A. Morgan

Further reading

Gillies 2000; Freedman 2009; Sweeney et al. 2018.

See also: Uncertainty, Risk, Complex systems modeling, System dynamics models, Climate change mitigation, Climate change adaptation.

References

Freedman, D.A. 2009. Statistical Models: Theory and Practice. Cambridge: Cambridge University Press.

Gillies, D. 2000. Philosophical Theories of Probability. London: Routledge.

Sweeney, J., Salter-Townshend, M., Edwards, T. et al. 2018. Statistical challenges in estimating past climate changes. Wiley Interdisciplinary Reviews: Computational Statistics 10(5): e1437.

F

Factor endowment theory

A neoclassical theory of international trade, which emphasizes the resources that a country has available that can be used for manufacturing. Factor endowment theory was pioneered by the Swedish economists Eli Heckscher and Bertil Ohlin in the early 1900s, which led to the Heckscher–Ohlin theorem: a country exports those commodities produced with relatively large quantities of the country's relatively abundant factor (Bohlin 1933; Heckscher 1919). In general, countries with larger factor endowments, based on the proportion between factors in comparison to other countries, exploit the more abundant factor for foreign trade by greater intensity of use. A country's comparative advantage in the production of specific commodities is thus determined by its factor endowment (Wilson 1977).

However, a country's factor endowment may only account for a small percentage of world commodity trade, as technology and other differences exist between countries. Thus, exceptions to the original Heckscher–Ohlin theorem are common (Jones 1956–1957; Deardorff 1982; Schott 2003; Hakura 1999).

BARRY D. SOLOMON

See also: Commodity trade, Comparative advantage.

References

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Wilson, R. 1977. "The factor endowment," pp. 1–21 in Trade and Investment in the Middle East. London: Palgrave Macmillan.

Fair bequest package

A concept of sustainability and intergenerational justice, a set of items that a given generation is morally obligated to pass on to the subsequent generation. The make-up of the fair bequest package determines the option set available to future generations. Its definition is considered an act of collective choice. The items to be passed on can be conceptualized as different stocks of capital (for example, physical capital, natural capital, knowledge, culture), with limited substitutability among them (strong sustainability). The term was first introduced by Norton (2005).

BARTOSZ BARTKOWSKI

Further reading

Klauer et al. 2017.

See also: Strong sustainability, Natural capital, Adaptive ecosystem management.

References

Klauer, B., Bartkowski, B., Manstetten, R. & Petersen, T. 2017. Sustainability as a fair

bequest: an evaluation challenge. Ecological Economics 141: 136–43.
Norton, B.G. 2005. Sustainability: A Philosophy of Adaptive Ecosystem Management. Chicago, IL: University of Chicago Press

Fallacy of composition

a. The error of assuming that what is true of a member of a group is true for the group.
b. The mistaken assumption that what might be true on a small scale must be true on a much larger scale. In an economic setting the fallacy of composition would be represented in a belief by the managers of an individual firm that if it released a small amount of effluent into a river, it would not affect the river's water quality. However, if all firms in the area made the same decision, the river water quality would degrade.

Teresa Ghilarducci

Further reading

Martin 1993; Grafton et al. 2012.

See also: Growth fallacies.

References

Martin, W. 1993. The fallacy of composition and developing country exports of manufactures. World Economy 16(2): 159–72.
Grafton, R.Q., Nelson, H.W., Lambie. N.R. & Wyrwoll, P.R., eds. 2012. "Fallacy of composition," p. 131 in A Dictionary of Climate Change and the Environment. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Fallacy of misplaced concreteness

A critique of economic growth models that equate abstract concepts with physical manifestations of wealth. An example is equating a system that generates an annual food harvest with a financial account that generates annual interest. The financial account does not actually generate something of value outside of the socio-economic system in which it is embedded. Another example is models of economic growth that do not consider resource constraints and entropic processes. Considering the models and their outputs, such as gross domestic product (GDP), to be certain of paths to human well-being is a fallacy. Overall, the critique warns us of the danger of depending too much on abstractions of reality as guides for making policies affecting the real world. The term was coined by mathematician/philosopher Alfred Whitehead (1929), applied to economics by Nicholas Georgescu-Roegen (1971), and elaborated by Herman Daly (1980; and elsewhere).

Brent M. Haddad

See also: Growth fallacies, Growth theory, Entropy, Entropic dissipation, Steady state economy.

References

Daly, H. 1980. Growth economics and the fallacy of misplaced concreteness. American Behavioral Scientist 24(1): 79–105.
Georgescu-Roegen, N. 1971. The Entropy Law and the Economic Process. Cambridge, MA: Harvard University Press.
Whitehead, A.N. 1929. Process and Reality. London: Macmillan.

Feminist ecological economics

a. A heterodox economics school of thought that grew out of two streams of contributions: ecological economists who addressed feminist issues, and feminist economists who addressed ecological topics. These contributions started to merge in the 1990s with various papers published, for example, in the 1997 *Ecological Economics* special issue on Women, Ecology, and Care edited by Ellie Perkins (Perkins 1997), and in the 2018 *Feminist Economics* symposium on Ecology, Sustainability, and Care edited

by Julie Nelson and Marilyn Power (Nelson & Power 2018).

b. An analytical perspective related to materialist ecofeminism and feminist political ecology that regards the formal, growth-driven, monetized economy as only a small part of "the economy." Feminist ecological economics (FEE) emphasizes that without social reproduction/unpaid care work on the one hand, and ecosystem functions/natural processes on the other—two spheres that resemble each other in being structurally invisibilized, devalued, and pillaged in the capitalist growth paradigm—no formal economic activity would be possible. Largely neglected or treated as externalities by mainstream economics, the non-monetized economy of socio-ecological provisioning becomes the starting point for FEE analyses.

Corinna Dengler

Further reading

O'Hara 2009.

See also: Ecofeminism, Feminist political ecology, Gender inequality.

References

Nelson, J. & Power, M. 2018. Ecology, sustainability, and care: developments in the field. Feminist Economics 24(3): 80–88.

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Perkins, E. 1997. Introduction: women, ecology and economics: new models and theories. Ecological Economics 20: 105–6.

Feminist political ecology

A term that brings to the fore the idea of gendered resource politics at multiple scales. It enables the analysis of gender relations of local ecological and economic systems vis-à-vis national and global environmental, political, and economic systems shaping use, access, and redistribution of resources. Intersectionality lies at the core of feminist political ecology, which provides a nuanced lens for analyzing complex situations where gender intersects with other social axes such as caste, class, race, and ethnicity to shape everyday practices and material interactions (Rocheleau et al. 1996; Resurrección 2017).

Niharika Tyagi

Further reading

Elmhirst 2011; Mollett & Faria 2013.

See also: Political ecology, Ecofeminism, Feminist ecological economics, Gender inequality.

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Rocheleau, D., Thomas-Slayter, B. & Wangari, E., eds. 1996. Feminist Political Ecology: Global Issues and Local Experiences. New York: Routledge.

Fiscal policy instruments

See: Environmental policy instruments.

See also: Money, Monetary policy, Environmental taxes, Pollution taxes, Carbon taxes.

Fisherian income

Irving Fisher's psychic income concept (from Fisher 1906) is related to the subjective experiences that are felt in the human psyche. Fisher distinguishes between "psychic income" and "psychic outgo." Psychic income is desirable and consists of the positive items of income that are obtained through using wealth or consuming. Psychic outgo is undesirable and related to negative income items such as the labor effort (that is, the necessary psychic cost that is needed to obtain and enjoy posi-

tive items of income) and the pains and other discomforts of the body that are not related to the voluntary decision to obtain psychic income. By subtracting psychic outgo from psychic income, one gets the "net subjective income." In the common economic jargon, psychic income and psychic outgo are known as utility and disutility.

JONAS VAN DER SLYCKEN

Further reading

Van der Slycken & Bleys 2020.

See also: Economic welfare, Measures of economic welfare, Hicksian income.

References

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Van der Slycken, J. & Bleys, B. 2020. A conceptual exploration and critical inquiry into the theoretical foundation(s) of economic welfare measures. Ecological Economics 176: 106753.

Fisheries management

Ideally, the application of scientific modeling, strategic planning, and stakeholder processes to deliver well-defined, and widely accepted, goals in relation to fishery resources. Over the past few decades best-practice fisheries management has encompassed ecosystem goals and non-market benefits associated with fisheries, as well as the inputs of a wide range of stakeholders, not just fishers. Best-practice fisheries management encompasses different knowledges, such as traditional ecological knowledge, into its decision processes, as well as consideration of broader oceans management, such as marine pollution and the effects of climate change.

R. QUENTIN GRAFTON

Further reading

Karpoff 1987; Charles 1988.

See also: Fishery, Fishery resources, Marine ecosystems, Common pool resources, Bioeconomic modeling, Maximum sustainable yield, Traditional knowledge, Indigenous knowledge, Stakeholder, Stakeholder participation, Strategic decision-making.

References

Charles, A.T. 1988. Fishery socioeconomics: a survey. Land Economics 64(3): 276–95.

Karpoff, J.M. 1987. Suboptimal controls in common resource management: the case of the fishery. Journal of Political Economy 95(1): 179–94.

Fishery

A complex socio-ecological system organized both as a fishing ground (an area where fish are harvested), and as a fishing business. It may involve capture of wild fish or farming of fish through aquaculture.

Ecology: in 1957, Milner Schaefer modeled fishery growth as a function of the fish stock in the form of a logistic curve, starting at the minimum viable population and ending at the carrying capacity, where growth of the fish stock is zero (Schaefer 1957).

Economics: in 1954, H. Scott Gordon modeled the fishing effort (number of fishers) starting from a biological fish stock growth model (Gordon 1954). He assumed that the fishery is a common property resource characterized by non-excludability and rivalness (open access). His static sustainable yield model recommended barriers to entry to achieve the socially efficient level of harvest that is able to generate economic rent in the fishery. In 1990, Colin Clark developed a dynamically efficient fishing model using discount rates (Clark 1990).

GABRIELA L. SABAU

See also: Aquaculture, Safe minimum standard (SMS), Carrying capacity, Common property resources, Open access, Rivalness, Non-excludable resource, Rent, Sustainable yield, Maximum sustainable yield, Logistic growth.

Further reading

Worm et al. 2009; Froese et al. 2020.

References

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Froese, R., Winker, H., Coro, G. et al. 2020. Estimating stock status from relative abundance

and resilience. ICES Journal of Marine Science 77(2): 527–38.
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Worm, B., Hilborn, R., Baum, J.K. et al. 2009. Rebuilding global fisheries. Science 325 (5940): 578–85.

Fishery resources

Marine and freshwater wild fish and shellfish species that are harvested for indirect use, such as a feed source for other animals, or for direct consumption or human use. These resources include pelagic species such as herrings and sardines, and demersal species such as cod. According to the Food and Agriculture Organization of the United Nations, about three-quarters of the world fishery resources are either fully exploited, overexploited, or depleted.

R. Quentin Grafton

Further reading

Gunderson 1993.

See also: Fishery, Fisheries management, Marine ecosystems, Bioeconomic modeling, Maximum sustainable yield.

Reference

Gunderson, D.R. 1993. Surveys of Fisheries Resources. New York: John Wiley & Sons.

Fitness

Biology and ecology: a biological and evolutionary term associated with Charles Darwin's concept of evolution by natural selection. Herbert Spencer came up with the term "survival of the fittest." Ever since, biologists have struggled to define fitness. On average, fitter individuals leave more descendants in future generations (Burger et al. 2021). Most definitions assume that fitness is the quantity that is maximized or optimized by natural selection. Several measures of fitness are well established in the literature of life history, evolutionary, and physiological ecology: (1) rate of population increase (Charlesworth 1994); (2) maximum power flow (Lotka 1922; Odum & Pinkerton 1955); (3) resource use efficiency (Vitousek 1982); (4) lifetime reproductive effort (Charnov 1991); and (5) energetic fitness (Brown et al. 2018). David Tilman (1996), among others, has argued for species diversity leading to ecosystem stability without explicitly considering fitness.

Economics: the principal attempt to define fitness in economics is based on the Universal Economic Fitness Metric used by the World Bank (e.g., Tacchella et al. 2012), which focuses on the diversity, versatility, and complexity of a country's economy and exports, terms not found in the biological definitions. Ironically, according to Joseph Tainter (1998), complexity is the characteristic that leads to the collapse of societies with expanding empires, as they become increasingly energetically expensive to manage. The term "sustainability" might come closer to the biological concept of fitness, but its use in the literature is too variable and vague to provide an explicit predictor (Goodland & Daly 1996). Howard Odum (1973) and many others use fitness for society implicitly in terms of actions that lead to the survivability and growth of cultures.

Charles A.S. Hall

See also: Darwinian theory, Sustainability, Sustainable development, Resilience, Economic resilience, Ecosystem resilience.

References

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the National Academy of Sciences of the United States of America 88: 1134–7.
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Lotka, A.J. 1922. Contribution to the energetics of evolution. Proceedings of the National Academy of Sciences of the United States of America 8(6): 147–51.
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Tainter, J.A. 1998. The Collapse of Complex Societies. Cambridge: Cambridge University Press.
Tilman, D. 1996. Biodiversity: population vs. ecosystem stability. Ecology 77(2): 350–63.
Vitousek, P. 1982. Nutrient cycling and nutrient use efficiency. American Naturalist 119(4): 553–72.

Flow-fund theory of production

First proposed by Georgescu-Roegen (1970) as an alternative to standard representations of economic production, such as the neoclassical production function, a theory based on the distinction between flows and funds. Flows, such as resources, wastes, and intermediate goods, are the objects of the transformation. Funds, such as capital, labor, and land, are the agents of the transformation. This conceptualization leads to different formalizations, including a time-explicit model of a single production process and a disaggregate representation of multiple processes in interaction. These tools have been applied in industrial economics, energy analysis, and macroeconomics.

QUENTIN COUIX

Further reading

Vittucci Marzetti 2013; Couix 2020.

See also: Production function, Input–output (I–O) analysis, Industrial economics, Flows, Fund-service resources, Energy analysis.

References

Couix, Q. 2020. Georgescu-Roegen's flow-fund theory of production in retrospect. Ecological Economics 176: 106749.
Georgescu-Roegen, N. 1970. The economics of production. American Economic Review 60 (2): 1–9.
Vittucci Marzetti, G. 2013. The fund-flow approach: a critical survey. Journal of Economic Surveys 27(2): 209–33.

Flows

Economics: the movement or circulation of money or income. The creation, exchange, and transformation of economic value between businesses and consumers.

Ecological economics: in Georgescu-Roegen's flow-fund theory of production, elements transformed by factors of production into resources, economic goods and commodities, secondary products, clean water, emissions, wastes, and so on (Georgescu-Roegen 1970).

Ecology:

a. The movement of water.
b. The movement of energy through an ecosystem.
c. The movement of raw materials, resources, substances or finished products across different industrial sectors or within ecosystems. The analysis of energy and materials flows is a major research area in the field of industrial ecology.
d. The movement of genetic material from one population to another.

BARRY D. SOLOMON

Further reading

Kraev 2002.

See also: Stocks, Renewable resource, Flow-fund theory of production, Circular flow model, Money, Material flow accounts, Material flow analysis, Energy flows, Transgenic, Industrial ecology.

References

Georgescu-Roegen, N. 1970. The economics of production. American Economic Review 60(2): 1–9.

Kraev, E. 2002. Stocks, flows and complementarity: formalizing a basic insight of ecological economics. Ecological Economics 43(2–3): 277–86.

Food insecurity

The experience of not having enough or a stable source of appropriate, nutritionally adequate food; may be chronic, aperiodic, or seasonal, and range in intensity from mild to severe, with starvation being at the extreme end of the spectrum (Hendriks 2015). Food insecurity is often measured subjectively by asking individuals and households to share their anxiety or concern over having enough (nutritious) food, and any coping strategies that they may have employed, such as reducing the amount or frequency of meals, and not eating for one or more days (Nord 2014). Food insecurity results from a multitude of factors, including a lack of food supply, financial constraints (Tarasuk et al. 2016), socio-cultural erosion such as loss of traditional knowledge (Hendriks 2015), market failures (Rocha 2007), and structural inequalities (Caplan 1994), which Sen (1981) calls "entitlement failures."

MAYA MOORE

Further reading

Dutko et al. 2012; Cooksey-Stowers et al. 2017.

See also: Food security, Food self-sufficiency, Sustenance.

References

Caplan, A. 1994. Feasts, fasts, famine: food for thought. Berg Occasional Papers in Anthropology. London: Routledge.

Cooksey-Stowers, K., Schwartz, M.B. & Brownell, K.D. 2017. Food swamps predict obesity rates better than food deserts in the United States. International Journal of Environmental Research and Public Health 14(11): 1366.

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Rocha, C. 2007. Food insecurity as market failure: a contribution from economics. Journal of Hunger and Environmental Nutrition 1(4): 5–22.

Sen, A. 1981. Poverty and Famines: An Essay on Entitlement and Deprivation. New York: Oxford University Press.

Tarasuk, V., Mitchell, A. & Dachner, N., 2016. Household food insecurity in Canada, 2014. Toronto: PROOF: Food Insecurity Policy Research.

Food security

a. The state along a continuum, which continues to evolve, in which all people have their nutritional and cultural food needs met in a socially acceptable manner. First coined at the 1974 World Food Conference, it replaced the term "food sufficiency," and was grounded in political concerns over the availability of food as it relates to global food supply, national food production, and price stability (Jones et al. 2013).
b. A decade later and following Amartya Sen's 1981 essay on entitlement, the United Nations Food and Agriculture Organization (FAO) expanded the production-focused definition to encompass food access for "all people, at all times" (FAO 1983).
c. The 1990 definition used by the United States Department of Agriculture (USDA) includes procuring food in socially acceptable ways; for example, not stealing or scavenging (Anderson 1990).
d. With the 1996 adoption of the Right to Adequate Food from the World Food Summit, food security took on a rights-based perspective, outlining the multidimensional nature of food security with its four pillars: availability, access,

utilization (including food safety), and stability (FAO 2008).

e. In Europe, the term "food security" is often used to denote food safety (Jones et al. 2013).
f. More recently, Cecilia Rocha (2007) has put forth the "Five A's of food security" framework: availability, accessibility, adequacy (nutritious, safe, and sustainably produced), acceptability (culturally and ethically), and agency. The addition of agency highlights the role of policy and systems that facilitate food-secure environments.

MAYA MOORE

Further reading

Patel 2009; Clapp 2014; Chappell 2018.

See also: Food insecurity, Food self-sufficiency, Food system, Sustainable food system, Human agency.

References

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Clapp, J. 2014. Food security and food sovereignty: getting past the binary. Dialogues in Human Geography 4(2): 206–11.

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Jones, A.D., Ngure, F.M., Pelto, G. & Young, S.L. 2013. What are we assessing when we measure food security? A compendium and review of current metrics. Advances in Nutrition 4(5): 481–505.

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Food self-sufficiency

The ability of an individual, community, or society to meet most of its own caloric needs without relying on the purchase or barter of foodstuffs. It is rooted in the belief that reliance on others for food resources, whether grocery stores or foreign lands, creates a dependent state of existence and a low level of resiliency. As a modern concept, it is an attempt to revive the idealized forms of self-sufficiency enjoyed by diverse farm communities, peasants, and indigenous societies the world over. In the 21st century, it is often invoked as a countermeasure to the increased globalization of food: the reliance on complex supply chains and distant "elsewheres" for basic nourishment. It is viewed more as an ideal to aspire to than an identifiable end point to achieve. This idealized state plays a major role in the overlapping food movements of the 21st century, including permaculture, the local food movement, organic agriculture, slow food, and the revival of indigenous polycultures.

JEREMY L. CARADONNA

Further reading

Clapp 2017.

See also: Sufficiency, Sustainable food system, Food security, Food insecurity, Food system, Indigenous knowledge, Sustenance, Resilience.

Reference

Clapp, J. 2017. Food self-sufficiency: making sense of it, and when it makes sense. Food Policy 66: 88–96.

Food system

A broad network of plants, animals, people, communities, businesses, and institutions whose multi-scalar interactions center on food production, processing, distribution, consumption, and disposal. A food system consists of the chain of activities by which people procure food, as well as complex intersecting factors, including infrastructure, technology, public health, environmental crises, socio-cultural histories, policy and

governance frameworks, and systems of oppression (Parsons et al. 2019). All interactions that constitute a food system are embedded in ecosystems. Food systems are thus complex adaptive systems in which changes in one part of a system may incur unexpected changes in multiple other parts of the system. Feedback loops and interdependence between diverse actors and processes produce unique relationships and adaptive responses across particular food systems (Nesheim et al. 2015).

Despite the connectivity of actors and processes across scales, food systems are often delimited in geographic terms (for example, local, regional, national, or global) (Duram & Oberholtzer 2010). Strengthening local food systems is deemed fundamental for realizing just economies, resilient livelihoods, food security, and food sovereignty (Pimbert 2009); however, there is no singular definition of what constitutes "local." Ecological economists also highlight the importance of non-market food systems (Bliss 2019). This aligns with critiques of the corporate food regime (Holt-Giménez & Shattuck 2011) and calls for rights-based food systems (Anderson 2008).

Catherine E. Horner

Further reading

Chappell & Schneider 2016; Holt-Giménez 2017; Fanzo et al. 2017.

See also: Food self-sufficiency, Local economies, Food security, Agribusiness.

References

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Chappell, M.J. & Schneider, M. 2016. "The new three-legged stool: agroecology, food sovereignty, and food justice," pp. 435–45 in The Routledge Handbook of Food Ethics. M. Rawlinson & C. Ward, eds. London: Routledge.

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Fanzo, J., Arabi, M., Burlingame, B. et al. 2017. Nutrition and Food Systems: A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome: Food and Agriculture Organization of the United Nations.

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Holt Giménez, E. & Shattuck, A. 2011. Food crises, food regimes and food movements: rumblings of reform or tides of transformation? Journal of Peasant Studies 38(1): 109–44.

Nesheim, M.C., Oria, M. & Yih, P.T. 2015. "A framework for assessing the food system and its effects," in A Framework for Assessing Effects of the Food System. Washington, DC: National Academies Press, 243–360.

Parsons, K., Hawkes, C. & Wells, R. 2019. Brief 2: Understanding the food system: why it matters for food policy. London: Centre for Food Policy.

Pimbert, M. 2009. Towards Food Sovereignty. London: International Institute for Environment and Development.

Forest conservation

Planting and maintaining forestlands in a sustainable manner. Forest management involves planning and implementing practices required for conserving and using forests (timber and non-timber products) to meet specific environmental, economic, social, and cultural goals. In addition, it involves providing a specific forest area with the necessary care in order to remain healthy and vigorous, thus ensuring the optimal products and amenities for the landowner. Thus, forest management is not so much a subject or science as it is a process, which includes conservation as an integral activity.

Adam M. Wellstead

Further reading

FAO 2021.

See also: Forestry, Forest resources, Sustainability, Conservation.

Reference

FAO (Food and Agriculture Organization of the United Nations). 2021. Forest Management Practices. Rome: FAO. http://www.fao.org/forestry/sfm/85084/en/.

Forest resources

Forests provide a variety of market and non-market goods/resources. Market-based resources include wood and fiber products, such as paper, lumber, veneer and plywood, furniture, poles, pilings, chips, bark, shavings, sawdust, among others. In some cases, forests provide land for development of housing, dams, mines, and other purposes. Forests can also provide food, such as edible fruits and nuts, forage for livestock, edible oils, medicinal herbs, and drugs.

Forests also provide numerous non-market goods and ecosystem services. These include clean air, clean water, wildlife habitats, stable soils, natural environmental beauty (aesthetic value), and recreational opportunities, which in some cases can be market-based as well.

BARRY D. SOLOMON

Further reading

Mather 1990; Oswalt et al. 2019.

See also: Forestry, Forest conservation, Community forestry, Agroforestry, Agroforestry Accounting System (AAS), Ecosystem services, Aesthetics.

References

Mather, A.S. 1990. Global Forest Resources. London: Belhaven Press.

Oswalt, S.N., Smith, W.B., Miles, P.D. & Pugh, S.A. 2019. Forest Resources of the United States, 2017. General Technical Report WO-97. Washington, DC: US Department of Agriculture.

Forestry

The science and practice of planting, cultivating, developing, managing, and caring for forests, along with associated waters and residues. Thus, the purpose of forestry is to conserve forest resources as well as produce timber, which is broader than the practice of silviculture.

BARRY D. SOLOMON

Further reading

Franklin et al. 2018.

See also: Forest resources, Forest conservation, Urban forestry, Community forestry, Silviculture.

Reference

Franklin, J.F., Johnson, K.N. & Johnson, D.L. 2018. Ecological Forest Management. Long Grove, IL: Waveland Press.

Fossil fuels

Petroleum, natural gas, coal, and peat, which release energy through combustion processes (Hall et al. 1986). These carbon-based fuels are non-renewable resources and were formed by natural processes through the anaerobic decomposition of buried dead plants and animals from millions of years ago. Fossil fuel combustion is the main anthropogenic source of greenhouse gas emissions. They account for the largest such source of global carbon dioxide emissions and the second-largest source of methane emissions after agriculture. As a result, there is growing social and political pressure in the 21st century to greatly reduce, if not eliminate, the use of fossil fuels in favor of sustainable energy sources to mitigate global warming and climate change, and ocean acidification, among other problems.

BARRY D. SOLOMON

Further reading

Hall and Klitgaard 2018; McGlade & Ekins 2015.

See also: Traditional energy sources, Non-renewable resource, Global warming, Global change, Climate change, Anthropogenic.

References

Hall, C.A.S., Cleveland, C.J. & Kaufmann, R. 1986. Energy and Resource Quality: The Ecology of the Economic Process. New York: Wiley-Interscience.

Hall, C.A.S. & Klitgaard, K. 2018. Energy and the Wealth of Nations: An Introduction to Biophysical Economics, 2nd edn. New York: Springer.

McGlade, C. & Ekins, P. 2015. The geographical distribution of fossil fuels unused when limit-

ing global warming to 2°C. Nature 517(7533): 187–90.

Fragmentation

General: the process or state of breaking or being broken into small or separate parts.

Economics:

a. An organized form of production that is split into different stages, which are divided among different suppliers often in different locations.
b. The splitting up of a previously integrated production process into multiple components.

Ecology: discontinuities in natural environments, mainly resulting from anthropogenic causes, which lead to biodiversity loss.

CHIAN A. JONES RITTEN

Further reading

Arndt & Kierzkowski 2003; Krauss et al. 2010.

See also: Disaggregation, Habitat fragmentation.

References

Arndt, S. & Kierzkowski, H., eds. 2003. Fragmentation: New Production Patterns in the World Economy. Oxford: Oxford University Press.

Krauss, J., Bommarco, R., Guardiola, M. et al. 2010. Habitat fragmentation causes immediate and time-delayed biodiversity loss at different trophic levels. Ecology Letters 13: 597–605.

Framing effects

a. (Noun) the phenomenon whereby decision-makers and consumers respond differently to different but objectively equivalent descriptions of the same problem (Levin et al. 1998).
b. (Verb) to intentionally present or manipulate the wording of key information, typically to examine or trigger a desired behavioral response from a decision-maker or consumer. Valence framing sees information presented in either a positive or a negative light and can be divided further into attribute framing, risky choice framing, and goal framing (see Levin et al. 1998). In the context of ecology, framing is the manipulation of environmental appeals or messages to effect pro-environmental decisions, particularly behavior.

AJA ROPRET HOMAR

See also: Risk aversion, Pro-environmental behavior (PEB).

Reference

Levin, I.P., Schneider, S.L. & Gaeth, G.J. 1998. All frames are not created equal: a typology and critical analysis of framing effects. Organizational Behavior and Human Decision Processes 76(2): 149–88.

Freedom

See: Free market.

See also: Liberty, Regulation, Command economy, Transition economies.

Free market

An economic system in which the prices for goods and services and any resulting transactions are determined by unrestricted competition, where potential buyers and sellers are free to negotiate in an open market that is free from government control or regulation. This is the starting point in most economics textbooks. However, the term "free market" is something of a misnomer because there can be substantial costs to acquire capital, information, business licenses, regulatory compliance, and so on.

BARRY D. SOLOMON

Further reading

Hazlitt 2008.

See also: Neoclassical economics, Microeconomics, Macroeconomics, Perfect markets, Market failure, Regulation.

Reference

Hazlitt, H. 2008. Economics in One Lesson: The Shortest and Surest Way to Understand Basic Economics. Auburn, AL: Ludwig von Mises Institute.

Free rider

A person who benefits from a public good (such as a public bridge) without paying for it (or underpaying for it) or by overexploiting a common pool resource (such as a fishery), which diminishes the availability of this resource for other users. Free riders consider only their own short-term material interest, while coordination with others (if possible) would improve the outcome for all.

Free riding can be prevented by the threat of peer punishment, reciprocity, and reputation in the long term. Policies and institutions such as rewards, subsidies, taxes, and presence of communication possibilities may also overcome the decline of cooperation because of free-riding behavior. Conditional cooperators, on the other hand, contribute to a public good, the more others contribute or do not overexploit a resource, if others are not overexploiting. Conditional cooperation may be a result of reciprocity preferences or frustration from the behavior of free riders.

PINAR ERTÖR-AKYAZI

Further reading

Fischbacher & Gächter 2010; Fischbacher et al. 2001; Vatn 2012; Bowles & Gintis 1998; Ostrom 2000.

See also: Tragedy of the commons, Collective action, Prisoner's dilemma, Reciprocity, Common pool resources.

References

Bowles, S. & Gintis, H. 1998. The moral economy of communities: structured populations and the evolution of pro-social norms. Evolution and Human Behavior 19(1): 3–25.

Fischbacher, U. & Gächter, S. 2010. Social preferences, beliefs, and the dynamics of free riding in public goods experiments. American Economic Review 100(1): 541–56.

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Ostrom, E. 2000. Collective action and the evolution of social norms. Journal of Economic Perspectives 14(3): 137–58.

Vatn, A. 2012. "Cooperative behaviour and institutions," pp. 103–28 in Sustainability Analysis: An Interdisciplinary Approach. S. Shmelev & I. Shmeleva, eds. London: Palgrave Macmillan.

Frequentist statistics

Also known as "Frequentist inference," the process of determining properties of an underlying distribution via the observation of sample data. This methodological branch of statistics (as opposed to Bayesian statistics) treats the property of probability in similar terms to the property of frequency, and draws conclusions from the sample data by emphasizing the "frequency" or the "proportionality" of findings in the sample data. Frequentist statistics does not treat "probability" as equivalent to "certainty."

Frequentist statistics is a well-established method of statistical hypothesis testing and confidence intervals. Most of frequentist statistics gravitates around the use of "good" estimators. The precise distributions of the estimators can be challenging to derive analytically.

HEICO WESSELIUS

Further reading

Cox 2006; Everitt 2002; Barker & Link 2015.

See also: Multivariate statistical techniques, Scientific method.

References

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a Bayesian perspective. Journal of Wildlife Management 79(5): 730–38.
Cox, D.R. 2006. Principles of Statistical Inference. Cambridge: Cambridge University Press.
Everitt, B.S. 2002. The Cambridge Dictionary of Statistics, 2nd edn. Cambridge: Cambridge University Press.

Frontier economy

a. An open economic system with limitless resource inputs and capacity to absorb by-products. In Kenneth Boulding's seminar 1966 article "The economics of the coming spaceship Earth," he invokes the image of a limitless frontier as the current era's perception of natural resource availability, a perspective that must be changed so that the challenges of resource scarcity and pollution can be addressed (Boulding 1966).
b. A nation that presents a high-risk, high-reward scenario to international companies due to its small or shrinking economy, endemic corruption, and arbitrary enforcement of rules and regulations. Musacchio and Werker (2016) provide advice for companies considering selling into, or producing goods and services in, such countries.

Brent M. Haddad

Further reading

Patterson & Glavovic 2013.

See also: Relative vs. absolute scarcity, Limits, Limits to growth, Resource scarcity, Recycling, Abundance, Spaceship Earth.

References

Boulding, K. 1966. "The economics of the coming Spaceship Earth," pp. 3–14 in Environmental Quality in a Growing Economy. H. Jarrett, ed. Baltimore, MD: Resources for the Future/Johns Hopkins University Press.
Musacchio, A. & Werker, E. 2016. Mapping frontier economies. Harvard Business Review 95(12): 40–48.
Patterson, M. & Glavovic, B. 2013. From frontier economics to an ecological economics of the oceans and coasts. Sustainability Science 8(1): 11–24.

Frugal innovations

Innovations that are generally considered frugal in: (1) use of materials and other resources; (2) price, which is affordable by the average consumer; and (3) inclusive of the poor or other disadvantaged people. A truly frugal innovation also should be frugal for nature, consumers, manufacturers, and the entire value chain. Consider the example of a 5 cent sachet of tea or shampoo. It is very frugal, affordable, and inclusive, and even the poorest people can access it. But calculate the cost of collecting pieces of plastic used for packing it for millions of villagers, and it is very costly for nature. Similarly, a mission to the Moon or Mars by India is very frugal compared to global estimates.

A frugal innovation is not only about products but also about services and supply chains. Supply chains can be frugal when reverse logistics is used besides other economical means of transport and storage, and when circularity is embedded in the design of the innovation. Some authors also include reverse innovations as a subset of frugal innovations, such as a device made for a developing country at low cost that can also be used in developed countries. The design of frugal innovations keeps the most essential, minimalist aspect of form, feature, and functions of a product or service.

Anil K. Gupta

Further reading

Gupta 2010; Gupta et al. 1997; McNicoll 2014; Prahalad & Mashelkar 2010; Radjou & Prabhu 2019.

See also: Grassroots innovations, Green innovations, Commodity supply chain, Supply chain management, Green supply chains, Circular economy, Conservation.

References

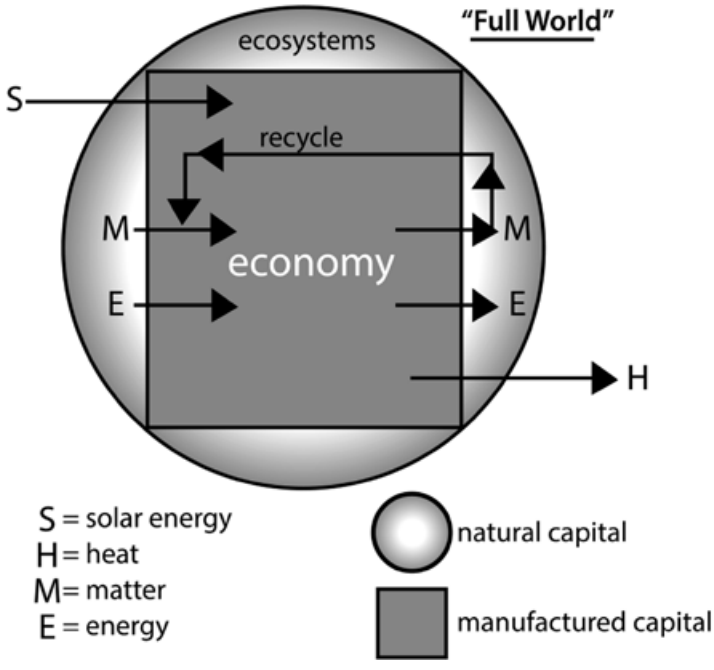
Gupta, A.K. 2010. "Grassroots green innovations for inclusive, sustainable development," pp. 137–46 in The Innovation for Development

Report 2009–2010. A. López-Claros, ed. London: Palgrave Macmillan.
Gupta, A.K., Patel, K.K., Pastakia, A.R. & Sherry Chand, V. 1997. "Building upon local creativity and entrepreneurship in vulnerable environments," pp. 112–37 in Empowerment for Sustainable Development: Towards Operational Strategies. International Institute for Sustainable Development. V. Titi & N. Singh, eds. London: Zed Books.
McNicoll, A. 2014. Enter India's amazing world of frugal innovation. CNN Business. September 16. https://edition.cnn.com/2013/06/25/tech/innovation/frugal-innovation-india-inventors/index.html.
Prahalad, C.K. & Mashelkar, R.A. 2010. Innovation's holy grail. Harvard Business Review 88(7–8): 132–41.
Radjou, N. & Prabhu, J. 2019. Do Better with Less: Frugal Innovation for Sustainable Growth. London: Penguin Random House.

Full world

A metaphorical device popularized by Herman Daly in the 1980s and 1990s to contrast and compare the economic situation between today and much earlier times. In the full world period, natural capital is relatively scarce, while manufactured capital and skilled labor as well as humans are abundant, in sharp contrast with earlier times (Figure 9). While Daly was always vague about when the full world period began, it can probably be thought of as the last four or five decades. During the full world period, lack of concern with overexploitation of natural capital is no longer reasonable. While the global economy has grown dramatically from the empty world to the full world period, the Earth and its ecosystems, which the economy is embedded in, has not changed in size. This change in world outlook, which has not been fully endorsed by neoclassical economics, has stark implications for sustainable development and environmental policy.

Barry D. Solomon



Source: Jill Gotschalk, reprinted with permission.

Figure 9 *The economy in a full world*

Further reading

Daly 1992, 2005.

See also: Empty world, Doughnut economics, Natural capital, Manufactured capital, Scarcity, Relative vs. absolute scarcity, Sustainable development.

References

Daly, H.E. 1992. "From empty-world economics to full-world economics: recognizing an historical turning point in economic development," pp. 18–26 in Population, Technology and Lifestyle: The Transition to Sustainability. R. Goodland, H.E. Daly & S. El-Serafy, eds. Washington, DC: Island Press.

Daly, H.E. 2005. Economics in a full world. Scientific American 293(3): 100–107.

Fund-service resources

The resources used to produce services in a given process without: (1) being fundamentally transformed with respect to their defining characteristics; and (2) being able to be stockpiled. This type of resource includes labor, capital, and Ricardian land, which are used as "funds" for the production of a certain "service." The fact that fund-service resources are not transformed implies that they are not depleted when used for a production of a service. Fund-service resources are distinguished from other resources, known as stock-flow, which become fundamentally transformed through a production process, can be stockpiled, and are depleted through the production process, even if some of these can be regenerated. This distinction provides the basis of Georgescu-Roegen's (1969) flow-fund model, but also more recent works such as Dafermos et al. (2017).

Giorgos Galanis

Further reading

Constanza et al. 2015; Georgescu-Roegen 1971.

See also: Flow-fund theory of production, Stock-flow consistent models, Ricardian land.

References

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Dafermos, Y., Nikolaidi, M. & Galanis, G. 2017. A stock-flow-fund ecological macroeconomic model. Ecological Economics 131: 191–207.

Georgescu-Roegen, N. 1969, "Process in farming versus process in manufacturing: a problem of balanced development," pp. 497–533 in Economic Problems of Agriculture in Industrial Societies. U. Papi & C. Nunn, eds. London: Macmillan.

Georgescu-Roegen, N. 1971. The Entropy Law and the Economic Process. Cambridge, MA: Harvard University Press.

G

Gaia hypothesis

The assumption that the Earth (Gaia) is an autonomous system with self-regulating behavior to withstand external challenges. The evidence for this hypothesis comes from the Earth's ability to retain a dynamic balance (homeostasis) and maintain a more or less unchanged temperature and composition despite a progressively warming Sun (Lovelock 2000, 2006).

The Gaia hypothesis emanates from and is underpinned by a deep ecological understanding, according to which ecosystems have inherent value and should not be used in an instrumental way by humans. In practical terms, the implication of this hypothesis is that humans would be advised to take the Earth's self-regulating capacity seriously, as a warning that the Earth may respond to anthropogenic climate change in ways that enable the Earth's survival but not humans' (Lovelock 2000, 2006).

The Gaia hypothesis has come under criticism from both the natural and social sciences. The former cast doubt on the actual mechanisms and processes internal to Earth that enable it to self-regulate (Onori & Guido 2012; Tyrell 2013). The latter approach it as a "misanthropic ecology" that circumscribes humans' ability to achieve their developmental goals on Earth (Heywood 2011, p. 392).

FILIPPOS PROEDROU

Further reading

Clarke 2017; Latour, 2017; Latour & Lenton 2019; Radford 2019.

See also: Biosphere, Deep ecology, Biocentrism, Applied systems analysis.

References

Clarke, B. 2017. Rethinking Gaia: Stengers, Latour, Margulis. Theory, Culture and Society 34(4): 3–26.

Heywood, A. 2011. Global Politics. Basingstoke: Palgrave Macmillan International Higher Education.

Latour, B. 2017. Why Gaia is not a God of Totality. Theory, Culture and Society 34(2–3): 61–81.

Latour, B. & Lenton, T. 2019. Extending the domain of freedom, or why Gaia is so hard to understand. Critical Inquiry 45(3): 659–80.

Lovelock, J. 2000. Gaia: A New Look at Life on Earth, 3rd edn. Oxford: Oxford University Press.

Lovelock, J. 2006. The Revenge of Gaia: Why the Earth Is Fighting Back—and How We Can Still Save Humanity. Santa Barbara, CA: Allen Lane.

Onori, L. & Guido, V. 2012. The GAIA theory: from Lovelock to Margulis. From a homeostatic to a cognitive autopoietic worldview. Rendiconti Lincei 23(4): 375–86.

Radford, T. 2019. James Lovelock at 100: the Gaia saga continues. Nature 570(7762): 441–3.

Tyrell, T. 2013. The Gaia hypothesis: the verdict is in. New Scientist 220(2940): 30–31.

Game reserves

See: Conservation areas.

See also: Reserves, Wildlife conservation.

Game theory

Economics and mathematics:

a. The analysis of decision-making among multiple actors (players) when outcomes are interdependent. Formal mathematical

framework and tools to identify objectives, options, and outcomes and how the decisions by individuals influence outcomes of all actors. Provides tools for identifying the best strategies to achieve particular outcomes, given that decisions by others are influential. Relies upon assumptions of rational behavior among actors.

b. Non-cooperative game theory is the subset whereby all individual actors are pursuing their own objectives and have no means to directly cooperate with others.
c. Cooperative game theory addresses the special cases where binding agreements and contracts can be used to bargain and achieve outcomes with greater total value, and all actors enjoy better outcomes than through an equivalent non-cooperative framework.
d. Variations exist based on the availability of information about the effect of decisions on outcomes, the objectives and decisions of other actors, and real-world behavior.
e. Provides a set of tools compatible with traditional microeconomics to consider interdependent decisions among individuals, firms, nations, and other institutions.

Biology and ecology:

a. Evolutionary game theory provides tools to understand and describe how decisions evolve over multiple iterations (for example, generations) based on competition for resources and adaptation over time. It is used to explain how various behaviors or traits that affect decisions result based on contextual characteristics. Applies to humans and other animals. It does not require assumptions of rational actors, but rather evaluation of how a particular strategy is likely to perform in a context with other actors (species) pursuing strategies as well.
b. Mathematical framework to explain the evolution of population-level behaviors, particularly in the context of competition such as predator–prey relationships.

Mark C. Buckley

Further reading

Gibbons 1992; Hanley & Folmer 1998.

See also: Nash equilibrium, Rational behavior, Rational choice, Bounded rationality, Behavioral economics, Behavioral ecological economics, Strategic decision-making, Maximin, Minimax regret criterion.

References

Gibbons, R. 1992. A Primer in Game Theory. Harlow: Harvester Wheatsheaf.

Hanley, N. & Folmer, H. 1998. Game Theory and the Environment. Cheltenham, UK and Lyme, NH, USA: Edward Elgar Publishing.

Gender inequality

Discrimination based on sex or gender that enables one to be privileged over another. Historically, it has often arisen from patriarchal gender norms, which gave men more power in society and therefore within households. The most pervasive of these norms is the "male breadwinner, female homemaker" norm. It has manifested itself in a range of inequalities in the labor market (pay gaps between the genders), asset ownership (male primogeniture rules or even sons inheriting rather than daughters), education gaps, nutrition gaps, gaps in political representation, and violence against women. The United Nations Development Programme (UNDP 2021) publishes the Gender Inequality Index for countries based on three dimensions—health, empowerment, and labor market outcomes—across the genders.

Gender inequality is usually discussed in binary terms: between men and women, who may experience unequal impacts from environmental degradation and manage natural resources differently. Women are more likely to be involved in care work of children, the elderly, and people with disabilities and thus may be more vulnerable with these populations during natural disasters (Floro & Poyatzis 2019). Especially in developing countries, women are often users and managers of natural resources such as water, firewood, and forest products.

The more equitable status, treatment, and inclusion of women in decision-making has been found to improve sustainable man-

agement of such resources (Agarwal 2013; UNDP 2010). More equal treatment of women, and the social restructuring that it would involve, are necessary in the transition to an equitable, low-throughput economy. Gender equality is seen by the United Nations (UN) as "a fundamental human right" and "a necessary foundation for a peaceful, prosperous and sustainable world"; it is therefore Goal 5 of the UN Sustainable Development Goals (UN 2021). By referring to it both as a human right and as necessary for the world, the UN draws attention to gender equality having both intrinsic and instrumental benefits for societies.

Uma S. Kambhampati & Nicholas E. Reksten

Further reading

Perkins 2007; Aslaksen et al. 2013; Reksten & Floro 2021.

See also: Inequality, Economic inequality, Sustainable Development Goals (SDGs), Feminist ecological economics, Feminist political ecology, Ecofeminism, Intrinsic value.

References

Agarwal, B. 2013. Gender and Green Governance: The Political Economy of Women's Presence Within and Beyond Community Forestry. Oxford: Oxford University Press.

Aslaksen, I., Bragstad, T. & Ås, B. 2013. "Feminist economics as vision for a sustainable future," pp. 21–36 in Counting on Marilyn Waring: New Advances in Feminist Economics, 2nd edn. M. Bjørnholt & A. McKay, eds. Bradford, Canada: Demeter Press.

Floro, M.S. & Poyatzis, G. 2019. "Climate change, natural disasters, and the spillover effects on unpaid care: the case of super-typhoon Haiyan," pp. 70–98 in Feminist Political Ecology and the Economics of Care: In Search of Economic Alternatives. C. Bauhardt & W. Harcourt, eds. London: Routledge.

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UNDP (United Nations Development Programme). 2021. Gender Inequality Index (GII). http://hdr.undp.org/en/content/gender-inequality-index-gii.

General equilibrium model

A mathematical model that uses econometric methods to provide an understanding of how the whole economy works. In a general equilibrium analysis, all prices in an economy can change at once. Such models include a set of equations designed to capture the key economic forces at work and dictate how prices behave. These equations recognize the interrelationships between all sectors of the economy. The data for the equations are usually drawn from a country's input–output table and econometric estimation. Key assumptions of the model ensure that following a disturbance, such as imposing a carbon tax, prices will settle at new levels that equate supply and demand in all markets represented. A popular form of such models is known as computable general equilibrium (CGE) models.

General equilibrium models have produced policy-relevant results in many applications. Intuitively, these models can "weigh up" the relative magnitudes of sectors or forces at play in a scenario. For example, models can indicate whether those who lose their jobs in a sector from which tariff protection is being removed could potentially be re-employed in industries benefiting from the tariff removal.

The foremost criticisms of general equilibrium modeling arise from analysts' tendency to dazzle readers with the detail of their results and opaque equations, and the poor representation of human behavior (Gowdy 2010). What is often missing is a clear explanation of exactly which assumptions are not so important, and which are critical, to the results.

Judith R. McNeill

Further reading

Arrow & Debreu 1954; Bhattacharyya 1996; Burfisher 2016; Dixon & Jorgensen 2012; Dellink 2005; McKenzie 1959.

See also: Models and modeling, Equilibrium, Equilibrium model, Partial equilibrium model, Econometrics, Input–output (I–O) analysis.

References

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Gowdy, J.M. 2010. Microeconomic Theory Old and New: A Student's Guide. Stanford, CA: Stanford University Press.

McKenzie, L.W. 1959. On the existence of general equilibrium. Econometrica 27(1): 54–71.

Generation

a. The act or process of producing something, such as energy or electricity.

b. A large group of people born and living around the same time. In mainstream economics and philosophy, it is central to intergenerational allocation and equity, as well as sustainability. The notion of a generation in economics is biological, in that individuals belonging to different generations do not live at the same time: generations are not overlapping. Alternatively, Mannheim's (1952) sociological theory of generations sees them delineated by shared early life experiences and to be overlapping, as notions of "baby boomers" and "millennials" exemplify. Future generations are assumed to be wealthier, which justifies positive discount rates that weigh the interests of the present generation more heavily in intergenerational allocation decisions. The preferences of future generations are also thought to be unknowable, and for this reason the concept of weak sustainability considers it sufficient to pass on an undiminished amount of overall stock of capital (Solow 1986) without considering its composition, for example, the amount of natural capital.

Other traditions consider that the current generation has obligations toward future generations. Howarth (1997), for example, suggests that equality of opportunity within a generation should be extended across generations, so that the life chances of future people are equal to those that we enjoy. Pragmatist philosophy goes further, arguing that we have a responsibility to cultivate certain preferences in future generations to realize our vision of a desirable future (Norton 2010). Correspondingly, the notion of strong sustainability requires that natural capital must not be depleted, because forms of capital are not fully substitutable.

JOUNI PAAVOLA

See also: Sustainability, Strong sustainability, Weak sustainability, Sustainable development, Intertemporal allocation, Overlapping generations model, Energy.

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Genetic resources

According to the Nagoya Protocol supplementary agreement to the 1992 Convention on Biological Diversity, any non-human biological materials of actual or potential value

to humans for exploitation, including those from plants, animals, and microbes (Welch et al. 2013). Genetic resources are one of the three levels of biodiversity defined by this Convention, along with species diversity and ecosystem diversity. This Convention promotes the conservation and sustainable use of biological diversity.

Barry D. Solomon

Further reading

Anderson 2003; Rege et al. 2003; Laird & Wynberg 2012.

See also: Biodiversity, Biodiversity conservation, Biodiversity indices, Transgenic.

Reference

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Rege, J.E.O. & Gibson, J.P. 2003. Animal genetic resources and economic development: issues in relation to economic valuation. Ecological Economics 45(3): 319–30.

Welch, E.W., Shin, E. & Long, J. 2013. Potential effects of the Nagoya Protocol on the exchange of non-plant genetic resources for scientific research: actors, paths, and consequences. Ecological Economics 86: 136–47.

Genuine progress indicator (GPI)

Ecological economics:

a. A measure of the economic well-being provided by the socio-economic subsystem.
b. Indicator of society's development.
c. A metric that incorporates environmental, social, and economic costs and benefits associated with economics production. The origins of the GPI are the measure of economic welfare (MEW) (from Nordhaus & Tobin 1973), and the index of sustainable economic welfare (ISEW) (from Daly et al. 1989). The GPI uses three principles: accountability of income inequality, inclusion of non-market benefits (for example, unpaid work, such as domestic and voluntary), and deduction of "bad" things (for example, cost of crime, cost of unemployment and overwork, and environmental degradation). The GPI has been used as a complement to conventional economic indexes to support policymakers. The GPI has been estimated for more than 70 countries and regions.

Junior Ruiz Garcia

Further reading

Cobb et al. 1995; Garcia 2021.

See also: Objective well-being, Development, Non-market value, Measures of economic welfare, Index of sustainable economic welfare (ISEW).

References

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Genuine saving

Adjusted net saving was initially denominated as "genuine saving" (Hamilton & Clemens 1999), and is still termed as such on an informal basis (Hamilton 2003).

Yacouba Gnègnè

See also: Adjusted net saving (ANS).

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Geography

The study of places and the interrelationships between humans and their environments, both cultural and physical.

a. Human geographers study the spatial distribution, attributes, and processes of human societies and phenomena.
b. Physical geographers study the spatial distribution, attributes, and processes of naturally occurring phenomena.
c. Nature–society geographers work at the cross-section of different areas of geography to study the relationships between people and the environment, using both quantitative and qualitative methods.
d. Biogeographers study the distribution of species and ecosystems over space and time.

BARRY D. SOLOMON

Further reading

Hess 2017; Knox & Marston 2015.

See also: Social sciences, Biogeography, Regional science, Social ecology, Landscape, Landscape ecology, Geonomics, Global change.

References

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Knox, P. & Marston, S. 2015. Human Geography: Places and Regions in Global Context, 7th edn. New York: Pearson.

Geonomics

a. Literally, Earth law.
b. An economic ideology and philosophy which holds that everyone owns what they create, but that everything found in nature, especially land, belongs equally to all of humanity. Inspired by the writings of Henry George ([1879] 2019).
c. The study of natural resources with an emphasis on land and land rent.

Geonomists also study social progress, and recognize that in addition to land, labor, capital and energy, social context, or order (for example, customs, laws, and so on) is important in determining economic production, output, distribution, income, and consumption. While output is bountiful, its distribution is concentrated, creating class differences. Geonomists predict by paying attention to the 18-year land price cycle. Central research questions include: who does the work and who gets the wealth? Key policy preferences include fiscal policy reform through a single land tax, resource taxes, pollution taxes, market-based patent fees, and fair and equitable distribution of tax revenues.

JEFFERY J. SMITH & BARRY D. SOLOMON

Further reading

Whitbeck 1926; Valero & Valero 2010.

See also: Land economics, Land types, Rent, Natural resource rents, Scarcity rent, Pollution taxes.

References

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Valero, A. & Valero, A. 2010. Physical geonomics: combining the exergy and Hubbert peak analysis for predicting mineral resources depletion. Resources, Conservation and Recycling 54(12): 1074–83.

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Gini index

An index comparing the actual distribution of wealth or income in a population to a perfectly equal one. A higher score on the scale of 0–100 indicates greater inequality. Sometimes also called the Gini coefficient or the Gini ratio. It was created by the Italian statistician and sociologist Corrado Gini in 1912, building on the work of the United States economist Max Lorenz. A simple formula for the Gini index is A / (A + B), where A is the area above the Lorenz curve and B is the area below the Lorenz curve. The Lorenz curve is a graph of the cumulative percentage of the total national income or wealth plotted against the cumulative percentage of the corresponding population, ranked by the increasing size of share. The countries with the highest Gini index for income inequality are in Africa, led by South Africa (World Bank 2021).

BARRY D. SOLOMON

Further reading

Gastwirth 1972; Dorfman 1979; Yitzhaki 1979; Milanovic 1997.

See also: Lorenz curve, Economic inequality, Income distribution, Wealth distribution.

References

Dorfman, R. 1979. A formula for the Gini coefficient. Review of Economics and Statistics 61(1): 146–9.
Gastwirth, J.L. 1972. The estimation of the Lorenz curve and the Gini index. Review of Economics and Statistics 54(3): 306–16.
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Yitzhaki, S. 1979. Relative deprivation and the Gini coefficient. Quarterly Journal of Economics 93(2): 321–4.

Global change

Anthropogenic impacts on natural processes that occur on a planetary scale. These include: climate change, ocean acidification, depletion of stratospheric ozone and accompanying increases in ultraviolet radiation, deforestation, desertification, biodiversity loss, changes in the water and nitrogen cycles, and decreases in soil, water, and air quality. Several of these changes result from significant changes in land use. Global changes alter the capacity of the Earth to sustain human life and biodiversity, and are the subject of a variety of major research programs and policy responses.

BARRY D. SOLOMON

Further reading

Vitousek 1994; Grübler 1998; Wilbanks & Kates 1999; Grimm et al. 2008.

See also: Climate change, Anthropogenic, Land use change, Biodiversity, Deforestation, Desertification, Soil health.

References

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Wilbanks, T.J. & Kates, R.W. 1999. Global change in local places: how scale matters. Climatic Change 43(3): 601–28.

Global Environment Facility (GEF)

An international environmental projects fund established jointly by the World Bank, United Nations Environment Programme, and United Nations Development Programme on the eve of the 1992 Earth Summit held in Rio de Janeiro. Its headquarters is in Washington, DC. The GEF has a Small Grants Programme and provides co-financing and technical support for environmental projects in 170 countries. Priority funding areas include: climate change; biodiversity; chemicals, wastes, and the circular economy; land degradation; international waters; and sustainable forest management/REDD+ (Reducing

Emissions from Deforestation and forest Degradation).

BARRY D. SOLOMON

Further reading

Luken & Grof 2006; Rosendal & Andresen 2011.

See also: Climate change mitigation, Climate change adaptation, Biodiversity, Circular economy, REDD (Reducing Emissions from Deforestation and forest Degradation), United Nations Environment Programme (UNEP), United Nations Development Programme (UNDP), World Bank.

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Rosendral, G.K. & Andresen, S. 2011. Institutional design for improved forest governance through REDD: lessons from the global environment facility. Ecological Economics 70(11): 1908–15.

Globalization

The multidimensional though uneven expansion, intensification, and interconnectedness of social relations and consciousness across world time and world space (Steger & Wahlrab 2017; Darian-Smith & McCarty 2017). Usually requires an additional adjective to add further specificity, for example: "economic" globalization or "ecological" globalization. Measuring globalization is contested, though several indices have been developed (e.g., Martens et al. 2015; Dreher 2006; Heshmati 2006; Gygli et al. 2019). Core issues include meanings and genealogy of globalization, proper units of analysis, the selection of domains and issues, and future dynamics.

AMENTAHRU WAHLRAB

Further reading

Steger 2020; Sklair 2020; Creutzig 2020.

See also: Interconnected, Anthropocene, Embeddedness.

References

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Global warming

The increase over time in the average global temperature measured near the Earth's surface. Over the past four decades the global average temperature has been increasing with each decade successively warmer than the previous one. According to the United States National Oceanic and Atmospheric Administration (NOAA), the average global temperature for the past five years was 0.9°Celsius above last century's average global temperature (NOAA 2021). Both the absolute increase in temperature and the historically rapid rate of temperature increase are concerning because of the potential impacts on the climate and natural and social systems such as melting ice caps, sea level rise, drought, increases in storm intensity, ocean acidification, loss of biodiversity, increased pests, pathogens, diseases, and health problems, and displacement of vul-

nerable populations. The most recent report of the Intergovernmental Panel on Climate Change (IPCC 2021) calls for global average temperature to not exceed 1.5 to 2° Celsius to avoid the worst impacts of climate change, which will be extremely difficult to achieve.

Global warming is caused by greater amounts of infrared radiation being trapped in the Earth's atmosphere because of its increasing concentration of greenhouse gases. The increasing concentration means that more of the Sun's rays that are reflected off the Earth's surface are re-radiated back to Earth rather than reflected out to space. This increase in greenhouse gases, and hence the greenhouse effect, is caused primarily by increases in anthropogenic emissions of carbon dioxide from fossil fuel combustion.

PAUL M. BERNSTEIN

See also: Climate change, Climate instability, Intergovernmental Panel on Climate Change (IPCC), Greenhouse gases, Anthropogenic.

References

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NOAA (National Oceanic and Atmospheric Administration). 2021. Global climate report—August 2021. Available at: https://www.ncdc.noaa.gov/sotc/global/202108.

Global warming potential

An index developed to represent the relative contribution of the emission of different greenhouse gases to global temperature increases and other climate effects, and to allow comparisons between the gases (Lashof & Ahuja 1990). The global warming potential of a greenhouse gas equals the heat energy that the emission of 1 ton of the gas will absorb in the atmosphere over a given time period, usually 100 years, relative to the emission of 1 ton of carbon dioxide (CO_2), which usually serves as the reference greenhouse gas. The global warming potential formula accounts for the different atmospheric residency times and radiative forcing strengths of the various greenhouse gases. Use of this formula allows policymakers to assess the likely effectiveness of alternative policies to mitigate climate change across different economic sectors and for different greenhouse gases.

BARRY D. SOLOMON

Further reading

Shine et al. 2005.

See also: Greenhouse gases, Global warming, Climate, Climate change, Climate change mitigation.

References

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Shine, K.P., Fugelstvedt, J.S., Hailemarian, K. & Stuber, N. 2005. Alternatives to the global warming potential for comparing climate impacts of emissions of greenhouse gases. Climatic Change 68: 281–302.

Goods (n.)

Physical, material items (and services); economic outputs of production processes intended for end use consumers.

Ecological economics: goods and services derive from natural resource systems; resource units (for example, tons of fish), which may be consumed by resource appropriators or further processed and transformed into intermediate or final goods as outputs of human socio-economic systems.

Neoclassical economics: goods are often defined by their quantity, price, and quality attributes. These core characteristics are less useful for environmental goods and services, which are subject to profound uncertainty: understanding the quality of ecological systems and services may require vast amounts of scientific and technical expertise and information over long time horizons; ascertaining the quantity—and appropriate harvest amounts—of renewable resources such as fish and forests requires

further knowledge of the size and growth rate of existing stocks and flows; calculating prices depends upon a shared socio-cultural approach and norms of economic valuation, the extent to which a given society weighs the relative benefits of resource use by people living in the present versus conservation of those resources and protection of essential ecosystem services for future generations (that is, use, non-use, and existence value).

There are four main classes of goods relevant to policy and management of the environment and natural resources: private goods, public goods, club goods (toll goods), and common pool resources (open access), defined by the relative ability of resource owners or appropriators to exclude other users (excludability) and the extent to which one individual's consumption reduces the amount of the resource available for other users (subtractability).

SHANA M. STAROBIN

Further reading

Douglas & Isherwood 2021; Ostrom 1990; Darby & Karni 1973.

See also: Private goods, Public goods, Common pool resources, Club goods, Environmental goods and services.

References

Darby, M.R. & Karni, E. 1973. Free competition and the optimal amount of fraud. Journal of Law & Economics 16(1): 67–88.

Douglas, M. & Isherwood, B. 2021. The World of Goods. New York: Routledge.

Ostrom, E. 1990. Governing the Commons: The Evolution of Institutions for Collective Action. New York: Cambridge University Press.

Governance

The shifting patterns, roles, and interactions of state and non-state actors involved in governing various aspects of social life. Although the term is fuzzy, there is consensus that it goes beyond the traditional hierarchical top-down model. Hence, governance is about binding political decisions that include state and non-state actors through steering mechanisms, cooperation, and coordination. Governance describes the tendency towards more decentralism and network-like governing on and across various levels starting from the local, regional, and national, to the international level.

The way and shape of regulating, steering, and coordinating varies from policy field to policy field and there is no common approach applicable to all problems. Governance can be understood in normative and in analytical terms, and comes in various forms such as multi-level governance (Bache & Flinders 2004), reflexive governance (Voß & Bornemann 2011), polycentric governance (Jordan et al. 2018), or is used in conjunction with a policy field such as water governance (Pahl-Wostl 2015).

KEVIN GRECKSCH

Further reading

Colebatch 2014; van Kersbergen & Van Waarden 2004; Offe 2009; Stoker 1998.

See also: Local governance, Water governance, Groundwater governance, Environmental governance, Adaptive governance, Accountability, Legitimacy.

References

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Voß, J.-P. & Bornemann, B. 2011. The politics of reflexive governance: challenges for designing

adaptive management and transition management. Ecology and Society 16(2): 9.

Grassroots innovations

Innovations by common people often not having a professional degree or diploma, often self-employed, but could also be a worker on a farm or in a workshop in the informal sector, and driven by unmet social needs. These innovations from the grassroots have evolved by people without outside help. These may address one's own local needs as well as that of a third party and society. Sometimes, grassroots innovators also address larger regional or national unmet needs out of their strong empathy for disadvantaged people, sectors, and regions. These must be distinguished from the innovations for the grassroots. The latter are developed by outsiders, professionals, non-governmental organizations, scientific organizations, private or public enterprises, and so on, for solving grassroots problems.

The transaction costs faced by informal sector grassroots innovators are different from those faced by the professional in an organized sector. Their respective access to material resources, technologies, and institutions is very different, and hence their social, ecological, and cultural significance. The grassroots innovators in mechanical/electrical fields often use second-hand parts and thus are pioneers of the circular economy. In biological fields, they often use local resources extremely economically, and generally do not have serious adverse ecological effects. However, grassroots innovation can sometimes do great damage to sustainability, such as by using dynamite to catch fish, which kills small as well as large fish.

ANIL K. GUPTA

Further reading

Gupta 1988, 1989, 2012, 2013, 2016; Gupta et al. 2003.

See also: Frugal innovations, Green innovations, Circular economy, Third party, Community-based, Bottom-up approaches, Traditional knowledge.

References

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Green accounting

See: Environmental accounting.

See also: System of National Accounts (SNA), Economic ecosystem accounting.

Green economy

A system that produces, distributes, and consumes goods and services in a way that reduces environmental impacts, risks, and scarcities; improves social equity; and enhances human well-being. The term gained popularity with publication of *Blueprint for a Green Economy* (Pearce et al. 1989).

ERIK E. NORDMAN

Further reading

Barbier & Markandya 2012; Loiseau et al. 2016; United Nations Environment Programme 2021.

See also: Circular economy, Well-being economy, Environmental economics, Ecological economics, Sustainable development.

References

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United Nations Environment Programme. 2021. Green Economy. Nairobi: UNEP. http://www.unep.org/explore-topics/green-economy.

Green golden rule

Introduced by Chichilnisky et al. (1995), a generalization of the golden rule of neoclassical growth theory. Defined as the maximum instantaneous utility level in which consumption and environmental assets (or natural capital) are valued subject to resource constraints. Thus, growth in environment assets is depleted by consumption expenditures, but partly renewed through a reproduction function (usually modeled as a logistic). Under certain conditions this need not be a concern in the maximization because any capital stock can be accumulated, given a sufficiently long horizon (Viscolani 2021; Faria et al. 2021). Optimality implies that the marginal rate of transformation equals the marginal rate of substitution between consumption and the environmental asset. Graphically, this can be represented as the point of tangency between the indifference curve and the renewal rate of the reproduction function.

A general theme in the "green golden rule" literature is the rejection of the traditional discounted utilitarian approach in favor of intertemporal welfare criteria that focus on long-run values of consumption and the environment.

Peter McAdam

See also: Utility, Natural capital, Restoring natural capital (RNC), Environmental goods and services, Carrying capacity, Production function, Logistic growth, Growth theory.

References

Chichilnisky, G., Heal, G. & Beltratti, A. 1995. The green golden rule. Economics Letters 49(2): 175–79.

Faria, J.R., McAdam, P. & Viscolani, B. 2021. Monetary policy, neutrality and the environment: implications of the green golden rule. European Central Bank Working Paper No. 2021/2573/.

Viscolani, B. 2021. On an environmental sustainability problem. Optimal Control Applications and Methods 42(2): 603–14. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3894145.

Green growth

a. A process of economic growth that increases the efficiency of resource use and maintains or improves the natural environment.
b. "[F]ostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies" (OECD 2011a). Green growth therefore implies decoupling between economic growth and resource use and environmental impacts. Organisation for Economic Co-operation and Development (OECD) green growth indicators measure environmental and resource productivity, the natural asset base, environmental quality of life, and economic opportunities and policy responses (OECD 2011b).

Paul W. Ekins

See also: Growth theory, Resource efficiency, Economic growth, Decoupling economic growth, Green economy, Green golden rule.

References

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OECD (Organisation for Economic Co-operation and Development). 2011b. Towards Green

Growth: Monitoring Progress—OECD Indicators. Paris: OECD Publishing.

Greenhouse gases

Trace gases found in the Earth's atmosphere that together comprise less than 0.1 percent of its composition, and which absorb and emit radiant energy within the thermal infrared range, causing the planetary greenhouse effect, global warming, and climate change. Water vapor is also a greenhouse gas, though it will generally stay in the atmosphere for just days, in contrast to the much longer-lasting trace gases that have atmospheric residency times ranging from years to centuries.

Greenhouse gases can be either natural or anthropogenic. The most important greenhouse gases, and the ones of greatest abundance, are water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and the family of fluorocarbons. The emission of each greenhouse gas is rated based on its global warming potential, which accounts for its atmospheric residency time and the strength of its radiative forcing property over a given time period compared to CO_2.

Barry D. Solomon

Further reading

Spash 2002; Goodstein 2007.

See also: Global warming, Global warming potential, Greenhouse gas neutral, Carbon footprint, Carbon stock, Climate, Climate change.

References

Goodstein, E. 2007. Fighting for Love in the Century of Extinction: How Passion and Politics Can Stop Global Warming. Hanover, NH: University Press of New England.

Spash, C. 2002. Greenhouse Economics: Values and Ethics. Abingdon: Routledge.

Greenhouse gas neutral

An action or policy whereby the total quantity of greenhouse gases released into the atmosphere is balanced by the quantity of greenhouse gases removed from the atmosphere. Can refer solely to anthropogenic sources and sinks of greenhouse gases, but may also include natural sources and sinks. Most often used in the context of climate change mitigation, including forestry and land use offsets.

Nicholas H. Johnson

Further reading

Mathews et al. 2018, Annex 1: Glossary; United Nations Climate Change 2021.

See also: Carbon capture, Carbon sequestration, Greenhouse gases, Climate change, Climate change mitigation, Net carbon, Net zero carbon, Sources, Sinks.

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United Nations Climate Change. 2021. A beginners guide to climate neutrality. https://unfccc.int/blog/a-beginner-s-guide-to-climate-neutrality.

Green industrial policy

Sector-targeted policies that support the growth and development of certain industries and technologies, with the aim of furthering both economic and environmental goals. Several broader but differing definitions exist in the literature. Some are akin to innovation policy for green technology industries (e.g., Rodrik 2014), while others include environmental policies, such as pollution taxes, aimed at a broad range of industries (e.g., Harrison et al. 2017). Other definitions emphasize the aim of structural change to support environmental or sustainable development goals (Hallegatte et al. 2013; Pegels & Lütkenhorst 2014; Altenburg & Assmann 2017).

Neoclassical economists tend to envisage the purpose of green industrial policy to be addressing various market failures. Other

authors are more likely to emphasize the goal of supporting learning and information discovery for both public and private actors (e.g., Lütkenhorst et al. 2014). The latter view brings green industrial policy very close to concepts such as socio-technical sustainability transitions.

EMMA K. AISBETT

See also: Green trade policy, Market failure, Environmental policy instruments, Pollution taxes, Environmental taxes, Carbon taxes, Sustainability transition, Energy transition.

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Green innovations

Innovations based on creative solutions to technological or institutional problems, and which are compatible with ecological resource conservation, augmentation, rejuvenation, and rehabilitation. Adverse effects are reduced or eliminated. Energy consumption is reduced, and dissipation of energy through waste is also reduced or eliminated. However, "grassroots innovators" advance greener objectives by using second-hand parts, use of limited natural resources, and try to use wastes more productively. In view of material constraints, the only resource that green grassroots innovators can leverage is their mind or knowledge. Thus, green innovations also tend to be more knowledge-intensive; for instance, a pollution control device in India developed by Virendra Kumar for a diesel engine reduces air pollution and captures carbon that can be used to make black dye used as industrial pigment (Kumar Sinha 2009).

ANIL K. GUPTA

Further reading

Leal-Millán et al. 2017; Carrillo-Hermosilla et al. 2009; Gupta 2010, 2012.

See also: Human capital, Conservation, Energy conservation, Sustainability, Grassroots innovations, Eco-innovation, Eco-design, Frugal innovations, Business innovation, Circular economy.

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Green national accounting

See: Economic ecosystem accounting, System of National Accounts (SNA).

See also: Environmental accounting, Natural resource accounting.

Green New Deal

A political and economic concept that first appeared in a *New York Times* op-ed by Thomas Friedman (2007) that was modeled after the economic and financial recovery and reform programs of United States (US) President Franklin D. Roosevelt during the Great Depression.

US Congresswoman Alexandria Ocasio-Cortez and Senator Ed Markey proposed House Resolution 109 (H.R. 109) in the US House of Representatives in 2019, whose preamble establishes that the Green New Deal should address the climate crisis, and an economic one of wage stagnation and growing inequality. To address the former crisis, H.R. 109 sets the goal for the US to achieve net zero greenhouse gas emissions through a ten-year mobilization. To address the latter crisis, H.R. 109 sets out numerous social objectives: creating high-quality union jobs and offering training for workers affected by the transition; expanding the welfare state by providing free health care and affordable housing to all citizens; and fostering environmental justice by stopping current, preventing future, and repairing historic oppression of frontline and vulnerable communities. The Green New Deal vision articulated in H.R. 109 points to the need for an interventionist economic approach to decarbonization by placing strong emphasis on public investments, industrial policies, and indicative planning. It aims at using the power of public investment and coordination to prioritize decarbonization at speed, scope, and scale.

Riccardo Mastini

Further reading

Aronoff et al. 2019; Galvin & Healy 2020; Riofrancos 2019; Wahlsten 2020; Mastini et al. 2021.

See also: Green industrial policy, Climate change, Climate change mitigation, Climate instability.

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Riofrancos, T. 2019. Plan, mood, battlefield—reflections on the Green New Deal. Viewpoint Magazine, May 16. http://www.viewpointmag.com/2019/05/16/plan-mood-battlefield-reflections-on-the-green-new-deal/.

Wahlsten, J. 2020. To assemble society anew? The political economy of contemporary Initiatives of socio-ecological transformation. Helsinki Centre for Global Political Economy Working Paper, 02/2020. Helsinki: University of Helsinki.

Green protectionism

A pejorative term whereby regulators are accused of using environmental measures as a means of disguised trade protectionism; so-called "non-tariff barriers" to trade. Most often it is developed jurisdictions that are accused of attempting to protect their industries from competition from producers in lower-income countries (see, e.g., Lottici et al. 2014). Measures that have been claimed to constitute green protectionism include the European Union's Biofuel Sustainability Directive (Richardson 2014) and the United States Environment Protection Agency's rules on gasoline standards (Schultz 1996).

There is no consensus in the academic literature on the extent of green protectionism versus genuine environmental motives. Available empirical evidence suggests that while green protectionism does exist, most environmental measures are likely not motivated by protectionist intent (Aisbett & Pearson 2012). Furthermore, anti-green protectionism in the form of "regulatory chill" for jurisdictions "stuck at the bottom" is at least as prevalent as green protectionism or a "race to the top" in standards (Aisbett & Silberberger 2020).

Emma K. Aisbett

See also: Trade liberalization, Green trade policy, Trade-related climate policy, Green growth.

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Schultz, J. 1996. The demise of "green" protectionism: the WTO decision on the US gasoline rule. Denver Journal of International Law and Policy 25(1): 1–24.

Green Revolution

The large increase in production of food grains, especially wheat and rice, which occurred in developing countries from 1950 through 1985, especially Mexico, the Philippines, India, Pakistan, and China (Pingali 2012; Eisenman 2018). Crop outputs doubled, and sometimes tripled. The Green Revolution was enabled by a series of agricultural research and development initiatives and technology transfer to these countries, including hybrid seed use; much greater application of chemical fertilizers, herbicides, and pesticides; diesel and electric pump-powered irrigation, mechanization, and transport improvements. The father of the Green Revolution was the agronomist Norman Borlaug, who received the Nobel Peace Prize for this work in 1970. These increased crop yields from the Green Revolution, however, came with increased costs for farmers, soil degradation, and increased health and environmental risks from the pesticide and herbicide use.

BARRY D. SOLOMON

See also: Food security, Food insecurity, Malthusian scarcity, Sustainable food system, Public goods, Transfers, Soil fertility.

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Green supply chains

An environmentally responsible approach to planning, organizing, and managing traditional commodity supply chains (Singh & Trivdei 2016). Environmental protection comes first, by creating corporate policies and preferences for sustainable environmental processes including product design, material sourcing and selection, manufacturing and production, operations, and end-of-life product management. Next, business managers design specific methods for logistics and transporting goods, including goods that are potentially dangerous to the environment and human health, as well as the choice of responsible business partners and product suppliers. Green supply chains contribute to the implementation of several United Nations Sustainable Development Goals. Otherwise, the time of delivery of goods and services and the time of passenger transportation can lengthen, and their cost can increase.

The basis of green supply chains is a progressively responsible society and responsible businesses, able to pay (with sufficient income) and willing to pay (assigning the corresponding values) the increased cost and incur other (for example, temporary) expenses in favor of environmental protection.

ELENA G. POPKOVA & BRUNO S. SERGI

Further reading

Haiyun et al. 2021; Jazairy & von Haartman 2020; Li et al. 2021; Stekelorum et al. 2021.

See also: Commodity supply chain, Supply chain management, Renewable energy, Sustainable energy, Eco-innovation, Green innovations, Sustainable business, Sustainable Development Goals (SDGs).

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Green taxes

See: Environmental taxes.

See also: Pollution taxes, Carbon taxes.

Green trade policy

Policies that target market failures related to trade whose expansion would have environmental benefit. Green trade policy is at the intersection of trade-related climate policy, climate-related trade policy, and green industrial policy. It achieves trade and environmental win–wins. Preferential liberalization, export credit, and trade facilitation measures for green goods and services are examples of green trade policy. Border carbon adjustments are not.

Emma K. Aisbett

Further reading

Maestad 1998.

See also: Green industrial policy, Trade-related climate policy, Green protectionism, Trade liberalization.

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Maestad, O. 1998. On the efficiency of green trade policy. Environmental and Resource Economics 11(1): 1–18.

Greenwashing

The process whereby a firm provides vague, misleading, or false marketing information to consumers and investors about its products, services, or business practices having positive environmental attributes or performance and thus being environmentally friendly or sustainable, when their actual environmental performance is poor (Laufer 2003; Ramus & Montiel 2005; Delmas & Burbano 2011). Thus, greenwashing is corporate disinformation designed to improve a company's image while deceiving others. In most cases little or no proof is provided for these claims. The term was coined by United States environmentalist Jay Westerveld in 1986, when he claimed that the practice in the hotel industry of encouraging guests to reuse their towels was a purely cost-saving measure (de Freitas et al. 2020).

The high prevalence of greenwashing can have adverse effects on consumer and investor confidence in actual green products and businesses. In investing, greenwashing occurs when an investment product is viewed to meet environmental standards so an investment portfolio can claim that it is meeting ESG guidelines (environmental; social; governance). Often these claims are trivial and unproven (Fancy 2021a, 2021b).

Barry D. Solomon

Further reading

Parquel et al. 2011; Mahoney et al. 2013.

See also: Corporate social responsibility, Pro-environmental behavior (PEB), Environmentalism, Investment.

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Gross domestic product (GDP)

The most-used standard measure of the value added created through the production of goods and provision of services in a country via formal markets during a certain period. It is a flow measure of value added that consists of one of the three ways of measuring such economic activity in the System of National Accounts (SNA), namely the production definition, while the same overall number should also be reached using the income or expenditure methods. This is because the total amount of value added created through the production and consumption of goods and delivery of services is defined to be equal to the income earned through that provision and transacting of goods and services (as wages and salaries or dividends and profits), and equal to the amount of expenditure on final goods and services (less imports and including inventories).

The original indicator of GDP is in nominal terms (also known as "GDP at current prices") and without seasonal adjustment. From this, so-called "real GDP" is calculated by subtracting estimates of "inflation." The measurement of services in the national accounts is more difficult than that of manufacturing, which was dominant in the 1920s and 1930s when the concepts were developed. To monitor the performance of developing countries, it has become common to consider per capita GDP. However, this understates performance when population growth is high.

GDP and its variants, such as gross national product (GNP) and gross national income (GNI), suffer from several serious shortcomings: inconsistent treatment of intermediate goods and services, incorrect treatment of replacement investment, generally ignoring the informal sector and housework/child rearing, counting spending on some negative externalities as positives while ignoring others, ignoring resource depletion, and not being a measure of well-being though it is often referred to as such.

Richard A. Werner

Further reading

Commission of European Communities et al. 1993; Werner 2018.

See also: Gross national product (GNP), System of National Accounts (SNA), Value added, Services, Service economy, Economic growth, Growth theory, Inflation.

References

Commission of European Communities, International Monetary Fund, Organisation for Economic Co-operation and Development et al. 1993. System of National Accounts. Brussels, Belgium; Luxembourg; New York, USA; Paris, France; Washington, DC, USA.

Werner, R.A. 2018. Princes of the Yen: Japan's Central Bankers and the Transformation of the Economy. London: Quantumpublishers.com.

Gross national product (GNP)

The measure of total value of a nation's output. It is measured by adding net overseas investment income to gross domestic product (GDP) (that is, by adding residents' investment income from abroad and subtracting foreign residents' investment income earned within the home country). Thus, GNP measures the output of a country's residents irrespective of the location of the underlying economic activity. There can be significant differences between GNP and GDP, especially when comparing the presently largest owner of net foreign assets, Japan, with the largest net debtor, the United States (US). Net national product is GNP minus the amount of GNP required to purchase new goods to maintain existing stock, that is, depreciation. It aims to address one of the shortcomings of GDP/GNP.

The US Bureau of Economic Analysis has used GNP since 1934, though it switched to GDP in December 1991. Internationally, GNP was the preferred measure of economic activity until around 1993 when the System of National Accounts (Commission of European Communities et al. 1993) manual switched to GDP. At the time, Japanese GNP was about to overtake that of the US within two years. Japan holds the largest foreign asset stock in the world, because of the large net capital outflows in the 1980s (Werner 2018). By switching to GDP, Japanese economic performance was understated, and US performance overstated. Japanese GDP never overtook US GDP. The switch from who owns economic value creation to where economic value is created may hide the political and long-term implications of ownership and control.

Richard A. Werner

See also: Gross domestic product (GDP), System of National Accounts (SNA), Depreciation, Economic growth, Growth theory, Inflation.

References

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Groundwater governance

"The overarching framework of groundwater use laws, regulations, and customs, as well as the processes of engaging the public sector, the private sector, and civil society" (Megdal et al. 2015, p. 678). Unlike surface water, which has been managed for a long time, interest in groundwater governance is much more recent. Indeed, groundwater has often been presented as the archetypal open access resource, as there were often no restrictions on use. Groundwater is now the subject of increasing attention, as its use has developed considerably since the second half of the 20th century, particularly for irrigation, drinking water supply, but also for industrial uses. The topic of groundwater governance is currently the subject of numerous academic studies (Faysse & Petit 2012; Villholth et al. 2018; Closas & Villholth 2020; Rinaudo et al. 2020), the first of which were probably initiated by Elinor Ostrom herself in the context of her doctoral thesis (Ostrom 1965).

In order to govern groundwater use, different institutional arrangements are generally adopted, combining regulation by public authorities, through regulatory instruments (authorizations, bans, quotas, zoning, closure of boreholes), economic instruments (fees, subsidies), or indirect measures linking water to other issues (food security, energy); and participatory mechanisms. However, these mechanisms come up against numerous obstacles that are often difficult to overcome, and inequalities in access to groundwater remain significant.

Olivier Petit

See also: Common pool resources, Governance, Water governance, Environmental governance, River basin management, Integrated water resources management (IWRM).

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Villholth, K., López-Gunn, E., Conti, K. et al., eds. 2018. Advances in Groundwater Governance. Leiden: CRC Press/Balkema.

Growth

A quantitative increase in the physical size of something, such as the macroeconomy or an organism, or an increase in throughput.

BARRY D. SOLOMON

Further reading

Daly & Farley 2011.

See also: Growth theory, Economic growth, Exponential growth, Growth paradigm, Growth rate, Green growth, Throughput, Limits to growth, Agrowth, Development.

Reference

Daly, H.E. & Farley, J. 2011. Ecological Economics: Principles and Applications, 2nd edn. Washington, DC: Island Press.

Growth fallacies

Favorable statements about economic growth that are logically and/or factually incorrect. Growth fallacies emphasized in ecological economics include the belief that economic growth is feasible without limit; that it is always desirable—its benefits always exceed its costs; that natural resources and environmental impacts can be reduced absolutely while the value of economic output (gross domestic product) continues to increase; that new technologies can be relied upon to solve whatever problems previous economic growth has created; and that human-built capital will always be able to substitute for any reduction in the availability of nature to provide the materials, energy, and ecosystem services required to sustain economic growth.

PETER A. VICTOR

Further reading

Daly 1977, 2012; Grant 1983; Jackson & Victor 2019; Dhara & Singh 2021; Jones 2019; Ketcham 2018; Spash 2014; Strauss 2008.

See also: Growth, Economic growth, Development, Economic development, Post-growth, Agrowth.

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Growth independence

Growth-dependent areas of the economy fulfill two criteria: (1) they contribute to a desirable function or a commonly agreed upon societal goal; and (2) their functionality depends on or is believed to depend on the continuous growth of the economy (Petschow et al. 2020, p. 91). Growth independence in turn means that such areas are organized in a manner so that the desirable function or societal goal can also be achieved without economic growth; that is, keeping the level of production and consumption constant or reducing it (Lange & Jackson 2019).

An important example is employment and income: the level of employment and thereby the income of many people is commonly seen as linked to economic growth. Another example is financing of the welfare state, be it via social insurance systems or tax revenues (Petschow et al. 2020, p. 91). Growth independence is needed for a sustainable transformation, because if important societal goals are growth-dependent it is difficult to introduce strong environmental policies that are necessary to stay within planetary boundaries but will—or are believed to—lead to a reduction in production and consumption (Seidl & Zahrnt 2010).

Steffen Lange

See also: Growth, Economic growth, Growth fallacies, Post-growth, Agrowth, Degrowth, Development, Economic development, Development economics, Sustainability transition, Societal transformation.

References

Lange, S. & Jackson, T. 2019. Speed up the research and realization of growth independence. Ökologisches Wirtschaften-Fachzeitschrift 33(1): 26–7.
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Seidl, I. & Zahrnt, A. eds. 2010. Postwachstumsgesellschaft: Konzepte für die Zukunft. Marburg: Metropolis.

Growth paradigm

a. The preanalytic vision of mainstream economists that justifies their belief in unlimited growth. According to ecological economist Herman Daly (1972), who first used this term, it describes the worldview and the implicit growth-oriented assumptions within the profession of economics.
b. A specific ensemble of societal, political, and academic discourses, theories, and statistical standards that jointly assert and justify the view that economic growth as conventionally defined is good, imperative, the main remedy for key social problems, and essentially limitless (from Dale 2012; Schmelzer 2015).
   This proposition, which became societally hegemonic in the mid-20th century, revolves around the following, widely held views that: (1) gross domestic product (GDP), with all its inscribed reductions, assumptions, and exclusions, adequately measures economic activity; (2) growth is a panacea for a multitude of (often changing) societal challenges; (3) growth is practically the same as, or a necessary means to achieve, some of the most essential societal goals such as progress, well-being, or national power; and (4) growth is essentially unlimited, provided that the correct governmental and intergovernmental policies are pursued (Schmelzer 2015, 2016).

Matthias G. Schmelzer

Further reading

Purdey 2009.

See also: Economic growth, Growth theory, Growth fallacies, Gross domestic product (GDP), Limits to growth, Preanalytic vision.

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Schmelzer, M. 2016. The Hegemony of Growth: The OECD and the Making of the Economic Growth Paradigm. Cambridge: Cambridge University Press.

Growth rate

Neoclassical economics: rate of quantitative change to a given variable in a series. Neoclassical economics typically refers to annual statistics for the monetary value of economic output or national income.

Environmental economics: presupposes economic growth as a desirable systemic feature and as a source of solutions to arising problems via its role in energizing dynamic efficiency and technological change. This leads to economic systems that target a positive annual economic growth rate in perpetuity.

Ecological economics: considers economic growth as an ideology of "growthism" that is incompatible with a finite planet, and distinguishes quantitative growth from norms of development, well-being, and social progress.

Josh Moos & Jamie A. Morgan

Further reading

Daly 1995; Daly & Farley 2011; Spash 2021; Hickel & Kallis 2020.

See also: Growth, Growth paradigm, Growth fallacies, Growth theory, Degrowth, Growth independence, Affluence, Limits to growth, Sustainable development, Decoupling economic growth, Steady state, Steady state economy, Gross domestic product (GDP).

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Daly, H.E. 1995. On Nicholas Georgescu-Roegen's contribution to economics: an obituary essay. Ecological Economics 13(3): 149–54.
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Spash, C.L. 2021. Apologists for growth: passive revolutionaries in a passive revolution. Globalizations 18(7): 1123–48.

Growth theory

Economic growth has been a central concern of economics since Adam Smith, who emphasized the role of capital investment and productivity growth (Smith 1776 [1789]). Neoclassical economic growth theory, also known as exogenous growth theory, holds that an external macroeconomic factor of technological progress is the main driver of economic growth. Robert Solow (1956) developed growth theory through a series of equations based on using only capital and labor as the independent variables, and using the Cobb–Douglas production function to allow his equations to be structured for unlimited substitutable inputs. This allowed his growth theory model to predict steady economic growth and eliminate volatility, while leaving an unexplained 70 percent "Solow residual" that he attributed to technological progress. However, Hall and Klitgaard (2018) explain that when Kümmel and colleagues (e.g., Kümmel et al. 2002) included energy and creativity in the list of independent variables, took the elasticities of the independent variables, and tested them with a LINEX function, the residual disappears, with energy being more powerful than labor and capital in driving economic growth.

In a classic work of development economics, Walt Rostow (1960) argued that modern economic growth must follow through five stages: (1) traditional agricultural and arti-

sanal society; (2) precondition for "take-off"; (3) "take-off," where growth becomes normal; (4) drive to maturity; and (5) age of high mass consumption.

For decades, biophysical and ecological economists have emphasized that not only is the real economy prone to recessions, financial instability, stagnation, and even collapse due to biophysical and social limits to growth, but also low-entropy energy is required for any economic process (Daly & Farley 2011; Victor 2010; Ayres et al. 2013; Daly 2014; Hall & Klitgaard 2018).

RIGO E.M. MELGAR

See also: Economic growth, Cobb–Douglas production function, Growth fallacies, Uneconomic growth, Limits to growth, Development economics.

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H

Habitat

a. The combined biotic and abiotic features that enable the survival of a specific species. Can be described at differing geographic and temporal scales or based on life-cycle stage, migration, breeding, or non-breeding locations.
b. A set of physical and often vegetative features that define a particular landscape and characterize a type of environment (for example, grassland).

Charlie M. Chesney

Further reading

Hall et al. 1997; Bamford & Calver 2014.

See also: Abiotic resources, Biotic resources, Carrying capacity, Community, Ecosystem.

References

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Hall, L.S., Krausman, P.R. & Morrison, M.L. 1997. The habitat concept and a plea for standard terminology. Wildlife Society Bulletin (1973–2006) 5(1): 173–82.

Habitat banking

An umbrella term for "conservation banking," "mitigation banking," and "biodiversity banking." It is a site, or set of sites, where natural habitats are restored, created, enhanced, and/or preserved for the purpose of offsetting ecological impacts generated by developers. Habitat banking also refers to the name of the organization in charge of managing these sites. The actions carried out in habitat banking create ecological gains that will be translated into offsetting "credits" or "units" and sold to developers who must offset their authorized impacts on habitats and/or species (Wende et al. 2018). These transactions are allowed only if the impacts occurred in the same ecosystem as the habitat banking (for example, a water basin for wetlands or the area of distribution for species), and if there is a strict ecological equivalency between the gains and losses. They are supervised by a third party, most often a public authority, and are governed by a contract and regulation forms.

The added value of habitat banking comes from the fact that it allows for anticipation of future impacts of development programs and the associate needs of offsetting in a specific territory, but also to mutualize the restoration projects on a large area, which are known to have a higher level of success in comparison with small and isolated restoration projects. The side-effect of habitat banking is that it can lead to compensation further from the impacted sites than the conventional permit system (Levrel et al. 2017).

Harold Levrel

See also: Habitat, Biodiversity conservation, Wetland, Endangered species, Banks.

References

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Habitat fragmentation

a. The process during which a large expanse of habitat is transformed into several smaller patches of a smaller total area, isolated from each other by a matrix of habitats unlike the original (Fahrig 2003).
b. A current group of smaller isolated patches of habitat in an area that used to be a large expanse of habitat.

Chian A. Jones Ritten

See also: Habitat, Fragmentation, Biodiversity.

Reference

Fahrig, L. 2003. Effects of habitat fragmentation on biodiversity. Annual Review of Ecology, Evolution, and Systematics 34: 487–515.

Happiness

a. A momentary emotional state ("hedonic well-being").
b. A way of describing overall life evaluations ("evaluative well-being").
c. Meaningfulness and a sense of purpose of one's life ("eudaimonic well-being") (Stone & Mackie 2013).

These three distinct meanings of happiness are not completely separable. The following are more precise definitions and the way that each can be measured using surveys.

Hedonic well-being: momentary states that combine momentary positive and negative emotions such as pleasure, joy, contentment, suffering, distress, sadness, stress, or worry. The hedonic measure of happiness can be captured on a Likert scale with a series of questions such as: "On a scale from 0 to 10 how happy (worried, stressed, or depressed) you felt yesterday" (OECD 2013).

Evaluative well-being: in social science studies, measures of evaluative well-being, also known as subjective well-being, are designed to capture judgments of overall happiness or life satisfaction. In addition to the overall evaluation, evaluative well-being can be applied to specific aspects of life, such as relationships, environment, health, or job. An example of an evaluative measure of well-being is "Overall, how satisfied/happy are you with life as a whole these days?" (OECD 2013).

Eudaimonic well-being: the Aristotelian definition of happiness, "eudaimonia," refers to the best life lived. Eudaimonia is a person's perception of meaningfulness, a sense of purpose in their life, and is a type of happiness or contentment that is achieved through self-actualization. The most common assessment of eudaimonia refers to individuals' overall assessments of meaning and purpose (Stone & Mackie 2013).

Mona Ahmadiani

See also: Life satisfaction, Quality of life (QoL), Egoistic hedonism, Subjective well-being, Objective well-being, Eudaimonia, Buen vivir.

References

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Stone, A.A. & Mackie, C.E. 2013. Subjective Well-being: Measuring Happiness, Suffering, and Other Dimensions of Experience. Washington, DC: National Academies Press.

Harmonization

Bringing separate policy goals into alignment. This concept recognizes that some goals can work at cross-purposes, such as attempting to increasing global trade and protect the environment. Policymakers seek to correct the problem through harmonization, such as forbidding certain practices, coordinating regulatory oversight, or other interventions. However, the process of harmonization may introduce competitive disadvantages if the parties affected are unequal to begin with, and should be pursued with care, as described by Steininger (1994).

Brent M. Haddad

See also: Convergence, Trade liberalization, Green trade policy, Trade-related climate policy, Environmental policy instruments.

Reference

Steininger, K. 1994. Reconciling trade and environment: towards a comparative advantage for long-term policy goals. Ecological Economics 9(1): 23–42.

Hartwick rule

In a simple economy with two assets—manufactured capital and a finite exhaustible natural resource—the requirement that the value of resource depletion is fully offset by investment of the rents on resource extraction in manufactured capital. Named for the neoclassical economist John Hartwick. The Hartwick rule is a precursor to the literature on the economics of sustainable development—specifically weak sustainability. Applying this rule at each point in time along a development path for the economy ensures that consumption can be maintained at a constant level everywhere along the path, over a potentially infinite time horizon. Stated differently, the rule requires that net saving be equal to 0 at each point along the development path. Such a path is considered egalitarian and sustainable. Solow (1974) proved that constant consumption in this economy is technically feasible, but Hartwick (1977) showed that the Hartwick saving rule is both intuitive and sufficient to support constant consumption over time.

Subsequent results in the Hartwick rule literature raise issues of the feasibility of a constant consumption development path. Pearce and Atkinson (1993) emphasize concern about the substitutability of manufactured capital for natural capital in policies for sustainable development; while Dasgupta and Heal (1979) show that an infinite stream of consumption supported by investment of rents on resource extraction is infeasible if the elasticity of substitution between produced and natural capital is less than 1. Asheim (2013) highlights the question of the feasibility of the Hartwick rule to lead to sustainable development in a more general model. The emphasis on substitutability of manufactured and natural capital also features prominently in the ecological economics literature on sustainability.

KIRK E. HAMILTON

See also: Weak sustainability, Strong sustainability, Solow sustainability, Investment.

References

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Solow, R.M. 1974. Intergenerational equity and exhaustible resources. Review of Economic Studies 41(Symposium): 29–46.

Harvesting

Ecology:

a. The process of picking and collecting ripe agricultural crops from farms, or the cutting and removal of trees from forests (Kusumastuti et al. 2016; Damette & Delacote 2011).
b. The killing (taking) of wild animal species to control and manage their population in an ecosystem, by hunters, trappers, fishers, or government wildlife management officials. The harvested animals are often eaten by humans (Mayaka et al. 2005; Salo et al. 2014; Gelcich et al. 2007; Tahvonen 2009).

Economics:

a. An exit or liquidity event when a business or person cashes out their product line investment or ownership position in a firm (Shava 2021).
b. Data harvesting refers to the automated collection of data or other online information from websites, for example, for economic modeling (Tan et al. 2015).

BARRY D. SOLOMON

See also: Sustainable agriculture, Sustainable food system, Food system, Agribusiness, Forest conservation, Deforestation, Wildlife conservation, Fisheries management.

References

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Tahvonen, O. 2009. Economics of harvesting age-structured fish populations. Journal of Environmental Economics and Management 58(3): 281–99.

Tan, K.H., Zhan, Y.Z., Ji, G. et al. 2015. Harvesting big data to enhance supply chain innovation capabilities: an analytic infrastructure based on deduction graph. International Journal of Production Economics 165: 223–33.

Hedging

An investment practice used in finance to manage and transfer risk, largely in the derivatives markets by taking a position in one market to balance and offset the risk in a contrary or opposing market (Telser 1955; Anderson & Danthine 1981). Historically, derivatives had been widely used in commodity futures to hedge against the risk of the price movements of physical underlying assets (from which derivatives derive their value) such as gold, wheat, petroleum, and so on. In recent decades, derivatives have been increasingly used to hedge and bet for the increasing or decreasing values of a variety of financial assets such as credit default swaps, currencies, stocks, bonds, and, most significantly, interest rates.

Rigo E.M. Melgar

See also: Risk, Risk aversion, Risk premium.

References

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Telser, L.G. 1955. Safety first and hedging. Review of Economic Studies 23(1): 1–16.

Hedonic pricing method

A method popularized by Sherwin Rosen (1974), used commonly in urban, environmental, and ecological economics, to derive the monetary value of non-market goods such as various ecosystem components or other environmental amenities and their features. It is based on revealed preferences (behaviors or choices) observed primarily in real estate markets.

The hedonic pricing method (HPM) is used to estimate monetary value as a marginal willingness to pay (MWTP) for a particular non-market good with the use of an econometric model. HPM regresses the property prices over structural, locational, and environmental features of those properties to obtain the estimated MWTP. HPM is based on the assumptions of: complete recognition of the property's features by real estate buyers; real estate market being in equilibrium; and real estate properties being represented by the respective sets of characteristics (composite goods). Due to the spatial nature of real estate market data, HPM typically uses spatial econometric models.

The traditional HPM used linear, log-linear, or double-log models to express functional relationship between the property prices and proximity of/distance to environmental amenities. Modern econometric models for HPM go beyond the simple estimation of MWTP and assess the non-linear distance decay functions of an impact of environmental amenities on the property's prices,

evaluate spatial heterogeneity of MWTP, or decompose MWTP for the quantiles of property prices. HPM results support the evaluation of environmental (in)justice and gentrification processes.

EDYTA ŁASZKIEWICZ

Further reading

Baranzini et al. 2008; Łaszkiewicz et al. 2019; Osland 2010; Tyrväinen 1997.

See also: Economic valuation techniques, Econometrics, Revealed preference methods, Travel cost method, Environmental justice.

References

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Tyrväinen, L. 1997. The amenity value of the urban forest: an application of the hedonic pricing method. Landscape and Urban Planning 37: 211–22.

Heterodox economics

Schools of thought that diverge from economic orthodoxy. There are many schools of economic thought that frame our perspective on capitalism (Lawson 2006; Davis 2006). The economics profession has been dominated by one school of thought known as neoclassical economics. Neoclassical economics is the orthodoxy in the economic profession. A heterodox economist employs a framework that is both cultural and historical, and generally presents capitalism in a more critical light. Examples of heterodox approaches include: evolutionary, institutional, Marxian, and post-Keynesian economics.

Heterodox economics should be distinguished from "methodological pluralism" used in ecological economics (Norgaard 1989). The former is used to frame analyses of capitalism, while the latter connects analyses of capitalism to analyses of the ecosphere where this is seen as the cask in which economic structure and dynamics ferment.

LISI KRALL

See also: Neoclassical economics, Evolutionary economics, Institutional economics, New institutional economics, Post-Keynesian economics, Radical ecological economics, Methodological pluralism.

References

Davis, J. 2006. The nature of heterodox economics. Post-Autistic Economics Review 40: 23–30.

Lawson, T. 2006. The nature of heterodox economics. Cambridge Journal of Economics 30(4): 483–505.

Norgaard, R.B. 1989. The Case for Methodological Pluralism. Ecological Economics 1: 37–57.

Heterogeneity

The state or quality of being diverse or dissimilar; for example, as in statistics, economics, organisms, groups, communities, populations, or societies. Heterogeneity and time are central aspects of economic activity and are especially emphasized by the Austrian School of economics (Faber & Winkler 2006).

BARRY D. SOLOMON

See also: Spatial heterogeneity, Homogeneity, Austrian School of economics.

Reference

Faber, M. & Winkler, R. 2006. Heterogeneity and time. American Journal of Economics and Sociology 65(3): 803–25.

Heuristic

A strategy for making decisions under uncertainty, that is, in situations where the optimal

course of action cannot be foreseen. Human intelligence, which evolved to live with uncertainty rather than calculable risk, relies on heuristics to make inferences about the physical and social world. Heuristics—also referred to as fast-and-frugal heuristics—ignore part of the information available to humans, with the goal of making decisions more quickly, frugally, and accurately than with more complex methods. Algorithmic models of heuristics specify the sequential process of action, such as where to search for information, when to stop searching, and how to make a final decision.

In artificial intelligence (AI), heuristic search is a key element for making computers smart. Biological research studies the rules of thumb that animals use to solve adaptive problems, such as finding a partner or a nest site. The repertoire of heuristics which an individual, culture, or species has at its disposal is called its adaptive toolbox, and the study of their ecological rationality investigates the situations in which individual heuristics are successful.

GERD GIGERENZER

Further reading

Gigerenzer et al. 2011; Todd et al. 2012; Hertwig et al. 2013.

See also: Adaptive capacity, Bounded rationality, Procedural rationality, Uncertainty, Risk.

References

Gigerenzer, G., Hertwig, R. & Pachur, T., eds. 2011. Heuristics: The Foundations of Adaptive Behavior. New York: Oxford University Press.

Hertwig, R., Hoffrage, U. & ABC Research Group. 2013. Simple Heuristics in a Social World. New York: Oxford University Press.

Todd, P.M., Gigerenzer, G. & ABC Research Group. 2012. Ecological Rationality: Intelligence in the World. New York: Oxford University Press.

Hicksian income

a. The central income criterion (from Hicks 1939) put forward by Sir John Hicks is the maximum amount that people can consume without impoverishing themselves. For Hicks, this criterion serves as a "guide for prudent conduct" because it tries to avoid impoverishment by maintaining consumption over time.

b. The operationalization of Hicks's central income principle in his so-called "Income No. 1" (from Hicks 1939) is the maximum amount that can be consumed while expecting to maintain capital intact. This *ex ante* expectation differs from the *ex post* realization that includes unexpected profits or losses. The *ex post* realization equals consumption plus capital accumulation (from Hicks 1939), and is commonly referred to as "Hicksian income." Another commonly regarded basic approximation of Hicksian income is the net national product (NNP), which is obtained by subtracting depreciation from the gross national product (GNP).

JONAS VAN DER SLYCKEN

Further reading

Van der Slycken & Bleys 2020.

See also: Fisherian income, Economic welfare, Measures of economic welfare.

References

Hicks, J. 1939. Value and Capital: An Inquiry into Some Fundamental Principles of Economic Theory. London: Oxford University Press.

Van der Slycken, J. & Bleys, B. 2020. A conceptual exploration and critical inquiry into the theoretical foundation(s) of economic welfare measures. Ecological Economics 176: 106753.

Hierarchy

Social sciences: the implicit or explicit ranking of positions of authority in an organization or social group, based on importance, influence, political power, or dominance (Tannenbaum et al. 1974). Such hierarchies include social classes (for example, upper class, middle class, working class, lower class) and castes, which are usually based on implicit rankings. Rigid caste systems exist in south Asia and over 15 countries in Africa. It was also traditionally assumed that the

sciences exist in a hierarchy, with the natural sciences on top and the social sciences at the bottom (Cole 1983).

Biology: the systemic organization of organisms into descending levels of complexity based on the taxonomy established by Swedish botanist Carl Linnaeus (Ereschefsky 2001). The biological hierarchy is: kingdom, phylum, class, order, family, genus, and species.

BARRY D. SOLOMON

See also: Social institutions, Social order, System scale and hierarchy.

References

Cole, S. 1983. The hierarchy of the sciences? American Journal of Sociology 89(1): 111–39.

Ereschefsky, M. 2001. The Poverty of the Linnaean Hierarchy: A Philosophical Study of Biological Taxonomy. Cambridge: Cambridge University Press.

Tannenbaum, A.S., Kavcic, B., Rosner, M. et al. 1974. Hierarchy in Organizations. San Francisco, CA: Jossey-Bass.

Holistic approach

The conception of the cosmos as one all-interconnected entity. No subject, such as the analysis of society in its economic affairs, is thought of as a separate unit of analysis. The concentration on an area of study is a matter of focus instead of parceling. The understanding of society in its economic affairs requires the consideration of other dimensions of human behavior and the environment, and thus a holistic approach plays a critical role in ecological economics. This approach requires an inclusion in the substance rather than a mere complement of the inquiry.

In recent years a holistic approach has been associated with chaos and complexity theories (Briggs & Peat 1990). Besides ecological economics, some other economics schools such as institutional economics, evolutionary economics, and even Marxian analysis, have found ways to embed a broader social analysis and its interactions with technology and the environment and natural resources within the core of theories of value and prices.

ANDRES F. CANTILLO

See also: Ecological economics, Interconnected, Evolutionary economics, Institutional economics, New institutional economics, Chaos theory, Complexity theory.

Reference

Briggs, J. & Peat, F.D. 1990. Turbulent Mirror: An Illustrated Guide to Chaos Theory and the Science of Wholeness. New York: Harper & Row.

Holling sustainability

The capacity to create, test, and maintain adaptive capability (Holling 2000). This view of sustainability, though one of hundreds, is based on the results of the involvement of the renowned ecologist C.S. Holling in the Resilience Project (Holling 2000; Gunderson & Holling 2002). Holling was also one of the conceptual founders of ecological economics. The Resilience Project was a five-year effort among ecologists, economists, social scientists, and mathematicians to develop an integrative theory of how systems function, sustainability, and resilience. This definition of sustainability by Holling leads to a view of sustainable development as the goal of fostering adaptive capabilities and creating opportunities.

BARRY D. SOLOMON

Further reading

Holling 1993.

See also: Adaptive capacity, Sustainability, Sustainable development, Sustainability metrics, Sustainability assessment, Economic resilience, Integrated ecological–economic systems, Panarchy theory.

References

Gunderson, L.H. & Holling, C.F., eds. 2002. Panarchy: Understanding Transformations in

Human and Natural Systems. Washington, DC: Island Press.
Holling, C.S. 1993. Investing in research for sustainability. Ecological Application 3(4): 552–55.
Holling, C.S. 2000. Theories for sustainable futures. Conservation Ecology 4(2): 7.

Homo economicus

A central assumption of neoclassical economic theory and models whereby economic decisions are undertaken by an isolated, self-maximizing individual who behaves as a rational actor at a point in time. *Homo economicus* is characterized as an insatiable, self-interested, outcome-oriented, and time-consistent (in discounting the future more than the present) individual with exogenous and predetermined preferences to produce, consume, and exchange goods and services in the marketplace. However, just as many of us can identify in our own behavior, Gintis (2000) has demonstrated that humans can also be strong reciprocators and hyperbolic discounters of the immediate future. This means that humans are more irrational than assumed in neoclassical economics, because we are just as likely to be altruistic/vindictive as self-regarding, and just as likely to be time-inconsistent as time-consistent (Camerer & Loewenstein 2004).

The caricaturized behavior of individuals that neoclassical economics assumes can generate the most welfare to society is also ahistorical, since humans' evolutionary success is due, in great part, to our ability to cooperate with one another (Henrich 2015; Moffett 2018). Once a utility function is affected by the welfare of others, it is no longer possible to show that markets generate a welfare-maximizing equilibrium. Therefore, economic theories and policies thereof that reinforce a market logic that leads to predominantly isolating, selfish, and short-term thinking behavior are at the core of our social, economic, and environmental unsustainability problems that imperil our future success as a species. Thus, a sustainability transition to a prosperous and thriving future requires economic policies that can foster human cooperation at a local, national, and global scale, to address issues such as pandemics, the climate crisis, and to manage our natural resources in ways that ameliorate long-term depletion.

Rigo E.M. Melgar

Further reading

Henrich et al. 2001.

See also: Rational behavior, Bounded rationality, Discounting, Egoistic hedonism, Welfare, Economic welfare, Social welfare function.

References

Camerer, C.F. & Loewenstein, G. 2004. "Behavioral economics: past, present and future," pp. 3–52 in Advances in Behavioral Economics. C.F. Camerer, G. Loewenstein & M. Rabin, eds. Princeton, NJ: Princeton University Press.
Gintis, H. 2000. Beyond *Homo economicus*: evidence from experimental economics. Ecological Economics 35(3): 311–22.
Henrich, J. 2015. The Secret of our Success: How Culture is Driving Human Evolution, Domesticating our Species, and Making us Smarter. Princeton, NJ: Princeton University Press.
Henrich, J., Boyd, R., Bowles, S. et al. 2001. Cooperation, reciprocity and punishment in fifteen small-scale societies. American Economic Review 91(2): 73–78.
Moffett, M.W. 2018. The Human Swarm: How our Societies Arise, Thrive, and Fall. New York: Basic Books.

Homogeneity

The state or quality of being similar or the same; for example, as in statistics, economics, organisms, groups, communities, populations, or societies.

Barry D. Solomon

Further reading

Droll et al. 2006; Druckman & Jackson 2008; Behera 2009.

See also: Heterogeneity.

References

Behera, B. 2009. Explaining the performance of state–community joint forest management in India. Ecological Economics 69(1): 177–85.

Droll, C.N.H., Muller, J.-P. & Morley, J.G. 2006. Mapping regional economic activity from night-time light satellite imagery. Ecological Economics 57(1): 75–92.

Druckman, A. & Jackson, T. 2008. Measuring resource inequalities: the concepts and methodologies for an area-based Gini coefficient. Ecological Economics 65(2): 242–52.

Horizontal integration

A business strategy that involves a firm acquiring an increased share of production capacity for the goods and services sold at the same level of the supply chain. Horizontal integration can occur through acquisition, merger, or internal expansion. This practice increases economic efficiency and economies of scale, and reduces costs, but also increases market share and market power. However, since horizontal integration can lead to a firm controlling its potential competition, in some cases this becomes anti-competitive and can violate antitrust laws.

In the United States, antitrust enforcement actions involving horizontal integration in the petroleum industry have been common (Federal Trade Commission 2004). From the late 1800s through the early 1900s, Standard Oil Company controlled 85–95 percent of the oil refining business, until it was sued and broken up by the US Department of Justice (Yergin 2008). Other industries that have practiced horizontal integration include automobiles, steel, and cement.

BARRY D. SOLOMON

See also: Fossil fuels, Vertical integration, Market power, Market failure, Market imperfections.

References

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Yergin, D. 2008. The Prize: The Epic Quest for Oil, Money & Power. New York: Free Press.

Hotelling model

a. Introduced by Harold Hotelling (1931) to study exhaustible resources exploited by a perfectly competitive industry, monopolist, or social planner. In the formulation with perfect foresight in continuous time, the firm has a known initial stock of an exhaustible resource from which it will extract a quantity q_t at time t. Let the remaining stock at time t be x_t and let π_t be either the instantaneous profit earned from extracting q_t when the price of the extracted resource is p_t, if the optimizing agent is a firm, or let π_t be a social planner's instantaneous objective function. Let δ be the discount rate (a constant, although this can be generalized). The problem is to maximize discounted π_t:

$$\max_{(q(t))_{t=0}^{\infty}} \int_0^{\infty} \pi(p_t, x_t, q_t, t) e^{-'\mathrm{t}}\, dt$$

subject to $\dot{x}_t = -q_t$ where a raised dot denotes a time derivative, and $q_t \geq 0$ and $x_t \geq 0$ for all t.

The solution is called the "Hotelling rule." In an intertemporal perfectly competitive equilibrium, the firm takes the future price path as given, as if a (fictional) Walrasian auctioneer calculated the future price path which would induce the firm at each future moment to extract exactly the amount of resource which that price path would induce the consumers at that moment to purchase. Nicholas Georgescu-Roegen (1979, p. 101) wrote:

> Beautiful mathematical piece though [Hotelling's] article is, it set a fallacious pattern of approach to the economics of exhaustible resources … For quasi-immortal entities—such as a nation and especially mankind—discounting the future is wrong from any viewpoint … If all future utilities are treated alike, the beautiful solution reached by Hotelling is of no use anymore.

b. A model mathematically related to the one in Hotelling (1931). For example, filling the gap between the Earth's current level of thermodynamic entropy and its maximum/equilibrium level of entropy (Lozada 2017, working in terms of entropy changes not levels).
c. Hotelling's spatial location ("linear city") model, also applied to product differentiation and, under the name "Hotelling–Downs model," to political competition.

GABRIEL A. LOZADA

See also: Hotelling rule, Exhaustible resource theory, Non-renewable resource.

References

Georgescu-Roegen, N. 1979. "Comments on the papers by Daly and Stiglitz," pp. 95–105 in Scarcity and Growth Reconsidered. V. Kerry Smith, ed. Baltimore, MD: Resources for the Future/Johns Hopkins University Press.

Hotelling, H. 1931. The economics of exhaustible resources. Journal of Political Economy 39(2): 137–75.

Lozada, G.A. 2017. The Hotelling rule for entropy-constrained economic growth. Ecological Economics 133: 35–41.

Hotelling rule

a. Marginal profit or marginal social welfare rises at the rate of interest. This rule arises as the solution of the Hotelling model of exhaustible resource exploitation (Hotelling 1931) under simplified assumptions.

Optimal control theory's Hamiltonian for that problem is $H_t = e^{-\delta t}\pi(p_t, q_t, t) - \lambda_t q_t$ where λ_t is the adjoint variable, and where for simplicity the x dependence of π has been removed. Using asterisks to denote optimal quantities, optimal control theory's maximum principle says that the solution to this problem maximizes H_t over q_t for all t, and that $\dot{\lambda}_t^* = -\partial H_t^* / \partial x_t$ (raised dots denote differentiation with respect to time). The latter implies $\dot{\lambda}_t^* = 0$, hence λ^* is a constant. The former implies a Kuhn–Tucker complementary slackness condition; letting $M\Pi$ denote marginal profit $\partial\pi / \partial q$, one has $\partial H^* / \partial q = e^{-\delta t} M\Pi_t^* - \lambda^*$ and complementary slackness implies

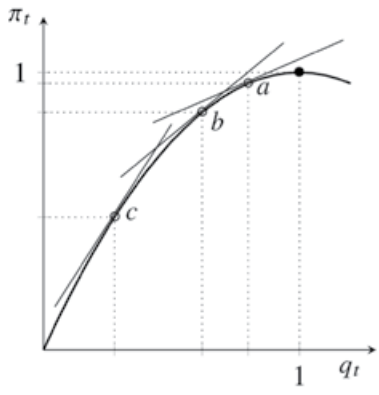
$$q_t^* \geq 0, e^{-\delta t} M\Pi_t^* - \lambda^* \leq 0, \text{ and } q_t^* \cdot \left(e^{-\delta t} M\Pi_t^* - \lambda^*\right) = 0.$$

If at date t, $q_t^* > 0$, then $e^{-\delta t} M\Pi_t^* - \lambda^* = 0$, so $M\Pi_t^* = \lambda^* e^{\delta t}$ or

$$M\Pi_t^* = M\Pi_0^* e^{\delta t} \Leftrightarrow \dot{M\Pi}_t^* / M\Pi_t^* = \delta \text{ if } M\Pi_t^* \neq 0,$$

which is the Hotelling rule.

During any intervals over which $q_t^* = 0$, as might happen when demand temporarily slumps, (2) need not hold and (1) would allow $M\Pi_t^*$ to fall below the $M\Pi_0^* e^{\delta t}$ path it follows when $q_t^* > 0$. If λ were equal to zero then $M\Pi_0 = 0$ and the first expression of (2) would imply that $M\Pi_t = 0$ for all t, which is not the traditional Hotelling rule, and instead is what static firms do, maximizing short-run profit, for example setting $q = 1$ in Figure 10. In Figure 10, the Hotelling rule has the firm instead extracting first at *a*, then *b*, then *c*, as marginal profit (the slope of the tangent line) rises at the rate of interest. Empirical attempts to confirm the Hotelling rule have generally failed (Slade & Thille 2009), and consideration should be given to the possibility that firms maximize short-run profit instead of following the Hotelling rule. Contrary to Solow (1974, p. 2), the Hotelling rule is not an asset market equilibrium condition, because the Hotelling rule describes optimal mine operation and asset market equilibrium does not require optimal mine



Note: Profit here can be called "rent" but therefore marginal profit should never be called "rent."
Source: Author.

Figure 10 Instantaneous profit versus quantity extracted (discrete-time example)

operation (see equation (3) of Lozada 1995).

b. The solution to a model resembling the Hotelling model of exhaustible resources.

GABRIEL A. LOZADA

See also: Hotelling model, Exhaustible resource theory, Non-renewable resource.

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Hotspots

a. A geographic concentration of high levels of air or water pollution, air toxins, radioactivity, or toxic wastes where exposed residents or workers may experience a higher risk of adverse health effects, including cancers. This may occur because of a high concentration of industrial emissions sources, heavy automobile or diesel truck traffic, a major industrial accident, or higher emission levels due to the purchase of tradable allowances or emission credits in an emissions trading system. The size and spatial distribution of hotspots varies but they are usually restricted to neighborhoods within highly populated urban areas, or areas surrounding industrial or mining sites. Hotspots raise significant environmental justice concerns but are difficult to address in practice.

b. Biogeographic regions with high levels of animal and/or plant biodiversity, primarily in developing countries in the Southern Hemisphere. The term "biodiversity hotspots" was coined by Norman Myers in the late 1980s (Myers 1989). Biodiversity hotspots provide high levels of ecosystem goods and services and are often threatened by human habitation and economic growth. In addition, biodiversity hotspots have lost at least 75 percent of their primary vegetation (Myers et al. 2000).

BARRY D. SOLOMON

Further reading

Zhang et al. 2008; Mittenmeier et al. 1998; Cincotta et al. 2000; Fisher & Christopher 2007.

See also: Biodiversity, Biodiversity indices, Ecosystem services, Pollution, Pollution abatement, Emissions trading, Tradable permits, Environmental justice.

References

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Household level

Sociology: a group of individual people physically and/or economically living together in one dwelling unit (such as a house or an apartment).

Economics: the place where household production and consumption take place. Household-level analysis focuses on the economic activities of the household, such as a relationship between household demographics and electricity consumption (Wu et al. 2021).

WENCHAO WU

See also: Social institutions, Microeconomics.

Reference

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Hubbert curve

A measure of the boom-and-bust cycles of resource production characterized by early exponential growth that peaks and then begins its depletion trajectory, based on the seminal work of M. King Hubbert (Hubbert 1956; Campbell & Laherrère 1998). The method uses Hubbert linearization to produce a bell-shaped curve based on differential equations (Hubbert 1980). Hubbert (1949) was a petroleum geologist and geophysicist who immersed himself in empirical data for the biophysical analysis of non-renewable energy resources. This led Hubbert to notice a bell curve of oil discoveries, which led him to predict that production must follow a similar path. He developed the pioneering "Hubbert curve," predicting the future availability of petroleum (Hubbert 1971). Hubbert (1956) initiated the discussion on conventional peak oil by forecasting a peak in 1970 (14 years after his prediction) for domestic oil production in the lower 48 United States states.

While a peak did occur in 1970, and production steadily fell until 2009, the old peak was surpassed in 2014, and ever since due to improved technologies such as hydraulic fracking and horizontal drilling that can exploit diffuse petroleum deposits. Fracked oil and other fossil fuels too will inevitably encounter a production peak (Hughes 2013; Heinberg 2014). Thus, technological advances merely delay depletion. Most ecological economists now believe that a reduction in fossil fuel use is more likely to result from sink constraints, due to the climate crisis, than from source constraints in the short term. However, depletion concerns for fossil fuels, water, phosphorus, and many other essential resources will continue to be a serious long-term problem unless we are able to bring our socio-economic systems within the levels that the biophysical world can sustain.

RIGO E.M. MELGAR

Further reading

Capellán-Pérez et al. 2014.

See also: Peak oil supply, Depletion, Fossil fuels, Non-renewable resource, Sinks, Sources.

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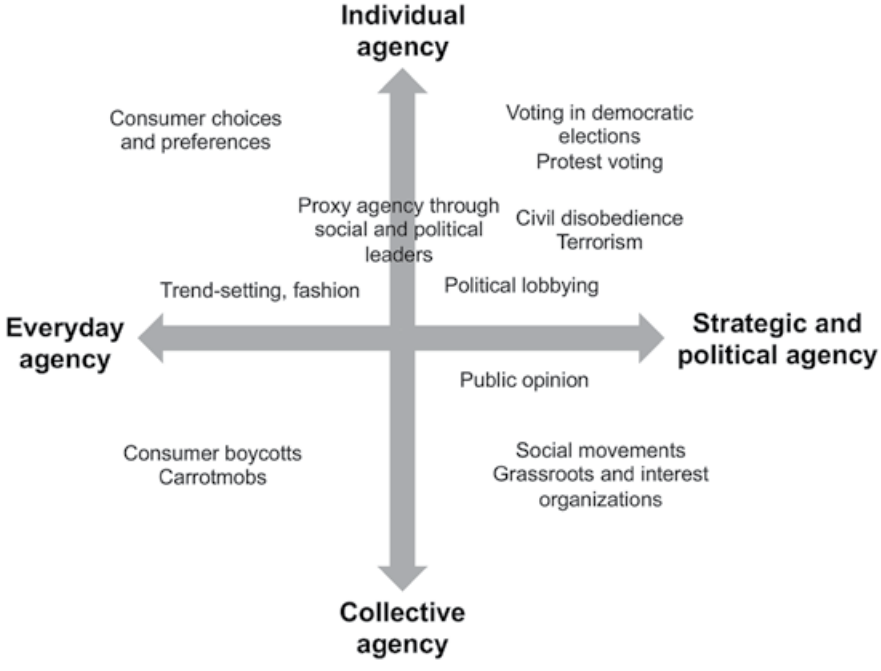
Human agency

The capacity possessed by human actors either individually or collectively to affect the fate of events and processes. In the governance of the Earth system (from Dellas et al. 2011) agency is referred to as the capacity to act in the face of Earth system transformation or to produce effects that ultimately shape natural processes. Two dimensions of agency are distinguished (Lister 2003; Coulthard 2012): (1) "everyday agency," being daily decision-making, and "strategic agency" involving long-term planning; and (2) "personal agency," which reflects individual choices, and "political and citizenship



Source: Authors.

Figure 11 Dimensions of human agency

agency" which is related to the capacity of people to affect wider change (see Figure 11).

Jordan P. Everall & Ilona M. Otto

Further reading

Otto et al. 2020.

See also: Resilience, Tipping point, Environmental governance, Autonomous institution.

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Human appropriation of net primary production (HANPP)

An aggregated indicator that measures to what extent land conversion and biomass harvest affect flows of trophic energy (biomass) in ecosystems, namely net primary production (NPP). HANPP is commonly defined (from Haberl et al. 2014) as the difference between the NPP of the natural vegetation thought to exist in the absence of land use, that is, the NPP of potential natural vegetation, and the fraction of NPP remaining in the ecosystem after harvest under current conditions. The current global average is around 25 percent. HANPP is referred to as a measure of the scale of human activities compared to natural processes.

Fridolin Krausmann

Further reading

Vitousek et al. 1986; Daly 1991.

See also: Net primary production (NPP), Biomass, Resource base.

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Human capital

An intangible asset that is the stock of education, training, knowledge, skills, and experience of an individual or group of people. A larger stock of human capital is thought to result in a higher level of labor productivity and economic output and value, and thus investment in it is encouraged. The concept of human capital dates to Adam Smith in the 18th century, while the modern theory was popularized by neoclassical economists such as Gary Becker (2009), Jacob Mincer (1993) and Theodore Schultz (1972).

Barry D. Solomon

See also: Human development, Human Development Index (HDI), Capital, Social capital.

References

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Human development

The term "development" having historically been attributed polysemic and dissimilar meanings, the "human development" discourse emerged in the early 1990s as a critique of unidimensional (economic-based and state-centric) development, while simultaneously acknowledging the multidimensionality of human well-being, giving a central role to freedom of choice and public deliberation in its definition and assessment, as is evident from the slogan of the United Nations Development Programme (UNDP): "development of the people, by the people, for the people." Its roots lie in the "capabilities approach" of Amartya Sen and Martha Nussbaum, whereby development is conceived as the removal of several forms of "unfreedom" or lack of capacity to choose (Sen 1989, 1999; Nussbaum & Sen 1993; Nussbaum 2000).

The concept has been criticized, however, for foreclosing or marginalizing conceptions of well-being beyond a Western, liberal political and economic framework (Selwyn 2014; Shrivastava & Kothari 2012; Walsh 2010), which could offer essential clues in the search of socio-ecologically sustainable futures (Beling et al. 2018). Human development has since permeated mainstream development thinking and policy internationally, as it became strongly associated with the work of the UNDP, and the publication of its flagship annual reports (e.g., UNDP 2021).

Adrian E. Beling

See also: Well-being economy, Objective well-being, Subjective well-being, Development, Post-development, United Nations Development Programme (UNDP), Human Development Index (HDI), Buen vivir, Discourse analysis.

References

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Human Development Index (HDI)

A statistical composite index, based on both qualitative and quantitative data, measuring the aggregation of three essential dimensions of human development: (1) a long and healthy life (measured by life expectancy at birth); (2) being knowledgeable (measured by mean of years of schooling completed and expected years of schooling); and (3) a decent standard of living (measured by gross national income, GNI per capita, expressed in power purchasing parity dollars, PPP $).

The HDI was introduced by the United Nations Development Programme in 1990, based on the early works of Mahbub ul Haq and Amartya Sen (see, e.g., ul Haq 1995; Sen 1993, 1999) on human beings and their capabilities, as the ultimate criteria for assessing the development of a country, beyond economic growth (UNDP 1990).

Panos Kalimeris

See also: Human development, Gini index, Index of sustainable economic welfare (ISEW), Genuine progress indicator (GPI).

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Human ecology

The study of the interrelationships between human societies and their environment. Some approaches consider only the natural environment, while others include the social and urban environments. Human ecology is an interdisciplinary field that may draw upon natural ecological and Earth system processes, environmental management, resource use and policy, cultural ecology, anthropology, archeology, geography, sociology, psychology, economic history, and the history and philosophy of environmental change (Dyball & Newell 2014).

Mark O. Diesendorf

See also: Human–nature relationships, Environmental management, Global change, Social ecology, Urban ecology, Sustainability.

Reference

Dyball, R. & Newell, B. 2014. Understanding Human Ecology: A Systems Approach to Sustainability. London: Routledge.

Human–ecosystem interaction

See: Human–nature relationships.

See also: Ecosystem, Coupled system dynamics.

Human health

Building on the 1948 definition from the Constitution of the World Health Organization, which refers to a "state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity," this term is increasingly refined to recognize that wellness is a dynamic process, with ecosystem health and social determinants of health as major components to it (Ryff & Singer 1998).

Laura Orlando, James C. Aronson, Adam T. Cross & Neva R. Goodwin

See also: Public health, Ecosystem health, Ecohealth, One health, Objective well-being, Matrix of human needs.

Reference

Ryff, C.D. & Singer, B. 1998. The contours of positive human health. Psychological Inquiry 9(1): 1–28.

Human-made capital

See: Manufactured capital.

See also: Capital, Natural capital.

Human nature

The fundamental psychological characteristics and traits of humans, including ways of thinking, feeling, beliefs, and behavior towards other people, institutions, and nature that humans have naturally, as opposed to being the result of learning or socialization. This concept is controversial, since the existence and nature of such an essence is contested (Hannon & Lewens 2018).

Barry D. Solomon

See also: Nature, Natural, Environment.

Reference

Hannon, E. & Lewens, T., eds. 2018. Why We Disagree About Human Nature. Oxford: Oxford University Press.

Human–nature relationships

A general umbrella term for a wide array of concepts and areas of study that address interactions between humans and the rest of the biosphere. Also called human–ecosystem interaction. Prominent examples of concepts of human–nature relationships are connectedness to nature, sense of place, ecosystem services, and (more recently) relational values and the "relational turn" in sustainability science (IPBES 2019; West et al. 2020). These concepts address many aspects of human–nature relationships, including material aspects (for example, food provision), non-material aspects (for example, sacredness of places), and the many ways that material and non-material entities intertwine. Diverse disciplines and fields contribute to the study of human–nature relationships (examples include psychology, geography, anthropology, religious studies, philosophy, economics, livelihood studies, environmental education; see Ives et al. 2017). An important critique of this term is that it perpetuates and reifies a separation between humans and nature; a separation that is inconsistent with many worldviews (for example, many Indigenous worldviews) and relatedly is difficult to translate into many languages (Coscieme et al. 2020).

RACHELLE K. GOULD

See also: Nature, Ecosystem services, Relational values, Sustainability science.

References

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Human needs assessment

A process to assess, evaluate, and provide a basis to improve a person or communities' well-being based on the ability to satisfy fundamental human needs. Typical approaches to human needs assessment involve an analysis to establish how human needs are currently being satisfied for the select community.

Human needs theorist Manfred Max-Neef (1991) proposed a reflexive, participatory process of needs assessment through identifying satisfiers of the target community using his proposed matrix as a guiding tool. Through participatory consultation, communities can diagnose their current situation, identify an idealized or utopian scenario, and then establish pathways to reach this desired visualization. An alternative to the human needs approach is the capabilities approach (as advocated by Amartya Sen; see Sen 1985, 1993).

REBECCA K.M. CLUBE

Further reading

Guillen-Royo 2016.

See also: Matrix of human needs, Objective well-being, Subjective well-being.

References

Max-Neef, M. 1991. Human Scale Development: Conception, Application and Further Reflection. London: Apex Press.

Guillen-Royo, M. 2016. Sustainability and Wellbeing: Human-scale Development in Practice. Oxford: Routledge.

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Human rights

Rights that every individual is entitled to as a human being, regardless of nationality, sex, ethnicity, color, religion, language, or any other status; for example, the right to life, freedom from torture and discrimination, and freedom of expression. Human rights are enshrined in the Universal Declaration of Human Rights (UN General Assembly 1948) and are recognized to be universal, inalienable, and indivisible. A subset of human rights—for example, the right to food, housing, education, health, social security, water and sanitation, fair wages, and equal remuneration for work of equal value, irrespective of gender, orientation, and racial identities (collective, economic, and social rights)—require proactive action from states, civil society, and market actors. The climate crisis threatens fundamental human rights (Shue 2019).

Social and environmental activists often use the institutional and legal infrastructure of human rights to critique the extractive and exploitative models of economic development, leading to environmental destruction and human rights violation. The International Labour Organization (ILO) Convention 169 (1989), the United Nations (UN) Declaration on Rights of Indigenous People (2007), the UN Declaration on the Rights of Peasants and Other People Working in Rural Areas (2018), and regional agreements—for example, the Escazú Agreement—bolster such activism. In October 2021 the Human Rights Council (a United Nations body) recognized the right to a safe, clean, healthy, and sustainable environment as a human right (UN 2021). A group of legal experts are demanding that ecocide be declared a crime against humanity (Higgins et al. 2013).

Prakash Kashwan & Malayna Raftopoulos

Further reading

Hiskes 2009; Engle 2011; Boyd 2019; Raftopoulos and Morley 2020; Kashwan et al. 2021.

See also: Rights, Indigenous rights, Environmental rights, Ecocide.

References

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UN General Assembly. 1948. The Universal Declaration of Human Rights. Paris: United Nations. http://www.un.org/en/documents/udhr/.

Hysteresis

a. A phenomenon in economics when, after a shock, a variable does not return to its initial value even after the cause of the shock has gone away (Blanchard 2021, p. 184).
b. The dependence of economic behavior on its history. Hysteresis is considered a stronger and specific form of path dependence, where earlier states of a system or behavior affect later ones.

Economists have attributed the cause for the continuation of certain phenomena after their initial causes have disappeared to hysteresis. For example, in labor economics, some economists refer to hysteresis in trying to understand the cause of long-lasting unemployment rates in numerous countries after a recession (O'Shaughnessy 2011, p. 312). In ecological economics, hysteresis has been incorporated into analysis of why farmers continue to use pesticides despite their high costs (Wilson & Tisdell 2001), and of the environmental Kuznets curve by the incorporation of pollution stock effects (Ranjan & Shortle 2007).

Oluwaseun A. Odusola

Further reading

Setterfield 2008.

See also: Stationarity, Non-stationarity, Path dependence, Labor markets, Environmental Kuznets curve (EKC), Stocks.

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Wilson, C. & Tisdell, C. 2001. Why farmers continue to use pesticides despite environmental, health and sustainability costs. Ecological Economics 39(3): 449–62.

I

Impact assessment

The process of identifying the future consequences of a current or proposed action (Becker 1997). "Impact assessment" is used mostly in the context of environmental impact assessment (EIA), environmental and social impact assessment (ESIA), cumulative impact assessment (CIA), transboundary impact assessment (TIA), and strategic impact assessment (SIA). These are legally and usually procedurally well-defined instruments for identifying impacts likely to arise due to a given project (EIA, ESIA); assessing all the projects in a given region, for example, along one river (CIA); projects in an international context, for example, international rivers, highways, or railroads (TIA); or development plans or strategies (SIA).

Impact assessments include identification of impacts and their importance, as well as avoidance, mitigation, and compensation measures and, to the extent possible, costs of impacts and measures. The assessment studies serve as the basis for deciding whether a project is acceptable from an environmental and social point of view—that is, in compliance with the respective legislation and standards—and to define the mitigation measures to be taken.

ROBERT ZWAHLEN

Further reading

Schrage & Bonvoisin 2008.

See also: Impact assessment models, Benefit–cost analysis (BCA), Environmental assessment, Environmental impact assessment, Environmental impact assessment tools, Mitigation, Compensability.

References

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Impact assessment models

Models that estimate the environmental, economic, social, health, and/or sustainability impacts of policy proposals and projects. There are a large range of such models, for example, air dispersion models, ecological models, hydrological models, general circulation models, ecological footprint analysis, econometric models, input–output models, general equilibrium models, system dynamics models, life-cycle analysis, optimization models, among many others.

BARRY D. SOLOMON

Further reading

Morgan 2012; OECD 2014.

See also: Impact assessment, Models and modeling, Climate, Environmental impact assessment, Ecological footprint, Econometrics, Benefit–cost analysis (BCA), Input–output (I–O) analysis, General equilibrium model, System dynamics models, Risk assessment, Life-cycle assessment (LCA), Decision-oriented optimization models.

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Impairment

Human health: temporary or permanent decrease in a person's previous level of ability or functioning, which can be physical (for example, physical impairment due to stroke or other diseases) or mental (for example, dementia, lack of motivation due to depression, and so on). Often physical and mental impairment go hand in hand, as physical causes influence mental ones, and vice versa.

Ecology:

a. Ecosystems, landscapes, or species are impaired if their condition has departed from a healthy or an acceptable state in a way that is ecologically or socially significant.
b. A water body is impaired if it fails to meet one or more government water quality standards, for example, drinkable, fishable, swimmable, boatable, due to pollution.

CHRISTIAN KREKEL

Further reading

Gautheir et al. 2006; Putnam 2002; Zweifel & Tyran 1994; Sharpley et al. 2013.

See also: Environmental degradation, Pollution, Polluted.

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Zweifel, P. & Tyran, J.R. 1994. Environmental impairment liability as an instrument of environmental policy. Ecological Economics 11(1): 43–56.

Implicit cost

See: Opportunity cost.

See also: Non-market value, Shadow price.

Impoverishment

a. The state of being poor or deprived of quality. Poverty is a relative concept that generally means having little money but can also denote a depletion of physical qualities such as soil fertility or biological diversity. Whether referring to money or other resources, it indicates a less than optimal condition that has deteriorated because of economic or other processes.
b. The act of making someone or something poor or deprived of quality. Processes of economic or ecological impoverishment may result from social relations of exchanges that deprive some people of money or resources. Dominant explanations of impoverishment are offered by Marxism, dependency theory, world-system analysis, and the theory of ecologically unequal exchange. Although they have different points of departure regarding the relation between economic value and biophysical resources, these approaches share a focus on how the organization of exchange causes asymmetric transfers of value or resources between social groups.

ALF HORNBORG

Further reading

Emmanuel 1972; Frank 1967; Hornborg 2011; Wallerstein 2011.

See also: Poverty, Exploitation, Ecologically unequal exchange, Overexploitation.

References

Emmanuel, A. 1972. Unequal Exchange: A Study of the Imperialism of Trade. New York: Monthly Review Press.

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Incentive compatibility

A property that characterizes a mechanism in which no participant can manipulate the process to their own advantage by behaving untruthfully, and each participant can achieve the best outcome by acting according to the truth (Hurwicz 1972). In ecological economics, the concept has been used particularly to describe a desired characteristic of stated preference value elicitation surveys. In an incentive-compatible value elicitation question, it is in a respondent's best interest to disclose their true preferences.

Conditions for assuring incentive compatibility in a stated preference survey concerning a public good include the following: (1) respondents understand the question and the value elicitation mechanism; (2) respondents care about the outcome; (3) the authority can actually provide the good and enforce payments from the concerned population; (4) respondents' answers can affect the authority's decision on the good provision; and (5) the preference elicitation involves a yes–no answer on a single good (Carson & Groves 2007). Recent research suggests additional conditions upon which other value elicitation formats are incentive compatible, such as a sequence of yes–no answers (Vossler et al. 2012), a payment card, and an open-ended question (Vossler & Holladay 2018).

Ewa Zawojska

See also: Contingent valuation method (CVM), Conjoint analysis, Stated preference methods, Consequentialism.

References

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Hurwicz, L. 1972. "On informationally decentralized systems," pp. 297–336 in Decision and Organization. C.B. McGuire & R. Radner, eds. Amsterdam: North-Holland.

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Income distribution

Classical economics: the division of total national income between citizens of a country. The classical economists viewed income distribution as the division of income between factors (inputs) involved in production (thus functional income).

Neoclassical economics: a division of national income between individuals and households. Metrics have been developed to measure income inequality in societies; a growing problem in the distribution of income in most countries. Commonly used metrics include the Gini coefficient, and the concentration of income at the top of the distribution, such as the percentage of income in the highest decile.

Ecological economics: how a country's wealth of biodiversity and ecosystems (services and benefits) is distributed or accessible to its citizens. It could be functional distribution of services and benefits (among factors of production: land, labor, and capital) as per the classical economics thinking, or it could be distribution between individuals and households as per the neoclassical economics thinking (Black et al. 2009; Martínez-Alier 1995). Whatever form it takes, the most important issue is how this wealth supports ecological life now and in the future.

Jane Kabubo-Mariara & Richard Mulwa

Further reading

Smith 1776 [1977].

See also: Economic inequality, Lorenz curve, Gini index, Wealth, Wealth distribution, Income effects.

References

Black, J., Hashimzade, N. & Myles, G. 2009. "Income distribution," in A Dictionary of Economics, 3rd edn. Oxford: Oxford University Press.

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Smith, A. 1776 [1977]. An Inquiry into the Nature and Causes of the Wealth of Nations. Chicago, IL: University of Chicago Press.

Income effects

Neoclassical economics: the change in consumer demand for and consumption of market goods and services, resulting from a change in an individual's purchasing power due to a change in real income or relative market prices.

Ecological economics: the change in consumer demand for ecological goods and services, resulting from a change in an individual's purchasing power due to a change in real income, results from changes in the prices of ecological goods and services.

Jane Kabubo-Mariara & Richard Mulwa

Further reading

O'Sullivan & Sheffrin 2003; Huhtala 2010.

See also: Total income, Income distribution, Demand, Derived demand.

References

Huhtala, A. 2010. Income effects and the inconvenience of private provision of public goods for bads: the case of recycling in Finland. Ecological Economics 69(8): 1675–81.

O'Sullivan, A. & Sheffrin, S.M. 2003. Economics: Principles in Action, 2nd edn. Hoboken, NJ: Pearson Prentice Hall.

Income inequality

See: Economic inequality.

See also: Inequality, Inequity.

Incommensurable

Two or more norms or goods and services (for example, market versus environmental) that can be measured or valued, but not in the same units, and thus cannot be compared to each other (Martínez-Alier et al. 1998; Lejano et al. 2019). Sometimes also called incomparable. For example, some ecological economists consider natural capital and environmental or ecosystem goods and services to be incommensurable with market goods and services, while many others conduct research to monetize ecosystem services.

Joan Martínez-Alier

Further reading

Aldred 2013; Martínez-Alier 2022; Allain & Salliou 2022.

See also: Incommensurable values, Pluralism.

References

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Allain, S. & Salliou, N. 2022. Making differences legible: incommensurability as a vehicle for sustainable landscape management. Ecological Economics 191: 107240.

Lejano, R.P., Newbery, N., Ciolino, M. & Newbery, D. 2019. Sustainability and incommensurability: narrative policy analysis with

application to urban ecology. Ecological Economics 164: 106348.
Martínez-Alier, J. 2022. Circularity, entropy, ecological conflicts and LFFU. Local Environment. 27(10–11): 1182–1207.
Martínez-Alier, J., Munda, G. & O'Neill, J. 1998. Weak comparability of values as a foundation for ecological economics. Ecological Economics 26(3): 277–86.

Incommensurable values

Two or more values that cannot be reduced to a common metric; for example, freedom, security, democracy, equality, ecological, cultural (Martínez-Alier et al. 1998; Lejano et al. 2019). Incommensurable values raise moral dilemmas and questions regarding the plausibility of utilitarianism and the foundations of liberalism. In a practical sense, questions of incommensurable values are often raised in the application of benefit–cost analysis for policies and projects that have significant environmental impacts.

Joan Martínez-Alier

Further reading

Aldred 2013; Martínez-Alier 2022; Allain & Salliou 2022.

See also: Incommensurable, Pluralism, Utilitarianism, Liberal individualism, Benefit–cost analysis (BCA).

References

Aldred, J. 2013. Justifying precautionary principles: incommensurability and uncertainty. Ecological Economics 96: 132–40.
Allain, S. & Salliou, N. 2022. Making differences legible: incommensurability as a vehicle for sustainable landscape management. Ecological Economics 191: 107240.
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Index of sustainable economic welfare (ISEW)

An alternative measure of economic welfare to evaluate economic performance in a broader way than the gross domestic product (GDP), and to replace it. Developed by Herman Daly and John Cobb in the late 1980s (Daly & Cobb 1989). It specifically serves as a tool to "debunk" GDP as a measure and as the dominant economic goal (Ziegler 2007). The ISEW and its variant, the genuine progress indicator (GPI), are macroeconomic monetary welfare indicators that measure the benefits and costs of economic activity. On the benefit side, these indicators typically value the contributions from the market, the state, the shadow economy and unpaid household care, and volunteer work. In this regard, input values are used to estimate welfare such as individual consumption expenditures, collective government expenditures, estimates for unpaid work, and the shadow economy.

Some deductions are made to the ISEW because not all consumption is beneficial to welfare. Defensive expenditures (from Leipert 1989), such as insurance expenditures, are deducted because they are intermediate expenses made to protect oneself from adverse, future impacts of economic production. Moreover, consumption expenditures are adjusted to account for the principle of diminishing marginal utility of income since an extra euro of income gives less satisfaction to people with high incomes than it does to people with low incomes. On the cost side, the social costs (for example, cost of road accidents) and ecological costs such as from air pollution, climate change, and non-renewable resource depletion, are deducted to account for the costs caused by economic activity.

Jonas Van der Slycken

Further reading

Kubiszewski et al. 2013; Lawn 2003; Talberth & Weisdorf 2017; Van der Slycken 2021.

See also: Genuine progress indicator (GPI), Defensive expenditures, Gross domestic product (GDP), Economic growth, Welfare.

References

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Leipert, C. 1989. National income and economic growth: the conceptual side of defensive expenditures. Journal of Economic Issues 23(3): 843–56.

Talberth, J. & Weisdorf, M. 2017. Genuine Progress Indicator 2.0: pilot accounts for the US, Maryland, and city of Baltimore 2012–2014. Ecological Economics 142: 1–11.

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Ziegler, R. 2007. Political perception and ensemble of macro objectives and measures: the paradox of the Index of Sustainable Economic Welfare. Environmental Values 16(1): 43–60.

Indicators

Quantitative variables that are used to measure current conditions and/or forecast trends, which can provide a broader, qualitative index, gauge, or barometer of the state or trend of a system, or of environmental or social conditions. State, pressure, and impact indicators have been developed. Applications for which a variety of indicators are commonly reported and used include economic, ecological, biodiversity, environmental, scarcity, progress, and sustainable development.

BARRY D. SOLOMON

Further reading

Frumkin 2006; Niemi & McDonald 2004; Norgaard 1990; Nordhaus & Kokkelenberg 1999.

See also: Environmental indicators, Ecological indicators, Economic indicators, Scarcity indicators, Progress indicators.

References

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Nordhaus, W.D. & Kokkelenberg, E.C. 1999. Nature's Numbers: Expanding the U.S. National Economic Accounts to Include the Environment. Washington, DC: National Academies Press.

Norgaard, E.B. 1990. Economic indicators of resource scarcity: a critical essay. Journal of Environmental Economics and Management 19(1): 19–25.

Indicator species

An organism whose characteristics (for example, presence or absence, population density, dispersion, reproductive success) are used as an index of attributes too difficult, inconvenient, or expensive to measure for other species or ecological or environmental conditions of interest (Landres et al. 1988).

SHELLY A. JOHNSON

Further reading

Caro & O'Doherty 1999.

See also: Ecological indicators, Environmental indicators, Keystone species, Conservation biology, Wildlife conservation.

References

Caro, T.M. & O'Doherty, G. 1999. On the use of surrogate species in conservation biology. Conservation Biology 13(4): 805–14.

Landres, P.B., Verner, J. & Thomas, J.W. 1988. Ecological use of vertebrate indicator species: a critique. Conservation Biology 2(4): 316–28.

Indigenous communities

a. All visible, invisible, physical, spiritual, human, and non-human beings that coexist and interact in a given territory. The territory is the vital space and essential condition for the existence of the community. Indigenous communities are sometimes also called indigenous peoples, first peoples, first nations, aboriginal peoples, native peoples, indigenous natives, autochtonous peoples, and endemic populations. The indigenous community is the territory itself: Mother Earth provides life, oxygen, water, food, knowledge, medicine, and shelter for this community of all beings.
b. The different beings that inhabit the territory and make up the community (that is, spirits, humans, animals, and plants) have their own forms of organization and sources of authority based on the duty to preserve this territorial harmony. Indigenous communities are often defined in relation to their human cultures, languages, autonomy, socio-political organization, and ways of thinking.

Sonia Mutumbajoy Hurtado & Iván D. Vargas Roncancio

Further reading

Coria & Calfucura 2012; Lewis & Sheppard 2006; Vargas Roncancio & Chindoy Chindoy 2021.

See also: Indigenous rights, Indigenous knowledge, Native, Autonomous institution.

References

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Indigenous knowledge

Knowledge that combines the accumulated wisdom of generations that have integrated their understandings of the way in which societies interact with their surroundings and an inherited cosmogony. Useful innovations are increasingly incorporated into these systems. Indigenous knowledge is increasingly recognized as crucial for conservation and planetary stewardship. The long histories of indigenous peoples and local communities' place-based living and time-honored traditions generated intricate and complex systems of knowledge about the world around them. Indigenous peoples number hundreds of millions worldwide and occupy more than one-quarter of the globe. They are generally organized into communities with common cultural and linguistic roots; their diversity creates multiple ways of valuing nature. Sometimes their relationships with the nation-states within which they live are codified in treaties with the colonial powers that invaded their territories, allowing them to transform this accumulated wisdom into autonomous institutions for governing themselves, for attempting to provide for their needs, and for caring for their territories.

The United Nations Declaration on the Rights of Indigenous Peoples (UN 2007) extended this protection globally. Their stewardship functions continue to effectively assure that their territories are the best-protected regions of biodiversity and forest landscapes on the planet (Garnett et al. 2018; Fa et al. 2020). Today, indigenous scholars are increasingly articulate about the importance of recognizing that this multidimensional indigenous knowledge offers alternative understandings of the world's social and ecosystems. In the process, they are developing decolonial epistemologies that require different intellectual and philosophical frameworks.

David P. Barkin

Further reading

Smith 2012; Wolf 1982; Boege 2008; Fernández-Llamazares et al. 2021; FAO et al. 2021.

See also: Autonomous institution, Indigenous rights, Indigenous communities, Traditional knowledge.

References

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FAO (Food and Agriculture Organization of the United Nations), Alliance of Biodiversity International & CIAT (International Center for Tropical Agriculture). 2021. Indigenous Peoples' Food Systems: Insights on Sustainability and Resilience from the Front Line of Climate Change. Rome: FAO.

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Wolf, E.R. 1982. Europe and the People Without History. Berkeley, CA: University of California Press.

Indigenous rights

Rights that exist based on specific conditions of indigenous peoples.

a. From the moment we are born there are rights and duties of care for Mother Earth. These include the rights to a territory, cultural identity, and local language, which are pre-existent to any state recognition and inherent to them are duties of care and protection: we are *wuasikamas* or guardians of the Earth. Although some indigenous rights have been recognized by the modern state in the context of historical and ongoing political struggles of local communities, these rights exist prior to any national or supra-national legal recognition. For example, based on indigenous legalities in the Andean Amazonian context—particularly the Inga community—rather than "rights," it may be preferable to speak of "responsibilities" and "duties" of care and respect for Mother Earth and her visible and invisible beings.
b. The exercise of self-government, recognition of traditional authorities, traditional forms of justice, and prior consultation of local communities before decisions are made affecting them. Some of these rights and ensuing responsibilities have emerged in the context of complex relationships between local communities and the modern state; for example, the right to prior consultation. Although the rights predate the state, their recognition has helped to protect the territory in the integrity of its cultural and ecological relations, thus providing a form of political-normative shield against the impacts of colonialism, development, extractivism, and the abuse of political power.

Iván D. Vargas Roncancio & Sonia Mutumbajoy Hurtado

Further reading

Xanthaki 2007; Corntassel 2008; Vargas Roncancio & Chindoy Chindoy 2021.

See also: Indigenous communities, Indigenous knowledge, Rights, Human rights, Environmental rights, Common law, Extractivism.

References

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Xanthaki, A. 2007. Indigenous Rights and United Nations Standards: Self-Determination, Culture. Cambridge: Cambridge University Press.

Indirect effects

Economics: the effects of business-to-business purchases in the supply chain that stem from an initial industry input purchase or investment, such as increased economic output and employment. Commonly measured through input–output (I–O) analysis and economic simulation models (for example, econometric and computable general equilibrium models).

Ecology: interactions between connected species through loops and webs that can occur through chains of direct species interactions, including predation and interference competition. For example, a healthy gray wolf population in northern Minnesota helps to control the local deer population, which indirectly leads to more ground-nesting birds due to improved habitat. Overall, the importance of different types of indirect effects in ecological communities is not well understood (Strauss 1991; Wootton 1994).

Climate change: increased global warming leading to sea level rise, melting glaciers, ocean acidification, more extreme and variable weather patterns, loss of biodiversity, increased pests, pathogens, diseases and health problems, and displacement of vulnerable populations.

Barry D. Solomon

Further reading

Miller & Blair 2009; Heer & Maussner 2009; Intergovernmental Panel on Climate Change 2014.

See also: Commodity supply chain, Supply chain management, Input–output (I–O) analysis, Econometrics, General equilibrium model, Systems-oriented simulation models, Species, Ecological perturbation, Climate change.

References

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Strauss, S.Y. 1991. Indirect effects in community ecology: their definition, study, and importance. Trends in Ecology and Evolution 6(7): 206–10.
Wootton, J.T. 1994. The nature and consequences of indirect effects on ecological communities. Annual Review of Ecology and Systematics 25: 443–66.

Indirect energy

Energy: a process, activity, consumption pattern, and so on, usually requires energy directly, such as gasoline or diesel in the fuel tank, natural gas in the furnace, electricity to the refrigerator. In addition, indirect energy is almost always required somewhere in the upstream extraction–conversion–transmission chain. This will include the energy required to make equipment, build, and operate factories, and so on. Indirect energy use can be large compared with direct. For example, roughly half the energy to support a typical United States household's lifestyle is "embodied" in food, housing, clothing, education, the beyond-fuel costs of the automobile, entertainment, haircuts, travel, yoga classes, and so on.

While research on indirect energy has produced interesting and useful results, the details retain classic and vexing issues of system boundaries in space, time, and concept. For example, should Americans count the energy burned in China to make their consumer goods, or the energy required to decommission a new nuclear power plant after 40 years of operation? How should we allocate roadbuilding and maintenance energy between trucks and cars?

Public Policy: while there is no optimizing principle except for a general thrust that using less energy is better (all else being equal),

accounting for indirect energy can connect desired consumption patterns for all goods and services to their total energy requirement, which is useful for energy planning. An application of indirect energy is for net energy analysis or net carbon analysis, which compares energy inputs with the energy produced by a coal mine, solar power panel, wind turbine, and so on (Herendeen 2004a).

ROBERT A. HERENDEEN

Further reading

Herendeen 2004b.

See also: Energy, Energy intensity, Emergy, Embodied energy, Energy analysis, Net carbon, Net zero carbon

References

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Individual choice

a. A cornerstone of liberalism, which emphasizes the essential role of autonomous choice in fostering individual and societal well-being, independent of the social and environmental context in which individuals make decisions.
b. One of the central tenets of mainstream economic theory. It is often referred to as rational choice, which leads individuals to select options that maximize their self-interested preferences. In the aggregate, the total of self-interested individual actions is argued to benefit society (as in Adam Smith's invisible hand; Smith 1776 [1977]).

Notable winners of the Sveriges Riksbank Prize in Economic Sciences, such as Herbert Simon (1955), Amartya Sen (1977), and Elinor Ostrom (1998), among others, have been critical of the rational choice foundation of economic theory due to its restrictive view of individual motivation (such as its failure to explain voluntary contributions to public goods that do not maximize an individual's welfare), and for its limited capacity to address complex social dilemmas (such as its inability to solve collective action problems such as climate change).

QUENTIN DUROY

Further reading

Creutzig 2020.

See also: Individualism, Liberalism, Liberal individualism, Collective action, Rational choice.

References

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Smith, A. 1776 [1977]. An Inquiry into the Nature and Causes of the Wealth of Nations. Chicago, IL: University of Chicago Press.

Individualism

a. A philosophical and political ideology closely associated with classical liberalism and neoliberalism, according to which individual action is exogenous, and foundational, to the social structure in which it takes place.
b. A doctrine which focuses on the individual as the central unit of analysis in social science research. In economics the term is synonymous with the concept of methodological individualism coined by Joseph Schumpeter (1909), at the turn of the 20th century. In its strictest definition methodological individualism (as applied in microeconomic theory and Austrian School economics, for instance),

asserts that social phenomena are fully reducible to individual actions. In the context of environmental governance, this doctrine has led to the contested argument that liberal reforms emphasizing the role of individual responsibilities and market-based approaches are sufficient to solve local and global environmental issues.

QUENTIN DUROY

Further reading

Ciplet & Timmons Roberts 2017; Witztum 2012; Oliveira & Suprinyak 2018.

See also: Individual choice, Liberalism, Liberal individualism, Neoliberalism, Austrian School of economics.

References

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Individual transferable quotas (ITQs)

A market-based fisheries regulation. In individual transferable quota (ITQ) systems, individual fishing operations are allocated a share of the total allowable catch, which they can lease out within a year or permanently transfer for future fishing seasons. As these entitlements closely resemble private property rights, ITQs are perceived as a tool to privatize access to fisheries.

MAARTJE OOSTDIJK

Further reading

Moloney & Pearse 1979; Christy 1973; Squires et al. 1995; Sumaila 2010; Arnason 2013.

See also: Total allowable catch (TAC), Environmental policy instruments, Depletion, Fishery, Stocks, Maximum sustainable yield, Common pool resources.

References

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Moloney, D.G. & Pearse, P.H. 1979. Quantitative rights as an instrument for regulating commercial fisheries. Journal of the Fisheries Research Board of Canada 36(7): 859–66.

Squires, D., Kirkley, J. & Tisdell, C.A. 1995. Individual transferable quotas as a fisheries management tool. Reviews in Fisheries Science 3(2): 141–69.

Sumaila, U.R. 2010. A cautionary note on individual transferable quotas. Ecology and Society 15(3): 36.

Induction

From epistemology, the question of whether we can induce from a series of similar observations or data that the next one will be the same. Similarly, inductive reasoning is where the premises of an argument support a particular conclusion but do not ensure or prove it. In ecological economics, the use of induction has been discussed by Bromley (2008), Ramos-Martin (2003), Forstater (2004), and Pezzey (Pezzey & Burke 2014), among others.

BARRY D. SOLOMON

See also: Epistemology, Epistemological bias, Methods, Scientific method.

References

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ecological economics. Ecological Economics 51(1–2): 17–30.
Pezzey, J.C.V. & Burke, P.J. 2014. Towards a more inclusive and precautionary indicator of global sustainability. Ecological Economics 106: 141–54.
Ramos-Martin, J. 2003. Empiricism in ecological economics: a perspective from complex systems theory. Ecological Economics 46(3): 387–98.

Industrial ecology

A multidisciplinary and transdisciplinary field of study that borrows concepts and techniques from systems ecology, systems dynamics modeling, engineering, toxicology, ecological economics, sociology, among others, to study material and energy flows ("industrial metabolism") through industrial systems. The start of the field is usually considered to be the publication of the seminal paper by Frosch and Gallopoulos (1989). A major concern of industrial ecology is the transformation of industrial processes from open loop to closed loop systems where "wastes" can become inputs for new industrial processes.

JEAN-BAPTISTE BAHERS

Further reading

Erkman 1997; Ayres & Ayres 2002; Graedel & Allenby 2003.

See also: Ecology, Industrial economics, System dynamics models, Political-industrial ecology, Metabolism, Multi-scale integrated analysis of societal and ecosystem metabolism (MuSIASEM), Eco-design, Eco-efficiency, Green industrial policy.

References

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Graedel, T.E. & Allenby, B.R. 2003. Industrial Ecology, 2nd edn. New York: Prentice Hall.

Industrial economics

A branch of economics focused on firms, industries, and markets of all sizes with respect to their output, capacity, prices, products, research and development, and environmental impacts (Ferguson & Ferguson 1994; Schmalensee 1988; Mani & Wheeler 1998). Sometimes called industrial organization. According to environmental criteria, industrial sectors are inferior to the others, since they are the least green: they account for the largest gross domestic product (GDP) capacity of natural and energy resources, as well as the largest waste production. Thus, industrial sectors are associated with the highest environmental costs of economic growth. For example, if the basis of the value-added created in the real sector is extractive industries (which is most typical for developing countries), economic growth is associated with the depletion of natural resources and the heritage of future generations. A new subtype of industrial economics is the neo-industrial economy, formed in the context of the Fourth Industrial Revolution and more reliant on digital technologies (Popkova & Haabazoka 2019). This new subtype is increasingly prevalent among industrialized economies, especially in developed countries.

Industrial economies contribute to the implementation of Sustainable Development Goals (SDGs) such as SDGs 7 to 9 by generating jobs, meeting energy demand (through extractive industries), and promoting industrialization (especially a new subtype). However, industrial economies in many cases hinder the implementation of SDG 13, as they exacerbate climate change. Overcoming the contradiction of the influence of industrial economies on sustainable development is possible due to its new subtype, the neo-industrial economy, since: (1) the manufacturing industry prevails in it; (2) stricter control over resource consumption and production waste is available; and (3) there are enhanced opportunities for real sector energy efficiency improvements.

ELENA G. POPKOVA

Further reading

Al-Thani & Al-Ansari 2021; Li & Wang 2020; Qiu & Gong 2021.

See also: Sustainable Development Goals (SDGs),

Green industrial policy, Industrial ecology, Green economy, Economic growth, Green growth.

References

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Li, M. & Wang, Q. 2020. Does industrial relocation alleviate environmental pollution? A mathematical economics analysis. Environment, Development and Sustainability 22(5): 4673–98.

Mani, M. & Wheeler, D. 1998. In search of pollution havens? Dirty industry in the world economy, 1960 to 1995. Journal of Environment and Development 7(3): 215–47.

Popkova, E.G. & Haabazoka, L. 2019. "The cyber economy as an outcome of digital modernization based on the breakthrough technologies of industry 4.0," pp. 3–10 in The Cyber Economy: Contributions to Economics. V. Filippov, A. Chursin, J. Ragulina & E. Popkova, eds. Cham: Springer.

Qiu, Y. & Gong, Y. 2021. Industrial linkage effects of RCEP economies' imports of producer services on manufacturing advantages. PLoS ONE 16: e0253823.

Schmalensee, R. 1988. Industrial economics: an overview. Economic Journal 98(392): 643–81.

Industrial metabolism

See: Material flow analysis.

See also: Industrial ecology, Industrial economics.

Inequality

Unequal. Inequality is a positive (descriptive) concept that encompasses outcomes, processes, and opportunities. It is most used to describe unequal access to resources (natural, economic, political, and social) and outcomes such as wages, income, and wealth. At a fundamental level, inequality restricts capabilities and therefore freedom (Sen 1992). The concept applies both within and across socio-economic contexts. Although commonly used, there is no universally accepted quantitative or qualitative measure of inequality. It should not be confused with inequity, which is a normative (prescriptive) concept: inequality does not imply and is not implied by inequity.

Neha Khanna

See also: Economic inequality, Gender inequality, Inequity, Ecologically unequal exchange.

Reference

Sen, A. 1992. Inequality Reexamined. Cambridge, MA: Harvard University Press.

Inequity

A degree of inequality that is unfair or unjust (Rawls 1971).

Economics: equity as no-envy occurs when no individual would prefer having someone else's bundle of commodities (Kolm 1972).

World systems theory: inequity represents a situation where centers and peripheries are coupled through unequal exchange in such a way that the gap in living standards between them increases (Wallerstein 2004).

Earth system governance: (in)equity appears in relation to access (that is, the ability to secure minimum resources) and allocation (that is, the wider distribution of resources, as well as harms and responsibilities) (Biermann et al. 2010).

Ecological economics: unequal exchange in the world system drives ecologically unequal exchange (EUA), that is, inequitable allocation of environmental harms (Hornborg 1998), and ecological distribution conflicts arise from inequitable allocation of resources and harms, including from EUA (Martinez-Alier & O'Connor 1996).

Crelis F. Rammelt

See also: Justice, Social justice, Inequality, Ecologically unequal exchange, Ecological distribution conflicts.

References

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Hornborg, A. 1998. Towards an ecological theory of unequal exchange: articulating world system theory and ecological economics. Ecological Economics 25(1): 127–36.

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Rawls, J. 1971. A Theory of Justice. Cambridge, MA: Belknap Press of Harvard University Press.

Wallerstein, I. 2004. World-Systems Analysis: An Introduction. London: Duke University Press.

Inflation

A continuous and sustained increase in the general price level of an economy. It is a symptom of imbalance between macro-level demand and supply of goods and services in an economy, leading to an overall rise in price levels over time. Constant and continuous increase in prices leads to a fall in the purchasing power of money, reducing consumption, and standards of living of the population. By increasing input costs, inflation affects investments, and foreign exchange rates as well, affecting trade. Inflation is measured from one time period to another by comparing the percentage change of a price index in the given period to that of the base period, such as monthly, quarterly, or annual change in the indices. For instance, if the Consumer Price Index in the base year was estimated to be 100, and in the current year it was 110, it shows that consumer prices (inflation) grew 10 percent over the base year.

PRABHA PANTH

Further reading

Cukeirman 2008: Green & Walker 2012; Hall 1994; Mishkin 2007; Paarlberg 1993.

See also: Monetary policy, Interest rate policy, Real interest rate.

References

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Green, E.L. & Walker, A.N., eds. 2012: Inflation and the Consumer Price Index: Costs and Considerations. London: Nova Science Publishers.

Hall, R.E., ed. 1994. Inflation: Causes and Effects. Chicago, IL: University of Chicago Press.

Mishkin, F.S. 2007: Monetary Policy Strategy. Cambridge, MA: MIT Press.

Paarlberg, D. 1993. An Analysis and History of Inflation. Westport, CT: Praeger.

Informal economy

See: Informal sector.

See also: Spheres of economic activity, Developing country.

Informal sector

a. Any economic activity that is not subject to government regulation or taxation.
b. Informality can be identified through sector (firms and production units that are unregistered), employment (employment that is not regulated or protected), and economy (covering both the above and activities that are outside the regulated sector, as well as all output that they produce) (Meagher 2013).
c. Units that "operate at a low level of organization, with little or no division between labor and capital as factors of production and on a small scale" (ILO 2021). Labor is employed on a casual basis and labor relations are personal rather than contractual. The sector is often called the shadow, hidden, underground, irregular, invisible, unofficial, or even the illegal economy.

The informal sector is core to growth and livelihoods in many economies and is seen as both a highly dynamic sector as well as a fragile one. It is hard to be precise about the size of the informal sector because, by

its nature of being unregulated, it is not well measured. Estimates suggest that there are approximately 2 billion workers, or over 60 percent of the world's adult labor force, engaged in this sector, and that it represents 15 percent of the gross domestic product (GDP) in advanced economies and approximately 35 percent in the low and middle-income economies in developing countries (ILO 2021).

UMA S. KAMBHAMPATI

See also: Spheres of economic activity, Developing country.

References

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Meagher, K. 2013. Unlocking the informal economy: a literature review on linkages between formal and informal economies in developing countries. WIEGO Working Paper No. 27. Cambridge, MA: Women in Informal Employment Globalizing and Organizing.

Information asymmetry

See: Asymmetric information.

See also: Moral hazard, Market failure.

Input–output (I–O) analysis

A methodological approach that analyzes the interdependencies of the different sectors in an economy. I–O analysis was developed by Wassily Leontief (1936), who received the Sveriges Riksbank Prize in Economics in 1973 for this contribution. The rows of an input–output table show the distribution of the economic output of each sector to other sectors and final consumers. The columns show the economic inputs required by each sector to produce its output, including intermediate inputs from other sectors and primary inputs. These transactions are usually expressed in monetary terms, though some tables express them in physical units or mix both.

The I–O model consists of a system of linear equations showing the distribution of the output of each sector throughout the economic system. The model computes the direct and indirect impacts of changes in the demand of the different sectors. The I–O model can be extended to include the interdependencies of the economic system with other related systems, such as the environment. Since the 1960s, several authors have extended the input–output analysis to consider the interrelations between the economy and the environment (see, e.g., Cumberland 1966; Daly 1968; Isard et al. 1968). Environmentally extended input–output analysis is widely used in ecological economics to analyze the linkages between economic activities and environmental impacts, such as environmental footprints (Kitzes 2013).

EMILIO PADILLA ROSA

Further reading

Miller & Blair 2009; Serrano 2008; Ten Raa 2006.

See also: Environmentally extended input–output analysis (EE-IOA), Environmental impact assessment tools, Impact assessment models, Ecological footprint.

References

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Serrano, M. 2008. "Input–output analysis: a suitable approach to study the interdependencies in and between the economy and the environment," pp. 13–73 in Economic Activity

and Atmospheric Pollution in Spain: An Input–Output Approach. PhD dissertation, Universidad de Barcelona.
Ten Raa, T. 2006. The Economics of Input–Output Analysis. Cambridge: Cambridge University Press.

Institutional analysis

Research that focuses on how institutions are formed, how they influence human behavior, interactions, transactions, and decision-making processes, and how they incrementally evolve over time. Different approaches can be found, depending on the definition, and understanding of institutions, whereby institutions can be the dependent, the independent, or the intervening variable. Studies can pay attention to the creation, maintenance, enforcement, disruption, change, functioning, and/or performance of institutions. The institutional analysis and development (IAD) framework, developed by Elinor Ostrom and her colleagues (e.g., Ostrom 2011) is one of the most famous approaches to institutional analysis.

RAOUL BEUNEN

Further reading

Ellickson 1991; Hodgson 2006; North 2010; Ostrom 2005.

See also: Institutions, Social institutions, Economic institutions, Institutional economics, New institutional economics, Autonomous institution.

References

Ellickson, R.C. 1991. Order Without Law. Cambridge, MA: Harvard University Press.
Hodgson, G.M. 2006. What are institutions? Journal of Economic Issues 40(1): 1–25.
North, D.C. 2010. Understanding the Process of Economic Change. Princeton, NJ: Princeton University Press.
Ostrom, E. 2005. Understanding Institutional Diversity. Princeton, NJ: Princeton University Press.
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Institutional change

The processes by which institutions are replaced with new ones and the meaning of institutions evolves over time. Different approaches to institutional change can be distinguished. For example some, such as the more traditional punctuated equilibrium approach, focus on radical changes in response to exogenous shocks; while others pay more attention to the gradual processes of change, considering changes that occur because institutions are interpreted, enacted, and enforced in new ways.

RAOUL BEUNEN

Further reading

Mahoney & Thelen, 2009; Ostrom 1990; Pierson 2000, 2011; Young 2002.

See also: Institutions, Institutional analysis, Punctuated equilibrium theory, Path dependence, Exogenous, Evolutionary economics.

References

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Pierson, P. 2000. Increasing returns, path dependence, and the study of politics. American Political Science Review 94(2): 251–67.
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Young, O.R. 2002. The Institutional Dimensions of Environmental Change: Fit, Interplay, and Scale. Cambridge, MA: MIT Press.

Institutional compatibility

The relationship between the institutional context that firms work in and the extent to which their practices are seen as appropriate in that institutional environment (Xia et al. 2009). A procedure for *ex ante* institutional compatibility assessment has been developed (Theesfeld et al. 2010). A significant portion of ecological economics considers the incompatibility between the economic institutions of private firms and sustainable development,

biodiversity, and controlling climate change, among others, and promotes reforms (e.g., Paavola & Adger 2005; Daly & Farley 2011; Rosendal & Andresen 2011; Padmanabhan & Jungcurt 2012).

BARRY D. SOLOMON

See also: Institutional economics, New institutional economics, Economic institutions, Social institutions, Institutional analysis, Institutional change.

References

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Padmanabhan, M. & Jungcurt, S. 2012. Biocomplexity—conceptual challenges for institutional analysis in biodiversity governance. Ecological Economics 81: 70–79.

Rosendal, G.K. & Andresen, S. 2011. Institutional design for improved forest governance through REDD: lessons from the global environment facility. Ecological Economics 70(11): 1908–15.

Theesfeld, I., Schleyer, C. & Aznar, O. 2010. The procedure for institutional compatibility assessment: ex-ante policy assessment from institutional perspective. Journal of Institutional Economics 6(3): 377–99.

Xia, J., Boal, K. & Delios, D. 2009. When experience meets national institutional environmental change: foreign entry attempts of U.S. firms in the central and eastern European region. Strategic Management Journal 30(12): 1286–1309.

Institutional economics

a. The study of informal and formal rules, ranging from regularized behaviors, norms, or patterns of behavior to laws, regulations, contracts, property rights, proceedings, and decisions and how they govern economic activity (Williamson 1985; Ostrom 2008; Vatn 2005). The rules can apply at any scale from interpersonal to society-wide, and can govern anything from instantaneous transactions to multi-decadal economic agreements. This definition focuses on rules rather than entities or organizations, so that the impact of rules on individual and collective choices, social organization, and economic and environmental outcomes can be examined.
b. The study of private and public sector organizations, partnerships, and networks engaged in economic activity. Examples include the United States (US) Surface Transportation Board, the US Federal Reserve System, and the Energy Star appliance certification system. This is the common understanding of an institution as an organized entity, such as a bank.

BRENT M. HADDAD

See also: Transaction costs, Institutions, Economic institutions, New institutional economics.

References

Ostrom, E. 2008. Institutions and the environment. Economic Affairs 28(3): 24–31.

Vatn, A. 2005. Institutions and the Environment. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Williamson, O. 1985. Economic Institutions of Capitalism. New York: Free Press.

Institutions

Any system of standardized norms, values, roles, and statuses that establishes and perpetuates social patterns through collective action. This system includes laws, rules, regulations, practices, norms, and/or customs.

Economics: economic institutions include private property, free markets, money, competition, division and combination of labor, social cooperation, government mandates, and international trade (North 1989; Granovetter 1992; Heilbroner & Milberg 2011).

Ecology: ecological institutions include private property, government, social or community groups, environmental laws, ordinances, and executive orders, treaties, compacts, and other multilateral agreements (Gibson et al. 2000; Costanza et al. 2000;

Dietz et al. 2003; Vatn 2005; Beddoe et al. 2009).

BARRY D. SOLOMON

See also: Institutional economics, New institutional economics, Economic institutions, Social institutions, Institutional analysis, Institutional change.

References

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Vatn, A. 2005. Institutions and the Environment. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Insurance value

a. A product, service, or resource that can provide risk-mitigation measures in the sense that it can reduce the negative effects caused by uncertainties.
b. The value obtained from gaining access to a resource or facility that would be impossible without engaging in an insurance contract.
c. The value estimate given by an insurance company to engage in an insurance contract to mitigate emotional or physical damages to the insured, caused by the prospect of an event specified in the insurance contract. Examples: the value assigned to one's home that the insurance company recommends for coverage; value obtained from health care services access by purchasing health insurance.

KHUSHBU MISHRA

Further reading

Mishra et al. 2020; Nyman 1999; Quaas et al. 2019.

See also: Risk, Risk aversion, Risk premium, Uncertainty.

References

Mishra, K., Gallenstein, R.A., Miranda, M.J., et al. 2020. Insured loans and credit access: evidence from a randomized field experiment in northern Ghana. American Journal of Agricultural Economics 103(3): 923–43.

Nyman, J.A. 1999. The value of health insurance: the access motive. Journal of Health Economics 18(2): 141–52.

Quaas, M., Baumgärtner, S. & De Lara, M. 2019. Insurance value of natural capital. Ecological Economics 165: 106388.

Integrated assessment model

A mathematical computer model that integrates different aspects or elements of the global system based on explicit assumptions about how the modeled system behaves. Integrated assessment models (IAMs) are used to describe the complex relations between environmental, social, and economic factors that, for example, determine future climate change and the effectiveness of climate policy, to derive policy-relevant insights (van Vuuren et al. 2011).

IAMs are constrained by the quality and character of the assumptions, equations, and data that underlie the model. One example is social complexity (heterogenous goals, opinions, and preferences), which is generally ignored and instead a utility-maximizing rational choice paradigm is frequently assumed as the basis for human action, which is a simplification and oversight in the context of the Holocene. Another is that

IAMs' core mechanisms rely on the principle of additivity, and therefore struggle to represent non-linearities or tipping points, whether in natural or social systems.

Jordan P. Everall & Ilona M. Otto

Further reading

Calvin & Bond-Lamberty 2018; Keppo et al. 2021.

See also: General equilibrium model, Non-linear, Tipping point.

References

Calvin, K. & Bond-Lamberty, B. 2018. Integrated human–earth system modeling—state of the science and future directions. Environmental Research Letters 13(6): 063006.

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van Vuuren, D.P., Lowe, J., Stehfest, E. et al. 2011. How well do integrated assessment models simulate climate change? Climatic Change 104: 255–85.

Integrated ecological–economic systems

See: Bioeconomic modeling.

See also: Bioeconomics, Biophysical economics, Coupled human and natural systems.

Integrated pest management (IPM)

A science-based decision-making process and ecosystem management strategy that uses a variety of tools to identify and manage pests in agriculture and natural resources management. Combines biological, chemical, mechanical, physical, and cultural control tools in a way that minimizes risks to the environment, beneficial and non-target organisms, human health, property, and the economy. IPM uses knowledge of pest and host biology in combination with environmental and biological monitoring to respond to and manage pest problems. Applied successfully, IPM can reduce the evolution of pest resistance to pesticides and other pest management practices.

Barry D. Solomon

Further reading

Kogan 1998; Flint & Van den Bosch 2012.

See also: Agricultural economics, Agribusiness, Agricultural ecosystem services.

References

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Kogan, M. 1998. Integrated pest management: historical perspectives and contemporary developments. Annual Review of Entomology 43: 243–70.

Integrated water resources management (IWRM)

Collaborative, comprehensive oversight of water resources in a region, including source protection, infrastructure, demand management, risk reduction and mitigation strategies, cost, pricing, access and fairness, environmental impacts, and impacts on neighboring regions. The term "integrated" can apply to any or all of: comprehensive consideration of all stages of water use; the importance of collaborative input from a wide range of stakeholders; and a water system's connections to other related systems, such as food production and energy production. It begins with documenting current conditions and identifying goals for water supply, and then specifies actions to take and a plan for doing so. It can occur at scales from cities to multinational watersheds. It is typically too expensive a process for smaller towns and rural regions to undertake.

Brent M. Haddad

Further reading

Prato & Herath 2007; Pahl-Wostl et al. 2008.

See also: Water resources, Virtual water, Water–energy–food nexus, Watershed management, Available water capacity.

References

Pahl-Wostl, C., Tàbara, D., Bouwen, R. et al. 2008. The importance of social learning and culture for sustainable water management. Ecological Economics 64(3): 484–95.

Prato, T. & Herath, G. 2007. Multiple-criteria decision analysis for integrated catchment management. Ecological Economics 63(2–3): 627–32.

Interconnected

Ecology: (from Commoner 1971, p. 29) one of the four laws of ecology: "Everything is connected to everything else. There is one ecosphere for all living organisms and what affects one, affects all."

Buddhist economics: (from Brown 2017) the health and well-being of all living beings and of the planet is interdependent, where "interdependent" includes interconnected in all planetary activities and at the human physical, mental, and spiritual levels.

Religion:

a. Buddhism (from Hanh 2013) teaches people's interconnection with Mother Earth requires us to appreciate and care for the Earth for our collective happiness and survival.
b. Catholicism (from Pope Francis 2015) teaches that all generations are interconnected with each other and with the planet, which mandates that we care for our common home, and that a meaningful life encompasses much more than material well-being.

Clair Brown

See also: Buddhist economics, Ecology, Human ecology, Ecological footprint, Objective well-being, Well-being economy.

References

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Commoner, B. 1971. The Closing Circle: Nature, Man, and Technology. New York: Random House.

Hanh, T.N. 2013. Love Letter to the Earth. Berkeley, CA: Parallax Press.

Pope Francis. 2015. Laudato Si. Encyclical letter of the Holy Father Francis on Care for Our Common Home. https://www.vatican.va/content/dam/francesco/pdf/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si_en.pdf.

Interdependence

See: Interconnected.

See also: Connectivity, Path dependence.

Interdisciplinary

The cooperation and collaboration among researchers from multiple scientific disciplines on a common study or project. This can take three forms (Baumbärtner et al. 2008):

1. Members of different disciplines work in parallel on different aspects of the common study or project based on their specialized expertise, unique concepts, theories, methods, and terminology, in loose coordination with each other. This is more properly considered to be multidisciplinary research (Max-Neef 2005).
2. A clear division of labor between the members of various disciplines, but with the intention of data and knowledge exchange, which might result in data interfaces and exchanges and an integrated model or analysis.
3. An even closer level of coordination and cooperation between members of different disciplines that results in some degree of cross-fertilization and revision of concepts, theories, and methods. Only in this third form of interdisciplinary research do scientists actively work together and

begin to transcend the boundaries of their own discipline. While all these forms of interdisciplinary research occur in ecological economics, the third form as well as transdisciplinarity are the most ideal.

BARRY D. SOLOMON

See also: Multidisciplinary, Transdisciplinarity.

References

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Max-Neef, M. 2005. Foundations of transdisciplinarity. Ecological Economics 53(1): 5–16.

Interest rate policy

The interest rate set by a monetary authority to influence the evolution of the main monetary variables in the economy; for example, consumer prices, credit expansion, and the exchange rate, as well as economic growth. Examining the empirical record concerning the hypothesis that lower interest rates result in higher growth and vice versa, Lee and Werner (2018) found that there was no empirical evidence to support it and that economic growth and interest rates are positively related. Concerning statistical causation, they found that economic growth was more likely to drive interest rates than the other way around. Concerning interest rate policy, central banks are largely acting passively in response to economic activity, by lowering rates after growth has decelerated, and raising rates after it has accelerated. However, the findings of Lee and Werner showed that the official description of monetary policy as well as the central banks' theoretical models are mistaken.

Since the late 20th century, central banks have come to define monetary policy largely in terms of their interest rate policy: by acting to lower interest rates, they say they would stimulate the economy, while they can slow an overheated economy by raising rates. Empirical research has shown that gross domestic product (GDP) growth is driven by bank credit creation for GDP transactions, which central banks can and do influence via other aspects of their monetary policy (Werner 1997, 2018; Lyonnet & Werner 2012; Ryan-Collins et al. 2016). This raises the question of which economic variable is the driver of economic activity and hence should be the focus of monetary policy if it is not interest rates. Furthermore, it raises the question of why central banks have been emphasizing interest rate policy in their publications, when this has no track record of influencing economic growth.

RICHARD A. WERNER

See also: Real interest rate, Monetary policy, IS-LM model, Economic growth, Growth theory.

References

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Werner, R.A. 1997. Towards a new monetary paradigm: a quantity theorem of disaggregated credit, with evidence from Japan. Kredit und Kapital 30(2): 276–309.

Werner, R.A. 2018. Princes of the Yen: Japan's Central Bankers and the Transformation of the Economy. London: Quantumpublishers.com.

Intergenerational analysis

See: Overlapping generations model.

See also: Weak sustainability, Strong sustainability.

Intergenerational equity

See: Sustainable development.

See also: Sustainability, Strong sustainability, Weak sustainability.

Intergovernmental Panel on Climate Change (IPCC)

An intergovernmental organization of the United Nations that was created in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) (Agrawala 1998; Hulme and Mahony 2010). The secretariat of the IPCC was initially located in Washington, DC, but eventually moved to Bonn and then Geneva (where it is currently hosted by the WMO).

The IPCC works through a large international network of scientists, and issues reports every five to eight years based on three working groups that assess: the scientific basis of climate change, its potential environmental and socio-economic impacts and options for adaptation, and policy options for limiting greenhouse gas emissions and mitigation. The purpose of the IPCC assessment reports is to provide all levels of governments worldwide with scientific information that they can use to develop climate policies. All IPCC reports must undergo an extensive review by scientific experts and governments. However, the IPCC itself does not conduct original research, nor does it monitor climate data or parameters. For its work, the IPCC along with former United States Vice President Al Gore were awarded and shared the Nobel Peace Prize in 2007.

BARRY D. SOLOMON

Further reading

IPCC 2021.

See also: Climate change, Greenhouse gases, Climate change mitigation, Climate change adaptation, Peer review process.

References

Agrawala, S. 1998. Context and early origins of the Intergovernmental Panel on Climate Change. Climatic Change 39: 605–20.

Hulme, M. & Mahony, M. 2010. Climate change: what do we know about the IPCC? Progress in Physical Geography 34(5): 705–18.

IPCC (Intergovernmental Panel on Climate Change). 2021. Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. V. Masson-Delmotte, P. Zhai, A. Pirani et al., eds. Cambridge: Cambridge University Press.

Internalizing externalities

The process of taxing the production or consumption sources of negative externalities, ideally based on the damage cost to the environment or human health. In most cases such taxes, often called Pigouvian, environmental, or pollution taxes, are set on a political basis by governments. Internalizing externalities is often said to reflect the "polluter pays" principle and provides incentive for people or firms to consider changing their behavior to lower the level of externalities that are generated. An emissions trading system, especially cap and trade, can also be used to internalize externalities since it results in a market price for emission allowances or credits. In practice, the resultant tax level or allowance/credit price is usually set too low to fully internalize the externalities.

BARRY D. SOLOMON

Further reading

Pigou 1920; Parry 1995; Tietenberg 1985.

See also: Externalities, Environmental externalities, Consumption externalities, Environmental taxes, Pollution taxes, Carbon taxes, Polluter pays principle, Emissions trading, Cap and trade.

References

Parry, I.W.H. 1995. Pollution taxes and revenue recycling. Journal of Environmental Economics and Management 29(3): S64–77.

Pigou, A.C. 1920. The Economics of Welfare. London: Macmillan.

Tietenberg, T.H. 1985. Emissions Trading: An Exercise in Reforming Pollution Policy. Washington, DC: Resources for the Future.

Intertemporal allocation

a. The apportioning, dividing up, or allotting of scarce resources over time. The classic work on this topic is Hotelling (1931) in the case of exhaustible natural resources, which determined the net price as a function of time while maximizing economic rent from the resource extraction. Because of the time element the choice of discount rate becomes critical and is controversial. Climate change presents a much broader and vexing problem of intertemporal allocation, as many policy decisions made today about climate change mitigation, including inaction, have significant implications for the distribution of economic and natural resources over a long period, including for biodiversity and species loss (Grubb et al. 2020). In this case the intertemporal allocation is to a large extent ungraspable rather than the result of conscious decision-making.
b. The investment sequence of firms to optimally apportion their costs over time to maximize profits or to meet other goals.

Barry D. Solomon

Further reading

Alig et al. 1997; Rogerson 2008.

See also: Hotelling model, Hotelling rule, Non-renewable resource, Fossil fuels, Discounting, Climate change, Climate change mitigation, Climate justice.

References

Alig, R., Adams, D., McCarl, B. et al. 1997. Assessing effects of mitigation strategies for climate change with an intertemporal model of the U.S. forest and agriculture sectors. Environmental and Resource Economics 9(3): 259–74.

Grubb, M., Lange, R.J., Cerkez, N. et al. 2020. Taking time seriously: implications for optimal climate policy. Amsterdam: Tinbergen Institute, Discussion Paper 2020-083/VI.

Hotelling, H. 1931. The economics of exhaustible resources. Journal of Political Economy 39(2): 137–75.

Rogerson, R.P. 2008. Intertemporal cost allocation and investment decisions. Journal of Political Economy 116(5): 931–50.

Intertemporal distribution

See: Intertemporal allocation.

See also: Hotelling model, Hotelling rule, Non-renewable resource, Fossil fuels, Discounting, Climate change, Climate change mitigation, Climate justice.

Intragenerational equity

a. The application of a concept of fairness and/or justice to members of a human population, each of whom is alive at the time the concept is applied (Shelton 2008, sec. 2.1).
b. Within countries: a measure of income inequality or income distribution that takes welfare into account (Stymne & Jackson 2000).
c. Between countries: substantial "parity between the socioeconomic development and environmental protection of all states" (French 2001, p. 10477).

Eric Kemp-Benedict

See also: Social equity, Inequity, Justice, Social justice, Income distribution, Economic inequality, Economic welfare, Distributive justice, Environmental justice, Ecological justice.

References

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equity. Environmental Law Reporter News and Analysis 31(5): 10469–85.
Shelton, D.L. 2008. "Equity," pp. 640–62 in The Oxford Handbook of International Environmental Law. D. Bodansky, J. Brunnée & E. Hey, eds. Oxford: Oxford University Press.
Stymne, S. & Jackson, T. 2000. Intra-generational equity and sustainable welfare: a time series analysis for the UK and Sweden. Ecological Economics 33(2): 219–36.

Intrinsic value

a. The non-instrumental value of something.
b. The inherent, real, or objective value of something, which depends solely on the inherent properties of the thing in question, independent of any economic or market valuation made of it by people (O'Neill 1992).

BARRY D. SOLOMON

Further reading

Attfield 1998.

See also: Existence value, Non-use value.

Reference

Attfield, R. 1998. Existence value and intrinsic value. Ecological Economics 24(2–3): 163–68.
O'Neill, J. 1992. The varieties of intrinsic value. The Monist 75(2): 119–37.

Invasive species

Any plant or animal species, or other living organism, which is not indigenous to a particular ecosystem, and which is introduced to a new location where their presence significantly modifies or disrupts the area that is colonized. Invasive species are sometimes intentionally introduced by people (for example, through the pet trade or global commerce) while at other times their spread is accidental. They can also arrive in new areas through natural migration. Irrespective of how they arrive, their presence can cause significant economic and environmental damage through competition with native species, habitat modification, and biodiversity reduction. However, in some cases they can also provide favorable effects such as new suitable habitat, food sources, and biological control of other invasive species.

BARRY D. SOLOMON

Further reading

Pimentel et al. 2005; Mehta et al. 2007.

See also: Species, Alien species, Endangered species, Keystone species, Indicator species, Biological control.

References

Mehta, S.V., Haight, R.G., Homans, F.R., Polasky, S. & Venette, R.C. 2007. Optimal detection and control strategies for invasive species management. Ecological Economics 61(2–3): 237–45.
Pimentel, D., Zuniga, R. & Morrison, D. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52(3): 273–88.

Investment

a. Investment spending is the part of income that is spent in the purchase of produced means of physical production such as machinery, tools, equipment, and buildings, which plays an important role in the productivity growth of manufactured capital.
b. Investment in natural capital has also become increasingly important in the 21st century for ecosystem recovery and environmental restoration (Wackernagel & Rees 1997; Parker & Cranford 2010).
c. Financial investment is the part of income that is saved in the form of financial assets such as bank accounts, stocks, and bonds.

ANDRES F. CANTILLO

Further reading

Keynes 1936; Lequiller & Blades 2014.

See also: Capital theory, Return on investment (ROI), Restoring natural capital (RNC), Ecological restoration, Environmental restoration.

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Keynes, J.M. 1936. The General Theory of Employment, Interest and Money. London: Harvest/Harcourt.

Lequiller, F. & Blades, D. 2014. Understanding National Accounts, 2nd edn. Paris: OECD Publishing.

Parker, C. & Cranford, M. 2010. The Little Biodiversity Finance Book: A Guide to Proactive Investment in Natural Capital. Oxford: Global Canopy Programme.

Wackernagel, M. & Rees, W.E. 1997. Perceptual and structural barriers to investing in natural capital: economics from an ecological footprint perspective. Ecological Economics 20(1): 3–24.

Irreducibility of valuation categories

A unifying system that assembles individuals with similar value belief systems together. It comprises the manners of collective thinking and acting in relation to various aspects of the natural world based on a well-defined set of beliefs and values. In the valuation categories literature, associated members construct categories based on shared sentiments and value judgments relative to the natural world to serve as common guides for collective action. Fundamentally, two divisions of valuation categories may be recognized: instrumental values, and intrinsic values. It is the latter that constitutes the irreducibility of valuation categories, which can be conceived as a collective social reflection of values grounded in culture, tradition, and symbolic or spiritual environmental experiences. The term "irreducibility" connects to the moral ideals of value pluralism and the philosophy of altruism or ecocentrism. These ideals are expressed in relation to the different aspects of the external world within which humans exist. They represent the category of objects for a common ground of collective action corresponding to a definite moral order of things.

Each category of collective action exhibits a range of values that cannot monetarily be reduced to one overarching instrumental value. This is the logical prerequisite of recognition for the diversity of intrinsically perceived and non-reducible values embedded in nature. Irreducibility is a powerful demonstration of the category label of altruism or ecocentrism as a defensive response to the risks engendered in the commodification of the irreducible aspects of the natural world.

Choy Yee Keong

Further reading

Galperin & Sorenson 2014; Choy 2018, 2020.

See also: Intrinsic value, Incommensurable values, Collective action, Collective choice, Ecocentrism, Biocentrism.

References

Choy, Y.K. 2018. Cost–benefit analysis, values, wellbeing and ethics: an indigenous worldview analysis. Ecological Economics 145: 1–9.

Choy, Y.K. 2020. Global Environmental Sustainability: Case Studies and Analysis of the United Nations' Journey toward Sustainable Development. Amsterdam: Elsevier.

Galperin, I. & Sorenson, O. 2014. Valuation, categories and attributes. PLoS ONE 9(8): e103002.

Irreversibility

A characteristic of a process that is not possible to undo. Ecological economics argues that a thermodynamic understanding of irreversibility is necessary to adequately analyze the interplay between nature and economy. For ease of understanding, let us assume that time is reversible. Accordingly, time has the same status as a spatial variable; hence time can move in two directions, into the past and into the future. Thus, its direction is not uniquely defined, and the past and future can be treated symmetrically. However, time moves only in one direction, for we cannot return to the past. Thermodynamic irreversibility restricts economic actions in time (Georgescu-Roegen 1971). Only those actions are possible that are not excluded by the two laws of thermodynamics. Hence, it is a constraint for economic action.

An example of irreversibility is the burning of a piece of coal. Once burned, you can never turn it back into coal. New insights into the concept of irreversibility were developed with the founding of thermodynamics: an understanding of time irreversibility requires a thermodynamic underpinning. In the second half of the 20th century, the physical chemist Ilya Prigogine discovered seminal insights regarding irreversibility in self-organizing systems, such as biological plants; and Nicholas Georgescu-Roegen introduced irreversibility into ecological economics. Mainstream economics has a flawed view of temporal irreversibility in production theory (Baumgärtner 2005) since it neglects thermodynamic considerations; for instance it generally assumes that all goods can be substituted by others.

MALTE M. FABER & MARC FRICK

Further reading

Faber et al. 2019, Faber et al. 1998, chapters 6–7; Prigogine 1980.

See also: Classical thermodynamics, Entropy, Entropy law, Entropic dissipation.

References

Baumgärtner, S. 2005. Temporal and thermodynamic irreversibility in production theory. Economic Theory 26(3): 725–28.

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Georgescu-Roegen, N. 1971. The Entropy Law and the Economic Process. Cambridge, MA: Harvard University Press.

Prigogine, I. 1980. From Being to Becoming: Time and Complexity in the Physical Sciences. San Francisco, CA: W.H. Freeman.

IS-LM model

A Keynesian macroeconomic model developed by Sir John Hicks (1937), which has become a standard method of macroeconomic analysis. Hicks's approach was to take money supply (M) and price (P) as given, to consider separately the equilibrium conditions for the products (IS curve) and assets market (LM curve), and then the conditions for simultaneous equilibrium in both markets. Therefore, the IS-LM model can be used to analyze the effects of fiscal policy and monetary policy on equilibrium income (or output) and market interest rates in macroeconomics. Sometimes also called the Hicks–Hansen model.

The IS curve: the alternative combinations of output (or aggregate demand) (y) and interest rate (r) that will produce equilibrium in the products market (where total private Investment (I) = total Saving (S)), can be plotted in (y, r) space as a negatively sloped curve.

The LM curve: the alternative combinations of output (or aggregate demand) (y) and interest rate (r) that will produce equilibrium in the assets market (where money demand (or Liquidity preference (L) = Money supply (M) for a given price), can be plotted in (y, r) space as a positively sloped curve.

CHIEN-MING LEE

Further reading

Sawyer 1989.

See also: Post-Keynesian economics, General equilibrium model, Monetary policy, Interest rate policy.

References

Hicks, J.R. 1937. Mr. Keynes and the "classics": a suggested interpretation. Econometrica 5(2): 147–59.

Sawyer, J.A. 1989. Macroeconomic Theory: Keynesian and Neo-Walrasian Models. Philadelphia, PA: University of Pennsylvania Press.

Isolated system

A self-contained system where nothing enters or exits, including energy and matter. Neoclassical economics has traditionally portrayed the economy by a circular flow diagram where there are no inputs from or outputs to the biosphere, thus violating biophysical realities. According to this model,

the economy for all practical purposes does not have an environment (Daly 1993, p. 813).

BARRY D. SOLOMON

See also: Circular flow model, Open system, Closed system.

Reference

Daly, H.E. 1993. Steady-state economics: a new paradigm. New Literary History 24(4): 811–16.

J

Jevons paradox

Based on the foundational work of economist William Stanley Jevons (1835–1882), a concept describing a situation in which increased resource efficiency in production does not provide environmental benefits, but instead leads to higher environmental impacts due to increased consumption. A classical example, introduced in Jevons's (1865) book *The Coal Question*, comes from the 19th-century British coal industry. When technological development enabled more efficient coal production, the per unit cost of produced coal decreased. Reduced price, then, increased the consumption of coal, because industrialization had created a large demand for affordable energy sources (Clark & Foster 2001). As a theoretical construct, the Jevons paradox is among the most famous, and most debated, paradoxes in the field of ecological economics (Alcott 2005; York 2006).

JARKKO LEVÄNEN

See also: Rebound effect, Fossil fuels, Resource efficiency.

References

Alcott, B. 2005. Jevons' paradox. Ecological Economics 54(1): 9–21.

Clark, B. & Foster, J.B. 2001. William Stanley Jevons and the coal question: an introduction to Jevons's "Of the Economy of Fuel". Organization and Environment 14(1): 93–8.

Jevons, W.S. 1865. The Coal Question. London: Macmillan & Co.

York, R. 2006. Ecological paradoxes: William Stanley Jevons and the paperless office. Human Ecology Review 13(2): 143–7.

Joint production

The phenomenon that several outputs necessarily emerge from economic activity. These joint outputs may be desired and positively valued goods; for example, ethanol and electric power generation produced from a biofuel refinery in Brazil. But in many other instances, some of them are undesired and may even be harmful to the natural environment. An example is the refining of crude oil, in which gasoline, kerosene, light-heating oil, and other mineral products are produced; but harmful sulfurous wastes and carbon dioxide emissions are also naturally generated.

The concept of joint production captures the fact that human economic activity always has unintended side-effects, which is the structural cause of many environmental problems. This makes the phenomenon of co-production a natural starting point for analyzing not only environmental problems and how they arise, but also how they can be solved in a sustainable way (Baumgärtner et al. 2001; Baumgärtner et al. 2006, p. 2). While an awareness of joint production (that is, combined production of at least two goods) played a key role in the early years of classical economics and Marx's thinking, it later fell into oblivion. Environmental crises have brought it back into practical and theoretical discussions. When physicists proved that (carbon-based) industrial production is always attended by the manufacture of at least one waste product, they also highlighted the general relevance of this concept for environmental issues. Their proof is based on the first and second laws of thermodynamics.

MALTE M. FABER & MARC FRICK

See also: Externalities, Environmental externalities, Classical thermodynamics, Entropy law.

References

Baumgärtner, S., Dyckhoff, H., Faber, M., Proops, J. & Schiller, J. 2001. The concept of joint production and ecological economics. Ecological Economics 36(3): 365–72.

Baumgärtner, S., Faber, M. & Schiller, J. 2006. Joint Production and Responsibility in Ecological Economics: On the Foundations of Environmental Policy. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Just distribution

A fair, equitable, and ethical division of resources, services, disservices, and costs among and between people. A key tenet of just distribution is a normative stance towards reducing inequality and providing egalitarian access to resources and services for current and future generations.

JOSHUA J. COUSINS

Further reading

Daly 1992; Raworth 2017.

See also: Justice, Distributive justice, Distributional effects, Inequality, Income distribution, Redistribution, Wealth distribution.

References

Daly, H.E. 1992. Allocation, distribution, and scale: towards an economics that is efficient, just, and sustainable. Ecological Economics 6(3): 185–93.

Raworth, K. 2017. Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist. White River Junction, VT: Chelsea Green Publishing.

Justice

A normative view of how relationships among and between humans and non-humans should exist. Social and cultural contexts of what is right and wrong influence how justice might be defined in relation to any set of problems. However, justice is best understood as a pluralistic and multilayered worldview, including elements of distributional, procedural, and recognitional justice alongside a focus on human capabilities. A pluralistic definition of justice encapsulates these elements in a way that frames justice as fairness in the allocation of benefits and burdens, as Rawls (1999) suggests, but also addresses justice in terms of equitable representation, and consideration of the culture and values situated among different groups of people in society (Fraser 2000; Whyte 2011). Finally, a focus on capabilities frames justice in terms of providing the means and mechanisms for people to be able to live valuable and meaningful lives (Sen 1999; Nussbaum 2001), but also in terms of a good and sustainable life for non-humans. Collectively, this pluralistic definition of justice focuses on enhancing the capabilities among current and future generations, as articulated in terms of sustainability, but also setting guidelines for the equitable (re)distribution of wealth and nature.

JOSHUA J. COUSINS

Further reading

Harvey 1996; Martínez-Alier 2003.

See also: Just distribution, Distributive justice, Environmental justice, Ecological justice, Climate justice, Social justice, Rawlsian ethics.

References

Fraser, N. 2000. Rethinking recognition. New Left Review 3(3): 107–18.

Harvey, D. 1996. Justice, Nature, and the Geography of Difference. Malden, MA: Blackwell Publishers.

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Sen, A. 1999. Commodities and Capabilities. Oxford: Oxford University Press.

Whyte, K.P. 2011. The recognition dimensions of environmental justice in Indian country. Environmental Justice 4(4): 199–205.

K

Kaldor–Hicks efficiency criterion

A society-wide moral perspective on economic exchange, named for the neoclassical economists Nicholas Kaldor and John Hicks. An exchange is an improvement for society as a whole if the gains, or utility, accrued to some are enough in theory to compensate any losses to others (Kaldor 1939; Hicks 1939). This scenario recognizes the likelihood that many economic activities will cause losses to some individuals, with little likelihood of actual compensation. If the gains accrued are greater than the compensation those harmed would accept, whether or not the compensation is paid, society can be considered better off, and the activity allowed.

The Kaldor–Hicks criterion provides the theoretical foundation for benefit–cost analysis and is generally accepted in neoclassical economics. However, it has numerous conceptual and practical shortcomings and has been widely criticized in ecological economics (e.g., Farrow 1998; Gowdy 2004).

BRENT M. HADDAD

See also: Pareto optimality, Efficiency, Efficiency-based arguments, Utility, Welfare economics, Economic welfare, Social welfare function, Benefit–cost analysis (BCA).

References

Farrow, S. 1998. Environmental equity and sustainability: rejecting the Kaldor–Hicks criteria. Ecological Economics 27(2): 183–8.

Gowdy, J.M. 2004. The revolution in welfare economics and its implications for environmental valuation and policy. Land Economics 80(2): 239–57.

Hicks, J.R. 1939. The foundations of welfare economics. Economic Journal 49(196): 696–712.

Kaldor, N. 1939. Welfare propositions in economics and interpersonal comparisons of utility. Economic Journal 49(145): 549–52.

Kantian ethics

An ethical theory subsumed under two pillars: deontology and individual autonomy. Deontological ethics are duty-bound and unencumbered by considerations of consequences, unlike the utilitarian ethics of neoclassical economics. Kantian ethics is additionally based on autonomous, self-legislating individuals through, in Kant's language, practical reason and a moral law which we impose upon ourselves (Taylor 1985).

This autonomous capacity is presented in Kant's famous categorical imperatives. These imperatives universalize ethical considerations, with Kant inferring that communities of morally free and rational beings will arrive at similar precepts based on their individual autonomies and reasoning capacities. However, the precise mechanism through which this individual-based ethics purportedly transcends collectives has remained mysterious and hard to grasp, with Kant making recourse to various concepts such as duty, goodwill, and natural law.

The difficulties in accommodating Kantian ethics to ecological economics are threefold. First, if an ethics is to be based on universal (categorical) imperatives, from where does it derive its foundation? Kant's Copernican revolution insisted that imperatives were derived from individual subjects, and this marked a distinct break in the West, where authority was historically derived from God

or the Good (Plato). Is an analogous break to ecological imperative(s) on the horizon today? Second, is such an approach to ethics fitted to current times, and to ecological economics, a transdiscipline that prides itself on plurality and diversity? Third, can humans locate universals (ecological or otherwise) fitted to all places and times? For this is what Kantian ethics sets out to achieve. And while scholars and activists associated with ecological economics can appear to hold such views based on ecological facts (climate change, rapid biodiversity loss, and so on)—"fact" here synonymous with imperative, "imperative" synonymous with universal—locating ecological imperatives beyond rhetoric is proving difficult, both ecologically and ethically.

MICHAEL L.R. BABCOCK

Further reading

Kant 2021; Körner 1990; Paton 1963; Guyer 2006.

See also: Environmental ethics, Bioethics, Discursive ethics, Deontological, Utilitarianism, Duty.

References

Guyer, P. 2006. "Introduction: the starry heavens and the moral law," pp. 1–27 in The Cambridge Companion to Kant and Modern Philosophy. P. Guyer, ed. Cambridge: Cambridge University Press.

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Taylor, C. 1985. Philosophy and the Human Sciences: Philosophical Papers 2. Cambridge: Cambridge University Press.

Keystone species

a. Any species whose addition to or loss from an ecosystem leads to significant changes in occurrence or abundance of other species. Thus, a keystone species has a disproportionately large effect on an ecosystem, although it is not always the most abundant or largest species. The term was coined in 1969 by the zoologist Robert Paine (1969, 1995).

b. Any species that has a positive influence on the structure or function of the ecosystems in which they occur.

SHELLY A. JOHNSON

Further reading

Mills et al. 1993; Simberloff 1998.

See also: Ecosystem structure and function; Indicator species, Conservation biology, Wildlife conservation.

References

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Simberloff, D. 1998. Flagships, umbrellas, and keystones: is single-species management passé in the landscape era? Biological Conservation 83: 247–57.

Knowledge networks

A "set of nodes—individuals or higher level collectives, that serve as heterogeneously distributed repositories of knowledge and agents that search for, transmit, and create knowledge—interconnected by social relationships that enable and constrain nodes' efforts to acquire, transfer, and create knowledge" (Phelps et al. 2012, p. 1117). In the field of the economic geography of innovation, knowledge networks focus on the social, organizational, or institutional networks involved in creating, developing, absorbing, distributing, applying, and/or using knowledge. Knowledge networks are identifiable from their organizational composition, which can be analyzed at different scales, from local communities to global policy and epistemic networks, and in relation to environmental and ecological issues.

ARMELLE MAZÉ

Further reading

Giuliani 2007; Glückler 2007; Glückler et al. 2017; Mazé et al. 2021.

See also: Networks, Bayesian belief networks, Social-ecological systems.

References

Giuliani, E. 2007. The selective nature of knowledge networks in clusters: evidence from the wine industry. Journal of Economic Geography 7(2): 139–68.

Glückler, J. 2007. Economic geography and the evolution of networks. Journal of Economic Geography 7(5): 619–34.

Glückler, J., Lazega, E. & Hammer, I., eds. 2017. Knowledge and Networks. Cham: Springer.

Mazé, A., Domenech, A.C. & Goldringer, I. 2021. Restoring cultivated agrobiodiversity: the political ecology of knowledge networks between local peasant seed groups in France. Ecological Economics 179: 106821.

Phelps, C., Heidl, R. & Wadhwa, A. 2012. Knowledge, networks, and knowledge networks: a review and research agenda. Journal of Management 38(4): 1115–66.

L

Labor markets

The supply and demand for labor where employees supply the labor and employers demand workers. Labor markets vary in geographic scope, from the local and regional to, in some cases, global markets.

JOHN M. POLIMENI

Further reading

Boeri & van Ours 2013; Borjas 2019; Ehrenberg & Smith 2017; Otsuki 1971.

See also: Circular flow model, Market, Microeconomics, Labor theory of value.

References

Boeri, T. & van Ours, J. 2013. The Economics of Imperfect Labor Markets, 2nd edn. Princeton, NJ: Princeton University Press.

Borjas, G.J. 2019. Labor Economics, 8th edn. New York: McGraw-Hill Education.

Ehrenberg, R.G. & Smith, R.S. 2017. Modern Labor Economics: Theory and Public Policy, 13th edn. New York: Routledge.

Otsuki, T. 1971. Labor market. Econometrica 39(4): 330–32.

Labor theory of value

A theory holding that a commodity's value and price is determined by the amount of labor required to produce it (Heilbroner 1983). Associated with classical economists Adam Smith and David Ricardo, it was later used by Karl Marx to analyze capitalism. The labor theory of value (LTV) claimed that natural resources only produced value when labor was applied, so labor was the ultimate source of value and prices. The amount of labor in a commodity determined the "natural price" around which market prices would fluctuate.

Several analytic problems faced the LTV. Two goods with very different prices could have equal amounts of labor. Labor could create something that no one would purchase. Different types of labor involve different skills, and equating them to one metric was analytically challenging. Finally, if labor is the sole source of value, then what explains profit and rent? Although Marx did not use the term for his own value theory, he linked the LTV to exploitation, arguing capitalist profits undeservedly took value from workers, leading to economic crises and political conflict. Economics moved away from the LTV in the late 19th century's "marginalist revolution."

RICHARD M. MCGAHEY

Further reading

Rees 1992.

See also: Classical economics, Labor markets, Value added, Total economic value (TEV), Incommensurable values, Marginal analysis.

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Laissez-faire economics

The advocacy of market capitalism as a self-regulating system, implying that state intervention for social purposes should be opposed. Intellectual origins include the affir-

mation by Pierre le Pesant, alias Boisguilbert (1646–1714), that one must "laisser faire la nature," because nature has the capacity to maintain and regulate itself to restore balance when disturbed. Transferred to the economic sphere, the thesis was advanced that, if unregulated, a market system will tend toward equilibrium. The phrase "laissez faire, laissez passer" was popularized by the physiocrat economist François Quesnay (1694–1774), but advocacy of laissez-faire became indelibly associated with British liberal economics, from Adam Smith onwards.

Gareth Dale

Further reading

Dale 2019; Keynes 1926; Møller Stahl 2019.

See also: Free market, Liberalism, Physiocrats, Classical economics.

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Land degradation

a. The temporary or permanent lowering of the productive capacity of land. The term "land" has a wider meaning than just soil. It covers climate and water resources, landform, soils, and vegetation—both grassland resources and forests. It also includes various forms of soil degradation, adverse human impacts on water resources, deforestation, and lowering of the productive capacity of rangelands.

b. A process in which the value of the biophysical environment is affected by a combination of human-induced processes acting upon the land. It is, therefore, a long-term loss of ecosystem function and productivity, caused by disturbances from which the land cannot recover unaided (Bai et al. 2008). It occurs slowly and cumulatively and has long-lasting impacts on rural people, who become increasingly vulnerable (Shah et al. 2011). It is also the aggregate diminution of the productive potential of the land, including its major uses (rain-fed, arable, irrigated, rangeland, forest), its farming systems (for example, smallholder subsistence) and its value as an economic resource.

c. The Food and Agriculture Organization of the United Nations defines soil degradation as a change in the soil health status resulting in a diminished capacity of the ecosystem to provide goods and services for its beneficiaries (FAO 2019).

Amita R. Shah

Further reading

Barrow 1991; FAO 1994; Kertész, 2009; Cherlet et al. 2018.

See also: Desertification, Soil health, Soil fertility, Landscape, Deforestation, Forest conservation, Degradation, Watershed.

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tutions," pp. 87–128 in Integrated Watershed Management in Rainfed Agriculture. S.P. Wani, J. Rockstrom & K.L. Sahrawat, eds. Leiden: CRC Press.

Land economics

A branch of economics that studies institutions, especially land and property rights more generally; the relations that grow out of landed property; how they shape society, economy, and environment; and theories as well as policies about such relations. The centrality of land in the explanation of, and solutions to, socio-economic and ecological problems is a distinctive feature of land economics, as is the view of "land" not as a single thing, but as property relations. Land economists typically challenge the idea that land is substitutable by capital in the process of growth and change. The approaches to treating land, however, vary widely.

One approach is land economics as a radical political-economic movement, either within academia (for example, Marxist land economics and Ricardian land economics), but particularly across and outside universities. An active radical approach pioneered by Henry George, often called Georgist urban land economics, is alive and vibrant (George 1879 [2015]). This land economics questions private property in land, endorses rewarding labor for its work, and supports state redistribution of socially created rents taxed back for social and public uses. Another approach is a more moderate, but quite diffused group of land economists—sometimes called the "Wisconsin School," pioneered by Richard Ely—who study institutions generally, with land as a major institution (Ely 1922, 1940). Unlike those land economists whose work focuses more strongly on using land to enable growth, just land economists are political economists typically committed to addressing unequal ecological exchange from a variety of institutional economics perspectives. In between these are some other traditions, notably the "Cambridge School" pioneered by Donald Denman. This school would seem to accept rent as a fair payment for land, established under conditions of perfect competition; while others see rent as an expression of dispossession, oligopoly, and monopoly.

Franklin Obeng-Odoom

Further reading

Obeng-Odoom 2021.

See also: Urban economics, Ricardian land, Radical ecological economics, Geonomics, Institutions, Economic institutions, Institutional economics, New institutional economics, Ecologically unequal exchange, Property regimes.

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Obeng-Odoom, F. 2021. The Commons in an Age of Uncertainty: Decolonizing Nature, Economy, and Environment. Toronto: University of Toronto Press.

Landscape

Any mixture of natural and anthropogenic-modified land cover and their spatial configuration in a defined area that jointly creates a unique array of tangible and intangible ecosystems. Turner et al. (2001, p. 3), who helped to advance the field of landscape ecology, suggested that: "landscape is an area that is spatially heterogeneous in at least one factor of interest." Landscape is a dynamic phenomenon; it is affected by land-use decisions, geological/geomorphological/hydrological processes, climate, and the multifaceted interaction between them. Landscape patterns are usually quantified by their composition, configuration, homogeneity, (de)fragmentation, (dis)connectivity, and position along the rural–urban continuum (McGarigal 2002).

Landscapes host a plethora of habitats and provide goods and services that create economic, ecological, and socio-cultural benefits (Haines-Young & Potschin 2010).

Since landscape services are used as a synonym for ecosystem services (ESSs) (Hermann et al. 2011), they can provide all kinds of ESSs, including aesthetics, food, water and air quality regulation, erosion protection, and weather extremes moderation. The specific ESSs supplied depend on the patterns, processes, and functionality of landscapes. Valuing the benefits of these ESSs is based on economic methods often formulated in terms of willingness to pay, and compensation value (de Groot et al. 2012). These methods have been criticized on several grounds (for example, they do not fully account for cultural and non-use value). Nevertheless, these valuations are important for better-informed landscape management, given that landscapes are dynamic and susceptible to disturbances that may alter their ecological functions irreversibly.

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Further reading

Smith et al. 2003; Forman & Godron 1986.

See also: Ecosystem services, Landscape ecology, Aesthetics, Economic valuation techniques.

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Landscape ecology

a. The study of the structure, function, and change of landscapes, where landscape structure refers to the spatial relationships among the distinctive ecosystems; landscape function refers to the flows of energy, materials, and species; and landscape change refers to the alteration in landscape structure and function over time (from Forman & Godron 1986). Landscape ecology was pioneered by the German geographer Carl Troll (1939).
b. The study of interactions between spatial pattern and ecological process, that is, the causes and consequences of spatial heterogeneity across a range of scales (Turner and Gardner 2005).
c. The science of studying and improving the relationship between spatial pattern and ecological processes across hierarchical levels of biological organization and different scales in space and time, focusing on the effects of landscape composition and configuration on biodiversity, population and ecosystem processes, ecosystem services, and human well-being (Wu 2013). Modern landscape ecology relies heavily on remote sensing data, geographical information systems (GIS), and spatial analysis and modeling techniques, with increasing emphasis on landscape sustainability in recent decades.

JIANGUO WU

Further reading

Risser et al. 1984; Forman 1995; Naveh & Lieberman 1994; Wu & Hobbs 2007; With 2019.

See also: Landscape, Spatial analysis, Spatial modeling, Spatial heterogeneity, System scale and hierarchy, Biodiversity, Ecosystem services.

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Land tenure

The relationship among either individuals or groups of people with respect to land including natural resources such as forests, water, and so on (FAO 2002). It can be defined in legal or customary terms depending on the institutions of the community or society concerned. Land tenure regimes determine both how property rights are to be allocated and how access is granted to rights to use, control, and transfer land, as well as associated responsibilities and restrictions.

The most common land tenure regimes are: (1) private: the rights are assigned to a private party (individual, group of people, commercial entity, non-profit organization), for example a family-owned farm; (2) open access: specific rights are not assigned to anyone and nobody can be excluded, for example fishing on the high seas; (3) commons: when community members have a right to independently use the holdings of the community, for example grazing cattle on a common pasture; and (4) public: property rights are assigned to a public authority, for example forestland belonging to a decentralized public body.

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Further reading

Feder & Feeny 1991; Hardin 1968; Ostrom 1990.

See also: Land economics, Resources, Property right, Property regimes, Open access regimes, Commons, the, Common property regimes.

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Land types

See: Land use designations.

See also: Land use mapping.

Land use categories

See: Land use designations.

See also: Land use mapping.

Land use change

A shift in the way that a group or individual manages land, which can result in altered land cover. Direct and indirect land use changes can occur. Socio-economic conditions both impact and are impacted by land use change. Roughly 75 percent of the planet's land

surface has been affected by human activity (from Winkler et al. 2021), including crop and livestock production, human settlements, and infrastructure development, all of which contribute to societal well-being. However, land use change and associated changes in land cover can also negatively impact society. Altered land cover affects a range of biophysical and ecological processes. Land cover change can lead to shifts in hydrology, surface albedo, evapotranspiration, and major sources and sinks of carbon, which affect the climate system both locally or globally (from IPCC 2021). Land use change is also "the foremost direct cause of biodiversity loss" (from UNCCD 2021) and drives degradation that costs billions of dollars in annual crop loss.

Rob Bailis

Further reading

Blackie & Brookfield 1987; Houghton 1994; IPCC 2019.

See also: Land use designations, Land use mapping, Deforestation, Desertification.

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Land use designations

The named classifications of defined areas of land related to their past, present, or intended use. These designations are typically selected to support specific applications such as conservation planning or monitoring urban change. The traditional classifications include residential, commercial, industrial, transportation, institutional and public buildings, recreation, forest, and agricultural.

Drawing land use boundaries is always contextual, and the process of creating and using land use designations has been largely shaped by a predominantly white, colonial tradition of land and resource ownership and use (Crampton 2001; Tuck et al. 2014). Land use designations are prone to semantic issues rooted in contrasting assumptions about similar land use types, extending beyond technical and organizational issues into political issues (Harvey et al. 1999). Because of this, there can be significant variation in land use designation across communities. For example, some communities may designate a cemetery as green space, implying that it is suitable for recreational purposes, while others may designate it as urban.

While there have been national efforts to standardize and create interoperable land use designations (American Planning Association 1994), the variety of local land use designations can also afford communities expressivity and control. Participatory land use planning considers the input of the community when developing designations, with the aim of improving the legitimacy of related decisions, such as zoning (National Research Council 2008).

Lindsay K. Barbieri

See also: Land use planning, Land use change, Land economics, Stakeholder participation, Land use mapping.

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Department of Transportation. https://www.planning.org/lbcs/background/scopingpaper/.
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Tuck, E., McKenzie, M. & McCoy, K. 2014. Land education: indigenous, post-colonial, and decolonizing perspectives on place and environmental education research. Environmental Education Research 20(1): 1–23.

Land use mapping

The process of creating maps to represent the use(s) of a defined area of land. Land use mapping is often the basis for the registration and evaluation of land resources, and land use maps support land management decisions and planning. Drawing boundaries of land use is always contextual, and the process of land use mapping has been largely shaped by a predominantly white, colonial tradition of land and resource ownership and use (Crampton 2001; Tuck et al. 2014).

Mapping agencies define land use differently depending on their functional requirements. Examples of broad land use categories agreed upon by the United States Geological Survey (USGS) include urban, agricultural, and forest (Anderson et al. 1976). Land use categories are typically non-overlapping, meaning that each portion of a land use map will only have one designation, but land use can be recorded at different levels of detail. Land use mapping can be done by in-person field visits, remote sensing methods, or a mix of in-person and remote methods. Today, land use mapping is often supported by geographic information systems (GIS), which helps to facilitate data-driven planning and decision-making (Tomlinson 2007).

Lindsay K. Barbieri

See also: Land use planning, Land use change, Land use designations.

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Land use planning

To direct the use of land towards a planned type of activity in a certain area. In this process, a local or regional (and in some countries, national) governmental authority concretizes ideas of how spatial development and organization can contribute to achieving broader societal and political goals such as sustainability, equitability, or resilience; goals that are changing over time.

In many countries, land use planning is the attempt to define and regulate the occupation or use of land or water areas for any human activity or purpose in a general plan by allocating land to uses defined in a nomenclature system. This system often covers environmental conservation areas, agricultural areas, transport uses, housing, economic activities, and social activities, among others. Its purpose is to identify, in a given area, the combination of land uses that is best able to meet the needs of stakeholders while safeguarding resources for the future. Cross-level and cross-sector coordination within administration follows national customs. Effective land use planning is legally binding, provides direction on the way land use activities should take place, and encourages synergies between different uses.

Meike Levin-Keitel & Franziska Sielker

Further reading

Kaiser et al. 1995; Savini & Aalbers 2016.

See also: Land use designations, Land use mapping, Urban planning, Regional environmental planning.

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Law of diminishing marginal utility

The marginal utility diminishes with an increasing quantity of a good or service, such as for example shown in behavioral experiments (Pine et al. 2009). The utility (that is, the intangible value, satisfaction, happiness, or welfare that a person receives from purchasing or consuming a good or service) of the last unit of a good or service a person or household can afford to use is the marginal utility (adopted with slight alterations from Kauder 1965).

The law implies that marginal utility depends on the current wealth of people. For example, a richer person will gain smaller utility from the same additional unit of wealth than would a poorer person (Li & Hsee 2021). Diminishing marginal utility also implies a concave utility function. Concavity of utility functions has been challenged, though: for example, by Kahneman and Tversky (1979), who propose a value function that is concave only for gains, but convex for losses.

THOMAS F. KNOKE

See also: Utility, Prospect theory, Behavioral economics, Behavioral ecological economics.

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Pine, A., Seymour, B., Roiser, J.P. et al. 2009. Encoding of marginal utility across time in the human brain. Journal of Neuroscience 29(30): 9575–81.

Law of increasing marginal cost

An observation that for some goods, as more are produced the cost of production increases (Fisher 1961). Marginal cost is the cost of producing or acquiring the next unit of something. Increasing marginal cost means that for each unit produced/acquired, the cost goes up, and/or the additional resources used are of lower quality. For example, as production of a good increases, its demand for energy, minerals, water, or other inputs, increases. Energy and minerals are pulled away from producing other products, making the other products more scarce and therefore more valuable. The trade-off in the value of other goods needed to produce the one good increases. If the alternative use of the inputs is to protect water inflows to a natural system such as a wetland, the increasing marginal cost can be seen as the increasing loss of wetland productivity and services as water is diverted to the expanding production process.

BRENT M. HADDAD

See also: Scarcity, Resource scarcity, Relative vs. absolute scarcity, Opportunity cost.

Reference

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Leakage

Pollution levels different from—usually more than—what would occur with no response in unregulated market segments. Leakage occurs when there is an incomplete regulatory framework for pollution, with unregulated market segments providing channels that allow polluting economic activities to avoid the regulation (Holland 2012; Lim et al. 2016). It can apply to the regulation of emissions, or the management forests, fisheries, or wildlife, and can have spatial and/or temporal dimensions (Cunningham et al. 2016; Fischer & Salant 2012).

While there are multiple possibilities for leakage channels, two that are policy-relevant are the competitiveness channel and the market redirection channel. Via the competitiveness channel, an emissions tax, or harvesting regulation, imposed on production in one jurisdiction may increase the product's price and lead to the reallocation of production to other jurisdictions with less stringent regulations, resulting in higher emissions, or more deforestation, in those jurisdictions and therefore to positive leakage (Fowlie 2009; Murray et al. 2004). The market redirection leakage channel diverts polluting products from regulated to unregulated markets. A unilateral restriction on the carbon content, or environmental-unfriendliness, of a jurisdiction's imports causes exporters of those products to divert their output to markets in jurisdictions without restrictions, rather than cutting back production and its associated emissions or environmental degradation (Böhringer et al. 2018; Felder & Rutherford 1993; Wilman 2019).

Elizabeth A. Wilman

See also: Emissions, Pollution, Pollution taxes, Regulation, Allocation, Reallocation, Trade-related climate policy.

References

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Wilman, E.A. 2019. Market redirection leakage in the palm oil market. Ecological Economics. 159: 226–34.

Legitimacy

Political science: acceptance of a collective decision-making process or of an authority—for example, a governmental agency—to develop regulations and norms as well as to implement them in a given constituency.

Democracy: process or input-based legitimacy in a democracy refers to the acceptability of a decision-making process by citizens or stakeholders of the decision. Output-based legitimacy relates to the results of the governance process and its acceptance by affected actors and groups.

Science–policy interface: the legitimacy of an assessment denotes "its ability to convince a participant that the goals pursued in the assessment correspond to those that the recipient would have used had he or she conducted the assessment" (Siebenhüner 2003, p. 115).

Bernd Siebenhüner

Further reading

Gilley 2009; Dingwerth et al. 2019; Risse & Stollenwerk 2018; Zürn 2018.

See also: Democracy, Governance, Environmental governance, Accountability.

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Siebenhüner, B. 2003. The changing role of nation states in international environmental assessments—the case of the IPCC. Global Environmental Change 13(2): 113–23.

Zürn, M. 2018. A Theory of Global Governance: Authority, Legitimacy, and Contestation. Oxford: Oxford University Press.

Lexicographic preferences

A method of choosing among options where a consumer (buyer) prefers any amount of some good y to another good x. The buyer has in mind one feature of the item sought that must be present; all items without the feature are excluded. Among the remaining items, a second feature is then evaluated, and all remaining options without it are excluded, and so on. This approach simplifies buying decisions by excluding the possibility of trading off some of the most desired features for more of the less-desired features. An ecological example would include people refusing to buy products that result in biodiversity loss (Spash & Hanley 1995). The buyer is unwilling to trade any biodiversity loss to gain other product features.

Lexicographic preferences are consistent with ethics-based purchase decisions. The utility-maximization understanding of exchange treats the satisfaction one gets from consistent ethical behavior as categorically similar to satisfaction with the features of the item purchased, meaning that they can be traded off to arrive at the most satisfactory combination of all features. This creates the moral quandary of ethical compromises being part of an optimal buying strategy. Lexicographic preferences avoid this dilemma. They do, however, introduce challenges in interpreting data from choice studies such as contingent valuation. It may not be clear whether a refusal to express a willingness to pay for an environmental trade-off is a lexicographic (ethical) decision, or strategic behavior to influence the results of the survey (Saelensminde 2006).

BRENT M. HADDAD

Further reading

Gelso & Peterson 2005.

See also: Duty, Environmental ethics, Bioethics, Contingent valuation method (CVM), Choice experiments, Utility, Utility function.

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Spash, C. & Hanley, N. 1995. Preferences, information and biodiversity preservation. Ecological Economics 12(3): 191–208.

Liberal individualism

A political philosophy defending the rights of individuals and supporting capitalistic free market competition, and representative democracy. Individualism holds that separate and unique individuals, not groups or institutions, are the proper unit of analysis in social science, ethics, politics, and law. It views societies as nothing more than aggregations of individual agents who are entitled to a wide scope of choices, including the right to lead an idiosyncratic lifestyle, so long as others are not harmed (Mill 1956).

In the 20th century, liberalism has been associated with civil and social liberties, non-discrimination, and protective government regulation in many areas of economic and social life (Pettit 2012). Liberalism and individualism have generally been mutually reinforcing, although extreme forms of indi-

vidualism (libertarianism) have clashed with more collectivist forms of liberalism (communitarianism) on some policy issues.

The legal and policy stances of liberal individualism often relate directly to the empirical findings of ecological economics. In the years ahead, the methodological tension between liberal individualism and ecological economics will be significant. This pits "methodological individualism" or social atomism against social holism, which ecological economics, like other sciences focusing on physical and biological systems, tends to adopt (Lukes 1973). Liberal individualism cannot and should not be set aside. However, the question for ecological economics is how to relate the values of human rights, dignity, and independence with the system sciences and their empirical findings of human interdependence in the social and biophysical world (Orr et al. 2020).

BRUCE JENNINGS

Further reading

Hardy 2002; Macpherson 1977; Plamenatz 1973.

See also: Liberalism, Neoliberalism, Free market, Democracy, Human rights, Atomism, Holistic approach.

References

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Orr, C.J., Kish, K. & Jennings, B. eds. 2020. Liberty and the Ecological Crisis: Freedom on a Finite Planet. Abingdon: Routledge.

Pettit, P. 2012. On the People's Terms: A Republican Theory and Model of Democracy. Cambridge: Cambridge University Press.

Plamenatz, J. 1973. "Liberalism," pp. 36–61 in Dictionary of the History of Ideas, 5 vols. P.P. Wiener, ed. New York: Charles Scribners.

Liberalism

First codified by John Locke, a philosophy predicated on the autonomy of sovereign individuals, government by consent and equality before the law, and generally associated with the panoply of Enlightenment liberties, values, and institutions—the free press, freedom of conscience and religion, freedom of association, secularism, democracy, meritocracy, scientific rationalism, market economy—that define modern liberal democracies. Alongside conservatism, socialism, and nationalism, liberalism is one of the distinctively modern ideologies that emerged in the late 18th century in tandem with the formation of nation-states and capitalism. Liberalism is rooted in a philosophical anthropology that posits a social contract between sovereign individuals. Although the projection of this anthropological individualism as a human universal is erroneous, the progressive impact of both markets and state bureaucracies is to move society in this direction.

From an ecological-economic perspective, a society of spatially and socially mobile individuals is a prerequisite for liberal thinking and institutions. As such, liberalism is synonymous with social complexity, and a historically unprecedented throughput of energy and matter in the economy. This is significant, suggesting that any project of degrowth, by definition, cannot be liberal. As a result of what Karl Polanyi (1944) called the "The Great Transformation" and the "disembedding" of the economy, individuals were partially detached from the ascriptive dependence on the livelihood relations of family and place-bound/subsistence forms of economy. In liberal societies, individuals tend to be dependent much more on the market (for example, jobs, private insurance; that is, neoliberalism) and/or the state (for example, public sector employment, welfare, social insurance, public health systems; that is, political liberalism).

STEPHEN QUILLEY

Further reading

Gray 1995; Ryan 2012; Quilley 2020.

See also: Liberty, Liberal individualism, Contractarian liberalism, Neoliberalism, Democracy, Individualism, Complexity, Throughput, Market, Degrowth.

References

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Polanyi, K. 1944. The Great Transformation. Boston, MA: Beacon Press.
Quilley, S. 2020. "Liberty in the near Anthropocene: state, market, and livelihood," pp. 17–34 in Liberty and the Ecological Crisis: Freedom on a Finite Planet. C.J. Orr, K. Kish & B. Jennings, eds. London: Routledge.
Ryan, A. 2012. The Making of Modern Liberalism. Princeton, NJ: Princeton University Press.

Liberty

Unimpeded agency in pursuit of ends valued by the agent. Some argue that liberty is compatible with any end; others argue that the goal sought must itself be good or morally justifiable. As to the means of human agency, to be at liberty is to be free from arbitrary outside interference and/or to be free to receive outside assistance. Again, there is a debate concerning whether liberty requires the absence of all interference, or merely unreasonable and "morally arbitrary" interference (Jennings 2018). For example, in economics it is widely held that liberty is compatible with being subject to the constraining forces of market competition (Jennings 2015), which does exercise constraints on individual agency. Liberty has historically been associated with an individualistic view of society as an aggregation of individuals (Brown & Timmerman 2015).

Liberty also has been closely associated with the concept of rights. To be free is to claim one's rights against others acting illegally or unjustly. Some see a state of freedom as intrinsically good for its own sake. Others argue that freedom or liberty is something instrumentally required to achieve the respect and dignity that rights confer. Currently, environmental law around the world is extending legal standing and rights—or granting negative freedom from harm—to other than human forms of life and ecosystems (Robinson 2019). As it develops, this trend in law and policy will intersect with the work of ecological economics in many ways (Orr et al. 2020).

BRUCE JENNINGS

Further reading

Hardy 2002; Mill 1956. Nedelsky 2013.

See also: Liberal individualism, Free market, Human agency, Rights, Human rights, Indigenous rights, Environmental rights.

References

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Life-cycle analysis

See: Life-cycle assessment (LCA).

See also: Material flow analysis, Energy flows.

Life-cycle assessment (LCA)

A methodological framework for assessing environmental impacts across the life cycle, traditionally of products, but more recently also of systems, organizations, regions, and economic sectors. Sometimes also called life-cycle analysis. LCA relates all material and energy inputs and environmental releases throughout a product's life cycle (inventory data) to impacts on the environment expressed as the amount of emissions, waste, or depleted resources per functional unit of the product. Besides the internationally standardized version (Finkbeiner et al. 2006), LCA is an evolving framework used as a decision-supporting tool in both private and public sectors.

Recent developments expand the scope of traditional LCA beyond product-level analysis towards territorial- and economy-level analysis, and beyond environmental impacts towards a more comprehensive life-cycle sustainability assessment (LCSA). Within these trends, conventional economics favors eco-efficiency-oriented LCA, and a monistic, value-free, expert-led interpretation and assessment of sustainability. In contrast, ecological economics favors sustainable scale of the economy, social LCA, and distributive justice besides eco-efficiency (Sala et al. 2013; Pelletier et al. 2019), and advocates for including biophysical boundaries in LCA (Bjørn & Hauschild 2015). It also recognizes embedded values in LCA (Hall 2015) and emphasizes the pluralistic, normative, value-laden nature of sustainability, calling for transdisciplinary approaches in LCSA (Troullaki et al. 2021).

KATERINA TROULLAKI

Further reading

Rebitzer et al. 2004; Finnveden et al. 2009; Guinée et al. 2011.

See also: Industrial ecology, Sustainability assessment, Sustainability assessment tools, Sustainable scale, Eco-efficiency, Monism.

References

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Life satisfaction

Global, evaluative measure of subjective well-being, capturing a person's self-assessed mental state when it comes to general conditions in life relative to an ideal life the person has in mind. It is most often measured using surveys, either by asking respondents a single-item Likert-scale question such as "Overall, how satisfied are you with your life nowadays?," or by using multi-item summary-scales such as the Satisfaction with Life Scale (SWLS). The measure is most often used to monetarily value intangibles.

CHRISTIAN KREKEL

Further reading

Diener et al. 1985; Dolan & Kudrna 2016; Dolan & Metcalfe 2012.

See also: Quality of life (QoL), Subjective well-being, Happiness.

References

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Dolan, P. & Metcalfe, R. 2012. Measuring subjective wellbeing: recommendations on measures for use by national governments. Journal of Social Policy 41(2): 409–27.

Limits

Traditionally the points or levels beyond which something does not or may not extend or pass, or the maximum level that is possible or permitted. The concept sparked a public debate when the Club of Rome's *Limits to Growth* report was published about the "predicament of mankind" (Meadows et al. 1972). The Club of Rome model used computer simulations to show that even if only one of the five parameters chosen in its simplest formulation—population, food, pollution, industrialization, and consumption of non-renewable resources—gets out of control, a catastrophe would result in rapid economic and population decline only a few decades later. This raised substantial scientific debate about maximum pollution levels, carrying capacity, and other ecological limits. It was the first criticism, known and widespread throughout the world, against the economic mainstream, which in the name of the growth of the gross national product (GNP) supported unlimited growth of the consumption of all underlying goods and natural resources. A few years earlier, Kenneth Boulding (1966) argued that society should replace the unlimited growth of the "Cowboy economy" with the circular economy, typically limited and necessary in the "spaceship Earth" with scarce resources to manage intelligently.

AURELIO ANGELINI

See also: Limits to growth, Ecological limits, Carrying capacity, Maximum sustainable yield, Circular economy.

References

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Meadows, D., Meadows, D., Randers, J. & Behrens III, W.W. 1972. The Limits to Growth. Washington, DC: Potomac Associates—Universe Books.

Limits to growth

Ecology: the extent to which an ecosystem can absorb waste and generate capacity sufficient to sustain human activity. The term was popularized by the 1972 report from the Club of Rome on the relationship between exponential economic and population growth and finite resource use using the World3 computer model (Meadows et al. 1972, 2004). The report concluded that given business as usual, limits to growth on Earth would become evident by 2072, including rapid declines in services, population, food, and industrial outputs.

Economics: a decreasing rate of marginal return in a production process.

KATIE M. KISH

Further reading

Daly 1996.

See also: Threshold, Tipping point, Models and modeling, Limits.

References

Daly, H.E. 1996. Beyond Growth: The Economics of Sustainable Development. Boston, MA: Beacon Press.

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to Growth. Washington, DC: Potomac Associates—Universe Books.
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Linear throughput

The unidirectional flow and depletion of valuable, low-entropy energy and materials from the environment into the economic system and back into the environment as high-entropy, degraded and dissipated energy, pollution, and waste materials (Daly 1985). While some materials can be recycled, recycling does not change the nature of this process.

BARRY D. SOLOMON

Further reading

Rees 2003; Lawn 2000.

See also: Throughput, Entropy, Entropy law, Sustainable recycling, Bioeconomics, Biophysical economics, Circular flow model.

References

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Rees, W.E. 2003. Economic development and environmental protection: an ecological economics perspective. Environmental Monitoring and Assessment 86: 29–45.

Living standards

Neoclassical economics: the average level of consumption (for example, gross domestic product per capita). "Minimum living standards" are equated to a level of income or expenditure that covers the necessities of life (for example, the international poverty line). Beyond monetary estimates, the "decent living standard" uses a set of proxy indicators, such as access to water or ownership of a television (Rao & Min 2018).
Ecological economics: living standards are defined as minimum floors and maximum ceilings (e.g., Jackson 2016; Raworth 2017; O'Neill et al. 2018).

Needs/capabilities approaches: living standards (satisfiers, generally material) are distinguished from fundamental needs (Max-Neef et al. 1987; Doyal & Gough 1991). Living standards (functionings) are also distinguished from one's potential to achieve alternative living standards (Nussbaum & Sen 1993).

CRELIS F. RAMMELT

Further reading

Sen 1984.

See also: Quality of life (QoL), Life satisfaction, Social welfare function, Utility function, Buen vivir.

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Jackson, T. 2016. Prosperity Without Growth: Foundations for the Economy of Tomorrow, 2nd edn. London: Routledge.
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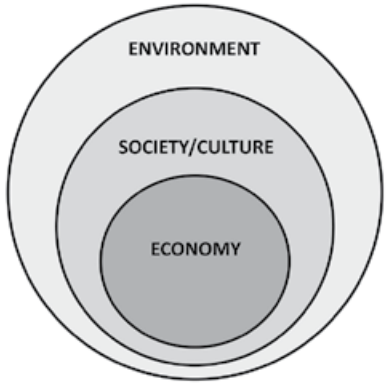

Source: Author.

Figure 12 *The economy is nested in society and the environment*

Local economies

Market and networking systems that are part of a specific community. One of the hallmarks of ecological economics is its recognition that context matters. Economic activity is therefore not determined by abstract principles of allocation, production, and consumption but by the social/cultural and environmental/physical context systems within which all economic activities take place. While neoclassical economics renders these context systems invisible and considers them "external" to its purview, ecological economics considers them as central to economic activity and value creation. This is reminiscent of spatial economics, which views economies as a series of circles representing the local economy at the center, followed by the regional economy, the national economy, and the global economy as the outer circle. Viewing the economy as nested within its social/cultural and environmental/physical context, however, recognizes not only that scale matters, but also that each system operates at a different time frame, and uses different measures to indicate its health and success (Figure 12).

The diversity of local economies offers opportunities to assess the complexity of nested context systems and to identify initiatives that result in sustainable scales and positive economic and context impacts. This shifts the focus of economic analysis to identifying sustainable scales, as well as quantitative and qualitative success measures of economic activity. A core tenet of ecological economics therefore holds that local efforts are key to identifying patterns that move toward a model of decentralized, accessible, and sustainable local economies. In this view local communities of manageable size offer the greatest hope for achieving a sustainable world.

Sabine O'Hara

Further reading

O'Hara & Baker 2020; O'Hara 2016; Prugh et al. 2000.

See also: Community, Community-based, Community currency, Community forestry, Regional economics.

References

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O'Hara, S. 2016. "Production in context: the concept of sustaining production," pp. 75–106 in Beyond Uneconomic Growth, Vol. 2: A Festschrift in Honor of Herman Daly. J.

Farley & D. Malghan, eds. Burlington, VT: University of Vermont.
Prugh, T., Costanza, R. & Daly, H. 2000. The Local Politics of Global Sustainability. Washington, DC: Island Press.

Local governance

The political and institutional processes through which decisions for local issues are made and implemented. Local governance is a broad, organized system of deliberation and decision-making, where elected councils exercise their power and responsibilities to achieve economic, social, and good governance goals for their municipal districts (Røiseland 2011). While the councils lie at the center of decision-making, local governance comprises several institutions including government agencies, non-governmental organizations (NGOs), the corporate sector, civil society, and development partners as stakeholders and participants (Andrew & Goldsmith 1998).

The competences of local governance systems vary in line with the degree of decentralization of different states. The agenda of local governance focuses on local issues, such as land-use planning, local infrastructure, environmental protection, and so on. Their implications, however, carry broader national, transregional and global implications (for example, with cities setting their own climate targets and action plans). Importantly, local governance enhances accountability mechanisms, as it generates feedback loops closer to the citizens. It is also more conducive to citizen engagement and participation, compared to the more distant national, supra-national, and global levels of governance.

Filippos Proedrou

Further reading

Shah 2006; John 2001; Bardhan & Dilip 2006; Stoker 2006, 2017.

See also: Civil society, Non-state actors, Stakeholder, Decentralization, Local economies, Land use planning, Accountability.

References

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Stoker, G. 2017. Transforming Local Governance: From Thatcherism to New Labour. Basingstoke: Palgrave Macmillan International Higher Education.

Logical positivism

A philosophical movement that spread in Vienna during the interwar period where philosophers, social scientists, physicists, and mathematicians gathered around Moritz Schlick and formed the Vienna Circle. Among them were Hans Hahn, Otto Neurath, Rudolf Carnap, Herbert Feigl, and Richard von Mises. In 1929 they published their Manifesto (Hahn et al. 1929). Inspired by Ludwig Wittgenstein (1922), they converged towards the idea according to which any metaphysical inquiry is neither true nor false, but meaningless. In fact, a statement is meaningful only if it is either verifiable by empirical data or else tautological. Logical positivism strongly supported the notion of unified science; that is, all genuine knowledge about nature can be expressed in a single language common to all the sciences, including economics. The need of verification through empirical data led logical positivists interested in economic theory to support the foundation of econometrics.

Giandomenica Becchio

Further reading

Neurath et al. 1969; Neurath 1987.

See also: Positivism, Empiricism, Econometrics, Models and modeling.

References

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Neurath, O., Carnap, R. & Morris, C. 1969. Foundations of the Unity of Sciences. Chicago, IL: University of Chicago Press.
Wittgenstein, L. 1922. Tractatus Logico-Philosophicus. London: Routledge.

Logistic growth

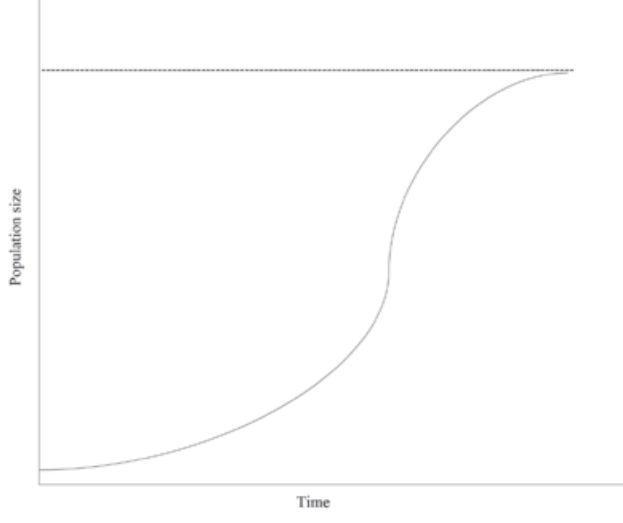
A growth process that can be represented by a logistic function or curve, also called an S-shaped or sigmoid curve (Figure 13). At first there is very slow growth, which eventually accelerates until a plateau or limit is reached. Logistic growth can be represented by the following equation:

$$f(x) = \frac{K}{1 + e^{-n(x - x_0)}}$$

where:
$f(x)$ = output of the function
K = maximum value on the curve
n = logistic growth rate of the curve
x_0 = x value at the curve's midpoint
x = real number

Economics: logistic growth curve can represent the diffusion of technological innovations, such as new energy technologies, computers, cellphones, and infrastructure. After a new product is introduced into the market and slow adoption, the quality of the product is increased and eventually the adoption rate accelerates until the market becomes saturated.

Ecology: the population growth rate of many animal species with access to limited resources follows a logistic curve in which the growth rate decreases as they approach the carrying capacity of their ecosystems.



Source: Author.

Figure 13 *Logistic population growth*

In agriculture, some crop species follow a logistic curve that is a function of the depth of the water table.

BARRY D. SOLOMON

See also: Saturation, Carrying capacity, Technology, Technological change, Technological progress, Exponential growth.

Further reading

Meyer et al. 1999; Pan & Köhler 2007; Seidl & Tisdell 1999.

References

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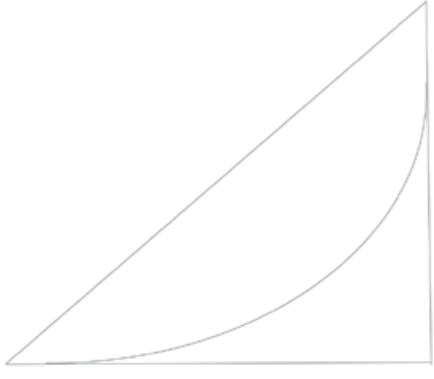
Seidl, I. & Tisdell, C.A. 1999. Carrying capacity reconsidered: from Malthus' population theory to cultural carrying capacity. Ecological Economics 31(3): 395–408.

Lorenz curve

A graphical representation of the total national income or wealth of a country, developed by the United States economist Max Lorenz in 1905. It is usually plotted by showing the cumulative share of the corresponding population from lowest to highest, ranked by the increasing share of income or wealth of the various portions (Gastwirth 1971, 1972). The degree that the curve sags below a straight diagonal line measures the degree of inequality of income or wealth distribution (see Figure 14). In Figure 14, the x-axis shows the cumulative share of people from the lowest to highest income or wealth levels, and the y-axis shows the cumulative share of income earned or wealth. The 45 degree straight diagonal line represents an equal distribution of income or wealth throughout society, while the curved line illustrates an unequal distribution. A metric to measure inequality based on the Lorenz curve was developed by Corrado Gini.

BARRY D. SOLOMON

See also: Gini index, Inequality, Economic inequality, Income distribution, Wealth distribution.



Source: Author.

Figure 14 *A Lorenz curve*

References

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M

Macroeconomics

The branch of economics concerned with the behavior and performance of the whole economy. Typical macroeconomic concerns focus on aggregate factors in the economy including gross domestic product (GDP), growth rate, unemployment, inflation, total consumer and business spending, government spending and taxes. In standard economic analysis, economic growth is generally promoted, and there are no inherent limits to growth. Mainstream macroeconomics includes classical and Keynesian perspectives, with classical approaches favoring minimal government intervention, while Keynesian economics supports an activist government role in the economy. Post-Keynesian approaches are more compatible with an ecological approach, leading to some attempts to combine the two in a "green Keynesian" macroeconomic perspective, suggesting guidelines for government intervention to limit ecosystem impacts and achieve sustainable economic scale, while maintaining full employment.

JONATHAN M. HARRIS

Further reading

Daly 1996; Harris 2013; Richardson 2013.

See also: Classical economics, Post-Keynesian economics, Optimal scale of the macroeconomy, Sustainable scale, Ecological macroeconomics.

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Harris, J.M. 2013. Green Keynesianism: beyond standard growth paradigms. Medford, MA: Working Paper 13-02, Global Development and Environment Institute, Tufts University.

Richardson, R.B. 2013. Building a Green Economy: Perspectives from Ecological Economics. East Lansing, MI: Michigan State University Press.

Mainstream economics

See: Neoclassical economics.

See also: Heterodox economics, Behavioral economics, Evolutionary economics, Experimental economics.

Maintenance cost valuation

Environmental accounting methods used to measure the imputed environmental costs of economic activities caused by households and industries. Maintenance cost valuation can be based on the avoidance, replacement, prevention, or restoration costs of environmental impacts caused by economic agents to natural capital.

BARRY D. SOLOMON

Further reading

Bartelmus 1998; Herbohn 2005.

See also: Maintenance services, Environmental accounting, Natural capital.

References

Bartelmus, P. 1998. "The value of nature: valuation and evaluation in environmental accounting," pp. 263–307 in Environmental Accounting in

Theory and Practice. K. Uno & P. Bartelmus, eds. Dordrecht: Springer.
Herbohn, K. 2005. A full cost environmental accounting experiment. Accounting, Organizations and Society 30(6): 519–36.

Maintenance services

Ecosystem services that usually accompany regulating (regulation) services. A separation between the meaning of regulation and maintenance was initially made by de Groot et al. (2002) that related the former to the capacity of natural and semi-natural ecosystems to regulate essential ecological processes through biogeochemical cycles and other biospheric processes; and the latter to the capacity to provide refuge and reproduction. Regulation services can provide direct and indirect benefits to humans (for example, clean air, water, and soil); maintenance services contribute to on-site conservation of biological and genetic diversity, and eventually to evolutionary processes, and thus have indirect and long-term benefits to humans that hardly perceive them.

Throughout the classification systems of ecosystem services, maintenance services have been:

1. Embedded into other groups of services: for example, in the Millennium Ecosystem Assessment they were reported partly as supporting services and partly as regulating services (MA 2005).
2. Separately reported as a group of services: in TEEB (The Economics of Ecosystems and Biodiversity) the group named "habitat services" fully reflects the meaning of maintenance services (Kumar 2010).
3. Grouped together with regulation services: this remains the most popular classification type that characterizes the Common International Classification of Ecosystem Services (CICES) (Haines-Young & Potschin 2018) and in turn the UN System of Environmental–Economic Accounting—Ecosystem Accounting (UN et al. 2021).
4. Individually identified as categories of "Nature Contribution to People" (Díaz et al. 2018), specifically as "Habitat creation and maintenance" and "Pollination and dispersal of seeds and other propagules."

With specific reference to CICES version 5.1, the general section is named "Regulation and Maintenance" with two main divisions. Within the second division named "Regulation of physical, chemical, biological conditions," there is a specific group called "Lifecycle maintenance, habitat and gene pool protection" which includes the following services (classes): (1) pollination (or "gamete" dispersal in a marine context); (2) seed dispersal; and (3) maintaining nursery populations and habitats (including gene pool protection).

Alessandra La Notte

See also: Ecosystem services, Regulating services, Economic ecosystem accounting, System of National Accounts (SNA), Common International Classification of Ecosystem Services (CICES), Millennium Ecosystem Assessment.

References

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Díaz, S., Pascual, U., Stenseke, M. et al. 2018. Assessing nature's contributions to people. Science 359: 270–72.
Haines-Young, R. & Potschin, M.B. 2018. Common International Classification of Ecosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure. Fabis Consulting, Nottingham, UK. https://cices.eu/content/uploads/sites/8/2018/01/Guidance-V51-01012018.pdf.
Kumar, P., ed. 2010. The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. London: Earthscan.
MA (Millennium Ecosystem Assessment). 2005. Ecosystems and Human Well-Being: Synthesis. Washington, DC: Island Press.
United Nations et al. 2021. System of Environmental-Economic Accounting–Ecosystem Accounting (SEEA-EA). White cover publication, pre-edited text subject to official editing. New York. https://seea.un.org/ecosystem-accounting.

Malthusian scarcity

Named after the classical economist Thomas Robert Malthus, referring to the quantitative, physical limits associated with food and other natural resources. Malthus argued that the human population will tend to exceed these limits unless controlled by policy or catastrophic consequences such as famine.

GEORGY TROFIMOV

See also: Scarcity, Resource scarcity, Relative vs. absolute scarcity, Ricardian scarcity.

Management science

The use of a variety of mathematical techniques to improve the operations and decision-making of systems. Management science is sometimes also called operations research (as well as operational research, operational analysis, or operations analysis), and decision science. The field began with early-warning radar analyses undertaken a couple of years before World War II. Some consider it a subfield of mathematical sciences. The discipline develops and uses mathematical and computational methods for decision-making. The field revolves around a mathematical core consisting of several fundamental topics including optimization, applied probability and statistical analysis, stochastic systems, simulation, economics, game theory, and network analysis.

In general, mathematical models are developed and used to represent an existing system, and then solved to find a more optimal way to operate the studied system. Thus, management science attempts to evaluate the effect of changes in any part of a system on the performance of the system as a whole, and to search for causes of a problem that arises in one part of a system in other parts or in the interrelationships between parts. The broad applicability of its core topics places management science at the heart of many important contemporary problems such as supply chain management, pricing and revenue management, financial engineering, market design and strategy, bioinformatics, production scheduling, managing water flows, energy systems planning and management, energy and environmental policy, and transportation logistics, among others.

PAUL M. BERNSTEIN

Further reading

Bertsimas & Freund 2004; Baumol 1977.

See also: Decision-oriented optimization models, Optimization, Game theory, Systems-oriented simulation models, Simulation modeling, Networks.

References

Baumol, W.J. 1977. Economic Theory and Operations Analysis, 4th edn. Upper Saddle River, NJ: Pearson College Division.

Bertsimas, D. & Freund, R. 2004. Data, Models, and Decisions: The Fundamentals of Management Science. Charlestown, MA: Dynamic Idea.

Manufactured capital

Any production factor built or produced by people. Sometimes also called built, physical, produced, or human-made capital. It can be owned by natural and legal persons as well as by a state entity. Potentially serves in conjunction with other production factors to produce goods and services. Includes all physical assets and infrastructure—for example, buildings, roads, machinery, tools, and so on—but not natural resources or money (financial capital).

Natural resources that after harvesting have undergone a finishing process that significantly changed the characteristics of the resource may also be considered manufactured capital. Differentiation between manufactured capital and natural resources is crucial regarding the assignation of property rights. It has been argued (e.g., Fuders & Pastén 2020) that to achieve allocative efficiency only manufactured capital should be privately owned.

FELIX FUDERS

Further reading

Costanza & Daly 1992; Costanza et al. 1997; Weisz et al. 2015.

See also: Natural capital, Resources, Property right.

References

Costanza, R. & Daly, H.E. 1992. Natural capital and sustainable development. Conservation Biology 6(1): 37–46.

Costanza, R., d'Arge, R., de Groot, R. et al. 1997. The value of the world's ecosystem services and natural capital. Nature 387(15): 253–60.

Fuders, F. & Pastén, R., 2020. "Allocative efficiency and property rights in ecological economics: why we need to distinguish between man-made capital and natural resources," pp. 43–56 in Ecological Economic and Socio Ecological Strategies for Forest Conservation—A Transdisciplinary Approach Focused on Chile and Brazil. F. Fuders & P.J. Donoso, eds. Cham: Springer.

Weisz, H., Suh, S. & Graedel, T.E. 2015. Industrial ecology: the role of manufactured capital in sustainability. Proceedings of the National Academy of Sciences of the United States of America 112(20): 6260–64.

Marginal analysis

Economics: a revolution that began at the start of the neoclassical economics period in the 1870s with the rise of the marginal utility school of thought, when economists moved away from the labor theory of value.

a. Producers use marginal analysis to decide how much output to produce to meet their goals, which is usually to maximize their potential profits.
b. A fundamental tool for benefit–cost analysis and used in policymaking.

In marginal analysis the additional benefit of an activity is compared against the additional costs incurred by that same activity. Note that "marginal" refers to the focus on the additional, not total, cost or benefit of the next unit of activity. Nor does marginal mean unimportant in this context. It is simply the costs and benefits for the addition of an activity, the activity on the margin. In competitive markets the benefits would be the revenue of selling one more unit compared to the extra cost to produce one more unit. For example, in assessing the costs and benefits of a carbon tax, the marginal cost of raising prices would be weighed against the extra benefits gained from reducing consumption of carbon.

TERESA GHILARDUCCI

Further reading

Onukwugha et al. 2014; Timmons et al. 2016.

See also: Equimarginal principle of optimization, Law of increasing marginal cost, Law of diminishing marginal utility, Marginal product of capital, Marginal user cost, Labor theory of value, Benefit–cost analysis (BCA).

References

Onukwugha, E., Bergtold, J. & Jain, R. 2014. A primer on marginal effects—Part I: theory and formulae. PharmacoEconomics 33: 25–30.

Timmons, D., Konstantinidis, C., Shapiro, A.M. & Wilson, A. 2016. Decarbonizing residential building energy: a cost-effective approach. Energy Policy 92: 382–92.

Marginal external cost (MEC)

The cost imposed upon a third party or parties from an externality, environmental or otherwise.

BARRY D. SOLOMON

Further reading

Mayeres 1993.

See also: Externalities, Environmental externalities, Consumption externalities, Third party.

Reference

Mayeres, I. 1993. The marginal external cost of car use—with an application to Belgium. Tijdschrift voor Economie en Management 38(3): 225–58.

Marginal product of capital

In economic theory, the additional output obtained from an additional unit of capital. Determines the share of income going to the owners of capital. In ecological economics, can be applied to manufactured capital (for example, machines), raising questions about the complementarity or substitutability of

manufactured capital with natural resources. Less frequently, the concept can also be applied to natural capital (for example, resources, sinks), in particular to reveal the type of returns—increasing, constant, or diminishing—of certain components of nature used in production processes.

ANTOINE A.G. MISSEMER

Further reading

Victor 1991.

See also: Manufactured capital, Natural capital.

Reference

Victor, P.A. 1991. Indicators of sustainable development: some lessons from capital theory. Ecological Economics 4(3): 191–213.

Marginal user cost

User cost can be defined as:

a. The returns one would receive renting a benefit-producing unit of a resource to someone else, after subtracting the wear-and-tear costs and taxes from the rent received. This definition focuses on the value of the services provided by the unit of the resource.
b. The value of the inputs consumed in the production process. This definition focuses on the value of the physical inputs to production.

Marginal user cost divides the process into consecutive units produced, and considers the cost of producing the next unit of the resource, which is the opportunity cost of producing one more unit today instead of in the future. If marginal user costs are increasing, either the value of the service provided by the resource is increasing or the cost of the inputs is increasing, for example, because of resource scarcity. In ecological economics the latter definition fits more closely with the field's emphasis on measuring and valuing the physical inputs to an economy, and recognizing their finitude (Common & Perrings 1992).

BRENT M. HADDAD

See also: Natural resource rents, Natural assets, Scarcity value.

Reference

Common, M. & Perrings, C. 1992. Towards an ecological economics of sustainability. Ecological Economics 6(1): 7–34.

Marine ecosystems

Aquatic systems with a high salt content, marine ecosystems cover over 70 percent of the Earth's surface. Depending upon water depth and shoreline features, marine ecosystems can be divided into several zones, including: the oceanic zone where animals such as whales, sharks, and tuna live; the benthic zone where many invertebrates live; the intertidal zone; and other near-shore zones such as mangroves, coral reefs, lagoons.

Marine ecosystems are complex in the sense that they account for a broad range of components and interactions, both ecological and economic. From the ecological viewpoint, marine ecosystems are characterized by a very rich biodiversity, from the blue whale to phytoplankton. Other complexities arise from trophic or competition-based multi-species interactions, the role of habitats, or the influence of climate change. From the socio-economic viewpoint, the complexity arises from the various uses and services of marine ecosystems, which include fisheries-related, recreational, and cultural services, as well as regulating services such as carbon sequestration.

Marine ecosystems are under pressure mainly because of overfishing, marine pollution, climate change, and building on coastal areas. Thus, the international community has prioritized "Life below water" as Sustainable Development Goal 14. In that context, many experts advocate an ecosystem approach to fisheries and ecosystem-based fishery management (EBFM), by contrast to a mono-specific approach including maximum sustainable yield (MSY) or maximum economic yield (MEY). However, the way to operationalize such EBFM in ecological-economic terms remains under debate.

LUC DOYEN

Further reading

Thébaud et al. 2014; Fulton et al. 2019; UNEP 2006; Garcia et al. 2003; Plagányi 2007; OECD 2016; Link et al. 2017; Holsman et al. 2020.

See also: Marine protected areas (MPAs), Ecosystem services, Complex systems modeling, Fishery, Sustainable Development Goals (SDGs).

References

Fulton, E.A., Punt, A.E., Dichmont, C.M. et al. 2019. Ecosystems say good management pays off. Fish and Fisheries 20(1): 66–96.

Garcia, S.M., Zerbi, A., Aliaume, C. et al. 2003. The ecosystem approach to fisheries: issues, terminology, principles, institutional foundations, implementation and outlook. FAO Fisheries Technical Paper No. 443. Rome: Food and Agriculture Organization of the United Nations.

Holsman, K.K., Haynie, A.C., Hollowed, A.B. et al. 2020. Ecosystem-based fisheries management forestalls climate-driven collapse. Nature Communications 11: 4579.

Link, J.S., Thébaud, O., Smith, D.C. et al. 2017. Keeping humans in the ecosystem. ICES Journal of Marine Science 74(7): 1947–56.

OECD (Organisation for Economic Co-operation and Development). 2016. The Ocean Economy in 2030. Paris: Éditions OCDE.

Plagányi, É.E. 2007. Models for an ecosystem approach to fisheries. FAO Fisheries Technical Paper No. 477. Rome: Food and Agriculture Organization of the United Nations.

Thébaud, O., Doyen, J., Innes, J. et al. 2014. Building ecological-economic models and scenarios of marine resource systems: workshop report. Marine Policy 43: 382–6.

UNEP (United Nations Environment Programme). 2006. Marine and Coastal Ecosystems and Human Wellbeing: A Synthesis Report Based on the Findings of the Millennium Ecosystem Assessment. Nairobi: UNEP. https://www.millenniumassessment.org/documents/Document.799.aspx.pdf.

Marine protected areas (MPAs)

Coastal and ocean regions regulated by governments to preserve unique ecosystem and cultural/historical attributes. MPA restrictions range from near-complete prohibition of human use (International Union for Conservation of Nature (IUCN) Category 1a – Strict Natural Reserve or "No-Take Zone") to minor limitations (IUCN Categories 5 or 6, allowing sustainable commercial use of seascapes). Scientific research is typically permitted in MPAs.

Brent M. Haddad

Further reading

Agarty 1994; Edgar et al. 2014.

See also: Biodiversity conservation, No-take zone, Conservation areas, Cultural services, Ecosystem services.

References

Agarty, M.T. 1994. Advances in marine conservation: the role of marine protected areas. Trends in Ecology & Evolution 9(7): 267–70.

Edgar, G.J., Stuart-Smith, R.D., Willis, T.J. et al. 2014. Global conservation outcomes depend on marine protected areas with five key features. Nature 506: 216–20.

Marine reserves

See: Reserves.

See also: Marine protected areas (MPA), Marine ecosystems.

Marine resources

See: Marine ecosystems.

See also: Reserves, Marine protected areas (MPAs), No-take zone.

Market

An institution that enables buying and selling through prices. This institution can be a physical space, a shared ritual, a set of norms, or any combination thereof. This definition combines all three ways that scholars have defined what a market is (Rosenbaum 2000): (1) based on what it looks like (prices, in this case); (2) what it does (enables buying and selling); and (3) what institutions or assem-

blages underlie it (a physical space, shared ritual, and/or set of norms). Authors have proposed numerous other definitions based on different observational, functional, and structural factors. Many more authors write extensively about markets without defining the term.

SAM C. BLISS

See also: Transaction prices, Institutions, Economic institutions, Market solution, Non-market economies.

Reference

Rosenbaum, E.F. 2000. What is a market? On the methodology of a contested concept. Review of Social Economy 58(4): 455–82.

Market-based instruments

See: Environmental policy instruments.

See also: Market mechanisms, Emissions trading, Carbon taxes, Carbon market, Pollution taxes, Environmental taxes.

Market failure

Instances where voluntary exchange through markets results in systematic loss of well-being of direct participants and others affected by the market activity. Market failures can arise for many reasons, for example:

1. The good itself is not amenable to exchange through markets. An example is when altering its prior location or characteristics in order to transfer ownership leads to broader harm in the original location, such as clearcutting a forest to sell the timber (externalities).
2. Information known only to one party leads to an unfair price or term, such as the sale of a faulty used car (information asymmetry).
3. Concentrated ownership or demand for a good or service allows market power to push prices higher or lower, such as a region's lone employer offering low wages (non-competitive markets).
4. People can use a good or service without paying for it, leading it to be overused, and underfinanced (public goods; tragedy of the commons).
5. An employee can hide the amount and quality of work from an employer, who ends up overpaying for the work (principal–agent problems).

In these and other cases, an unregulated market is unlikely to yield transactions that optimize social well-being.

Ecological economists are interested in market failures because many goods and services connected to natural systems cannot be separated (for example, via market transactions) from the system without damage to the system and resulting harm to those who rely on it. Ecological economists also study instances of inequity and power imbalance in which some parties utilize markets to improve their well-being at the cost of uncompensated harm to others. Because incidences of market failure mean that not all members of society are made better off through free market exchange, they provide powerful, specific justifications for government interventions to regulate markets to improve social outcomes.

BRENT M. HADDAD

Further reading

Hardin 1968; Jaffe et al. 2005; Akerlof 1970.

See also: Human agency, Bounded rationality, Common pool resources, Efficiency, Excludability, Externalities, Asymmetric information, Market power, Pollution, Property right, Regulation, Rivalness, Transaction costs.

References

Akerlof, G.A. 1970. The market for "lemons": quality uncertainty and the market mechanism. Quarterly Journal of Economics 84(3): 488–500.

Hardin, G. 1968. The tragedy of the commons. Science 162(3859): 1243–8.

Jaffe, A.B., Newell, R.G. & Stavins, R.N. 2005. A tale of two market failures: technology and environmental policy. Ecological Economics 54(2–3): 164–74.

Market goods

Things that are exchanged via markets. Some items are easily exchanged through markets because their value, terms of ownership, and ease of conveyance are clear. Other things, often categorized as non-market goods, are of value but cannot be transferred easily via markets. While typically considered as two distinct categories of goods, there is more of a gradient on which different goods and services fall. Twentieth-century economic theory focused largely on market goods and the organization of markets that could efficiently transact them. Environmental and ecological economists identified the importance of non-market goods, turning the focus of research from pure markets as an ideal to more complex regulated market or no-market scenarios.

BRENT M. HADDAD

Further reading

Arrow 1969; Rosenbaum 2000.

See also: Public goods, Externalities, Market, Non-market economies.

References

Arrow, K. 1969. "The organization of economic activity: issues pertinent to the choice of market versus non-market allocation," pp. 59–73 in The Analysis and Evaluation of Public Expenditure: The PPB System, Vol. 1, US. Joint Economic Committee, 91st Congress, 1st Session, Washington, DC: US Government Printing Office.

Rosenbaum, E.F. 2000. What is a market? On the methodology of a contested concept. Review of Social Economy 58(4): 455–82.

Market imperfections

A violation of one or more of the conditions for perfect markets.

BARRY D. SOLOMON

See also: Market failure, Free market, Perfect markets, Transaction costs, Market power, Externalities.

Market mechanisms

Policy instruments that rely on market incentives to reduce pollution or conserve natural resources; specifically emissions trading, pollution taxes or fees, subsidies, rebates, tax refunds or credits, and information disclosure regimes. An emissions trading scheme creates a market in pollution allowances. Both pollution taxes/fees and subsidies/rebates/tax refunds or credits create incentives for market actors to reduce pollution without requiring reductions. Similar approaches can apply to conservation of natural resources, such as tradable allowances to fish, or laws allowing polluters to offset greenhouse gas emissions with projects to enhance ecosystems (which sequester carbon). Information disclosure can influence the market behavior of consumers, shareholders, and firms making the disclosures in ways that reduce environmental impacts. Economists regard these mechanisms as relying on "markets" and economic incentives to reduce pollution, even though governments usually establish all these schemes, and more traditional regulation also creates markets in pollution-reducing technology.

DAVID M. DRIESEN

Further reading

Freeman & Kolstad 2006; Driesen 1998, 2014.

See also: Cap and trade, Carbon taxes, Carbon market, Carbon trading, Emissions trading, Environmental taxes, Pollution taxes, Tradable permits.

References

Driesen, D. 1998. Is emissions trading an economic incentive program? Replacing the command and control/economic incentive dichotomy. Washington and Lee Law Review 55(2): 289–350.

Driesen, D. 2014. Putting a price on carbon: the metaphor. Environmental Law 44(3): 695–722.

Freeman, J. & Kolstad, C., eds. 2006. Moving to Markets in Environmental Protection: Lessons From 20 Years of Experience. New York: Oxford University Press.

Market power

The ability of a firm to charge a price such that it earns excess profits over what it would under competitive conditions, which is measured in degrees along a continuum. A firm with market power does not control the price, it is merely able to charge a price greater than the marginal cost of producing additional goods or services. Market power is a form of market failure. For example, monopoly or oligopolistic power refers to the fact that if a firm dominates all or part of a market, it does not produce as much as it would in competitive situations.

The determinants of market power are the ability of a firm or firms to control the supply of inputs, convince customers that there are no substitutes, get favorable terms from government so that competitors are constrained, or produce products that have increasing returns to scale. Increasing returns to or economies of scale mean that the average cost of producing one more unit continues to fall as production increases. The largest firms can produce the good or service with least cost for the most quality.

Conventional measurements of monopolization or oligopolization include the Herfindahl–Hirschman Index, which is an index of the number of firms in the market and their market shares, and the Lerner Index that measures the degree to which prices exceed marginal cost. Antitrust restrictions are implemented if the firm is deemed to have actively created its market or monopoly power by restricting output—to force a shortage—or restrict the output of the firm's rivals or collude with rivals to collectively restrict supply. The Organization of the Petroleum Exporting Countries (OPEC) is a self-organizing oligopoly formed for the purposes of creating market power. The other way to become a monopoly is if the government grants a company the exclusive right to provide goods or services, because large firms produce much more efficiently (this may be true for an increasing number of goods) and then the company is subject to regulations; utility companies are primary examples.

Teresa Ghilarducci

Further reading

Robinson 1933; Krattenmaker et al. 1987; Syverson 2019.

See also: Microeconomics, Horizontal integration, Market failure, Economies of scale, Utility.

References

Krattenmaker, T.G., Lande, R.H. & Salop, S.C. 1987. Monopoly power and market power in antitrust law. Georgetown Law Journal 76: 241–69.

Robinson, J. 1933. The Economics of Imperfect Competition. London: Macmillan.

Syverson, C. 2019. Macroeconomics and market power: context, implications, and open questions Journal of Economic Perspectives 33(3): 23–43.

Market simulation

See: Systems-oriented simulation models.

See also: Agent-based modeling (ABM).

Market solution

A class of decentralized mechanisms that facilitate transactions between parties who hold private information relevant to the achievement of a defined objective. Market solutions are designed through a reverse engineering process (mechanism design). Market solutions created for ecological and environmental applications include single-sided mechanisms such as auctions (for example, to allocate nature conservation contracts and access to natural resources) and double-sided mechanisms (for example, tradable emission permit, offset and mitigation markets). Matching markets are an important class of market solutions where goods or services are not monetized (Roth 2002).

Gary C. Stoneham

Further reading

Hurwicz & Reiter 2006.

See also: Market mechanisms, Market imperfections, Market failure.

References

Hurwicz, L. & Reiter, S. 2006. Designing Economic Mechanisms. Cambridge: Cambridge University Press.

Roth, A. 2002. The economist as engineer: game theory, experimentation, and computation as tools for design economics. Econometrica 70(4): 1341–78.

Marshallian economics

Refers to the influence of University of Cambridge (England) economist Alfred Marshall (1842–1924), author of the multi-edition *Principles of Economics* (Marshall 1890). This influence follows two different strands of interpretation, which correspond to two different strands of ecological economics: the formal market-based approach, and the evolutionary approach. Marshall's contribution to the marginal revolution and his legacy for the subsequent development of neoclassical economics derives from the tools and concepts he introduced. He constructed a formal demand-and-supply apparatus for comparative static analysis of markets whereby partial equilibrium is established through price adjustment. He also introduced such key concepts as the price elasticity of demand, consumer surplus, producer surplus, and quasi-rents.

Particularly important for ecological economics is Marshall's concept of external economies (from which the concept of externalities evolved). While this is the most common understanding of "Marshallian," the formal market analysis is seen by Marshall scholars as only part of Marshall's much broader system of thought applied to a dynamic socio-political-economic system (Whitaker 2008). Indeed, Raffaelli (2003) interprets him explicitly as an evolutionary economist. Marshall applied his theory of the evolution of the mind to industrial organization, each understood as complex open systems. Here equilibrium is understood in the dynamic terms of a balanced interplay between order and process, where economic, social, and political order arise from successful routines that are nevertheless open to disruption. Marshall's dynamic systems approach emphasized the importance of the evolution of the real context.

SHEILA C. DOW

See also: Marginal analysis, Neoclassical economics, Evolutionary economics, Evolutionary analysis.

References

Marshall, A. 1890. Principles of Economics. London: Macmillan.

Raffaelli, T. 2003. Marshall's Evolutionary Economics. London: Routledge.

Whitaker, J.K. 2008. "Marshall, Alfred (1842–1924)," pp. 360–79 in The New Palgrave Dictionary of Economics. S.N. Durlauf and L.E. Blume, eds. London: Palgrave Macmillan.

Mass balance

See: Material flow analysis.

See also: Material flow accounts, Urban metabolism, Multi-scale integrated analysis of societal and ecosystem metabolism (MuSIASEM), Industrial ecology.

Material cycling

a. Biogeochemical cycling that consists of natural processes in which chemical substances and/or materials (for example, carbon, nitrogen, and oxygen) circulate among biotic (biosphere) and abiotic (lithosphere, atmosphere, and hydrosphere) compartments of the Earth in ecosystems, mainly driven by metabolism of organisms, geological processes, or chemical reactions.
b. Anthropogenic material cycling that consist of human-induced transfer and transformation processes of materials (such as metals, wood, chemicals, wastes, and pollutants) within anthropogenic systems (for example, the anthroposphere of a country or a city) or between anthropogenic systems and natural systems (for example, atmosphere, hydrosphere, biosphere, or pedosphere); a typical anthropogenic cycle of a metal includes mining,

smelting and refining, fabrication, manufacturing, use in different end-use sectors, waste management, recycling, and final disposal of the metal.

c. Anthro-biogeochemical cycling for certain materials such as metals and chemicals that consist of both nature-induced and human-induced processes driving the circulation of materials among anthroposphere and natural systems. Industrializing, urbanization, and technology development are now making humankind increasingly become a dominant force in promoting material cycling, and some material cycles have been significantly perturbed, or even dominated, by anthropogenic influences over the past century.

Wei-Qiang Chen

Further reading

Chen & Graedel 2011; Graedel 2019; Rauch & Gradel 2007; Schlesinger & Bernhardt 2020; Elser & Bennett 2011; Dontsova et al. 2020.

See also: Cycle, Nutrient cycling, Anthropogenic, Material flow analysis, Material flow accounts, Material footprint.

References

Chen, W.-Q. & Graedel, T.E. 2012. Anthropogenic cycles of the elements: a critical review. Environmental Science and Technology 46(16): 8574–86.

Dontsova, K., Balogh-Brunstad, Z. & Le Roux, G. 2020. Biogeochemical Cycles: Ecological Drivers and Environmental Impact. Hoboken, NJ: John Wiley & Sons.

Elser, J. & Bennett, E. 2011. A broken biogeochemical cycle. Nature 478: 29–31.

Graedel, T.E. 2019. Material flow analysis from origin to evolution. Environmental Science and Technology 53(21): 12188−96.

Rauch, J.N. & Graedel, T.E. 2007. Earth's anthrobiogeochemical copper cycle. Global Biogeochemical Cycles 21(2), GB2010.

Schlesinger, W.H. & Bernhardt, E.S. 2020. Biogeochemistry: An Analysis of Global Change, 4th edn. London: Academic Press.

Material flow accounts

A statistical accounting framework describing the physical interaction of a country's economy with the natural environment and with the rest of the world economy in terms of flows of materials. Material flow accounts cover all solid, gaseous, and liquid materials, except for flows of air and water, measured in mass units per year.

Bruno Kestemont

Further reading

Longva 1981; Ščasný et al. 2003; Eurostat 2018.

See also: Material flow analysis, Material footprint, System of National Accounts (SNA), Natural resource accounting, Economic ecosystem accounting, Human ecology, Ecological anthropology, Multi-scale integrated analysis of societal and ecosystem metabolism (MuSIASEM).

References

Eurostat (European Commission). 2018. Economy-wide Material Flow Accounts: Handbook, 2018 edn. Luxembourg: EU Bookshop (European Union, Publications Office).

Longva, P. 1981. A System of Natural Resource Accounts. Oslo: Rapporter 8 i/9 Statistisk Sentralbyra.

Ščasný, M., Kovanda, J. & Hák, T. 2003. Material flow accounts, balances and derived indicators for the Czech Republic during the 1990s: results and recommendations for methodological improvements. Ecological Economics 45(1): 41–57.

Material flow analysis

A method to quantify stocks and flows of materials mobilized by economic processes and required to build, maintain, and fuel the physical assets of an economy. Sometimes called "substance flow analysis," it is based on the law of conservation of mass (mass balance). Material flow analysis (MFA) studies the domestic extraction and trade of materials, wastes, and emissions in one empirical framework. MFA can analyze national economies, industries, subnational regions, and cities. Specific methods are now

globally agreed upon (Fischer-Kowalski et al. 2011), and MFA studies have been published for most countries and regions (Schandl et al. 2018) and many cities (Pincetl et al. 2012). Analyzing material flows enables an understanding of society's natural relations in history, the present and future.

MFA operationalizes the concept of industrial metabolism and is a core method in ecological economics and industrial ecology. It is used to measure the physical scale of the economy as the throughput of materials (biomass, fossil fuels, metal ores, and non-metallic minerals) in tonnes. It analyzes the quality and quantity of materials used in socio-economic processes and can be used to establish a sustainable scale of natural resource use, which is key for analysis in ecological economics but mostly ignored in mainstream economic theory.

MFA and indicators derived from material flow accounts feature prominently in modern environmental and sustainability policy. They are used by the European Commission, Japanese and Chinese governments, United Nations Environment Programme, and the Organisation for Economic Co-operation and Development. Indicators derived from material flow accounts inform resource efficiency, waste minimization, and greenhouse gas abatement policies, and support policy integration of environment and economic objectives. MFA has become an integral part of the United Nations System of Environmental–Economic Accounting framework. Material flow accounts have been used to measure the role of global material use for sustainable development (Krausmann et al. 2017), and to establish science-based targets for sustainable resource use (Bringezu 2019) to enable human development within planetary boundaries.

HEINZ SCHANDL

See also: Material flow accounts, Urban metabolism, Multi-scale integrated analysis of societal and ecosystem metabolism (MuSIASEM), Industrial ecology, Steady state economy, Decoupling economic growth, United Nations Environment Programme (UNEP), Organisation for Economic Co-operation and Development (OECD).

References

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Fischer-Kowalski, M., Krausmann, F., Giljum, S. et al. 2011. Methodology and indicators of economy-wide material flow accounting. Journal of Industrial Ecology 1596: 855–76.

Krausmann, F., Schandl, H., Eisenmenger, N. et al. 2017. Material flow accounting: measuring global material use for sustainable development. Annual Review of Environment and Resources 42: 647–75.

Pincetl, S., Bunje, P. & Holmes, T. 2012. An expanded urban metabolism method: toward a systems approach for assessing urban energy processes and causes. Landscape and Urban Planning 107(3): 193–202.

Schandl, H., Fischer-Kowalski, M., West, J. et al. 2018. Global material flows and resource productivity: forty years of evidence. Journal of Industrial Ecology 22(4): 827–88.

Material footprint

A metric of the material requirements of final demand of a country, and a proxy for overall environmental pressure and impact caused by household and government consumption and capital investment. The metric is established by measuring the raw material equivalent (RME) of traded materials and commodities as RME of imports + domestic extraction – RME of exports, by calculating all upstream and downstream material requirements of final demand. The most common method for the attribution of global material extraction of biomass, fossil fuels, metal ores, and non-metallic minerals to final demand is by environmentally extended input–output analysis using a global multi-regional input–output (MRIO) table. Alternatively, life-cycle assessment and hybrid methods can be used.

First introduced in 2015 (Wiedmann et al. 2015), the metric has been adopted by the United Nations Environment Programme (UNEP), Organisation for Economic Co-operation and Development, and the European Statistical Office, among others. The metric is important because it corrects the notion that some countries, for example, Japan and the United Kingdom, have reduced their material use and associated environmental pressures and impacts when using

territorial metrics (domestic material consumption), when material intensive processes have been outsourced. The material footprint approach demonstrates that these countries rely on large upstream material requirements that occur beyond their borders and cause environmental pressures abroad. The material footprint metric shows that there is no country and level of wealth at which the material footprint has declined or stabilized. Empirical results show a material footprint of 30–40 tonnes per capita per year for high-income countries, compared to 2–4 tonnes per capita per year for low-income countries.

The MRIO method has become the main approach to calculate material footprints, and several global MRIOs are available for the accounting; studies have compared the merit of different approaches (Giljum et al. 2019). The most comprehensive MRIO has been developed for the UNEP International Resource panel and the UN Life Cycle Initiative (Lenzen et al. 2021) to measure resource efficiency and sustainable use of natural resources in the context of the Sustainable Development Goals.

HEINZ SCHANDL

See also: Ecological footprint, Carbon footprint, Waste absorption footprint, Material flow accounts, Environmentally extended input–output analysis (EE-IOA), Life-cycle assessment (LCA), Sustainable Development Goals (SDGs).

References

Giljum, S., Wieland, H., Lutter, S. et al. 2019. The impacts of data deviations between MRIO models on material footprints: a comparison of EXIOBASE, Eora, and ICIO. Journal of Industrial Ecology 23(4): 946–58.

Lenzen, M., Geschke, A., West, J. et al. 2021. Implementing the material footprint to measure progress towards Sustainable Development Goals 8 and 12. Nature Sustainability 5(2): 157–66.

Wiedmann, T.O., Schandl, H., Lenzen, M. et al. 2015. The material footprint of nations. Proceedings of the National Academy of Sciences of the United States of America 112(20): 6271–6.

Materialism

Economics: a viewpoint common in capitalist societies that material possessions and the physical comfort of people are more important than ethical or spiritual values or beliefs, which promotes vanity, greed, and materialism as social values.

Social sciences: the materialist conception of history, also called historical materialism, is a methodology used by Marxist historiographers and socialists which argues that human (economic and social) history is the result of material conditions of a society's mode of production rather than its ideals (Huber 2009).

BARRY D. SOLOMON

Further reading

Foster & Burkett 2008.

See also: Economism, Podolinsky myth.

References

Foster, J.B. & Burkett, P. 2008. Classical Marxism and the second law of thermodynamics: Marx/Engels, the heat death of the universe hypothesis, and the origin of ecological economics. Organization and Environment 21(1): 3–37.

Huber, M.T. 2009. Energizing historical materialism: fossil fuels, space and the capitalist mode of production. Geoforum 40(1): 105–15.

Material services

Those functions that materials contribute to personal or societal activity with the purpose of obtaining or facilitating desired end goals or states, regardless of whether a material flow or stock is supplied by the market (Whiting et al. 2021, p. 3). In this definition, the term "function" refers to the overall characteristic that society requires to do something. It should not be confused with material properties or technical attributes such as steel's tensile strength or a motor's revolutions per minute. Based on this definition, and using visual comfort as an example, we know that for human beings to undertake certain activities (for example, reading, writing, or simply navigating a room) a certain amount

of illumination is required (which could be measured in lumen-hour, lux, or candela per square meter) to provide visual comfort, which is the material service. Other examples include mobility, thermal comfort, shelter, and sustenance.

Kai Whiting

Further reading

Allwood et al. 2013; Carmona et al. 2017; Whiting et al. 2020.

See also: Energy services, Ecosystem services, Universal basic services (UBS).

References

Allwood, J.M., Ashby, M.F., Gutowski, T.G. & Worrell, E. 2013. Material efficiency: providing material services with less material production. Philosophical Transactions of the Royal Society A 371(1986): 20120496.

Carmona, L.G., Whiting, K., Carrasco, A. et al. 2017. Material services with both eyes wide open. Sustainability 9(9): 1508.

Whiting, K., Carmona, L.G. & Carrasco, A. 2021. The resource service cascade: a conceptual framework for the integration of ecosystem, energy and material services. Environmental Development 40: 100647.

Whiting, K., Carmona, L.G., Brand-Correa, L. & Simpson, E. 2020. Illumination as a material service: a comparison between Ancient Rome and early 19th century London. Ecological Economics 169: 106502.

Matrix of human needs

a. A matrix as proposed by the human-scale development approach in which the preferred satisfiers chosen by an individual or a community may be listed. It was developed by Manfred Max-Neef and his colleagues in the late 1980s (Max-Neef et al. 1989). In the vertical axis of the matrix nine fundamental needs—subsistence, protection, affection, understanding, participation, idleness, creation, identity, and freedom—are presented according to their axiological nature; while on the horizontal axis needs are classified according to their ontological nature, that is, the way they are satisfied according to different ways of being, doing, having, and interacting.
b. A matrix that allows individuals or communities to visualize the nature of their development model according to the satisfiers they seek, aiming to satisfy their fundamental human needs.
c. A matrix that allows for the classification of the satisfiers privileged by different cultures and development models according to their capacity to satisfy human needs, distinguishing between synergic, singular, pseudo, inhibiting, or destructive satisfiers.

Andri W. Stahel

Further reading

Cruz et al. 2009.

See also: Total human welfare, Human needs assessment, Life satisfaction.

References

Cruz, I., Stahel, A. & Max-Neef, M. 2009. Towards a systemic development approach: building on the human-scale development paradigm. Ecological Economics 68(7): 2021–30.

Max-Neef, M., Elizalde, A. & Hopenhayn, M. 1989. "Re-reading the Latin American situation: crisis and perplexity," pp. 1–6 in Human Scale Development: Conception, Application and Further Reflections. New York: Apex Press.

Maximin

A risk-averse approach to decision-making. It applies when each choice could result in a range of outcomes from negative to positive. A maximin strategy selects the choice that makes the worst-case outcome as positive or beneficial as possible. For example, one chooses the climate-change policy with the greatest benefits for the poorest and most vulnerable in society even if that limits the possibility of extremely positive results offered by other paths. The maximin concept is found in John Rawls's (1971) theory of justice. Rawls points out that if decision makers don't know where they stand in a society's hierarchy of wealth, they will adopt what amounts to a maximin decision

strategy in case they are in fact on the bottom rung of society. Maximin decision making is also similar to the Precautionary Principle in that both approaches are willing to sacrifice potential benefits to protect those subject to worst-case harms.

Further reading

Iverson 2012; Aldred 2013.

See also: Minimax regret criterion, Uncertainty, Decision-oriented optimization models, Decision support systems, Precautionary Principle, Rawlsian ethics, Risk.

References

Aldred, J. 2013. Justifying precautionary policies: incommensurability and uncertainty. Ecological Economics 96: 132–40.

Iverson, T. 2012. Communicating trade-offs amid controversial science: decision support for climate policy. Ecological Economics 77: 74–90.

Rawls, J. 1971. A Theory of Justice. Oxford: Clarendon Press.

Maximum sustainable yield

The maximum output from a renewable resource that, under current levels of extraction, would be expected to be sustained indefinitely. In the case of a fishery, it would be the maximum harvest, typically measured in tonnes per year, that could be expected to be harvested indefinitely without reducing the size of the fishery stock. Some fisheries managers have as their target fish stock size that which ensures the maximum sustainable yield. However, Legovič et al. (2010) have shown that the application of the maximum sustainable yield policy will lead to extinction of many fish species in most ecosystems because of the interdependence of species at different trophic levels. In addition, the biologically maximum sustainable yield is generally not the economically optimal yield.

R. Quentin Grafton

Further reading

Deriso 1987.

See also: Sustainability, Sustainable yield, Fisheries management.

References

Deriso, R.B. 1987. Optimal $F_{0.1}$ criteria and their relationship to maximum sustainable yield. Canadian Journal of Fisheries and Aquatic Sciences 44(S2): 339–48.

Legović, T., Klanjšček, J. & Geček, S. 2010. Maximum sustainable yield and species extinction in ecosystems. Ecological Modelling 221(12): 1569–74.

Measures of economic welfare

Monetary measures that consider the benefits and costs of economic activities. The benefits are typically measured through household consumption expenditures that are adjusted for several welfare-related issues (for example, distribution effects and defensive expenditures) and the value of specific non-market activities such as household labor. The costs include a series of environmental issues ranging from local degradation to the depletion of natural capital stocks.

Two distinct welfare interpretations exist: measures of economic welfare (MEW) can focus on either: (1) the costs and benefits that are currently being experienced; or (2) the costs and benefits associated with present economic activities including future impacts. Prominent examples of MEW include the index of sustainable economic welfare (ISEW) and the genuine progress indicator (GPI).

Brent Bleys

Further reading

Cobb et al. 1995; Daly & Cobb 1989; Van der Slycken and Bleys 2020.

See also: Economic welfare, Index of sustainable economic welfare (ISEW), Genuine progress indicator (GPI), Threshold hypothesis.

References

Cobb, C., Halstead, T. & Rowe, J. 1995. The Genuine Progress Indicator: Summary of Data and Methodology. San Francisco, CA: Redefining Progress.

Daly, H. & Cobb, J. 1989. For the Common Good: Redirecting the Economy Toward Community, the Environment and a Sustainable Future. Boston, MA: Beacon Press.

Van der Slycken, J. & Bleys, B. 2020. A conceptual exploration and critical inquiry into the theoretical foundation(s) of economic welfare measures. Ecological Economics 176: 106753.

Mechanics

A worldview emerging from Isaac Newton's laws of force and motion. Philosophers and economists were inspired to seek axiomatic foundations and predictive power in understanding human behavior and society. A perspective in classical mechanics is the separability of things that then act upon each other. Neoclassical economics follows classical mechanics in its description of the economic process (Georgescu-Roegen 1971, p. 319).

Mechanics has been criticized as a metaphor for the workings of human society because it lacks space for interconnections that bind and give meaning to separate objects, something Whitehead (1966) called organism. Ims et al. (2015) provide an example of fair trade products, such as coffee. These products bind sellers and buyers into mutual, lasting behavioral commitments, which can be countenanced in an organic (ecological economics) conception of social ordering. Alternatively, a mechanics-inspired understanding of trade envisions an instantaneous transaction among parties that are optimizing individual welfare. It would not take characteristics of the other party into account beyond what influences their ability to complete the transaction.

BRENT M. HADDAD

Further reading

Daly & Cobb 1994.

See also: Neoclassical economics, Microeconomics, Macroeconomics, Interconnected.

References

Daly, H. & Cobb, J. 1994. For the Common Good—Redirecting the Economy Toward Community, the Environment, and a Sustainable Future. Boston, MA: Beacon Press.

Georgescu-Roegen, N. 1971. The Entropy Law and the Economic Process. Cambridge, MA: Harvard University Press.

Ims, K.J., Jakobsen, O.D. & Zsolnai, L. 2015. Product as process—commodities in mechanic and organic ontology. Ecological Economics 110: 11–14.

Whitehead, A. 1966. Modes of Thought. New York: Free Press.

Mental models

Simplified mental representations or organizing frameworks that shape people's worldviews and understanding of the world, guide information processing, and influence decision-making. They include the underlying beliefs, associations, and assumptions attached to concepts or issues. Mental models organize new information quickly and efficiently, and often filter out conflicting information, thus influencing people's selective attention and confirmation bias. The idea of a mental model was initially laid out by the philosopher and psychologist Kenneth Craik in 1943.

M. FERNANDA TOMASELLI

Further reading

Gentner & Stevens 1983; Jones et al. 2011; Lynam & Brown 2012; Morgan et al. 2002.

See also: Models and modeling, Cultural values.

References

Craik, K.J.W. 1943. The Nature of Explanation. Cambridge: Cambridge University Press.

Gentner, D. & Stevens, A. 1983. Mental Models. Hillside, NJ: Lawrence Erlbaum Associates.

Jones, N.A., Ross, H., Lynam, T. et al. 2011. Mental models: an interdisciplinary synthesis of theory and methods. Ecology and Society 16(1): 46.

Lynam, T. & Brown, K. 2012. Mental models in human–environment interactions: theory, policy implications and methodological explorations. Ecology and Society 17(3): 24.

Morgan, M.G., Fischoff, B., Bostrom, A. & Atman, C.J. 2002. Risk Communication: A Mental

Models Approach. New York: Cambridge University Press.

Metabolic rift

a. A tendency described by Karl Marx, who, drawing on the work of Justus von Liebig, noted how capitalist agriculture, industrialization, urbanization, and trade were combining to cause the rapid depletion of nutrients from agricultural soils, even as sewage accumulated as waste in the exploding towns (Angus 2018); indications that capital already in the 19th century was provoking an irreparable rift in the interdependent process of the social metabolism (Burkett 1999; Foster 2000). This in turn called for the "systematic restoration" of the metabolism as a regulative law of social production, and in a form adequate to the full development of humanity.
b. The expanded theory based on the insights that John Bellamy Foster (1999) and others have drawn from Marx's material-dialectical critique of capital as an alienated system of metabolic control (Mészáros 2005), according to which humanity's social metabolism—mediated throughout history by social labor—is estranged from the "universal metabolism of nature," resulting in systemic ruptures in the nature–society dialectic. In this broader sense, the theory provides a framework for the systematic and critical examination of numerous ecological rifts of capital (Foster et al. 2011; see the bibliography compiled by Wishart et al. 2013), rooted in Marx's own critical analysis of capitalist agriculture and urbanization.

Brian M. Napoletano

Further reading

Burkett 2009.

See also: Alienation, Capital, Social metabolism, Nutrient cycling, Material cycling, Podolinsky myth.

References

Angus, I. 2018. Cesspools, sewage, and social murder. Monthly Review 70(3): 32−68.
Burkett, P. 1999. Marx and Nature. New York: St Martin's Press.
Burkett, P. 2009. Marxism and Ecological Economics. Chicago, IL: Haymarket Books.
Foster, J.B. 1999. Marx's theory of metabolic rift. American Journal of Sociology 105(2): 366−405.
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Foster, J.B., Clark, B. & York, R. 2011. The Ecological Rift. New York: Monthly Review Press.
Mészáros, I. 2005. The Power of Ideology. London: Zed Books.
Wishart, W., Jonna, R.J. & Besek, J. 2013. Metabolic rift: a selected bibliography. MRonline. https://monthlyreview.org/commentary/metabolic-rift/.

Metabolism

See: Social metabolism, Urban metabolism, Metabolic rift.

See also: Multi-scale integrated analysis of societal and ecosystem metabolism (MuSIASEM).

Metapopulation

Ecology: a regional group of a discontinuous but connected population of an animal or plant species, for example, checkerspot butterflies or coral reef fishes. A population of subpopulations, in naturally or artificially fragmented habitats, where migration from one local population to at least some other patches is possible (Hanski & Simberloff 1997). The term "metapopulation" was coined by mathematical ecologist Richard Levins (1969).

Barry D. Solomon

Further reading

Brown & Roughgarden 1997.

See also: Population, Population dynamics, Conservation, Wildlife conservation.

References

Brown, G. & Roughgarden, J. 1997. A metapopulation model with private property and a common pool. Ecological Economics 22(1): 65–71.

Hanski, I. & Simberloff, D. 1997. "The metapopulation approach, its history, conceptual domain, and application to conservation," pp. 5–26 in Metapopulation Biology: Ecology, Genetics, and Evolution. London: Academic Press.

Levins, R. 1969. Some demographic and genetic consequences of environmental heterogeneity for biological control. Bulletin of the Entomological Society of America 15: 237–40.

Methodological individualism

See: Austrian School of economics.

See also: Methods, Individualism, Individual choice, Methodological pluralism.

Methodological pluralism

A way of practicing science that relies on a variety of methods systems. A methodology is the theoretical rationale for using a specific set of research methods and thus has ties to ontological and epistemological presuppositions (Harding 1987). Methodological pluralism has been advocated as a basis for trans- and interdisciplinary research in complex social and environmental systems (Norgaard 1989), especially to reject disciplinary orthodoxy and hierarchy in ecological economics (Howarth 2008).

Debates over methodological pluralism have centered on these early claims. One key debate regards how open or structured methodological pluralism should be in ecological economics (Dow 2007; Spash 2012; Söderbaum 2015). The degree of structuredness necessary in methodological pluralism varies by school of thought, the way that ecological economists understand reality (ontology), and the ways in which they know that reality (epistemology) (Baumgärtner et al. 2008; Goddard et al. 2019; Spash 2012).

JESSICA J. GODDARD & JACK WRIGHT

Further reading

Dow 2004.

See also: Pluralism, Interdisciplinary, Transdisciplinarity, Multidisciplinary, Methods.

References

Baumgärtner, S., Becker, C., Frank, K. et al. 2008. Relating the philosophy and practice of ecological economics: the role of concepts, models, and case studies in inter- and transdisciplinary sustainability research. Ecological Economics 67(3): 384–93.

Dow, S.C. 2004. Structured pluralism. Journal of Economic Methodology 11(3): 275–90.

Dow, S.C. 2007. Variety of methodological approach in economics. Journal of Economic Surveys 21(3): 447–65.

Goddard, J.J., Kallis, G. & Norgaard, R.B. 2019. Keeping multiple antennae up: coevolutionary foundations for methodological pluralism. Ecological Economics 165: 106420.

Harding, S., ed. 1987. Feminism and Methodology: Social Science Issues. Bloomington, IN: Indiana University Press.

Howarth, R.B. 2008. Editorial. Ecological Economics 64(3): 469.

Norgaard, R.B. 1989. The case for methodological pluralism. Ecological Economics 1(1): 37–57.

Söderbaum, P. 2015. Varieties of ecological economics: do we need a more open and radical version of ecological economics? Ecological Economics 119: 420–23.

Spash, C.L. 2012. New foundations for ecological economics. Ecological Economics 77: 36–47.

Methods

The techniques, tools, and procedures that are commonly used by a discipline or transdiscipline such as ecological economics. While Norgaard (1989) has made the case for methodological pluralism because of the complexity of ecological-economic systems, there are several commonalities among the methods used in ecological economics. First, there is overwhelming support for the scientific method and the use of quantitative methods. Second, there are many practitioners who use statistical analysis and econometrics, simulation modeling, stated preference and revealed preference methods, with many applications of the latter to ecosystem services valuation (among other problems). While these methods are largely quantitative, many

ecological economists also use qualitative methods. This reinforces Norgaard's call for methodological pluralism, since methodology is the contextual framework, rationale, and justification for using particular research methods.

Barry D. Solomon

Further reading

Faber et al. 1996.

See also: Scientific method, Quantitative analysis, Models and modeling, Multivariate statistical techniques, Econometrics, Revealed preference methods, Stated preference methods, Qualitative research.

References

Faber, M., Manstetten, R. & Proops, J. 1996. Ecological Economics: Concepts and Methods. Cheltenham, UK and Brookfield, VT, USA: Edward Elgar Publishing.

Norgaard, R.B. 1989. The case for methodological pluralism. Ecological Economics 1(1): 37–57.

Microbiome

The total assemblage of microbes in a given environment for example, soils, the atmosphere, the human or other animals' guts and skins. A healthy and diverse gut microbiome—to take one example—is linked to improved immune and metabolic function, whereas a compromised gut microbiome impairs homeostasis and can facilitate the development of disease. Exposure to a healthy ecosystem appears to result in the development of human microbiomes with notable similarities to ecosystem microbiomes; much research is under way to test this idea as well as the recent "microbiome rewilding hypothesis" (Mills et al. 2017), which suggests that increasing the biodiversity of an ecosystem through restoration activities will contribute to improved human health.

Adam T. Cross, Neva R. Goodwin, Laura Orlando & James C. Aronson

See also: Ecological restoration, Ecohealth, Ecosystem health, Public health.

Reference

Mills, J.G., Weinstein, P., Gellie, N.J. et al. 2017. Urban habitat restoration provides a human health benefit through microbiome rewilding: the microbiome rewilding hypothesis. Restoration Ecology 25(6): 866–72.

Microeconomics

A major branch of economics that focuses on individual choices and how they interact with market contexts. The most basic model of human decision-making is one of rational maximizing self-interest. The most basic model of market activity involves frictionless, costless, instantaneous exchange of goods in the absence of any market failures. The famous price/quantity graph of supply and demand curves is found here and demonstrates the potential for microeconomics to predict market exchange outcomes and the impact of regulation. Microeconomics is sometimes called price theory, since it also seeks to explain how market prices are determined and why and when they are high or low.

Microeconomics extends well beyond this starting point. Individuals can be persons, companies, government agencies, or any other decision-making units. More realistic variants of individual behavior lead to more interesting models. They explore the market effects of weaker cognitive powers, comparatively less or more knowledge of markets and goods, and alternative motivations to self-interested profit-seeking (for example, duty, charity). Variants to perfect markets and goods include market failures, heavily regulated markets, and non-market exchange. Insightful extensions of microeconomics include game theory and institutional economics.

Brent M. Haddad

Further reading

Mankiw 2017.

See also: Neoclassical economics, Behavioral economics, Behavioral ecological economics, Individual choice, Game theory, Institutional economics, New institutional economics, Macroeconomics.

Reference

Mankiw, N.G. 2017. Principles of Microeconomics, 8th edn. Boston, MA: Cengage Learning.

Millennium Development Goals (MDGs)

Eight international development goals that were established following the United Nations Millennium Summit held at its New York headquarters in September 2000, and agreed to by all 19 member states and 22 international organizations. The commitment to these goals was announced by the United Nations Millennium Declaration, with an intent to achieve the goals by 2015. The goals were to: (1) eradicate extreme poverty and hunger; (2) achieve universal primary education; (3) promote gender equality and empower women; (4) reduce child mortality; (5) improve maternal health; (6) combat HIV/AIDS, malaria, and other diseases; (7) ensure environmental sustainability; and (8) develop a global partnership for development (Hulme 2009).

Critics argued that there was a lack of analysis and rationale behind the goals, and progress between countries was uneven. The eight goals were replaced by 17 Sustainable Development Goals in 2015, with a target to achieve them in 2030 (Sachs 2012; Kumar et al. 2016).

BARRY D. SOLOMON

See also: Development, Sustainable Development Goals (SDGs), Human Development Index (HDI), United Nations Development Programme (UNDP).

References

Hulme, D. 2009. The Millennium Development Goals (MDGs): a short history of the world's biggest promise. BWPI Working Paper No. 100, University of Manchester, UK.

Kumar, S., Kumar, N. & Vivekadhish, S. 2016. Millennium Development Goals (MSGs) to Sustainable Development Goals (SDGs): addressing unfinished agenda and strengthening sustainable development and partnership. Indian Journal of Community Medicine 41(1): 1–4.

Sachs, J. 2012. From Millennium Development Goals to Sustainable Development Goals. The Lancet 379(9832): 2206–11.

Millennium Ecosystem Assessment

A major assessment of the human impacts on the global environment that was initiated by the United Nations (UN) in 2001 and published in 2005 in five technical volumes and six synthesis reports (Millennium Ecosystem Assessment 2005). Over $14 million supported the effort, with funding from the Global Environment Facility, UN Foundation, Packard Foundation, and the Government of Norway. More than 1360 experts from 95 countries contributed to the work.

The assessment had four main findings: (1) humans have changed ecosystems more rapidly and extensively over the past 50 years than at any comparable time in history, resulting in a largely irreversible loss of biodiversity; (2) anthropogenic changes to ecosystems have resulted in large gains in human well-being and economic development, but the gains have also resulted in growing degradations of ecosystem services; (3) the degradation of ecosystem services could significantly worsen during the next 50 years and is a barrier to achievement of the UN Millennium Development Goals; and (4) the reversal of the degradation of ecosystems while meeting increasing demands for ecosystem services can be partially met by significant changes in policies, institutions, and practices.

BARRY D. SOLOMON

See also: Biodiversity, Ecosystem services, Economic development, Objective well-being, Millennium Development Goals (MDGs), Anthropogenic, Global Environment Facility (GEF), United Nations Environment Programme (UNEP), United Nations Development Programme (UNDP).

Reference

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Synthesis. Washington, DC: Island Press.

Minimax

See: Minimax regret criterion.

See also: Risk, Game theory.

Minimax regret criterion

A decision rule used in game theory, statistics, decision theory, and related fields to minimize the impact of worst-case scenario for a potential loss. Sometimes called MM, Minimax, MinMax, or the saddle point. In a situation with potential gains, a comparable rule is called Maximin, which would seek to maximize the minimum gain.

BARRY D. SOLOMON

Further reading

Palmini 1999; Hof et al. 2010.

See also: Risk, Game theory, Maximin.

References

Hof, A.F., van Vuuren, D.P. & den Elzen, M.G.J. 2010. A quantitative minimax regret approach to climate change: does discounting still matter? Ecological Economics 70(1): 43–51.

Palmini, D. 1999. Uncertainty, risk aversion, and the game theoretic foundations of the safe minimum standard: a reassessment. Ecological Economics 29(3): 463–72.

Misplaced concreteness

See: Fallacy of misplaced concreteness.

See also: Economic growth, Growth fallacies, Growth theory, Steady state economy.

Missing markets

A domain of the economy where markets have not evolved to facilitate transactions that would otherwise create value. Markets for ecological and environmental goods and services are missing primarily because of public good/externality problems.

Even if interventions are established to address these problems, a range of complexities can also impede transactions in ecological services including: policy complexities, where participation rules and regulatory requirements are onerous (for example "like-for-like" trading rules in offset markets); transaction complexities: coordination problems, information asymmetry, non-convexity, synergies between items (for example, sites in a wildlife corridor); strategic complexities, where buyers and sellers can behave in ways that impede the exchange process (for example, holdouts and strategic posturing strategies); and time complexities, where buyers and sellers asynchronously arrive at the market. These and other complexities increase transaction costs (Arrow 1969) that in the extreme extinguish all the value created from transactions (leading to missing markets) or reduce the economic efficiency and efficacy properties of market solutions.

GARY C. STONEHAM

Further reading

Coase 1960.

See also: Transaction costs, Public goods, Externalities, Market solution.

References

Arrow, K.J. 1969. "The organization of economic activity: issues pertinent to the choice of market versus non-market allocation," pp. 47–64 in The Analysis and Evaluation of Public Expenditures, the PPB System, Vol. 1. Washington, DC: US Congress, Joint Economic Committee.

Coase, R.H. 1960. The problem of social cost. Journal of Law and Economics 3(1): 1–44.

Mitigation

Any action that avoids or reduces the severity, loss, danger, or harm from an undesirable event, hazard, or environmental or social impact. The process of controlling air or water pollution, toxic, hazardous, or radioactive wastes, flooding, climate change, or invasive species. Mitigation can also refer to mitigation banking, where a government agency may require a developer to compensate for the destruction of a wetland, stream, or endangered species habitat by preserving, enhancing, restoring, or creating an equivalent or larger new wetland, stream, or habitat.

BARRY D. SOLOMON

Further reading

Dale et al. 2005; Ming et al. 2007; Robertson 2004; Perrings 2005.

See also: Pollution abatement, Climate change mitigation, Habitat banking, Banks, Invasive species, Adaptation.

References

Dale, V., Archer, S., Chang, M. & Ojima, D. 2005. Ecological impacts and mitigation strategies for rural land management. Ecological Applications 15(6): 1879–92.

Ming, J., Xian-guo, L., Lin-shu, X. et al. 2007. Flood mitigation benefits of wetland soil—a case study in Momoge National Nature Reserve in China. Ecological Economics 61(2–3): 217–23.

Perrings, C. 2005. Mitigation and adaptation strategies for the control of biological invasions. Ecological Economics 52(3): 315–25.

Robertson, M.M. 2004. The neoliberalization of ecosystem services: wetland mitigation banking and problems in environmental governance. Geoforum 35(3): 361–73.

Models and modeling

A conceptual, mental, mathematical (statistical), analytical, simulation, or even physical representation of processes, events, or ideas in the real world. Scientific models used in ecological economics and other fields simplify what they are intended to represent, and are usually based on observations, inferences, and past research results. The most useful models will be consistent with theory and other models developed and used for similar processes and across contexts, and will have explanatory and sometimes predictive power.

The mathematical modeling process normally follows several steps: (1) Specify the problem or research question to be investigated. (2) Develop and review relevant theory and formulate research hypotheses. (3) Formulate the model, based on the problem under study. (4) Determine the model's functional form (for example, linear, non-linear, quadratic, dynamic, and so on). (5) Collect data for the model's variables. (6) Model calibration: parameter estimation by comparing observed with simulated data based on a computer program, and in some cases expert knowledge. (7) Model validation: comparison of the model output and its behavior to the real system and its behavior beyond the time frame or location of historical data, to determine if the output is acceptable. In many cases adjustments to the model calibration are iteratively made. (8) Model-based prediction, or more commonly in the case of economic phenomenon forecasting or projection based on different scenarios and sensitivity analyses. Most economic time-series models perform poorly beyond 5–10 years.

BARRY D. SOLOMON

Further reading

Voinov 2008; Forrester 1985; Frigg & Hartmann 2020.

See also: Conceptual models, Mental models, Analytical models, Dynamic models, Spatial modeling, Agent-based modeling (ABM), Systems-oriented simulation models, Circular flow model, System dynamics models, Sensitivity analysis.

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Frigg, R., and Hartmann, S. 2020. "Models in science," in The Stanford Encyclopedia of

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Voinov, A.A. 2008. Systems Science and Modeling for Ecological Economics. Amsterdam: Elsevier.

Modern

See: Modernity.

See also: Modernism, Modernization.

Modernism

A socially progressive cultural and political movement in the late 19th century through the mid-20th century that promoted modernization and modernity instead of tradition in a variety of fields and areas of life. Modernity is characterized by progress and an ethos of "the temporality of the new" (Griffin 2007).

BARRY D. SOLOMON

Further reading

Habermas 1990.

See also: Modernity, Modernization, Progress, Progressive.

References

Griffin, R. 2007. "The birth of fascism from modernism," pp. 191–218 in Modernism and Fascism. London: Palgrave Macmillan.
Habermas, J. 1990. The Philosophical Discourse of Modernity: Twelve Lectures. Cambridge, MA: MIT Press.

Modernity

A historical period or age and a set of norms, beliefs, institutions, and practices (a "discourse") that emerged in the European Enlightenment and subsequently developed around the world (Habermas 1990). Modernity is rooted in rationalism and is deeply connected to the rise of capitalism, the scientific method, specialization, and the emergence of the disciplines, Enlightenment views of progress, and the differentiation of societies into political, economic, and other spheres (Smart 1990). Modernity contrasts with pre-modern beliefs wherein legitimacy was secured via external sources of validity such as religion or cultural tradition (Habermas 1990). In modernity, legitimacy is secured through the application of reason, a capacity deemed inherent to all humans, as well as democratic deliberation. Modernity thus embraces a universalistic, liberational discourse, where technology and expertise can drive progress that benefits all.

Modernity's optimistic narrative has been critiqued both in theory and in practice. Postmodernists have expressed "incredulity toward metanarratives" (Lyotard 1984, XXIV) such as reason and progress, describing them as masks for the oppressive application of power. In practice, critics have pointed to the justification of colonialism as "civilizing progress" and the use of science, technology, and rational planning for genocidal purposes, such as in the Holocaust (Horkheimer & Adorno 2002). Critical modernists have tried to reform the project of modernity through cosmopolitan approaches that root modernity in communicative action and deliberative democratic practice (Habermas 1987; Sen 2009). Debates regarding the methodological roots and direction of ecological economics versus orthodox economics parallel many debates about the past, present, and future of the discourse of modernity (Ott 2012; Spash 2012; Wironen & Erickson 2020).

MICHAEL B. WIRONEN

See also: Modernism, Liberalism, Progress, Technology, Power, Scientific method.

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A Critique of Functionalist Reason. Boston, MA: Beacon Press.
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Ott, K. 2012. Variants of de-growth and deliberative democracy: a Habermasian proposal. Futures 44(6): 571–81.
Sen, A.K. 2009. The Idea of Justice. Cambridge, MA: Belknap Press.
Smart, B. 1990. "Modernity, postmodernity, and the present," pp. 14–30 in Theories of Modernity and Postmodernity. B.S. Turner, ed. Thousand Oaks, CA: SAGE.
Spash, C.L. 2012. New foundations for ecological economics. Ecological Economics 77: 36–47.
Wironen, M.B. & Erickson, J.D. 2020. A critically modern ecological economics for the Anthropocene. Anthropocene Review 7(1): 62–76.

Modernization

a. Large-scale, complex, and far-reaching set of processes, which aim to enable a transition from pre-modern to modern societies, primarily through the advent of industrialization and technological innovation. Dominant conceptualizations of modernization have been deterministic as long as they used leading regions in the so-called Western world as a benchmark for assessing the progress of other Western regions or whole non-Western nations. The linearity and determinism of these dominant approaches have been challenged by more recent elaborations such as ecological modernization and reflective modernization.
b. Ecological modernization: planned response to environmental degradation, which involves several institutional reforms (for example, environmental legislation, introduction of market-based instruments) aiming to regulate access to natural resources and encouraging uptake of green technology. Ecological modernization has shaped environmental policy worldwide under the main assumption that environmental regulations can be congruent with economic growth, and indeed, it can propel it, in the long run.
c. Reflexive modernization (from Beck 1986): transition from a first, simple modernity to a second modernity, which is marked by the acknowledgment that society needs to confront unintended consequences resulting from its own undertakings. Industrial society in the first modernity was supposed to produce and distribute "goods," while a risk society in the second, reflexive modernity needs to confront and distribute "bads" (for example, those related to environmental degradation). Subjects in that second, reflexive modernity are interpellated to decide upon dangers and uncertainty caused by their own action or inaction.

TASOS HOVARDAS

See also: Institutional change, Industrial economics, Modernity, Risk, Unintended consequences.

Reference

Beck, U. 1986. Risikogesellschaft—Auf dem Weg in Eine Andere Moderne (in German; Risk Society—On the Way Toward Another Modernity). Frankfurt am Main: Suhrkamp.

Monetary policy

Commonly defined by central banks as being the sum of actions taken "in response to disturbances" to the economy (Federal Reserve Board 2019). Monetary policy is the process of money supply and interest rate management by which the government, central bank, or monetary authority of a country seeks to achieve macroeconomic objectives. These objectives may include controlling inflation, full employment, economic growth, and a balance of payments that promotes sustainable economic growth. The analytical framework used by central banks (including dynamic stochastic general equilibrium models) assumes that any fluctuation of the economy is due to exogenous shocks, and the primary responsibility of central banks is to react to such external shocks. This suggests

that central banks always react and do not themselves cause economic cycles.

Monetary policy can be broadly classified as either expansionary (aimed at increasing economic growth and expanding economic activity) or contractionary (aimed to bring down inflation). Tools include open market operations (buying or selling government bonds), the discount rate, bank reserve requirements, unconventional emergency lending programs, quantitative easing (buying predetermined amounts of government bonds or other financial assets), and public service announcements (managing market expectations). The impact of monetary policy on the performance of an economy affects the central bank's credibility.

Chien-Ming Lee & Richard A. Werner

Further reading

Mathai 2009; Warin 2005; O'Connell & Schmidt 2021.

See also: Money, Interest rate policy, IS-LM model, Economic growth, Growth theory.

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Warin, T. 2005. Monetary policy: from theory to practices. Middlebury College Economics Discussion Paper No. 05-08. Middlebury, VT.

Money

Economics:

a. A sovereign unit of account for denominating credits that can settle all debts public and private (Ament 2020); capable of functioning as a medium of exchange and store of value.
b. The universal equivalent central to capitalist productive and trading activities: nation-states sanction a legal tender with which they, and those in their territories, operate. Contemporary states generally contract its creation through commercial banks, and the management of its supply through central banks (Svartzman et al. 2019).
c. *Sine qua non* for capital, the concept of money is a scarcely questioned, preanalytic category for most orthodox economic schools, notwithstanding much debate around technical issues such as money supply and interest rates. Many heterodox economists such as post-Keynesians subject money to scrutiny, particularly the process of its creation (Rochon & Rossi 2013).

Ecological economics: ecological economists question the centrality of monetary values, prices, and accounting in the context of non-monetary environmental evaluative processes and tools. Issues surrounding money include the role of interest rates in economic growth, the sustainability potential of community-based and local currencies as alternatives to sovereign legal tender (Dittmer 2013), and the role of public banking in sustainability transitions. Simultaneously, major applications of ecological economics involve monetary exercises such as pricing carbon, water trading, environmental taxes, and willingness to pay or willingness to accept. Questions surrounding monetary valuation remain theoretical and distinct from most practical policy-oriented ecological economics research.

Anitra R. Nelson & Joseph A. Ament

Further reading

Nelson 2001; O'Neill & Uebel 2015; Martinez-Alier et al. 1998.

See also: Post-Keynesian economics, Environmental taxes, Carbon taxes, Monetary policy, Interest rate policy, Community currency, Emergy.

References

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Rochon, L.P. & Rossi, S. 2013. Endogenous money: the evolutionary versus revolutionary views. Review of Keynesian Economics 1(2): 210–29.

Svartzman, R., Dron, D. & Espagne, E. 2019. From ecological macroeconomics to a theory of endogenous money for a finite planet. Ecological Economics 162: 108–20.

Monism

An economics pedagogy that emphasizes the teaching of only neoclassical (environmental) economics or its variants (for example, new institutional economics and behavioral economics). Based on a functionalist foundational philosophy centered on positivist methods and methodological individualism, with greener economic growth as the usual goal. In this environmental economics pedagogy, students are hardly encouraged to question the orthodoxy, to explore heterodoxy, or to embrace transdisciplinary ecological political economy. In the teaching environment, the emphasis is on the teacher or the teacher's delivery as the repository of all knowledge, not on engaging students' experiences and critical thinking to develop learning. Although a well-established teaching approach that is successful in offering technical training, monism has been widely criticized by those who espouse its antitheses, namely methodological pluralism, and pedagogical citizenship.

Critics of monism identify three main drawbacks. First, it lacks a more critical and diverse approach to environmental and ecological problems in which not only is neoclassical environmental economics taught, but also other heterodox approaches such as ecological economics, feminist environmental economics, and Marxist ecology are learnt critically. Second, it tends to detach environmental economics from questions of race, class, gender, caste, color, disabilities, and other identities that are central to global ecological economics. Even if some pedagogical monists consider some of these identities, for critics, monism is reductionist, and hence would address questions about identities problematically, much like how monism treats concerns about justice, capital, and land. Third, it is usually based on theories and concepts developed by dominant white, often male, environmental economists, with little or no appreciation or acknowledgment of radical or justice-oriented ecological economics and social sciences from the global South.

Franklin Obeng-Odoom

Further reading

Obeng-Odoom 2020; Ardalan 2018; Bryant & Stilwell 2019.

See also: Conceptual pluralism, Methodological individualism, Methodological pluralism, Neoclassical economics, Environmental economics, Behavioral economics, Heterodox economics, Feminist ecological economics, Radical ecological economics, North–South relations.

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Obeng-Odoom, F. 2020. Teaching sustainability: from monism and pluralism to citizenship. Journal of Education for Sustainable Development 14(2): 235–52.

Monte Carlo simulation

A common computational algorithm used to quantify uncertainties around potential outcomes based on random experiments. A Monte Carlo simulation repeatedly selects a random sample of possible data values for uncertain variables to estimate possible ranges and distributions; for example, for future ecological or financial information.

ELIZABETH J. GOSLING

Further reading

Knoke et al. 2021.

See also: Uncertainty, Risk assessment, Multivariate statistical techniques, Models and modeling.

Reference

Knoke, T., Gosling, E., Thom, D. et al. 2021. Economic losses from natural disturbances in Norway spruce forests—a quantification using Monte-Carlo simulations. Ecological Economics 185: 107046.

Moral hazard

Economics: phenomenon where insured parties exercise less precaution than they would in the absence of insurance. Since the insurer usually cannot monitor all actions of the policyholders, these actions are hidden from the insurer. Such hidden actions increase the policyholders' exposure to the very risk against which they bought an insurance policy, because they now do not bear the full costs of that risk. For example, upon purchasing an insurance policy that completely reimburses for any form of damage to an automobile, people might either drive faster and more recklessly than before, or take less care to protect the car against vandalism and theft. Or a financial company may take on much higher risk when it expects an insurance company or its stockholders, whoever the full insurer might be, to effectively pay all associated costs every time the risk is realized. Both examples imply the insured's taking of excessive risks from a social point of view. Thus, the term has been used in economics mainly to signify inefficiencies that arise when risks are not fully evaluated in advance, rather than to describe any immoral behaviors of the involved people such as fraud or misrepresentation.

Economists regard moral hazard, along with "adverse selection" (where buyers and sellers have unequal or different information), as a representative example of the situation of asymmetric information where one party knows more about its own actions than another party.

Ecology: Fayle (2015) suggested that moral hazard may be a useful construct for analyzing foraging, raising offspring, among other ecological interactions.

ILJOONG KIM

Further reading

Arrow 1971; Holmstrom 1979; Laffont & Martimort 2002.

See also: Asymmetric information, Risk, Risk perception, Insurance value, Principal–agent problem.

References

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Holmstrom, B. 1979. Moral hazard and observability. Bell Journal of Economics 10: 74–91.

Laffont, J. & Martimort, D. 2002. The Theory of Incentives: The Principal–Agent Model. Princeton, NJ: Princeton University Press.

Motivation crowding

A phenomenon based on the psychological and microeconomic notions of intrinsic versus extrinsic motivation for certain behaviors, and how extrinsic incentives can sometimes undermine intrinsic motivation for performing that same behavior (Deci 1971). Intrinsic motivation refers to engaging in an activity for the inherent satisfaction, the fun or challenge involved, or otherwise because of personal conviction. Under motivation crowding, extrinsic rewards (typically in the form of money or other material incentives) reduce ("crowd-out") or increase

("crowd-in") people's "intrinsic" motivation for an action (Ryan & Deci 2000).

Different underlying mechanisms have been proposed to explain motivation crowding, frequently related to people's sense of competence, autonomy, and relatedness (Ryan & Deci 2000; Bowles & Polonía-Reyes 2012; Rode et al. 2015; Ezzine-de-Blas et al. 2019). Motivation crowding-out was first demonstrated empirically for blood donations (Titmuss 1971), and later for behaviors in many domains, often related to voluntary work effort or charitable activities (Bowles & Polonía-Reyes 2012).

Frey (1992) introduced crowding-out to the realm of environmental policy. Concerns about motivation crowding effects have been particularly persistent in the academic debate on incentive-based policies for conservation and sustainable management of natural resources, notably payments for ecosystem services. In this context, a large body of empirical evidence has shown that crowding-out as well as crowding-in can happen (Rode et al. 2021) depending, *inter alia*, on socio-cultural conditions and specifics of the policy design.

Julian Rode

See also: Crowding out, Market mechanisms, Incentive compatibility, Behavioral economics, Behavioral ecological economics, Payment for ecosystem services (PES).

References

Bowles, S. & Polanía-Reyes, S. 2012. Economic incentives and social preferences: substitutes or complements? Journal of Economic Literature 50(2): 368–425.

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Frey, B.S. 1992. Pricing and regulating affect environmental ethics. Environmental and Resource Economics 2: 399–414.

Rode, J., Gómez-Baggethun, E. & Krause, T. 2015. Motivation crowding by economic incentives in conservation policy: a review of the empirical evidence. Ecological Economics 117: 270–82.

Rode, J., Krause, T., Ortiz-Riomalo, J. et al. 2021. How do monetary incentives affect intrinsic motivations for nature conservation? Taking stock of the empirical research. Research paper prepared for submission at the 2021 BioECON conference.

Ryan, R.M. & Deci, E.L. 2000. Intrinsic and extrinsic motivations: classic definitions and new directions. Contemporary Educational Psychology 25(1): 54–67.

Titmuss, R. 1971. The Gift Relationship: From Human Blood to Social Policy. New York: Pantheon Books.

Multi-criteria analysis

See: Deliberative multi-criteria analysis.

See also: Multi-criteria assessment.

Multi-criteria assessment

A set of methods and mathematical aggregation procedures aimed at decision support when faced with a set of options. By means of multi-criteria assessment or analysis, at least two alternatives are assessed using at least one criterion. Its three basic concepts are as follows (from Roy 2016): (1) alternative: the set of options or potential actions considered at a given stage of the decision-aiding process; (2) criterion: a tool for evaluating and comparing alternatives according to a well-defined point of view; and (3) problem formulation: the way in which decision aiding is envisaged, primarily aimed at prescribing or recommending by means of a choice among alternatives (selecting a "good" single alternative), sorting alternatives (assigning each alternative to the most appropriate category), or ranking alternatives (ordering alternatives for comparing options pairwise).

In ecological economics, incommensurability of values (from Martínez Alier et al. 1998), that is, "the absence of a common unit of measurement between plural values," has become rooted within multi-criteria assessment to avoid reductionism and emphasize public participation in the decision-aiding process.

Iker Etxano

Further reading

Keeney & Raiffa 1976; Roy 1996; Munda 2008.

See also: Deliberative multi-criteria analysis, Incommensurable values, Pluralism, Methodological pluralism.

References

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Multidimensional Poverty Index (MPI)

An assessment of poverty beyond just a single attribute, such as income, to include other factors. In a multidimensional assessment framework, poverty is evaluated inclusive of participation in social and political activities, and the psychological impact of poverty is incorporated, among other variables (Alkire & Santos 2013; Lemanski 2016). The holistic evaluation of poverty characterized by the inclusion of its attributions allows for a broader view of economic well-being as it relates to the poor (Knight 2017).

For example, multidimensional poverty assessment acknowledges that a person who is poor may not be able to afford the ability for social interaction, and that isolation in turn can result in social and psychological impacts. It also recognizes the relationship between poverty, housing conditions, and location, which can result in health and nutrition impacts related to the delivery of basic needs such as clean water and clear air. Also, and related, education is often limited in both access and availability to the poor, prompting both a vicious cycle and limitation in poverty alleviation, which affects the broader evaluation of poverty. Poverty can also be exacerbated and affected by time. Time poverty measures the impact of lack of time on well-being, including demands related to unpaid and paid work.

Madhavi Venkatesan

Further reading

Saqib & Arif 2012; Atkinson et al. 2019.

See also: Poverty, Poverty trap, Objective well-being, Subjective well-being.

References

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Saqib, N.U. & Arif, G.M. 2012. Time poverty, work status and gender: the case of Pakistan. Pakistan Development Review 51(1): 23–46.

Multidisciplinary

The cooperation and collaboration among researchers from multiple scientific disciplines on a common study or project, but without close coordination and exchange of the unique concepts, theories, methods, and terminology from their separate disciplines. In general, the work of the members of a multidisciplinary team is done independently.

Barry D. Solomon

Further reading

Max-Neef 2005.

See also: Interdisciplinary, Transdisciplinary.

Reference

Max-Neef, M. 2005. Foundations of transdisciplinarity. Ecological Economics 53(1): 5–16.

Multiplier effect

Economics:

a. The proportionate change in national income and consumption that results from an injection (increase) or withdrawal (decrease) in spending or investment by the government, which is a type of fiscal policy that originated with John Maynard Keynes (Blinder 2008). The multiplier effect accounts for the totality of change in final income for the whole economy that results from the initial change in government spending.
b. The increase in money supply created by commercial banks through fractional-reserve banking, which becomes available to make additional bank loans (Harris 2006; Carpenter & Demiralp 2012).

Ecology:

a. A measure of the direct and indirect physical resources required to produce a dollar of economic output (Victor 1971; Hannon 1973). Ecological multipliers can measure systemwide eco-efficiency of production processes or sectors (McDonald & Patterson 1999; Jollands 2003). A tool for such a study is an environmentally extended input–output analysis.
b. A biotic multiplier effect can occur from a disturbance or perturbation such as climate change, altering the structure and diversity of ecosystems (Zarnetske et al. 2012).
c. The tendency of leading genotypes to accumulate in habitats in which they do well (McNamara & Dall 2011).

BARRY D. SOLOMON

See also: Investment, Banks, Money, Post-Keynesian economics, Eco-efficiency, Environmentally extended input–output analysis (EE-IOA), Disturbance, Ecological perturbation, Ecosystem structure and function, Biodiversity.

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McNamara, J.M. & Dall, S.R.X. 2011. The evolution of unconditional strategies via the "multiplier effect." Ecology Letters 14(3): 237–43.
Victor, P.A. 1971. Input–output analysis and the study of economic and environmental interactions. Unpublished doctoral dissertation, University of British Columbia, Canada.
Zarnetske, P.L., Skelly, D.K. & Urban, M.C. 2012. Biotic multipliers of climate change. Science 336(6088): 1516–18.

Multi-scale integrated analysis of societal and ecosystem metabolism (MuSIASEM)

A relational accounting framework that can simultaneously study a set of processes of production, consumption, and disposal, each of which belongs to hierarchically organized, multi-level metabolic systems. Each process's dynamics and its interactions with other processes are represented in terms of flow elements (energy, water, materials, and final forms of such flows as products and

wastes) and fund elements (human time, land, and capital equipment). A certain number of flow-fund ratios are also calculated as indicators of process speed of metabolic systems.

The crucial characteristic of the MuSIASEM framework is an accounting protocol that creates "closure": the summation of each type of flow and fund elements is fixed at a given time. Due to this "closure" nature, it is possible, without arbitrary and often complicated ad hoc assumptions associated with dynamical specifications, to identify binding constraints and possible future options in terms of four system aspects: (1) energy and material feasibility; (2) environmental health acceptability; (3) socio-economic desirability; and (4) technological viability.

Mario E. Giampietro & Kozo T. Mayumi

Further reading

Giampietro & Mayumi 1997; Giampietro et al. 2009.

See also: Integrated assessment model, Flow-fund theory of production, Social metabolism.

References

Giampietro, M. & Mayumi, K. 1997. A dynamic model of socioeconomic systems based on hierarchy theory and its application to sustainability. Structural Change and Economics Dynamics 8(4): 453–69.

Giampietro, M., Mayumi, K. & Ramos-Martin, J. 2009. Multi-scale integrated analysis of societal and ecosystem metabolism (MuSIASEM): theoretical concepts and basic rationale. Energy 34(3): 313–22.

Multivariate statistical techniques

A suite of statistical analysis methods that can be used to analyze problems in ecological economics that involve two or more outcome variables. The user should carefully consider the nature of the problem under study, relevant theory, data availability, data quality, and other factors in selecting the technique to use, and in some cases multiple techniques may be required. The most commonly used techniques include: multiple regression analysis, logistic regression analysis, analysis of variance, multivariate analysis of variance, structural equation modeling, factor analysis, and principal component analysis. Other popular techniques include: discriminant analysis, cluster analysis, multidimensional scaling, correspondence analysis (which is similar to principal components analysis, but used for categorical data), conjoint analysis, and Spearman's rank correlation coefficient.

Barry D. Solomon

Further reading

Pituch & Stevens 2016; Warner 2020.

See also: Complex systems modeling, Dynamic models, Systems-oriented simulation models, Bioeconomic modeling, Spatial modeling.

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N

Narrative

A communicative form that is used to integrate the multiple, seemingly random, events, people, objects, and circumstances in a life or a complex environment into a coherent, logical whole. Integration in narrative is achieved through emplotment (Ricoeur 1983). In contrast to technical language, narrative is the natural mode of communication of community (Lyotard 1979). Similarly, narrative is a mode of description that can reflect the social ecology of a place, where biotic, abiotic, and semiotic elements come together, in a non-reductionistic and non-utilitarian way, that respects the complexity of the system (Lejano et al. 2019). So being, one way to represent the coherence of an ecosystem is to represent it using narrative.

RAUL P. LEJANO

Further reading

Bruner 1991; Lejano et al. 2013.

See also: Social ecology, Ecosystem, Complexity.

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Lejano, R.P., Ingram, M. & Ingram, H. 2013. The Power of Narrative in Environmental Movements. Cambridge, MA: MIT Press.

Lejano, R.P., Newbery, N., Ciolino, M. & Newbery, D. 2019. Sustainability and incommensurability: narrative policy analysis with application to urban ecology. Ecological Economics 164: 106348.

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Ricoeur, P. 1983. Time and Narrative, Vol. 1. K. Blarney & D. Pellhauer, Translators. Chicago, IL: University of Chicago Press.

Nash equilibrium

In game theory and economics, the solution to a non-cooperative game involving two or more players. Named after the mathematician John Forbes Nash Jr, though the principle dates to 1838 to the time of Antoine Cournot. In a Nash equilibrium, no participant can gain by a unilateral change of strategy if the strategies of the other players remain unchanged, and each player is assumed to know the equilibrium strategies of the other players (Osborne & Rubinstein 1994). Ecological economists have applied the concept to economic inequality and local environmental quality (Cardenas et al. 2002), common pool resource management (Vollan 2008), biodiversity conservation (Parkhurst et al. 2002), and climate change negotiations (DeCanio & Fremstad 2013).

BARRY D. SOLOMON

See also: Game theory, Minimax, Management science.

References

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the provision of local environmental quality. Ecological Economics 40(3): 379–95.
DeCanio, S.J. & Fremstad, A. 2013. Game theory and climate diplomacy. Ecological Economics 85: 177–87.
Osborne, M. & Rubinstein, A. 1994. A Course in Game Theory. Cambridge, MA: MIT Press.
Parkhurst, G.M., Shogren, J.M., Bastian, C. et al. 2002. Agglomeration bonus: an incentive mechanism to reunite fragmented habitat for biodiversity conservation. Ecological Economics 41(2): 305–28.
Vollan, B. 2008. Socio-ecological explanations for crowding-out effects from economic field experiments in southern Africa. Ecological Economics 67(4): 560–73.

National accounts

See: System of National Accounts (SNA).

See also: Environmental accounting, Economic ecosystem accounting.

National security

The safety of a nation in its military, economic, societal, and environmental sectors. There is a growing recognition that climate change, energy security, and access to natural resources affect national security in all its areas. The analysis of national security in the post-Cold War period has been extended beyond its military aspect by introducing economic, demographic, ecological, and democratic dimensions (Adibe 1994; Dalby 2002). Buzan et al. (1998) provided an early synthesis of this extended perspective of national security. Considering that global risks such as climate change, rising energy and food prices, and mass migration would likely endanger safety at the national level, some authors contextualize national security within the pursuit of sustainability (Matutinović 2015; Pierce et al. 2017).

IGOR MATUTINOVIĆ

Further reading

Dalby 2013.

See also: Climate change, Food security, Biosecurity.

References

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Buzan, B., Wæver, O. & De Wilde, J. 1998. Security: A New Framework for Analysis. Boulder, CO: Lynne Rienner Publishers.
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Matutinović, I. 2015. National security in the context of sustainability. In Conference Proceedings: Croatia in Contemporary Security Environment—Threats, Challenges and Responses. Zagreb, Croatia, June 14–16, 2015. Zagreb: Institute for Development and International Relations and Center for Defence and Strategic Studies "Janko Bobetko."
Pierce, G., Cleary, P., Holland, C. & Rabrenovic, G. 2017. "Security challenges in the 21st century: the changing nature of risk, security and sustainability," pp. 180–90 in Advances in Cross-Cultural Decision Making. M. Hoffman, ed. Cham: Springer International.

Native

a. A person or people born or raised in a specified place.
b. A plant, person, people, or other type of animal species indigenous to a specific geographic area. Native species are indigenous to an area or an ecosystem solely due to natural processes. Native people are also sometimes called indigenous people, aboriginal people, or first people.

BARRY D. SOLOMON

Further reading

Sanders 1999; Webb 1985.

See also: Indigenous communities, Indigenous rights, Species, Invasive species, Biogeography.

References

Sanders, D. 1999. Indigenous peoples: issues of definitions. International Journal of Cultural Property 8: 4–13.

Webb, D.A. 1985. What are the criteria for presuming native status? Watsonia 15: 231–6.

Natural

a. (Adjective) denoting the absence of any trace of human influence in the environment.
b. Given that there are few, if any, places on Earth that have not been influenced by humans, the term "natural" can denote a degree of naturalness.

SARA LATORRE TOMÁS

Further reading

Moriarty 2013.

See also: Nature, Naturalness.

Reference

Moriarty, P.V. 2013. "Nature and the natural," pp. 3549–58 in The International Encyclopedia of Ethics. H. LaFollette, ed. Hoboken, NJ: Wiley-Blackwell.

Natural assets

The stocks of natural resources or ecosystems that contribute to the provision of one or more services required for the health, well-being, and long-term sustainability of a community and its residents.

MICHELLE L. MOLNAR

Further reading

Municipal Natural Assets Initiative 2017.

See also: Natural capital, Ecosystem services, Ecohealth, One health.

Reference

Municipal Natural Assets Initiative. 2017. Defining and scoping municipal natural assets. https://mnai.ca/key-documents/.

Natural capital

An economic metaphor for the finite stocks of physical and biological elements naturally found on Earth, some of which are of direct use to society (these are then referred to, anthropocentrically, as resources), and some of which are not.

According to Rees (1995) and the Millennium Ecosystem Assessment (2005), there are four partially overlapping types of natural capital: renewable (living species and ecosystems), non-renewable (subsoil assets such as petroleum, coal, and diamonds), replenishable (for example, the atmosphere, potable water, and fertile soils), and cultivated (for example, heritage seeds, and local races of livestock; traditional horticultural and ecological knowledge associated with agriculture, animal husbandry, and silviculture). Note that the concept of renewable natural capital as an asset includes all elements of ecosystems, not just the obviously marketable parts.

Following on with the metaphor, if natural capital is a stock or an asset, then the "dividend" is the flow in ecosystem goods and services derived from assets such as forests (which, among other things, provide services of cleaning water and air), or land used to produce food.

JAMES C. ARONSON, ADAM T. CROSS, NEVA R. GOODWIN & LAURA ORLANDO

See also: Capital, Manufactured capital, Restoring natural capital (RNC), Ecosystem services.

References

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Synthesis. Washington, DC: Island Press.

Rees, W.E. 1995. Cumulative environmental assessment and global change. Environmental Impact Assessment Review 15: 295–309.

Natural disaster

Any disruptive, rapid, or instantaneous event in nature that is caused by biological, climatological, extraterrestrial, geophysical, hydrological, or meteorological hazards, with a significant adverse effect on socio-economic systems to the extent of direct impacts (for example, manifold loss of life, damaged assets) or indirect impacts (for example, unemployment, reduced economic activity). Examples include hurricanes, floods, earthquakes, and volcanic eruptions.

Mark A. Andor, Benjamin Koch & Leonie Matejko

Further reading

Alexander 2018; Andor et al. 2020; Botzen et al. 2019; Hallegatte & Przyluski 2010; IRDR 2014; IFRC n.d.

See also: Disaster risk management (DRM), Risk, Risk aversion.

References

Alexander, D. 2018. Natural Disasters. London: Routledge.

Andor, M.A., Osberghaus, D. & Simora, M. 2020. Natural disasters and governmental aid: is there a charity hazard? Ecological Economics 169: 106534.

Botzen, W.J.W., Deschenes, O. & Sanders, M. 2019. The economic impacts of natural disasters: a review of models and empirical studies. Review of Environmental Economics and Policy 13(2): 167–88.

Hallegatte, S. & Przyluski, V. 2010. The economics of natural disasters: concepts and methods. World Bank Policy Research Working Paper 5507, Washington, DC.

IFRC (International Federation of Red Cross). n.d. What is a disaster? Geneva: IFRC. https://www.ifrc.org/what-disaster.

IRDR (Integrated Research on Disaster Risk). 2014. Peril classification and hazard glossary. IRDR DATA Publication No. 1. Beijing: Integrated Research on Disaster Risk.

Natural environment

See: Natural, Naturalness, Nature.

See also: Environment.

Natural insurance

Insurance provided by natural entities or processes that reduce the costs of risk-bearing to humans. More precisely, any risk faced by a risk-averse actor is associated with a cost of carrying that risk—that is, the risk premium—defined as the perceived benefit the agent would be willing to sacrifice to fully eliminate that risk. Based on this, a natural insurance value is defined as the reduction of that risk premium due to natural processes or entities.

Martin F. Quaas

Further reading

Baumgärtner 2007; Quaas et al. 2019; Yachi & Loreau 1999.

See also: Insurance value, Risk, Risk premium, Nature, Natural.

References

Baumgärtner, S. 2007. The insurance value of biodiversity in the provision of ecosystem services. Natural Resource Modeling 20(1): 87–127.

Quaas, M.F., Baumgärtner, S. & De Lara, M. 2019. Insurance value of natural capital. Ecological Economics 165: 106388.

Yachi, S. & Loreau, M. 1999. Biodiversity and ecosystem productivity in a fluctuating environment: the insurance hypothesis. Proceedings of the National Academy of Sciences of the United States of America 96(4): 1463–8.

Naturalness

A vague term referring to that which would exist and would exist in the way it does without being touched, altered, or shaped by humans, especially with technology. The philosophical tradition has assumed an intrinsic superiority of the natural over the artificial. However, naturalness does not constitute an intrinsic value since this would require the rejection of modern medicine as "going against" nature, as well as all cultural techniques (Birnbacher 2019).

Three main forms of naturalness can be conceptually identified: history-based, property-based, and relation-based (Siipi 2008). Since few, if any, places on Earth have not been touched, altered, or shaped by humans, however, the term "naturalness" may be best thought of in terms of relative or continuous degrees, rather than an all-or-nothing state. Machado (2004) developed and proposed a qualitative index of naturalness based on ecological principles that ranged from 10 (maximum naturalness) to 0 (artificial systems), and applied it to ecosystems in the Galapagos and Canary Islands. But given the lack of consensus on its meaning, naturalness is likely to remain a vague and contested term.

BARRY D. SOLOMON

Further reading

Anderson 1991; McKibben 1989.

See also: Natural, Nature, Intrinsic value.

References

Anderson, J.E. 1991. A conceptual framework for evaluating and quantifying naturalness. Conservation Biology 5(3): 347–52.

Birnbacher, D. 2019. Naturalness. Online Encyclopedia Philosophy of Nature. https://journals.ub.uni-heidelberg.de/index.php/oepn/article/view/65607.

Machado, A. 2004. An index of naturalness. Journal of Nature Conservation 12(2): 95–110.

McKibben, B. 1989. The End of Nature. New York: Random House.

Siipi, H. 2008. Dimensions of naturalness. Ethics and the Environment 13(10): 71–103.

Natural resource accounting

A method used in environmental economics and ecological economics to account for the contribution of natural resources to the well-being of people in a country. In economics, well-being is measured as either income (a flow) or wealth (a stock). Wealth is measured as current monetary value of existing manufactured capital and natural capital (stocks of renewable and exhaustible resources). Income is measured as monetary value of various services offered by both manufactured capital and natural capital annually.

Valuation of various ecological services offered by natural resources is an important component of natural resource accounting. This requires the use of non-market valuation methods (revealed preference and stated preference methods). The environmental economics and ecological economics literatures have developed the following four methods of natural resource accounting: (1) the United Nations (2003) methodology of System of Environmental and Economic Accounting; (2) the de Koning et al. (2011) methodology of extended input–output tables for accounting of environmental externalities; (3) the World Bank (Hamilton & Clemens 1999) methodology of measuring genuine saving of countries; and (4) the Arrow et al. (2012) methodology for measuring wealth.

MADDIPATI N. MURTY

See also: Adjusted net saving (ANS), Genuine saving, Environmental accounting, Economic ecosystem accounting.

References

Arrow, K.J., Dasgupta, P., Goulder, L.H. et al. 2012. Sustainability and the measurement

of wealth. Environment and Development Economics 17(3): 317–53.
de Koning, A., Heijungs, R. & Tukker, A. 2011. A new environmental accounting framework using externality data and input–output tools for policy analysis. Technical Report, Exiopol. https://www.exiobase.eu/index.php/publications/documentation/8-technical-reportexiobase/file.
Hamilton, K. & Clemens, M. 1999. Genuine savings rates in developing countries. World Bank Economic Review 13(2): 333–56.
United Nations. 2003. Handbook of National Accounting: Integrated Environmental and Economic Accounting. New York: United Nations.

Natural resource depletion

The use/consumption of a natural resource at a faster rate than the rate of its replacement/replenishment. "Natural resource" is a broad term used for any feature of the natural environment that can be useful or may be beneficial to humans, including exhaustible/non-renewable and renewable resources.

PANOS KALIMERIS

Further reading

Cleveland & Morris 2018; Cleveland et al. 2001; Pearce & Rose 1975.

See also: Resource depletion, Natural resources, Resource scarcity, Renewable resource, Non-renewable resource.

References

Cleveland, C.J. & Morris, C.G., eds. 2018. Dictionary of Energy, 2nd edn. London: Elsevier.
Cleveland, C.J., Stern, D.I. & Costanza, R., eds. 2001. The Economics of Nature and the Nature of Economics. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.
Pearce, D.W. & Rose, J., eds. 1975. The Economics of Natural Resource Depletion. London: Macmillan Press.

Natural resource economics

The study of the optimal allocation of both renewable and exhaustible natural resources. Renewable natural resources have some regenerative capabilities, while exhaustible natural resources have a finite stock. The early neoclassical approaches (Hotelling, Dasgupta) were primarily concerned about allocating the resource to maximize the benefit derived from the resources over time. These models led to optimal allocation paths and decision allocation rules that natural resource rent should increase at the rate of interest. Increasing scarcity is reflected in increasing resource rent.

Since the publication of Krutilla's "Conservation reconsidered" (Krutilla 1967), the focus of natural resource economics has been more concerned with how the utilization of natural resources affects the flow of ecological services. For example, since Faustmann's (1849) classic article, forestry economics has focused on the optimal rotation (the cut, regrow, cut cycle) of a forest to maximize the flow of wood or the flow of income coming from the forest. Now we are more interested in the flow of ecological services coming from the forest, and how the extraction systems can be altered to protect those flows (Viitala 2013). Similarly, several decades ago people were worried about the prospect of running out of petroleum. Now we are more worried about how the extraction and use of oil affects the climate and other environmental variables.

JAMES R. KAHN

Further reading

Hotelling 1931; Dasgupta & Heal 1979.

See also: Environmental economics, Dynamic models, Renewable resource, Exhaustible resource theory, Natural resource rents.

References

Dasgupta, P.S. & Heal, G.M. 1979. Economic Theory and Exhaustible Resources. Cambridge University Press.
Faustmann, M. 1849. "On the determination of the value which forest land and immature stands possess for forestry," in Faustmann and the Evolution of the Discounted Cash

Flow. W. Linnard, ed. Oxford: Document 42, Commonwealth Forestry Institute.
Hotelling, H. 1931. The economics of exhaustible resources. Journal of Political Economy 39(2): 137–75.
Krutilla, J.V. 1967. Conservation reconsidered. American Economic Review 57(4): 777–86.
Viitala, E.J. 2013. The discovery of the Faustmann formula in natural resource economics. History of Political Economy 45(3): 523–48.

Natural resource rents

The difference between the unit market price of the resource and the average extraction or production cost, plus a normal return to capital for oil, natural gas, coal, minerals, and forest resources. Extraction cost, in turn, equals all relevant production costs. These could include exploration, development, mining, milling, beneficiation, smelting, transportation, and royalty payments. In the case of oil, natural gas, and coal, the extraction cost is often called the lifting cost.

Some studies combine rents together for all applicable natural resources, while others consider them separately. Unit rent for some natural resources such as diamonds, phosphorus, rare Earth minerals, or water will be higher because of scarcity, real or perceived, or if the resource is a luxury or positional good. Natural resource rents have been shown to be detrimental to short-run economic growth, though a positive influence in the long-run, and with mixed effects on human development (Ben-Salha et al. 2018; Sinha & Sengupta 2019).

Barry D. Solomon

Further reading

De Soysa & Neumayer 2007; Duchin & Levine 2015.

See also: Rent, Scarcity rent, Resource scarcity, Rent-seeking behavior, Non-renewable resource, Royalties, Positional goods.

References

Ben-Salha, O., Dachraoui, H. & Sebri, M. 2018. Natural resource rents and economic growth in the top resource-abundant countries: a PMG estimation. Resources Policy 74:101229.
De Soysa, I. & Neumayer, E. 2007. Resource wealth and the risk of civil war onset: results from a new dataset of natural resource rents, 1970–1999. Conflict Management and Peace Science 24: 201–18.
Duchin, F. & Levine, S.H. 2015. Rents in the era of resource scarcity: global payment flows under alternative scenarios. Journal of Economic Structures 4(8). https://doi.org/10.1186/s40008-015-0016-5.
Sinha, A. & Sengupta, T. 2019. Impact of natural resource rents on human development: what is the role of globalization in Asia Pacific countries? Resources Policy 63: 101413.

Natural resources

See: Resources.

See also: Natural resource depletion, Natural resource rents.

Natural selection

See: Darwinian theory.

See also: Evolutionary economics, Evolutionary analysis, Coevolution, Fitness.

Nature

Appeared among the Greeks for the first time in Homer (c. 8th century BCE) and was initially applied to plants to describe their specific "character." This archaic usage of the word refers to innate characteristics of things and beings (Arias-Maldonado 2015). Nowadays, in Western culture the word nature has different meanings.

Ecological economics:

a. A system that includes societal (human) and ecological (biophysical) subsystems in mutual interactions.
b. The largest system (ecosphere) in which the economy as a subsystem of the social

system is embedded, and with which biophysical exchanges (flows of energy and materials) take place.

Neoclassical economics: capital assets made of renewable and non-renewable resources that underpin the economy and yield a flow of goods and services that contribute to human well-being.

Ecology:

a. The defining features or distinguishing quality of living organisms (biotic) or physical and chemical (abiotic) phenomena.
b. An inherent force at large in the world; for example, the natural selection force.
c. The Earth system itself understood as a self-sustaining hierarchical nesting system that starts with subcellular particles and continues up through cells, tissues, organs, and individuals, and follows to higher levels of organization such as populations, communities, ecosystems, and biomes.
d. The non-human world.

Sara Latorre Tomás

Further reading

Castree 2014; Constanza 1996; Bear 2017; Spash 2017.

See also: Environment, Natural, Ecosystem, Social-ecological systems, Natural capital, Biodiversity, Ecosystem services, Biosphere, Social metabolism.

References

Arias-Maldonado, M. 2015. "Nature," pp. 1–13 in The Encyclopedia of Political Thought. M.T. Gibbons, ed. New York: John Wiley & Sons.
Bear, C. 2017. "Socio-nature," pp. 1–5 in International Encyclopedia of Geography: People, the Earth, Environment and Technology. D. Richardson, N. Castree, M.F. Goodchild et al., eds. New York: John Wiley & Sons.
Castree, N. 2014. Making Sense of Nature. London: Routledge.
Constanza, R. 1996. Ecological economics: reintegrating the study of humans and nature. Ecological Applications 6(4): 978–90.
Spash, C.L., ed. 2017. Routledge Handbook of Ecological Economics: Nature and Society. New York: Routledge.

Neoclassical economics

An approach to economics that has a conceptual and ideological focus on markets, production, consumption, and valuation of goods and services that is understood in terms of supply and demand as mechanistic forces. Sometimes also called orthodox economics, conventional economics, or mainstream economics. Neoclassical economics is perhaps best defined by the way economics is presented in popular textbooks used in most university departments of economics. Prices and more generally the monetary dimension with costs and benefits of each market actor are emphasized. The only kind of productive organization considered is the "firm," which is normally assumed to maximize monetary profits and dividends to shareholders. Individuals are consumers, assumed to maximize "utility" of commodities that can be bought in markets, subject to a monetary budget constraint.

At the level of nations, market transactions are aggregated to form a measure of gross domestic product (GDP). There is an ideological focus on economic growth in GDP terms as an indicator of social welfare, even though it is widely acknowledged that GDP does not measure welfare. This simplistic view of progress is questioned by many, ecological economists included.

Neoclassical economics is science in some sense, but at the same time it is ideology. In a democratic society, advocates of paradigms in economics that refer to different conceptual and ideological orientations should be encouraged and at least accepted. A specific version of ecological economics can be regarded as an alternative or complement to mainstream neoclassical economics. Ecological economics can be roughly defined with respect to its ideological purpose as "economics for sustainable development," although "sustainable development" itself is a highly contested concept.

Peter Söderbaum

Further reading

Samuelson & Nordhaus 2009; Fullbrook & Morgan 2019; Söderbaum 2020.

See also: Market, Microeconomics, Gross domestic product (GDP), Mechanics, Macroeconomics, Classical economics, Ecological economics,

Heterodox economics, Paradigm, Sustainable development.

References

Fullbrook, E. & Morgan, J., eds. 2019. Economics and the Ecosystem. Bristol: World Economics Association Books.

Samuelson, P.A. & Nordhaus, W.D. 2009. Economics, 19th edn. New York: McGraw-Hill/Irwin.

Söderbaum, P. 2020. "Ecological economics: redefining economics for democracy and sustainability," pp. 207–21 in Alternative Approaches to Economic Theory: Complexity, Post Keynesianism and Ecological Economics. V.A. Baker, ed. London: Routledge.

Neoliberalism

a. A global ideology or policy (with regional varieties) supporting market signals as superior information and action drivers to government; including such tendencies as globalization, free trade, deregulation, privatization, competition, and (generally) private goods over public services.
b. Disembedded neoliberalism: a form of unadulterated neoliberalism that generates (directly or indirectly) environmental destruction, inequality, alienation, and economic crises, plus recessions over recent decades.
c. Neoliberal conservation (NC): views ecology as a subset of economy (rather than vice versa), and supports expanded economic growth and investment over highly limited environmental protection of species and natural habitats.
d. Embedded neoliberalism: a slightly embedded form of NC that supports market mechanisms for protecting the environment, such as a price on carbon, technological changes, and population adaptation for global warming.

PHILLIP A. O'HARA

Further reading

Fletcher & Büscher 2017; Guéorguieva-Bringuier & Ottaviani 2018; O'Hara 2005.

See also: Laissez-faire economics, Free market, Trade liberalization.

References

Fletcher, R. & Büscher, B. 2017. The PES conceit: revisiting the relationship between payments for environmental services and neoliberal conservation. Ecological Economics 132: 224–31.

Guéorguieva-Bringuier, L. & Ottaviani, F. 2018. Opposition and isomorphism with the neoliberal logic in community exchange systems. Ecological Economics 149: 88–97.

O'Hara, P.A. 2005. Contradictions of neoliberal globalisation: the importance of ideologies and values in political economy. Journal of Interdisciplinary Economics 16(3): 341–66.

Neo-Malthusian

Followers of the classical economist Thomas Robert Malthus, who have held strong views on population control and the absolute scarcity of natural resources. The term was first used in 1877 by Samuel Van Houten, who strongly favored birth control and the use of contraceptives, but also identified working-class populations as the source of the overpopulation problem, and thus he had a eugenic element in his neo-Malthusian theory (Stuurman 1989).

In the 1960s and 1970s, many prominent ecologists and some economists were called neo-Malthusians, with their catastrophic predictions based on environmental and ecological trends and an emphasis on overpopulation and the finite nature of many key resources (Ehrlich 1968; Hardin 1968; Meadows et al. 1972; Lipton 1989). Many ecological economics today are sometimes considered neo-Malthusians as well. However, Ayres (1993) argued that this label is false or misleading, since environmentalists consider the most important scarcities to be outside the market domain, such as soil fertility, clean fresh water, clean fresh air, unspoiled landscapes, climatic stability, biological diversity, biological nutrient recycling, and environmental waste assimilative capacity.

BARRY D. SOLOMON

See also: Population, Population dynamics, Limits, Limits to growth, Scarcity, Relative vs. absolute scarcity.

References

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Ehrlich, P.R. 1968. The Population Bomb. San Francisco, CA: Sierra Club/Ballantine Books.
Hardin, G. 1968. The tragedy of the commons. Science 162(3859): 1243–8.
Lipton, M. 1989. Responses to rural population growth: Malthus and the moderns. Population and Development Review 15(Suppl.): 215–42.
Meadows, D.H., Meadows, D.L., Randers, J. & Behrens III, W.W 1972. The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind. New York: Universe Books.
Stuurman, S. 1989. Samuel Van Houten and Dutch liberalism. Journal of the History of Ideas 50(1): 135–52.

Neo-Ricardian

A strand of economic theory built upon Piero Sraffa's major work (Sraffa 1960 [1963], 1962), also known as "Sraffian" theory. The term "neo-Ricardian" arises from Sraffa's crediting of David Ricardo as a source. Neo-Ricardian theory focuses attention on the role of production—particularly the production of capital goods—rather than exchange (Pasinetti 1981), in the determination of relative prices, the functional income distribution, and the level of economic activity.

ERIC KEMP-BENEDICT

Further reading

Judson 1989; Kemp-Benedict 2014; Kurz & Salvadori 2003; Marzetti 2013.

See also: Ricardian land, Ricardian scarcity, Sraffian economics, Sraffian models, Classical economics, Joint production, Vertical integration.

References

Judson, D.H. 1989. The convergence of neo-Ricardian and embodied energy theories of value and price. Ecological Economics 1(3): 261–81.
Kemp-Benedict, E. 2014. The inverted pyramid: a neo-Ricardian view on the economy–environment relationship. Ecological Economics 107: 230–41.
Kurz, H.D. & Salvadori, N. 2003. Fund–flow versus flow–flow in production theory: reflections on Georgescu-Roegen's contribution. Journal of Economic Behavior and Organization 51(4): 487–505.
Marzetti, G.V. 2013. The fund-flow approach: a critical survey. Journal of Economic Surveys 27(2): 209–33.
Pasinetti, L.L. 1981. "Introduction," pp. 1–25 in Structural Change and Economic Growth: A Theoretical Essay on the Dynamics of the Wealth of Nations. Cambridge: Cambridge University Press.
Sraffa, P. 1960 [1963]. Production of Commodities by Means of Commodities: Prelude to a Critique of Economic Theory. Indian edn, 1963. Bombay: Vora & Co.
Sraffa, P. 1962. Production of commodities: a comment. Economic Journal 72(286): 477–79.

Net carbon

a. A measure of the carbon dioxide (CO_2) emissions released to the atmosphere from an activity, after deducting any CO_2 captured and sequestered or offset. Typically used to track progress in reducing emissions as part of an action on climate heating, and applied to individual products or activities, to an organization, or to a country.
b. Applied specifically to biomass-based fuels, a measure of the CO_2 emissions released to the atmosphere in the preparation and combustion of the fuel, minus the CO_2 captured and stored in the biomass material as it grows. Plants absorb CO_2 from the atmosphere as part of photosynthesis, and release about half of it again through respiration, with the balance converted to carbohydrates and stored as plant growth. When released in combustion, the stored carbon can in theory be regarded as neutral in terms of climate heating, as it was previously removed from the atmosphere, if the biomass is replaced with equivalent planting as part of sustainable land management. But the preparation of biomass fuels typically incurs additional emissions, including fossil fuels used for fertilizer, harvesting, and transportation, which can result in a net contribution to climate heating. In addition, even if biomass is regenerated, this process can take many decades

in the case of mature forests, creating a long-term pulse of additional carbon to the atmosphere.

Matthew A. Leach & Jari M. Lyytimäki

Further reading

Antar et al. 2021.

See also: Net zero carbon, Carbon footprint, Carbon intensity, Biofuel.

Reference

Antar, M., Lyu, D., Nazari, M. et al. 2021. Biomass for a sustainable bioeconomy: an overview of world biomass production and utilization. Renewable and Sustainable Energy Reviews 139: 110691.

Net national product (NNP)

Gross national product (GNP) minus depreciation.

Barry D. Solomon

See also: Gross national product (GNP), Gross domestic product (GDP), Depreciation.

Net present value (NPV)

The total value today of monetary flows from the present to a future time for a policy or project, where future monetary values are discounted by the choice of discount rate and discount function (for example, exponential, quasi-hyperbolic, and hyperbolic). Costs are subtracted from benefits. High discount rates imply time-preference for present-day monetary flows. The discount function determines the strength of the discount rate at a point in time. A common decision metric is used in benefit–cost analysis (BCA), where a positive net present value normally suggests that a policy or project is worth implementing, while a negative one suggests that a policy or project should normally not be pursued.

Janne V. Artell

Further reading

Arrow et al. 1996; Hanley & Spash 1993; OECD 2018.

See also: Benefit–cost analysis (BCA), Discounting, Social discount rate, Time horizon, Time preference, Pure rate of time preference.

References

Arrow, K.J., Cropper, M.J., Eads, G.C. et al. 1996. Is there a role for benefit–cost analysis in environmental, health, and safety regulation? Science 272(5259): 221–2.

Hanley, N. & Spash, C. 1993. Cost–Benefit Analysis and the Environment. Aldershot, UK and Brookfield, VT, USA: Edward Elgar Publishing.

OECD (Organisation for Economic Co-operation and Development). 2018. Cost–Benefit Analysis and the Environment: Further Developments and Policy Use. Paris: OECD Publishing.

Net primary production (NPP)

In the process of photosynthesis, plants use radiant energy from the Sun to convert inorganic inputs (primarily water and carbon dioxide) into energy-rich compounds (biomass), eventually producing oxygen as a by-product. The total amount of organic material produced through photosynthesis is denoted as "gross primary production" or GPP, a fraction of which is used by the plants for their own metabolism ("plant respiration"). Gross primary production minus plant respiration is denoted as "net primary production" (NPP). NPP is used for plant growth or consumed by heterotrophic organisms such as animals and fungi. NPP is the trophic energy input of all food webs, that is, a key energy source sustaining the diversity of life on the planet. Approximately 10–15 percent of the NPP of plants on global land is harvested for human purposes through agriculture and forestry (Haberl et al. 2014), thereby representing a key input to social metabolism.

Helmut Haberl

Further reading

Krausmann et al. 2018; Odum 1971.

See also: Human appropriation of net primary production (HANPP), Social metabolism.

References

Haberl, H., Erb, K.-H. & Krausmann, F. 2014. Human appropriation of net primary production: patterns, trends, and planetary boundaries. Annual Review of Environment and Resources 39: 363–91.

Krausmann, F., Lauk, C., Haas, W. & Wiedenhofer, D. 2018. From resource extraction to outflows of wastes and emissions: the socioeconomic metabolism of the global economy, 1900–2015. Global Environmental Change 52: 131–40.

Odum, E.P. 1971. Fundamentals of Ecology. Philadelphia, PA: Saunders College Publishing.

Net social benefit

In benefit–cost analysis, the difference between the discounted present value of benefits and the discounted present value of costs.

Barry D. Solomon

See also: Benefit–cost analysis (BCA), Discounting.

Net value added

Economics:

a. An operating net income derived from the production factor services of human labor and total immobilized capital embedded in the total products consumed and accumulated in the accounting period (Campos et al. 2021). From ecosystem accounting frameworks this procedure overcomes the standard System of National Accounts (SNA) net value added omissions and valuation shortcomings, due to its measurement being consistent with sustainable total income theory. It is estimated as a balancing item of the production account after subtracting from the total product the intermediate consumption and the consumption of fixed capital.

   The net value added reveals the ecosystem biophysical flows contributions, whether economic or non-economic (for example, gift environmental production factors), to the total products of the economic activities in the economic unit of the ecosystem accounts. Only employee labor receives guaranteed compensation from the farmer and the government without the risk of depending on the residual self-employed compensations and net operating margin results. In net mixed income factorial allocation, labor is assumed to receive the prior compensation at a maximum rate below employee compensation (Oviedo et al. 2017). Its factorial distribution is attributed to labor compensation and net operating margin.

b. The System of Environmental–Economic Accounting—Ecosystem Accounting (SEEA-EA) accumulated final product only measures the manufactured gross capital formation (UNSD 2021, p. 93). The environmental net operating surplus incorporates the depletion (work in progress used) valued at opening inventory unit natural resource rent. The SEEA-EA proposes to use the degradation adjusted net value added. Degradation is considered as a negative change of provisioning ecosystem environmental assets in the accounting period.

Pablo Campos Palacín

Further reading

Campos et al. 2020; European Commission et al. 2009.

See also: System of National Accounts (SNA), Value added, Gross domestic product (GDP), Natural resource rents, Total income.

References

Campos, P., Álvarez, A., Mesa, B. et al. 2020. Total income and ecosystem service sustainability index: accounting applications to holm oak *dehesa* case study in Andalusia-Spain. Land Use Policy 97: 104692.

Campos, P., Álvarez, A., Mesa, B. et al. 2021. Linking standard Economic Account for Forestry and ecosystem accounting: total forest incomes and environmental assets in publicly-owned

conifer farms in Andalusia-Spain. Forest Policy and Economics 128: 102482.
European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development et al. 2009. System of National Accounts 2008 (SNA 2008). New York. http://unstats.un.org/unsd/nationalaccount/docs/SNA2008.pdf.
Oviedo, J.L., Huntsinger, L. & Campos, P. 2017. The contribution of amenities to landowner income: cases in Spanish and Californian hardwood rangelands. Rangeland Ecology and Management 70(4): 518–28.
UNSD. 2021. System of Environmental–Economic Accounting—Ecosystem Accounting, final draft. United Nations Statistical Division: New York. https://unstats.un.org/unsd/statcom/52nd-session/documents/BG-3f-SEEA-EA_Final_draft-E.pdf.

Networks

A mathematical abstraction used to analyze complex adaptive evolving systems. A network is a structure composed of two collections of things: nodes, and edges which connect the nodes. Nodes are usually things that can exercise agency. Edges are usually hierarchical or co-equal dynamic relationships. A network is an abstract representation of any structure that fits this description at any level or scale. It becomes a specific network when nodes and edges are given specific biophysical meanings. In a simple ecological example, nodes could be species, edges could be predator–prey relationships, and the network would represent an abstract trophic web. In a simple social example, nodes could be people, edges could be friendships, and the network would represent a real social web. In a simple economic example, the nodes would be businesses, the edges would be buyer–seller relationships, and the network would represent supply chains.

Simple networks can become more complex networks in several ways. For example, nodes and edges can each have several characteristics so each node can interact with other nodes in several ways. Networks are rarely static, and nodes can often connect and disconnect as circumstances change. Because of the diversity of nodes and edges, and the diversity of the overall behavior of these dynamic nodes when they are connected in different ways, networks are a significant component of all complex adaptive evolving systems such as ecosystems, social systems, and economies.

Xi Ji

Further reading

Kőnig 1990; Newman 2003, 2018; Ji 2015.

See also: Knowledge networks, Bayesian belief networks, Water–energy–food nexus, Applied systems analysis.

References

Ji, X. 2015. Taking the pulse of urban economy: from the perspective of systems ecology. Ecological Modelling 318: 36–48.
Kőnig, D. 1990. Theory of Finite and Infinite Graphs. R. McCoart, transl. Boston, MA: Birkhäuser.
Newman, M.E.J. 2003. The structure and function of complex networks. SIAM Review 45(2): 167–256.
Newman, M. 2018. Networks: An Introduction, 2nd edn. Oxford: Oxford University Press.

Net zero carbon

Balance achieved between carbon dioxide released to the atmosphere and emissions either sequestered or offset. Often used to refer to scenarios or strategies for decarbonization of activities over time or by a target date, for a country, an organization, or a product, as part of action on climate heating. Efforts are usually directed primarily at reducing emissions, but use of the term "net zero" reflects the challenge of eliminating emissions completely, balancing the most difficult or expensive emissions reductions with sequestration through some form of carbon capture and storage, or offsetting through purchase of carbon credits. "Net zero carbon" is used as shorthand for net zero carbon dioxide; "net zero" is also used as a further shorthand for net zero carbon dioxide, but more properly refers to the balance for all greenhouse gas emissions.

Matthew A. Leach

Further reading

IPCC 2018; IEA 2021; SBTi 2021.

See also: Net carbon, Greenhouse gas neutral, Carbon footprint.

References

IPCC (Intergovernmental Panel on Climate Change). 2018. Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C Above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty. Geneva: Intergovernmental Panel on Climate Change.

IEA (International Energy Agency). 2021. Net Zero by 2050: A Roadmap for the Global Energy Sector. Paris: International Energy Agency.

SBTi (Science Based Targets initiative). 2021. SBTi Corporate Manual, TVT-INF-002, Version 2.0. https://sciencebasedtargets.org/resources/files/SBTi-Corporate-Manual.pdf.

New environmental pragmatism

According to Clive Spash (2009), a transdisciplinary branch of ecological economics that uncritically focuses on methods and concepts that are perceived to be most expedient and effective in promoting desirable environmental policy under the current political economy of capitalism and neoliberalism. He argues that this approach is also popular among ecologists, conservation biologists, environmental scientists, and environmentalists. Research priorities include a strong emphasis on economic valuation—commodifying and pricing nature; institutions for trading, profits, and individual gain—and little if any focus on theory. Examples of such work are readily found in ecosystem services valuation, natural capital, green accounting, carbon trading, and biodiversity offsets and banking (Spash 2013, p. 354).

Critics of this approach besides Spash (Spash 2009, 2013; Spash & Aslaksen 2015) include O'Neill (1993), Norton and Noonan (2007), among others, who reject the placement of a monistic monetary valuation on nature.

Barry D. Solomon

Further reading

Light & Katz 1996.

See also: Pragmatism, Conservation biology, Environmental science, Environmentalism, Monism.

References

Light, A. & Katz, E. 1996. Environmental Pragmatism. London: Routledge.

Norton, B.G. & Noonan, D. 2007. Ecology and valuation: big changes needed. Ecological Economics 63: 664–75.

O'Neill, J. 1993. Ecology, Policy and Politics: Human Well-Being and the Natural World. London: Routledge.

Spash, C.L. 2009. The new environmental pragmatists, pluralism and sustainability. Environmental Values 18: 253–6.

Spash, C.L. 2013. The shallow or the deep ecological economics movement? Ecological Economics 93: 351–62.

Spash, C.L. & Aslaksen, I. 2015. Re-establishing an ecological discourse in the policy debate over how to value ecosystems and biodiversity. Environmental Management 159: 245–53.

New institutional economics

A branch of economics that focuses on the transaction as the unit of inquiry, postulating that market participants seek to minimize the cost of transacting by manipulating the institutional structure (that is, the formal and informal rules) of markets. Markets evolve into forms that minimize the cost of exchange, including the size of individual firms, whether agreements are long-term or one-off, and the role of government in markets, providing a nuanced account of economic organization. Governments play a role in new institutional economics in establishing, enforcing, and sometimes forbidding rules of exchange.

Transaction costs include the pre-agreement research and negotiations that result in an exchange, as well as the post-agreement

enforcement of its terms. Transactions have costs because individuals are thought to have "bounded rationality," an intention of acting rationally but with limited capacity to do so. This makes it impossible to costlessly negotiate and enforce complex agreements.

An example of a transaction risk is a "specific asset," something that a party to a transaction invests in to carry out a specific transaction, that has minimal value in any other setting (such as customized delivery equipment). The owner of the specific assets must protect against a renegotiation of terms once it becomes harder to walk away from the agreement.

New institutional economics is attractive to some ecological economists because it recognizes an active, non-neutral role for government in establishing and enforcing the structure of markets, as well as the complex and non-uniform nature of goods and markets that result in the wide variety of economic organization found.

BRENT M. HADDAD

Further reading

Coase 1937; Williamson 1975.

See also: Institutional economics, Institutions, Bounded rationality, Transaction costs.

References

Coase, R.H. 1937. The nature of the firm. Economica New Series 4(16): 386–405.

Williamson, O. 1975. Markets and Hierarchies: Analysis and Antitrust Implications. New York: Free Press.

New resource economics

A neoclassical economics paradigm that emerged in the late 1970s and 1980s in an attempt to improve upon natural resource economics, with the following features: (1) a recognition that market failure is pervasive in natural resource allocation, though a non-market alternative and government planning are not necessarily better; (2) an assumption that resource managers generally have inadequate information to make economically efficient decisions; and (3) a recognition that the incentive structure in the public sector is quite different from that in the private sector. As a result, new resource economics (NRE) began by emphasizing property rights, public choice, and Austrian economics perspectives for addressing natural resources management and policy (Anderson 1982).

This term, however, is not widely used. Spash (2013, pp. 356–7) argues that what is new in the NRE is the priority given to issues of ecosystem functioning, and promotes what he calls social ecological economics as the alternative.

BARRY D. SOLOMON

Further reading

Fisher 1981.

See also: Natural resource economics, Property right, Austrian School of economics, Market failure, Market solution, Social ecological economics.

References

Anderson, T.L. 1982. The new resource economics: old ideas and new applications. American Journal of Agricultural Economics 64(5): 928–34.

Fisher, A.C. 1981. Resource and Environmental Economics. Cambridge: Cambridge University Press.

Spash, C.L. 2013. The shallow or the deep ecological economics movement? Ecological Economics 93: 351–62.

Non-commensurable

See: Incommensurable.

See also: Incommensurable values, Commensurability.

Non-competitive market

A market where the firms in it have market power and the ability to influence or set the price, either directly or indirectly, which increases their revenue and profits. In such cases firms are price makers rather than price takers. Non-competitiveness can occur in

oligopolistic, duopolistic, and monopolistic markets, and when there are otherwise a small number of firms in the relevant market. Barriers to entry can also be a problem. Non-competitive behavior can also occur if firms have access to relevant market information not accessible to other potentially competing firms, or are considered "natural monopolies" such as electricity transmission, natural gas distribution, and water and sewerage service.

If non-competitive behavior persists, an antitrust analysis and possibly enforcement action could be undertaken by a government agency as well as public utility regulation. Examples of non-competitive industries in several countries at different points in time have included oil, tire, and steel manufacturing, railroads, airlines, telephone service, wireless carriers, recorded music, and film and television production.

BARRY D. SOLOMON

Further reading

Georgantzis & Attanasi 2016; Crew & Kleindorfer 1986.

See also: Competitive market, Market power, Market failure, Utility, Experimental economics.

References

Crew, M.A. & Kleindorfer, P.R. 1986. The Economics of Public Utility Regulation. Basingstoke: Macmillan Press.

Georgantzis, N. & Attanasi, G. 2016. "Non-competitive markets," pp. 21–36 in Experimental Economics. P. Branas-Garza & A. Cabrales, eds. London: Palgrave Macmillan.

Non-consumptive use value

Ecology: where the species or ecosystem is valued for the human desire to interact with it (for example, whale watching).

Environmental economics: as a subset or component of total economic value, understood as a direct use value resulting from direct human "use" of biodiversity associated with recreation, spiritual/cultural well-being, research, or education. Valuation methodologies include landing receipt data, contingent valuation surveys, hedonic pricing, and travel cost estimates. Non-consumptive use values can be included in economic-based management strategies and future management models for endangered species.

STEPHEN G. FLOOD

Further reading

Duffus & Dearden 1990; Flood et al. 2020; Guerra et al. 2018; Pascual et al. 2010; Spangenberg & Settele 2010.

See also: Use value, Non-use value, Existence value, Total economic value (TEV).

References

Duffus, D.A. & Dearden, P. 1990. Non-consumptive wildlife-orientated recreation: a conceptual framework. Biological Conservation 53(3): 213–31.

Flood, S., O'Higgins, T. & Lago, M. 2020. "The promise and pitfalls of ecosystem services classification and valuation," pp. 87–103 in Ecosystem-Based Management, Ecosystem Services and Aquatic Biodiversity: Theory, Tools and Applications. T. O'Higgins, M. Lago & T.H. De Witt, eds. Cham: Springer.

Guerra, A.S., Madigan, D.J., Love, M.S. & McCauley, D.J. 2018. The worth of giants: the consumptive and non-consumptive use value of the giant sea bass (*Stereolepis gigas*). Aquatic Conservation: Marine and Freshwater Ecosystems 28: 296–304.

Pascual, U., Muradian, R., Brander, L. et al. 2010. "The economics of valuing ecosystems services and biodiversity," pp. 183–256 in The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. P. Kumar, ed. London: Routledge.

Spangenberg, J.H. & Settele, J. 2010. Precisely incorrect? Monetising the value of ecosystem services. Ecological Complexity 7(3): 327–37.

Non-excludable resource

A good, service, or resource that everybody can access and benefit from. Institutions can make almost anything excludable with sufficient force, but ecological economists have deemed some resources inherently non-excludable (Kemkes et al. 2010). For example, it would be virtually impossible to exclude someone from the benefits of climate

regulation or to keep people from breathing atmospheric oxygen.

SAM C. BLISS

Further reading

Ostrom 2010.

See also: Excludability, Common pool resources, Public goods.

References

Kemkes, R.J., Farley, J. & Koliba, C.J. 2010. Determining when payments are an effective policy approach to ecosystem service provision. Ecological Economics 69(11): 2069–74.

Ostrom, E. 2010. Beyond markets and states: polycentric governance of complex economic systems. American Economic Review 100(3): 641–72.

Non-linear

Non-linearity is a common condition in ecological and economic systems since they do not always progress or develop smoothly or predictably.

BARRY D. SOLOMON

See also: Complexity, Complex systems modeling, Dynamic systems, Chaos theory, Surprise, Panarchy theory, Non-linear cointegration, Agent-based modeling (ABM).

Non-linear cointegration

A non-linear statistical property of some time series variables. Cointegration tests have been developed in econometrics to determine whether there are long-term correlations between several time series data, which can cause spurious regression. Non-linear cointegration has been observed in some ecological and environmental studies. Non-linear cointegration is complex since it involves non-linearity as well as non-stationarity. However, the analysis of non-linear cointegration is important because of the frequent non-linear behavior of ecological and environmental variables. Non-linear extensions of the cointegration test in econometrics of Granger (1981) and Engle and Granger (1987) have been developed from the perspective of threshold cointegration and its smooth versions by Balke and Fomby (1997) and Hansen and Seo (2002), among others. Another option is to conduct non-linear regression with integrated regressors or non-linear cointegrating regression (Park & Phillips 1999, 2001).

MELIKE E. BILDIRICI

See also: Non-linear, Non-stationarity, Cointegration, Econometrics.

References

Balke, N.S. & Fomby, T.B. 1997. Threshold cointegration. International Economic Review 38(3): 627–45.

Engle, R.F. & Granger, C.W.J. 1987. Co-integration and error correction: representation, estimation, and testing. Econometrica 55(2): 251–76.

Granger, C.W.J. 1981. Some properties of time series data and their use in econometric model specification. Journal of Econometrics 16(1): 121–30.

Hansen, B.E. and Seo, B. 2002. Testing for two-regime threshold cointegration in vector error correction models. Journal of Econometrics 110(2): 293–318.

Park, J.Y. & Phillips, P.C.B. 1999. Asymptotics for nonlinear transformations of integrated time series. Econometric Theory 15(3): 269–98.

Park, J.Y. and Phillips, P.C.B. 2001. Nonlinear regression with integrated time series. Econometrica 69(1): 117–61.

Non-market economies

Economic practices and institutions that do not involve buying and selling. These encompass: (1) production that is not intended for sale; and (2) transfers and allocation mechanisms other than buying and selling, such as gifts and sharing. Non-market production and transfers, or non-market economies, are ubiquitous in all societies.

SAM C. BLISS

Further reading

Bliss & Egler 2020.

See also: Non-market value, Market, Subsistence, Informal sector.

Reference

Bliss, S. & Egler, M. 2020. Ecological economics beyond markets. Ecological Economics 178: 106806.

Non-market value

Estimated value for goods and services that are not intended to be traded in markets (for example, health, quality of life, some aspects of culture and education, water or air quality, and endangered species), divided into three categories: use values, option values, and non-use values. They are estimated through non-market valuation techniques aiming at reflecting the economic value of changes, in the availability or quality, of non-market goods and services.

Non-market values are often associated with market failures, such as the existence of public goods or externalities. When negative externalities are present in a consumption or a production activity (for example, pollution), additional costs larger than the private costs are imposed on society (for example, decreased quality of life, higher health care costs). In a neoclassical perspective, estimations of non-market values aim at evaluating the impacts of decisions on social welfare, to manage non-market goods and services by considering their social or total value to society. Several criticisms are made of these approaches, notably that they do not consider values as plural, and because they are considered as incommensurable.

Léa Tardieu

Further reading

Pascual et al. 2015; OECD 2018; Kumar 2010.

See also: Benefit–cost analysis (BCA), Externalities, Environmental externalities, Total economic value (TEV).

References

Kumar, P., ed. 2010. The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. London: Routledge.

OECD (Organisation for Economic Co-operation and Development). 2018. Cost–Benefit Analysis and the Environment: Further Developments and Policy Use. Paris: OECD.

Pascual, U., Balvanera, P., Keune, H. et al. 2015. Preliminary Guide Regarding Diverse Conceptualization of Multiple Values of Nature and its Benefits, Including Biodiversity and Ecosystem Functions and Services. Kuala Lumpur: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

Non-renewable resource

Any natural resource that cannot be replenished or replaced by natural means at a pace required to keep up with its exploitation (consumption or depletion) by humans. These include the fossil fuels petroleum, natural gas, and coal; metallic and non-metallic minerals including uranium (except where used in breeder nuclear fission reactors); and much groundwater (Gleeson et al. 2016). Non-renewable resources are sometimes called stocks or stock resources. The classical analysis of the price and extraction path of non-renewable resources was developed by Harold Hotelling (1931).

Barry D. Solomon

Further reading

Swallow 1990; Krautkraemer 1998; Pirani 2018.

See also: Fossil fuels, Hotelling model, Hotelling rule, Stocks, Renewable resource, Groundwater governance.

References

Gleeson, T., Befus, K.M., Jasechko, S. et al. 2016. The global volume and distribution of modern groundwater. Nature Geoscience 9: 161–7.

Hotelling, H. 1931. The economics of exhaustible resources. Journal of Political Economy 39(2): 137–75.

Krautkraemer, J. 1998. Nonrenewable resource scarcity. Journal of Economic Literature 36: 2065–107.

Pirani, S. 2018. Burning Up: A Global History of Fossil Fuel Consumption. London: Pluto Press.

Swallow, S.K. 1990. Depletion of the environmental basis for renewable resources: the economics of interdependent renewable and nonrenewable resources. Journal of Environmental Economics and Management 19(3): 281–96.

Non-rival resources

A resource that when used by one person does not limit the use by another person, and therefore it does not reduce the quantity of the resource available for others. All fund-service resources (that is, regulating, and cultural services) are non-rival. For example, the benefits obtained by one person from the climate regulation service provided by a mangrove forest does not reduce this same benefit for everyone else.

Marcello Hernández-Blanco

Further reading

Hernández-Blanco et al. 2021; Hernández-Blanco & Costanza 2019.

See also: Fund-service resources, Ecosystem services, Regulating services, Cultural services, Rival resource.

References

Hernández-Blanco, M. & Costanza, R. 2019. "Natural capital and ecosystem services," pp. 254–68 in The Routledge Handbook of Agricultural Economics. G.L. Cramer, K.P. Paudel & A. Schmitz, eds. London: Routledge.

Hernández-Blanco, M., Costanza, R. & Cifuentes-Jara, M. 2021. Economic valuation of the ecosystem services provided by the mangroves of the Gulf of Nicoya using a hybrid methodology. Ecosystem Services 49: 101258.

Non-state actors

Actors that are autonomous, either largely or entirely, from the structure and machinery of the formally sovereign state. Non-state actors can work within one or more sovereign states or on a transnational level (Josselin & Wallace 2001). Examples of non-state actors include individual, or organized groups of, civil society organizations (non-profit organizations and networks), economic entities (businesses and trade unions), local and regional governments, and transnational institutions. Thus, "non-state actors" is a comprehensive term that covers all these other organizations (Schoenefeld 2021).

Yuhao Ba

Further reading

Cashore 2002; Bäckstrand et al. 2017; Chan et al. 2019.

See also: Civil society, Legitimacy, Stakeholder, Stakeholder participation, Democracy, Networks.

References

Bäckstrand, K., Kuyper, J.W., Linnér, B.-O. & Lövbrand, E. 2017. Non-state actors in global climate governance: from Copenhagen to Paris and beyond. Environmental Politics 26(4): 561–79.

Cashore, B. 2002. Legitimacy and the privatization of environmental governance: how non-state market-driven (NSMD) governance systems gain rule-making authority. Governance 15(4): 503–29.

Chan, S., Boran, I., van Asselt, H. et al. 2019. Promises and risks of nonstate action in climate and sustainability governance. Wiley Interdisciplinary Reviews: Climate Change 10(3): e572.

Josselin, D. & Wallace, W., eds. 2001. Non-state Actors in World Politics. London: Palgrave Macmillan.

Schoenefeld, J.J. 2021. Interest groups, NGO or civil society organisations? The framing of non-state actors in the EU. VOLUNTAS: International Journal of Voluntary and Nonprofit Organisations 32: 585–96.

Non-stationarity

The name given to a data series whose mean values change over time, and therefore the exhibited trend over time is stochastic. Various economic time series attain non-stationary processes and are distributed around a stochastically changing trend over a given period. Since the two series are not stationary—that is, they have similar trends—it is called spurious regression to conclude that a relationship exists, although there is no actual relationship between them.

Ali Eren Alper

Further reading

Fryzlewicz et al. 2003; Kao 1999.

See also: Stationarity, Multivariate statistical techniques, Econometrics, Cointegration.

References

Fryzlewicz, P., Van Bellegem, S. & Von Sachs, R. 2003. Forecasting non-stationary time series by wavelet process modelling. Annals of the Institute of Statistical Mathematics 55(4): 737–64.

Kao, C. 1999. Spurious regression and residual-based tests for cointegration in panel data. Journal of Econometrics 90(1999): 1–44.

Non-use value

A measure of the value that people assign to an environmental asset (good), attribute (natural capital), or ecosystem service, even if they have never used it and never will. Non-use value includes existence value, altruistic value (for the enjoyment of current generations), and bequest value (for the enjoyment of future generations). Among the categories of non-use value, it is often difficult if not impossible to separate the three subcategories. For these different types of values there need to be rigorous valuation techniques to estimate the value of benefits. Also, it can be difficult to separate someone's use from non-use valuation, as the value of one may affect the value of the other. Thus, it is risky to estimate non-use value in isolation.

BARRY D. SOLOMON

Further reading

Garrod & Willis 1997; Hutchinson et al. 1995.

See also: Environmental asset, Natural capital, Ecosystem services, Altruistic value, Existence value, Bequest value, Economic valuation techniques.

References

Garrod, G.D. & Willis, K.G. 1997. The non-use benefits of enhancing forest biodiversity: a contingent ranking study. Ecological Economics 21(1): 45–61.

Hutchinson, W.G., Chilton, S.M. & Davis, J. 1995. Measuring non-use value of environmental goods using the contingent valuation method: problems of information and cognition and the application of cognitive questionnaire design methods. American Journal of Agricultural Economics 46(1): 97–112.

No-regrets strategy

A policy that should be enacted because it provides net environmental, economic, and/or social benefits in response to a crisis of uncertain or unknown proportions, even if the worst-case scenario is never realized (Gray & Rivkin 1991). No-regrets strategies are most promoted to mitigate or adapt to climate change, and may involve the pursuit of cost-effective measures by policymakers for energy conservation and efficiency improvements, renewable energy development, afforestation, and reforestation, among others. Such measures are sometimes called "win–win" actions since they can simultaneously deliver multiple benefits. Some mitigation measures may even have negative net social costs, and should be pursued first as part of a no-regrets strategy portfolio (Rose & Lin 1995; Bréchet & Jouvet 2009).

BARRY D. SOLOMON

See also: Climate change mitigation, Climate change adaptation, Renewable energy, Energy efficiency, Energy conservation, Pollution abatement, Disaster risk management (DRM), Precautionary principle.

References

Bréchet, T. & Jouvet, P.A. 2009. Why environmental management may yield no-regret pollution abatement options. Ecological Economics 68(6): 1770–77.

Gray, C.B. & Rivkin Jr, D.B. 1991. A "no regrets" environmental policy. Foreign Policy 83: 47–65.

Rose, A. & Lin, S.M. 1995. Regrets or no regrets—that is the question: is conservation a costless CO_2 mitigation strategy? Energy Journal 16(3): 67–87.

Normative assessment of social systems

An evaluation of social systems in terms of being morally right or wrong. Two common categories of normative assessment are: deontological, or procedural rightness; and teleological, or outcome-related rightness. A normative assessment of social systems would first posit its standards of right and

wrong. Examples could be the presence of democratic decision-making (a deontological standard) or equitable distribution of economic output (teleological). The assessment then gathers data about social systems and compares the findings to the normative criteria. One can argue that nearly any comparative assessment or ranking of social groupings includes the above steps, even if implicit, and is therefore a normative assessment.

In ecological economics, the selection of norms typically includes long-term environmental preservation, widespread political representation, and equitable allocation of the benefits of economic activity within and between generations.

BRENT M. HADDAD

Further reading

Daly 1977.

See also: Norms, Steady state economy, Biophysical equilibrium.

Reference

Daly, H. 1977. Steady-State Economics: The Economics of Biophysical Equilibrium and Moral Growth. San Francisco, CA: W.H. Freeman.

Norms

a. The standard, typical, or expected social behavior of a group of people.
b. Expectations or rules that are socially enforced. By guiding social expectations, norms determine acceptable and unacceptable conduct in a society.

BARRY D. SOLOMON

Further reading

Sethi & Somanathan 1996; Ostrom 2000; Keefer & Knack 2008.

See also: Social capital, Status seeking, Cultural values.

References

Keefer, P. & Knack, S. 2008. "Social capital, social norms and the new institutional economics," pp. 701–25 in Handbook of New Institutional Economics. C. Ménard & M.M. Shirley, eds. Berlin: Springer.
Ostrom, E. 2000. Collective action and the evolution of social norms. Journal of Economic Perspectives 14(3): 137–58.
Sethi, R. & Somanathan, E. 1996. The evolution of social norms in common property use. American Economic Review 86(4): 766–88.

North–South relations

The geopolitical dynamics between the relatively historically wealthy and powerful states (the so-called "global North") and the relatively and historically poorer and less powerful states (the so-called "global South"). The nations referred to as the "North" are generally from the Northern Hemisphere (for example, from the continents of North America and Europe). The nations referred to as the "South" are generally located southward of the global North, including from the Southern Hemisphere (for example, from the continents of South America and Africa).

The binary is not always true based on geography (for example, Australia, recognized as being part of the global North, is in the Southern Hemisphere while Mexico, recognized as being part of the global South, is in the Northern Hemisphere), or indeed current economic or political power (for example, China is considered a part of the global South, and Russia is considered a part of the global North). The stronger marker of whether a nation is a part of the North or South is whether it has historically been viewed as a "developed nation" (and therefore a part of the North) or a "developing nation" (a part of the South).

In recent times, North–South relations have been highlighted in global climate politics and law-making. Those relations have been strained, because the global North is viewed as having contributed most to climate change and having achieved most developmentally from carbonized economies; while the global South is likely to experience greater hardship from the effects of climate change while having development potential constrained by laws and policies being driven by the North

that require all nations to limit greenhouse gas emissions.

BRAD S. JESSUP

Further reading

Hurrell & Sengupta 2012; Mickelson 2009.

See also: Development, Economic development, Sustainable development, Post-development.

References

Hurrell, A. & Sengupta, S. 2012. Emerging powers, North–South relations and global climate politics. International Affairs 88(3): 463–84.

Mickelson, K. 2009. Beyond politics of the possible: South–North relations and climate justice. Melbourne Journal of International Law 10(2): 411–23.

No-take zone

Any area that has been set aside by a government agency where no extractive activity of any kind is permitted, and human activity is extremely limited. These can be on land or in water. No-take zones are common in marine protected areas (MPAs). The world's largest MPA at ~1 510 000 square kilometers, Papahānaumokuākea Marine National Monument of the northern Hawaiian Islands, is a 100 percent no-take zone. No-take zones raise classic collective action problems for managing common pool resources (Jones 2006).

BARRY D. SOLOMON

See also: Marine protected areas (MPAs), Conservation areas, Common pool resources, Collective action.

Reference

Jones, P.J.S. 2006. Collective action problems posed by no-take zones. Marine Policy 30(2): 143–56.

Nutrient cycling

The repeated pathways of specific organic and inorganic nutrients between the biotic and abiotic parts of the environment through cells, communities, and ecosystems into the production of matter and back to the environment. Sometimes also called biogeochemical cycles. The major nutrient cycles include nitrogen, carbon, water (hydrologic), oxygen, phosphorous, and sulfur. Nutrient cycles are essential for sustaining life and carrying away waste materials.

BARRY D. SOLOMON

Further reading

Bormann & Likens 1967; Vitousek 1982, 2004; Hobbie 1992.

See also: Cycle, Nutrient retention, Soil fertility, Soil conservation, Soil health.

References

Bormann, F.H. & Likens, G.E. 1967. Nutrient cycling: small watersheds can provide invaluable information about terrestrial ecosystems. Science 155(3761): 424–9.

Hobbie, S.E. 1992. Effects of plant species on nutrient cycling. Trends in Ecology and Evolution 7(10): 336–9.

Vitousek, P.M. 1982. Nutrient cycling and nutrient use efficiency. American Naturalist 119(4): 553–72.

Vitousek, P.M. 2004. Nutrient Cycling and Limitation: Hawai'i as a Model System. Princeton, NJ: Princeton University Press.

Nutrient retention

a. The capacity of soils to retain added nutrients against losses from leaching. Soil nutrient retention is a function of the soil's structure, texture, organic matter accumulation, slope, drainage, aeration, moisture, temperature, and pH.
b. The amount of nutrients that is biogeochemically transformed, taken up, or retarded by biota.

BARRY D. SOLOMON

Further reading

Havlin et al. 2013; Vitousek & Reiners 1975.

See also: Nutrient cycling, Soil fertility, Soil conservation, Soil health, Ecological succession.

References

Havlin, J.L., Tisdale, S.L., Nelson, W.L. & Beaton, J.D. 2013. Soil Fertility and Fertilizers: An Introduction to Nutrient Management, 8th edn. New York: Pearson.

Vitousek, P.M. & Reiners, W.A. 1975. Ecosystem succession and nutrient retention: a hypothesis. BioScience 25(6): 376–81.

O

Objective well-being

a. A function of access to essential goods and services for human life.
b. A function of quality-of-life indicators (for example, income level, having food, clothes, and housing), social aspects (for example, having education, health, and political freedom), and environmental aspects (for example, air or water pollution rate).
c. Described in objective human conditions, such as stability and level of income, having food, clothes, and housing, and other conditions.
d. Associated with having opportunities, such as to realize social and civil rights, to access to quality food, clothing, housing, education, and employment, having safety and environmental quality.
e. Depends on people's objective conditions and capabilities.
f. Objective aspects of people's quality of life.
g. Socio-environmental indicators (for example, infant mortality, literacy or illiteracy, and crime rates, longevity, income level, and air or water pollution levels) that reflect objective well-being.
h. Has been identified with multiple dimensions of human well-being, such as health, socio-economic, environment, safety, and politics.
i. The objective well-being approach originates from Amartya Sen's work in welfare economics (Western & Tomaszewski 2016).

Junior Ruiz Garcia

Further reading

Diener & Suh 1997; Alatartseva & Barysheva 2015; Voukelatou et al. 2021.

See also: Well-being economy, Subjective well-being, Indicators, Progress indicators, Environmental indicators, Economic indicators.

References

Alatartseva, E. & Barysheva, G. 2015. Well-being: subjective and objective aspects. Procedia—Social and Behavioral Sciences 166: 36–42.

Diener, E. & Suh, E.M. 1997. Measuring quality of life: economic, social, and subjective indicators. Social Indicators Research 40(1): 189–216.

Voukelatou, V., Gabrielli, L., Miliou, I. et al. 2021. Measuring objective and subjective well-being: dimensions and data sources. International Journal of Data Science and Analytics 11: 279–309.

Western, M. & Tomaszewski, W. 2016. Subjective wellbeing, objective wellbeing and inequality in Australia. PLoS ONE 11(10): e0163345.

Objectivism

A philosophical system that stresses what is independent of human knowledge and our perceptions or biases, and thus the validity of objective phenomena over subjective experience. In other words, the examination of a pure causality relationship of phenomena or ideas. According to objectivism, which is the opposite of subjectivism, scientific knowledge can be repeated over time, does not change from person to person, and its methods are open to everyone. While there can be more precise outputs for objectivity in natural sciences, social sciences are relatively more prone to subjective inferences since the objects studied both in general and in specific disciplines have more irrational and non-parametric elements.

Cengizhan Güler

Further reading

Diesing 1966; Graham 2010; Dewey 1941.

See also: Subjectivity, Epistemological bias.

References

Dewey, J. 1941. The objectivism–subjectivism of modern philosophy. Journal of Philosophy 38(20): 533–42.

Diesing, P. 1966. Objectivism vs. subjectivism in the social sciences. Philosophy of Science 33(1–2): 124–33.

Graham, P.A. 2010. In defense of objectivism about moral obligation. Ethics 121(1): 88–115.

Objectivity

See: Objectivism.

See also: Subjectivity, Epistemological bias.

Obligation

Ethics: a moral duty of conduct based on considerations of right and wrong (Prichard 1968).

Economics: any outstanding financial debt or regular payment that an individual, firm, or government is required to make (Offer 2012).

Biology: an obligate is an organism restricted to a particular condition of life and which can exist only under one set of environmental conditions (Moran & Yun 2015).

Fisheries: refers to the "landing obligation" in the European Union (EU)'s Common Fisheries Policy, Article 15, which is a policy to reduce unwanted fish catches and discards by requiring an obligation of fishers to land all catches. The requirement was introduced in 2015 and has been fully in force since January 2019 (Veiga et al. 2016; Guillen et al. 2018; Vilasante et al. 2016). Similar discard bans, with exceptions, predate the EU landing obligations in Norway, Iceland, Chile, Argentina, and New Zealand (Karp et al. 2019).

Fisheries management: the internal moral requirement of fishers to comply with fisheries management rules and regulations, based on their legitimacy (Nielsen 2003).

BARRY D. SOLOMON

See also: Duty, Legitimacy, Total allowable catch (TAC), Total allowable commercial catch (TACC), Fishery, Fisheries management.

References

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Karp, W.A., Breen, M., Borges, L. et al. 2019. "Strategies used throughout the world to manage fisheries discards—lessons for implementation of the EU landing obligation," pp. 3–26 in The European Landing Obligation: Reducing Discards in Complex, Multi-Species and Multi-Jurisdictional Fisheries. S.S. Uhlmann, C. Ulrich & S.K. Kennelly, eds. Cham: Springer Nature.

Moran, N.A. & Yun, Y. 2015. Experimental replacement of an obligate insect symbiont. Proceedings of the National Academy of Sciences of the United States of America 112(7): 2093–6.

Nielsen, J.R. 2003. An analytical framework for studying: compliance and legitimacy in fisheries management. Marine Policy 27(5): 425–32.

Offer, A. 2012. The economy of obligation: incomplete contracts and the cost of the welfare state. Oxford Economic and Social History Working Papers No. 103, University of Oxford, Department of Economics.

Prichard, H.A. 1968. Moral Obligation (and) Duty and Interest: Essays and Lectures. New York: Oxford University Press.

Veiga, P., Pita, C., Rangel, M. et al. 2016. The EU landing obligation and European small-scale fisheries: what are the odds for success? Marine Policy 64: 64–71.

Vilasante, S., Pierce, G.J., Pita, C. et al. 2016. Fishers' perception about the EU discards policy and its economic impact on small-scale fisheries in Galicia (North West Spain). Ecological Economics 130: 130–38.

Offtake

Ecology:

a. The number of individuals, usually mammals or birds, removed from the

environment through hunting or harvesting by humans (Ingram et al. 2015).
b. The channel or drainage point of a river.

Economics:

a. The purchase or "taking off" of goods during a given time period.
b. An offtake agreement is a contract between the buyer and producer or seller of a good, which involves an offtake buyer purchasing all or a large portion of the output from a specific facility, and thereby providing support for project financing through the revenue stream. Offtake agreements are common for energy and infrastructure projects.
c. A pipe or passage for conducting smoke or air pollution, such as in a steel mill.

Barry D. Solomon

Further reading

Hoffman 2007.

See also: Wildlife conservation, Sustainable yield, Industrial economics, Effluent, Industrial ecology, Environmental finance.

References

Hoffman, S. 2007. The Law and Business of Project Finance, 3rd edn. Cambridge: Cambridge University Press.
Ingram, D.J., Coad, L., Collen, B. et al. 2015. Indicators for wild animal offtake: methods and case study for mammals and birds. Ecology and Society 20(3): 40.

Oikos

Literally "house," but also the family, and the family's property, from ancient Greek (Davies 1992). Ecology and economics share the same root. Thus, "ecology" literally means the "study of the house" while economics means the "management of the house" where "house" means the world. This leads to the meaning of ecological economics as the study and management of the world in an integrated manner (Costanza 2020).

Barry D. Solomon

See also: Ecology, Economics, Ecological economics.

References

Costanza, R. 2020. Ecological economics in 2049: getting beyond the argument culture to the world we all want. Ecological Economics 168: 106484.
Davies, J.K. 1992. "Society and economy," p. 290 in The Cambridge Ancient History, Volume V: The Fifth Century B.C. D.M. Lewis, J. Boardman, J.K. Davies & M. Ostwald, eds. Cambridge: Cambridge University Press.

One health

A concept that is concerned with the link between humans, animals, and the environment in the evolution and emergence of disease. It encourages fluid boundaries between medical and veterinary practice for the detection of diseases in humans and animals, with the aim of impacting the control of infectious diseases.

Laura Orlando, James C. Aronson, Adam T. Cross & Neva R. Goodwin

Further reading

Hinchliffe 2015.

See also: Human health, Public health, Ecohealth, Ecosystem health, Environmental health.

Reference

Hinchliffe, S. 2015. More than one world, more than one health: re-configuring inter-species health. Social Science and Medicine 129: 28–35.

Open access

A resource that is used according to the "first come, first served" principle (for example, unregulated fish stocks, timber, or pastures; free public transport). Open access resources are typically common pool resources (CPR), whose characteristics make it difficult (costly) to exclude potential users. If their regulation is not properly conceived and implemented,

CPRs can easily become open access. Open access situations are often considered in relation to sustainability because open access resources are exposed to a risk of use conflicts, overuse, and therefore destruction.

Open access situations are suboptimal from a social and environmental justice perspective, because resource units are often allocated according to the power of potential users, less powerful actors being less equipped to access resource units (Ribot & Peluso 2003).

The risk of destruction of resources in open access has gained broad awareness following a controversial article published by Hardin (1968), in which he depicts the overuse of resources—symbolized by a pasture exploited by maximizing and selfish cattle herders—because of open access (which he confusingly refers to as "commons"). Numerous scholars and policymakers have used this argument to legitimize a one-size-fits-all remedy to the destruction of open access resources, namely the introduction of either private or state property; but Hardin's article has also triggered the development of an abundant literature demonstrating that common property can be a viable alternative (Bromley 1992).

JEAN-DAVID GERBER

See also: Open access regimes, Common pool resources.

References

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Hardin, G. 1968. The tragedy of the commons. Science 162(3859): 1243–48.

Ribot, J.C. & Peluso, N.L. 2003. A theory of access. Rural Sociology 68(2): 153–81.

Open access regimes

The set of rules (institutions) whose shortcomings, incoherencies, or lack of implementation lead to a situation of open access. Open access regimes are unable to guarantee the exclusion of unauthorized users of the resource or to properly regulate its uses, therefore potentially leading to overuse and degradation of the resource.

Resources under a full open access regime are very rare. From a social constructionist perspective, the definition of resources evolves together with the definition of the rules governing their uses. At least partial regulation exists in almost all cases, through localized regulatory arrangements (Ostrom's rules in use), or a state's public policies, or legal property rights (Gerber et al. 2020). Dominant economic or state actors may ignore rules in use by local resource users, due to ignorance, or ideological biases, or strategy. Specific discourses are often used—such as the discourse of "idle land" or "dead capital" that needs to be "put at work"—to facilitate appropriation through enclosures (Ferguson 1990).

Empirical studies reveal that under specific conditions resource users can develop rules, which may be formal or informal, to prevent conflicts and overuse (Ostrom 1990). Unlike non-political explanations of resource degradation, such as population increase, human greed, laziness, or ignorance, actor-centered analyses stress that conflicts, overuse, and degradation often arise in situations where users become incapable of deciding on the institutions governing resource uses (for example, in situations of legal pluralism, asymmetric distribution of power to access the resource, or elite capture of use rights to the resource).

JEAN-DAVID GERBER

See also: Open access, Common pool resources, Commons, the.

References

Ferguson, J. 1990. The Anti-Politics Machine: Development, Depoliticization, and Bureaucratic Power in Lesotho. Cambridge: Cambridge University Press.

Gerber, J.-D., Lieberherr, E. & Knoepfel, P. 2020. Governing contemporary commons: the institutional resource regime in dialogue with other policy frameworks. Environmental Science and Policy 112: 155–63.

Ostrom, E. 1990. Governing the Commons: The Evolution of Institutions for Collective Action. New York: Cambridge University Press.

Open system

A system that interacts with anything outside of it. The economy is an open system, since it receives and discharges both energy and matter. The economy receives energy and materials as inputs to produce goods and services, and discharges them in the form of wastes and pollution.

BARRY D. SOLOMON

See also: Closed system, Isolated system, Energy, Fossil fuels, Renewable energy, Pollution, Waste management.

Operationalize

In quantitative research, to define the measurement of an abstract concept or phenomenon that is not directly observable or measurable, which thereby can be inferred by other concepts or phenomena through empirical observation. The term was first used by the British physicist N.R. Campbell (1920) and American physicist Percy Williams Bridgman (1927).

Ecological economists might attempt to operationalize, for example, sustainable development by integrated dynamic modeling, sustainable development indicators, or the ecological footprint; or social development through the Human Development Index (van den Bergh & Nijkamp 1991; Baumgärtner et al. 2008).

BARRY D. SOLOMON

See also: Empiricism, Sustainable development, Sustainable Society Index (SSI), Ecological footprint, Index of sustainable economic welfare (ISEW), Human Development Index (HDI).

References

Baumgärtner, S., Becker, C., Frank, K. et al. 2008. Relating the philosophy and practice of ecological economics: the role of concepts, models, and case studies in inter- and transdisciplinary sustainability research. Ecological Economics 67(3): 384–93.

Bridgman, P.W. 1927. The Logic of Modern Physics. New York: Macmillan Company.

Campbell, N.R. 1920. Physics: The Elements. Cambridge: Cambridge University Press.

van den Bergh, J. & Nijkamp, P. 1991. Operationalizing sustainable development: dynamic ecological economic models. Ecological Economics 4(1): 11–33.

Opportunism

Economics: a behavioral assumption found in new institutional economics positing that humans are both self-interest seeking and guileful (Williamson 1993). People will take advantage of an economic opportunity even if they must perform acts of bad faith or illegality to do so. Protecting against a trading partner's opportunism becomes a major explanatory factor of economic organization. For example, opportunities for opportunistic market behavior are reduced if transacting parties merge into one company, thereby aligning their incentives to pursue the same profit motive. In ecological economics some firms are seen as participating in voluntary environmental protection programs that they know do not result in actual environmental improvement. The stakeholder/regulatory challenge is to design programs that result in improvements (Lannelongue & González-Benito 2012).

Ecology: the behavior of an animal or plant species with a low level of specialization that can exploit newly available habitats, food sources, or other resources, and rapidly colonize new environments (MacArthur 1970).

BRENT M. HADDAD

See also: Greenwashing, Asymmetric information, New institutional economics, Behavioral economics, Invasive species, Alien species.

References

Lannelongue, G. & González-Benito, J. 2012. Opportunism and environmental management

systems: certification as a smokescreen for stakeholders. Ecological Economics 82: 11–22.
MacArthur, R. 1970. On the relative abundance of species. American Naturalist 94(874): 25–36.
Williamson, O. 1993. Opportunism and its critics. Managerial and Decision Economics 14: 97–107.

Opportunity cost

The economic value or benefit foregone of the next-highest-valued alternative use of a particular resource, engaging in a particular activity, or return on an investment (for example, in natural capital). The opportunity cost of a selected option (or investment) can be approximated as the cost of the highest-valued foregone alternative (or foregone expected return on investment) minus the cost of the chosen option (or expected return on the chosen investment). Thus, opportunity cost includes both implicit costs and explicit costs. However, opportunity cost cannot be fully represented by monetary value, as it may also be reflected in time and intangible satisfaction or utility; for example, the utility of enjoying a forest or birdwatching.

BARRY D. SOLOMON

Further reading

Buchanan 1991.

See also: Microeconomics, Utility, Natural capital.

Reference

Buchanan, J.M. 1991. "Opportunity cost," pp. 520–25 in The World of Economics. J. Eatwell, M. Milgate & P. Newman, eds. London: Palgrave Macmillan.

Optimal allocation

See: Pareto optimality.

See also: Resource allocation, Intertemporal allocation.

Optimal depletion

See: Exhaustible resource theory.

See also: Optimization, Hotelling model, Hotelling rule.

Optimal pollution

Neoclassical economics: the point at which the marginal abatement cost for control of a specific category of pollution equals its marginal damage cost, and thus the marginal social benefit of pollution control. This is the point that maximizes social welfare, and economists frequently recommend a pollution tax as an instrument to achieve this outcome. However, in practice it is very difficult to determine the optimal pollution level, due to data scarcity and the difficulty of correctly calculating marginal damage cost.

BARRY D. SOLOMON

Further reading

Dasgupta et al. 1980; Baumol & Oates 1988.

See also: Damage function, Pollution abatement, Pollution taxes, Social welfare function.

References

Baumol, W.J. & Oates, W.E. 1988. The Theory of Environmental Policy, 2nd edn. Cambridge, UK & New York, USA: Cambridge University Press.
Dasgupta, P., Hammond, P. & Maskin, E. 1980. On imperfect information and optimal pollution control. Review of Economic Studies 47(5): 857–60.

Optimal scale of the macroeconomy

A metaphorical device introduced by Herman Daly in the early 1990s to represent the theoretical point at which the increasing marginal environmental and social costs of additional expansion of a macroeconomy equal the declining marginal benefits of the extra economic output (Daly 1991). Beyond

the optimal scale of the macroeconomy all additional economic growth will be "uneconomic" growth, even if it contributes to growth of the gross domestic product (GDP).

BARRY D. SOLOMON

See also: Uneconomic growth, Economic growth, Sustainable scale.

Reference

Daly, H.E. 1991. Towards an environmental macroeconomics. Land Economics 67(2): 255–9.

Optimization

Any action by a person or a business to make the most effective use of resources, or to make a situation as good or effective as possible. Mathematical economics and economic theory traditionally assumed and used optimization in basic neoclassical microeconomics; for example, consumers maximize utility, and businesses maximize profits. However, behavioral economics has proven that humans commonly face serious limitations in gathering complete and accurate information and making the most rational decisions, which is called bounded rationality, and in such cases will make a satisfactory decision rather than an optimal one (Simon 1955; Sent 2017).

BARRY D. SOLOMON

Further reading

Baumol 1979.

See also: Decision-oriented optimization models, Pareto optimality, Bounded rationality, Behavioral economics, Behavioral ecological economics.

References

Baumol, W.J. 1979. Economic Theory and Operations Analysis, 4th edn. Delhi: Prentice Hall of India.
Sent, E.M. 2017. Rationality and bounded rationality: you can't have one without the other. European Journal of the History of Economic Thought 25(6): 1370–86.
Simon, H.A. 1955. A behavioral model of rational choice. Quarterly Journal of Economics 69(1): 99–118.

Option value

The value that a private person places on preserving the right to consume an environmental good or service in the future, even if there is little or no likelihood that they will do so. Mathematically this can be expressed as:

$$OV = OP - E(CS)$$

where OV = option value, OP = option price, and E(CS) = the expected value of consumer surplus from having that option, assuming risk aversion. Option value can be either positive, zero, or negative, while option price = maximum willingness to pay for the environmental good or service in the future under uncertainty and risk; for example, the option to visit Yellowstone National Park next year when visitation may be restricted. However, it is very difficult if not impossible to estimate OV in practice, because we must know each individual person's utility or preference function and risk aversion.

BARRY D. SOLOMON

Further reading

Weisbrod 1964; Long 1967; Bishop 1982.

See also: Consumer surplus, Risk aversion, Quasi-option value, Total economic value (TEV), Willingness to pay (WTP), Economic valuation techniques.

References

Bishop, R.C. 1982. Option value: an exposition and extension. Land Economics 58(1): 1–15.
Long, M.F. 1967. Collective consumption service of individual consumption goods: comment. Quarterly Journal of Economics 81: 351–2.
Weisbrod, B.A. 1964. Collective-consumption services of individual-consumption goods. Quarterly Journal of Economics 78: 471–7.

Organisation for Economic Co-operation and Development (OECD)

An intergovernmental group founded in 1961 and based in Paris, which evolved from the Organisation for European Economic

Co-operation established after World War II to help administer the Marshall Plan in Europe (Woodward 2009). The OECD promotes economic growth, development, and world trade. It is committed to free market economics and democratic political systems, and serves as an exchange forum among member countries to share ideas and policy experiences, identify best practices, and address common problems. There are currently 38 members, which are primarily the developed countries in Europe, North America, Japan, South Korea, Australia, and New Zealand, plus several recent transition economies and several developing countries.

BARRY D. SOLOMON

See also: Economic growth, Development, Development economics, Economic development, Commodity trade, Trade liberalization, World Trade Organization (WTO), Developed country, Developing country, Transition economies.

Reference

Woodward, R. 2009. The Organisation for Economic Co-operation and Development (OECD). London: Routledge.

Origin product

Ecological economics: a product—often food or fiber—with known geographical origin in a particular cultural and natural landscape, with qualities, traits, and reputation attributable to that same landscape, and real or potential market and/or non-market value from a perspective of (food) sovereignty.

Development studies: a product with known origin and potential for registration with protected geographical indication or protected designation of origin.

HENRIK EGELYNG

Further reading

Egelyng et al. 2017.

See also: Commodity trade, Agroforestry, Food self-sufficiency.

Reference

Egelyng, H., Bosselmann, A.S., Warui, M. et al. 2017. Origin products from African forests: a Kenyan pathway to prosperity and green inclusive growth? Forest Policy and Economics 84: 38–46.

Orthodox economics

See: Neoclassical economics.

See also: Heterodox economics, Behavioral economics.

Overexploitation

Ecology: natural resources in ecological regions are overdeveloped as compared with the natural ecological resilience or government plans.

Economics: the depletion of natural resources due to investment projects in ecological regions under environmental and social risks is greater than depletion under a first-best solution. Such overexploitation problems are usually caused by asymmetric information related to environmental violations by private firms.

SU XIU XU

Further reading

Xu 2021.

See also: Corporate social responsibility, Resource depletion, Asymmetric information.

Reference

Xu, S.X. 2021. Overexploitation risk in “green mountains and clear water.” Ecological Economics 179: 106804.

Overlapping generations model

A framework for studies in macroeconomic dynamics and economics growth where finitely lived economic agents overlap (John & Pecchenino 1994). The model was developed by Maurice Allais (1947) and Paul Samuelson (1958). The most basic overlapping generations (OLG) model includes economic agents (that is, individuals) who live for two periods: young in the first period and old in the second period. They work and earn in the first period, and do not work or earn in the second period. They allocate their income in the first period between consumption (in the first period) and savings, which might be invested. Consumption in the second period of life is equal to savings from the first period and any interest earned on them.

Typical applications include life-cycle behavior, and resource allocations across the generations, among others (e.g., Howarth 1991). In the context of ecological economics, for example, the definitions of weak and strong sustainability and optimal climate change policies can be explained using an OLG model (e.g., Howarth 1996, 1998).

SHAIKH ESKANDER

Further reading

Malinvaud 1987; Weil 2008.

See also: Economic growth, Agent-based modeling (ABM), Weak sustainability, Strong sustainability, Climate change mitigation, Sustainable development.

References

Allais, M. 1947. Économie et Intérêt. Paris: Imprimerie Nationale.

Howarth, R.B. 1991. Intertemporal equilibria and exhaustible resources: an overlapping generations approach. Ecological Economics 4: 237–52.

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Howarth, R.B. 1998. An overlapping generations model of climate–economy interactions. Scandinavian Journal of Economics 100(3): 575–91.

John, A. & Pecchenino, R. 1994. An overlapping generations model of growth and the environment. Economic Journal 104(427): 1393–1410.

Malinvaud, E. 1987. Communication: the overlapping generations model in 1947. Journal of Economic Literature 25(1): 103–5.

Samuelson, P.A. 1958. An exact consumption-loan model of interest with or without the social contrivance of money. Journal of Political Economy 66(6): 467–82.

Weil, P. 2008. Overlapping generations: the first jubilee. Journal of Economic Perspectives 22(4): 115–34.

Overshoot

The state in which human demand, within a given time period, exceeds the amount that ecosystems renew in the same period (Meadows et al. 1972; Catton 1980). Overshoot is possible because ecosystems' accumulated stock can be depleted. Examples of overshoot include deforestation, overfishing, groundwater depletion, or atmospheric accumulation of greenhouse gases. As global depletion is not a long-term option, global overshoot inevitably will end. The question is only whether it ends by design or disaster. The amount that ecosystems can renew can be measured in different ways: (1) net primary productivity (biomass accumulation over a year); (2) carrying capacity (number of animal units that can be sustained); or (3) biocapacity (regeneration measured in area, which is scaled proportionally to its potential net primary productivity).

Some researchers model the approach of carrying capacity as a logistical function that asymptotically reaches carrying capacity. However, in the real world, demand can exceed regeneration if feedbacks are weak or delayed, leading to large overshoot. Light overshoot causes slight oscillations in the demand if feedbacks are strong and relatively fast. If ecological feedback is weak or delayed, the most likely scenario of overshoot is a gradual (as with forests) or rapid (as with fisheries) reduction of the amount that hosts can harvest. The extent of such a crash

depends on how depleted stocks are and how much renewal rates are lowered.

MATHIS WACKERNAGEL & DAVID LIN

See also: Carrying capacity, Deforestation, Depletion, Net primary production (NPP), Biocapacity, Logistic growth.

References

Catton Jr, W. 1980. Overshoot: The Ecological Basis of Revolutionary Change. Urbana, IL: University of Illinois Press.

Meadows, D.H., Meadows, D.L., Randers, J. & Behrens III, W.W. 1972. The Limits to Growth. New York: Universe Books.

Ownership

The condition or state of having exclusive rights and control over property, which can include land and buildings (real property), personal property, private property, public property, and intellectual property. Ownership has been institutionalized by the legal system; for example, by the creation of corporations, estates, trusts, titles, deeds, partnerships, co-operatives, and so on. From an ecological perspective the (legal) idea of human ownership of land is misguided, as it fails to account for the interconnectedness between a piece of land and the wider ecosystem in which it is embedded, as well as fails to take a long-term perspective (Freyfogle 1993).

BARRY D. SOLOMON

Further reading

Haddad 2003; Prettenhaler & Steininger 1999.

See also: Property systems, Property right, Private property, Common property, Rights, Embeddedness.

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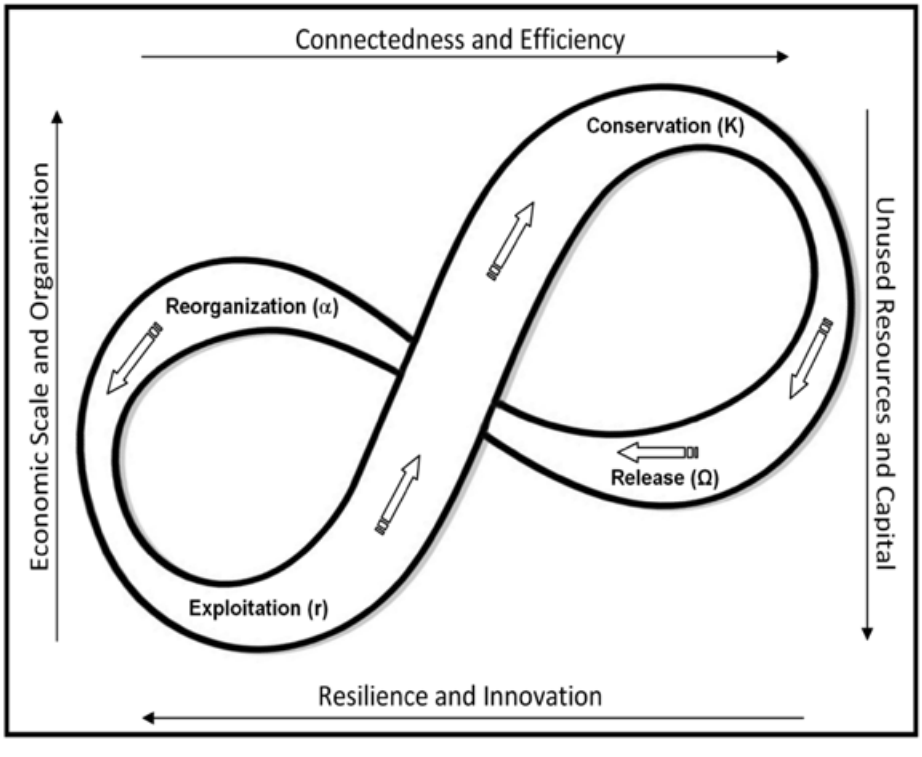
Panarchy theory

Also known as resilience theory or adaptive cycle theory, a transdisciplinary meta framework within systems theory used to explain ecological resilience and patterns of adaptive evolutionary change that have been observed in all types of complex social-ecological systems, from forests to civilizations. Panarchy was named by C.S. Holling and Lance Gunderson after Pan, the creative yet unpredictable Greek god of nature (Holling 1986).

The theory posits that systems continually evolve through alternating episodes of growth and decline that can be depicted with a figure-of-8 diagram, now inseparable from the theory (see Figure 15). There are four key successive phases: a "front loop" defined by exploitation (r) and conservation (K), and a "back loop" defined by chaotic release (Ω) and usually reorganization (α) (Walker et al. 2004). Predictable accumulation phases deplete resilience and lock in



Source: Author.

Figure 15 A panarchy theory depiction of systems evolution as a figure-8 adaptive cycle

structures and functions that determine the system's later vulnerability to unpredictable shocks. With sufficient resilience the system recovers potential and resumes the cycle with freed-up resources and novel new adaptations; with insufficient resilience it collapses. Figure-of-8s simultaneously operating at many different scales and speeds combine to form a mutually reinforcing nested hierarchy that stabilizes the tendency of individual cycles to become overconnected and brittle (Redman & Kinzig 2003).

A major insight of panarchy theory is that over the long run, catastrophic downturns and dynamic change are as normal as upward growth and routine persistence in a world governed by unpredictability and entropy; in fact, they beget each other through creative destruction. Within ecological economics, panarchy theory has largely remained confined to analysis of particular ecosystems rather than the economy or civilization as a whole.

CONRAD B. STANLEY

Further reading

Gunderson et al. 2002; Sundstrom & Allen 2019.

See also: Resilience, Adaptive capacity, Social-ecological systems, Societal transformation, Collapse, Creative destruction, Complexity theory.

References

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Sundstrom, S.M. & Allen, C.R. 2019. The adaptive cycle: more than a metaphor. Ecological Complexity 39: 100767.

Walker, B., Holling, C.S., Carpenter, S.R. & Kinzig, A.P. 2004. Resilience, adaptability and transformability in social-ecological systems. Ecology and Society 9(2): 5.

Paradigm

A specific conceptual, theoretical, methodological, and ideological orientation or perspective on what comprises a legitimate contribution to a field of study. In social sciences, such as economics, values and ideology are necessarily involved. "Values are always with us" according to Gunnar Myrdal (1978), and economics is always "political economics." When framing an issue, ecological economists face a choice between paradigms. Not only conceptual, theoretical, and methodological aspects are considered, but also ideological ones. The fact that values are involved suggests that pluralism in ecological economics research and education must be respected. In a democratic society, respecting only one ideological orientation is not enough.

PETER SÖDERBAUM

See also: Growth paradigm, Institutional economics, Political economy.

References

Myrdal, G. 1978. Institutional economics. Journal of Economic Issues 12(4): 771–83.

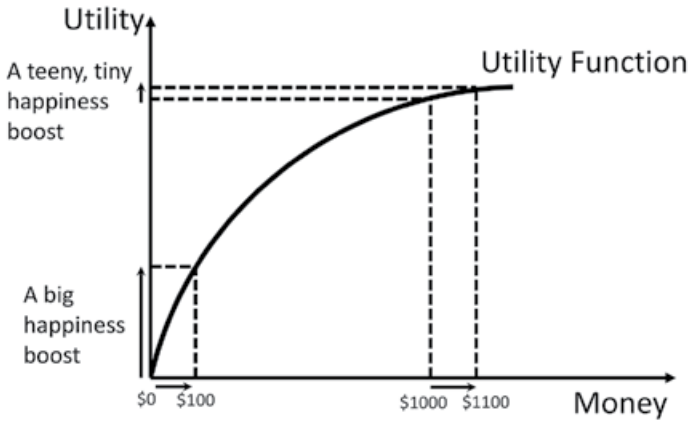
Pareto efficiency

See: Pareto optimality.

See also: Efficiency, Efficiency frontier.

Pareto optimality

A fundamental goal of neoclassical welfare economics, which requires a state in which nobody can be made better off without making someone else worse off. Also called Pareto efficiency. Named after the Italian economist Vilfredo Pareto, who defined the concept in 1906. However, it offers no guidance when confronted with a policy that lifts a million people out of poverty but imposes a loss on a single billionaire. Any policy alternative that makes anyone worse off in their own estimation, even while other people



Source: Author.

Figure 16 *Pareto optimality conflicts with the notion of diminishing marginal utility*

are made better off in their own estimation, are "Pareto incomparable."

While Pareto developed optimality theory, he also described the idea of "indifference curves" in conjunction with Francis Edgeworth, which captures each person's preferences for different combinations of goods. It established the idea of ordinal rather than cardinal welfare and eliminated comparisons of utility between people. According to Pareto and neoclassical orthodoxy, each person can only decide how well off they are "in their own estimation". This avoids any consideration of justice in current social conditions. According to Daly and Farley (2011, p. 304), "The extreme individualism of economics insists that people are so qualitatively different in their hermetical isolation one from another that it makes no sense to say that a leg amputation hurts Smith more than a pin prick hurts Jones."

Utility curves of an individual assume diminishing marginal utility: the more of something a person has, the less utility an additional unit provides. Consider the difference in utility from receiving $100 for a person with $1000 compared to the same person with $0 (Figure 16). If this curve represented two people, rather than one person at different times, then the wealthier person gets less utility from $100 than the poorer person. Economists can only accept Pareto efficiency as a central goal of economics and welfare maximization by rejecting the notion of diminishing marginal utility of income (Flomenhoft 2017).

GARY FLOMENHOFT

Further reading

Pareto 1906.

See also: Optimization, Utility, Efficiency, Efficiency frontier, Allocation, Resource allocation, Kaldor–Hicks efficiency criterion, Welfare economics, Total human welfare.

References

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Flomenhoft, G. 2017. The triumph of Pareto. Real-World Economics Review 80: 14–31.

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Parity

See: Purchasing power parity (PPP).

See also: Gender inequality, Economic inequality.

Partial equilibrium model

A mathematical model used to provide an understanding of how one market of an economy works in isolation, typically through the application of econometric methods; for example, the petroleum industry. The focus is on price movements in one section of an economy, and the analysis holds constant everything else that is occurring in the rest of the economy. In addition, policy analysis scenarios or actions are frequently assessed in partial equilibrium models.

JUDITH R. MCNEILL

Further reading

Francois & Hall 1997; Green et al. 1976.

See also: Models and modeling, Equilibrium, Equilibrium model, General equilibrium model, Energy economics, Industrial economics, Econometrics.

References

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Green, J., Kohlberg, E. & Laffont, J.H. 1976. Partial equilibrium approach to the free-rider problem. Journal of Public Economics 6(4): 375–94.

Participatory action research

See: Participatory modeling.

See also: Environmental governance, Water governance, Groundwater governance, Stakeholder participation, Human needs assessment, Autonomous institution.

Participatory modeling

An analytical-deliberative approach to engage a group of stakeholders in the co-creation of a model or in a participatory process where a previously built model is used. Participatory modeling provides a structure for deliberation and education, and a tool for technical analysis (Stave 2002). The aim of participatory modeling is typically to facilitate learning and support decision-making regarding complex socio-ecological issues. Examples of modeling methods used in participatory modeling processes include system dynamics, agent-based modeling, fuzzy cognitive mapping, and Bayesian networks (Voinov & Bousquet 2010).

NUNO VIDEIRA

Further reading

Videira et al. 2017; van den Belt 2004; Anderson et al. 2007.

See also: Stakeholder, Stakeholder participation, System dynamic models, Agent-based modeling (ABM), Bayesian belief networks, Deliberative valuation, Deliberative multi-criteria analysis, Deliberative ecological economics.

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Path dependence

A process whereby prior decisions or events, including chance and contingent events, constrain future available decision options and make reversals more costly. Implies that the origins of the process may be different from

the factors driving its reproduction, which include self-reinforcement or increasing returns. Examples include technologies that persist despite the availability of more efficient alternatives, or policies and institutions that get locked in because they create incentives for actors to adjust their preferences and behavior, which supports the policy's or institution's continued existence.

STEFAN RENCKENS & GRAEME AULD

Further reading

David 1985; North 1990; Thelen 1999, Mahoney 2000.

See also: Institutional analysis, Carbon lock-in.

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David, P.A. 1985. Clio and the economics of QWERTY. American Economic Review 75(2): 332–7.

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North, D.C. 1990. Institutions, Institutional Change and Economic Performance. Cambridge: Cambridge University Press.

Thelen, K. 1999. Historical institutionalism in comparative politics. Annual Review of Political Science 2: 369–404.

Pathway

A hypothetical course of actions, events, and consequences required or anticipated to lead to a specified goal or endpoint, such as from the current situation to a sustainable steady state economy. Often used to explore the feasibility of specific options or to compare the costs and benefits of alternative actions and assumptions. Pathways can be limited to qualitative narrative or defined quantitatively, allowing mathematical modeling. A prominent example is the "shared socio-economic pathways" (SSPs) formulated by the Intergovernmental Panel on Climate Change (IPCC) as reference scenarios for climate change mitigation modeling (see Nakicenovic et al., 2014; Riahi et al. 2017).

JANE N. O'SULLIVAN

See also: Energy pathways, Path dependence, Scenario, Narrative, Intergovernmental Panel on Climate Change (IPCC).

References

Nakicenovic, N., Lempert, R.J. & Janetos, A.C. 2014. A framework for the development of new socio-economic scenarios for climate change research: introductory essay. Climatic Change 122: 351–61.

Riahi, K., van Vuuren, D.P. et al. 2017. The shared socioeconomic pathways and their energy, land use, and greenhouse gas emissions implications: an overview. Global Environmental Change 42: 153–68.

Payment for ecosystem services (PES)

An incentive-based policy instrument for considering ecological health and vitality in land management and conservation schemes. In economic terms, rather than focusing solely on the goods produced, PES systems change the economics of a land-based business through incentivizing management strategies that produce goods, but also reawaken the ecological systems that provide ecological services. PES systems can also be used for wetlands, fisheries, and aquaculture. Ecosystem services are functions that an ecosystem or landscape may provide that benefit human society. The services provided can be hyper-local, such as flood resiliency and cooling effects; global, such as carbon sequestration and storage; or somewhere in between, such as increases to and maintenance of biodiversity or cleaning water.

Currently, the economy only gives value to land-based goods and services such as crop and timber production, and that value is tied to the amount and quality of the good produced. A PES system, in contrast, aims to account for positive environmental impacts produced when producers utilize certain land management strategies. These transactions involve a buyer of the service and the service provider, and sometimes an intermediary such as an aggregator. Most of these transactions are performed through contracts for a set amount of time. These systems can be designed to address a specific natural resource or ecological health concern, such

as a rural economic program supporting the economic viability of land-based businesses, or both.

GORDON N. MERRICK

Further reading

Fisher et al. 2009; Jack et al. 2008; Salzman et al. 2018; Merrick & Kruswesk 2021; Merrick 2021.

See also: Goods, Services, Ecosystem services, Environmental policy instruments, Agricultural ecosystem services, Wetland ecosystem services, Fisheries management, Aquaculture, Ecosystem service valuation.

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Salzman, J., Bennett, G., Carroll, N. et al. 2018. Payments for ecosystem services: past, present and future. Texas A&M Law Review 6(1): 199–227.

Peak oil supply

The highest extraction level of petroleum from natural reserves over the long term. Three additional substantiations define the common term "peak oil" as a supply peak. First, the peak oil concept refers to conventional petroleum being more restricted than the upcoming term "liquid fuels," also including unconventional oil from oil sands, heavy oil, shale oil, natural gas liquids, gas to liquids, and biofuels. Second, the peak should result from physical shortage in crude oil supply due to unrestrained exploitation of natural reserves. Third, the common visualization is based on Hubbert's curve, being a bell-shaped density function, with the corollary that an approximately equal quantity of oil used up to the peak year is also available after the peak year.

While peak oil supply in the United States appeared to occur in 1970, the 1970 production level was surpassed starting in 2014, due to unconventional oil supplies coming onto the market. The global peak oil supply year has been regularly announced as impending, but has yet to occur. New discoveries of reserves and improved technologies for extracting oil continue to extend oil supplies well beyond the absorption capacity of the atmosphere as a sink for the yearly multiple billion tons of carbon dioxide emissions. If climate policy results in lowered use of fossil fuels, a peak oil demand year will occur, followed by declining demand. This would preclude peak oil supply from ever happening.

AVIEL VERBRUGGEN

Further reading

Verbruggen & Van de Graaf 2013; Kaufmann & Shiers 2008; Murphy & Hall 2011; Reynolds 2014.

See also: Hubbert curve, Fossil fuels, Exhaustible resource theory, Reserves, Resources.

References

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Murphy, D.J. & Hall, C.A.S. 2011. Energy return on investment, peak oil, and the end of economic growth. Annals of the New York Academy of Sciences 1219: 52–72.

Reynolds, D.R. 2014. World oil production trend: comparing Hubbert multi-cycle curves. Ecological Economics 98: 62–71.

Verbruggen A. & Van de Graaf, T. 2013. Peak oil supply or oil not for sale? Futures 53: 74–85.

Peer review process

The review of academic work to verify the validity and relevance of the research design

and the results. Traditionally, peer review is carried out prior to publication by scholars working in a related field. In this way, the peer review process acts as a gatekeeper to ensure the integrity of scientific study.

While peer review is sometimes presented as a neutral and objective process, scholars such as Funtowicz and Ravetz (1993) posit that the production of scientific knowledge occurs within a value-laden, social institution. This institution contains "structures of prestige and influence" (Ravetz 1999, p. 648), and is subject to bias, which can lead to motivated elevation or suppression of research results.

A "post-normal" understanding of science admits the inevitable subjectivities present in the production of scientific knowledge (Ravetz 1999). To account for these subjectivities, academic work can be evaluated using "extended peer review" by an "extended peer community" consisting of "all those with a desire to participate in the resolution of the issue" (Ravetz 1999, p. 651). In this approach, "quality depends on open dialogue between all those affected" (Ravetz 1999, p. 651). This process of extended peer review and participation can begin in the early stages of the research process by including extended peer communities in the setting of research objectives and research design (van den Belt 2004; Videira et al. 2017; Dolter 2021).

Brett D. Dolter

See also: Scientific method, Post-normal science.

References

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Perceptions

Emerging in the field of behavioral geography and environmental psychology, the term describes the cognitive process through which individuals receive, filter, and evaluate information of their surroundings to develop a subjective image of their environment. People's worldviews, decisions, and behavior are based on how they perceive their environment, using their senses, as well as prior indirect and direct knowledge.

In ecological economics, it refers primarily to environmental perceptions. The perception of the environment is important because individuals base their judgments on the environment as they perceive it, not as it is. The nature of such perception includes warm feelings for an environment and an understanding, however subjective, of the environment. Environmental perception is an interdisciplinary concept that can be applied to a variety of questions, including attitudes towards the quality of the environment, environmental policies and programs, natural hazards, and society. Most notably, information about people's perceptions of the environment can inform policymakers about public environmental values and concerns, and about people's probable responses to environmental conditions.

Manuel Frondel

Further reading

Saarinen 1974; Steg & de Groot 2019; Ittelson 1978; García-Mira & Real 2005.

See also: Geography, Behavioral ecological economics, Behavioral economics, Social sciences, Risk perception, Pro-environmental behavior (PEB).

References

García-Mira, R. & Real, J.E. 2005. Environmental perception and cognitive maps. International Journal of Psychology 40(1): 1–2.

Ittelson, W.H. 1978. Environmental perception and urban experience. Environment and Behavior 10(2): 193–213.

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Manners & M.W. Mikesell, eds. Washington, DC: Association of American Geographers.
Steg, L. & de Groot, J.I., eds. 2019. Environmental Psychology, 2nd edn. Hoboken, NJ: John Wiley & Sons.

Perfect markets

Neoclassical economics: economically efficient, well-functioning markets, which must meet several requirements. These include: a large number of buyers and sellers; access to perfect information about prices; homogeneity in the market good or service; no barriers to market entry or exit; the absence of monopoly or oligopoly; no or minimal transaction costs; and no externalities. In practice, few real markets meet all these conditions, and the meaning of some of the requirements is ambiguous, especially the requirement for a large number of buyers and sellers.

BARRY D. SOLOMON

Further reading

Baumol & Blackman 1991.

See also: Market failure, Market imperfections, Free market, Transaction costs, Market power, Externalities.

Reference

Baumol, W.J. & Blackman, S.A.B. 1991. Perfect Markets and Easy Virtue: Business Ethics and the Invisible Hand. Oxford: Blackwell.

Peri-urban interface

Spaces located in the urban peripheries that serve as an interface between urban and rural territories. Peri-urban interfaces are distinguished from urban and rural spaces by their greater heterogeneity of land uses: built, cultivated, and natural. These often combine modern and traditional ways of life and produce particular social interactions of individuals, groups and/or institutions, granting the interface its own characteristics. Populations in peri-urban interfaces might still develop traditional activities, sometimes in the primary sector, but pursue a wider range of employment activities in the nearby cities given their proximity (Morton et al. 2014). They often benefit from a greater range of economic activities and access to public services associated with their proximity to urban areas.

In developing countries these spaces often have scarcer public service infrastructures, with a predominance of households living in poverty, and under pressure from urban expansion (Soto-Montes-de-Oca & Alfie-Cohen 2019). Ecosystems in the peri-urban interface might still be rich in natural capital and resources that provision water, food, energy, recreational activities, and regulating ecosystem services, such as flood and erosion control that are critical for climate change adaptation. The peri-urban interface increases the opportunity for exploring the interaction between nature and economic systems.

GLORIA SOTO-MONTES-DE-OCA

Further reading

Iaquinta & Drescher 2000; McGregor & Simon 2005; Soto-Montes-de-Oca et al. 2020; Yang & Ye 2020.

See also: Urbanization, Urban ecology, Urban density, Urban unsustainability, Ecosystem services.

References

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Soto-Montes-de-Oca, G. & Alfie-Cohen, M. 2019. Impact of climate change in Mexican peri-urban areas with risk of drought. Journal of Arid Environments 162: 74–88.
Soto-Montes-de-Oca, G., Bark, R. & González-Arellano, S. 2020. Incorporating the insurance value of peri-urban ecosystem services into natural hazard policies and insurance products: insights from Mexico. Ecological Economics 169: 106510.
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Persistence

Ecologists and ecological economists are interested in studying the stability of a variable, where "variable" denotes a particular level of ecological organization. Following Pimm (1991, pp. 13–15), one of the (at least) five senses in which ecologists have used the word "stability" is persistence, where "persistence" refers to how long a variable lasts before it is changed to a new value. So, persistence is measured in time units. Ecological economics research (see Batabyal 2003) has adopted this definition with the understanding that the variable of interest is an ecological-economic system.

In general, ecological-economic systems are jointly determined, dynamic, stochastic, and therefore the persistence of such systems is determined by how they respond to shocks that occur either at a point in time or over time. Ecological economists have studied how persistence is impacted by human-induced shocks such as those arising from excessive grazing on rangelands and disproportionate fishing in fisheries. A second category of shocks that affects persistence stems from the interaction between the extinction of and invasion by species. As such, we can have ecological-economic systems whose persistence is primarily extinction-driven, or those for which persistence is mainly invasion-driven. Finally, following Homer-Dixon (1991) and Perrings (1999), many ecological-economic systems are subject to threshold effects. For such systems, persistence is the mean time until a threshold is reached.

Amitrajeet A. Batabyal

See also: Resilience, Ecosystem reslience, Stability, Ecosystem persistence.

References

Batabyal, A.A. 2003. The persistence of ecological-economic systems: alternate measures and their properties. Annals of Regional Science 37: 323–36.
Homer-Dixon, T.F. 1991. On the threshold: environmental changes as causes of acute conflict. International Security 16: 76–116.
Perrings, C. 1999. Comment on "ecological and social dynamics in simple models of ecosystem management", by Carpenter, S.R., Brock. W.A. & Hanson, P. Conservation Ecology 3(2).
Pimm, S.L. 1991. The Balance of Nature? Chicago, IL: University of Chicago Press.

Perturbation

Change in the variables or parameters of a dynamic system, whose origin is not part of the description of that system; sometimes used as a synonym of disturbance and stress (Rykiel 1985). In the technical sense, a perturbation is not the originating cause or event (for example, a fire or an economic shock), but that cause's most direct effect on the quantities under study (for example, the induced change in biomass or prices).

Given a system described as a set of processes, variables, and parameters, for which we define a reference (for example, initial or equilibrium) state, any deviation from that reference state can then be decomposed into perturbation and response. The perturbation is the outcome of all processes that are not being measured or modeled explicitly (for example, human action in an ecological context, biological processes in an economic context), while the response is the subsequent dynamics in the observed variables.

Perturbations are usually characterized by dynamic features such as their intensity, their target (which variable or parameter is affected), and their temporal structure (short-term pulse, or long-lasting effects such

as a constant press, cyclic oscillation, or stochastic noise; Arnoldi et al. 2016).

Matthieu Barbier

See also: Disturbance, Stressors, Ecological perturbation.

References

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Rykiel, E.J. 1985. Towards a definition of ecological disturbance. Australian Journal of Ecology 10(3): 361–65.

Physiocrats

A school of 18th-century French political economy, and the first to refer to themselves as "economists." They helped to formalize political economy as an objective science, and contributed to the theorization of capital and profit, the "national economy," and the idea of general equilibrium. The physiocrats are sometimes considered proto-environmentalists, in that they regarded land as the source of all wealth, but their view of nature was instrumental: nature is synonymous with natural resources, conceived of as "free gifts" for exploitation by owners of productive property and land.

The overarching goal of physiocracy was to convert France's political economy to the English model, with agrarian capitalists as the vanguard force and principal beneficiaries. To this end, they pressed government to remove obstructions to the flow of capital into agriculture and to put its weight behind wealthy "improving" farmers and other agricultural "entrepreneurs."

Gareth Dale

Further reading

Dale 2021; Gudeman 1980; Meek 1962.

See also: Laissez-faire economics, Classical economics.

References

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Gudeman, S. 1980. Physiocracy: a natural economics. American Ethnologist 7(2): 240–58.

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Planetary health

The intersection of human health, human civilization, and natural systems, as outlined by the Rockefeller Foundation–Lancet Commission on planetary health (Whitmee et al., 2015). Planetary health focuses on human-caused environmental degradation and its impacts on human health and aims to address the multitude of environmental threats to the planet.

Laura Orlando, James C. Aronson, Adam T. Cross & Neva R. Goodwin

See also: Human health, Public health, Environmental health, Ecohealth, Ecosystem health.

Reference

Whitmee, S., Haines, A., Beyrer, C. et al. 2015. Safeguarding human health in the Anthropocene epoch: report of the Rockefeller Foundation–Lancet Commission on planetary health. The Lancet 386(10007): 1973–2028.

Plausible

A descriptor of a statement, belief, argument, assumption, scenario, hypothesis, or theory that is seemingly reasonable, convincing, probable, credible, or believable by others. For example, a plausible scenario is one that is highly likely to be true or valid, and which fits prior knowledge well with many different sources of corroboration, without complexity of explanation, and with minimal conjecture (Connell & Keane, 2010).

Barry D. Solomon

See also: Scenario, Models and modeling, Critical theory.

Reference

Connell, L. & Keane, M.T. 2010. A model of plausibility. Cognitive Science 30(1): 95–120.

Pluralism

Philosophy:

a. A way of interpreting science through multiple beliefs, principles, frameworks, or theories. Within philosophy, pluralism has become a common frame for interpreting science. This contrasts with mid-20th-century attempts to describe a single epistemology, logic, method, or ontology for science (Oppenheim & Putnam 1958). Pluralists argue that such attempts are fruitless, given that scientists employ a great diversity of ontologies, epistemic outlooks, and methodologies (Kellert et al. 2006).
b. A way of practicing science. Pluralism is often offered as a normative end. Science as a whole and/or individual sciences should exhibit a variety of some key variable (Chang 2012): normally goals, ontological presuppositions, epistemic outlook, outputs, and/or methods. The justifications for pluralism as an end are typically ontological (for example, the social world is such that we must investigate it in a variety of ways), epistemological (for example, humans only ever see a partial picture of the world, so we ought to combine as many of those partial pictures as possible), or based on a claim about the aims of science (for example, science serves a variety of ends so should contain a variety of means). Debates about pluralism often turn on: (1) what variable(s) to focus on; and (2) what counts as sufficient plurality of the identified variable(s).

Ecological economics: the second definition above is more common, but the first one often also rests in the background. Typically, the input to be pluralized is methods or schools of thought, but these are often also based on pluralistic ontologies and/or epistemologies.

Jack Wright & Jessica J. Goddard

Further reading

Morgan & Rutherford 1998.

See also: Methodological pluralism, Conceptual pluralism, Monism, Dogmatism, Epistemology, Deontological, Scientific method.

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Morgan, M.S. & Rutherford, M. 1998. From Interwar Pluralism to Postwar Neoclassicism. Durham, NC: Duke University Press.
Oppenheim, P. & Putnam, H. 1958. "The unity of science as a working hypothesis," pp. 3–36 in Minnesota Studies in the Philosophy of Science, Volume II: Concepts, Theories, and the Mind–Body Problem. H. Feigl, M. Scriven & G. Maxwell, eds. Minneapolis, MN: Minnesota University Press.

Podolinsky myth

The name given to the once widespread notion within ecological economics that neglect of the work of the 19th-century socialist Sergei Podolinsky was evidence of the failure on the part of classical historical materialists Karl Marx and Friedrich Engels to seriously address issues of energetics and ecology. Podolinksy, a Ukrainian socialist, strongly influenced by Marx (1976), published several closely related manuscripts on agricultural energetics in the years 1880–1883. The charge that Podolinsky's pathbreaking work was simply dismissed out of hand and ignored by Marx and Engels was influentially presented by Martínez-Alier and Naredo (1982) and Martínez-Alier (1987).

However, later analyses (from Burkett & Foster 2008; Foster & Burkett 2016), accompanied by translations of Podolinsky's work into English, pointed to the erroneous nature of these contentions, leading to the coining of the term "the Podolinsky myth." These thinkers highlighted: (1) Marx's extensive notes (still unpublished) on Podolinsky's work, together with his correspondence with Podolinsky; and (2) Engels's detailed criticisms of Podolinsky's energy reductionism,

including Podolinsky's failure to incorporate fertilizer use into his calculations of energy transformations. Podolinsky's attempt to develop an energy theory of economic value, and his contention that humanity could augment the global environment by increasing the retention of solar energy on Earth, were both shown to have run into serious contradictions. Foundational ecological economist Nicholas Georgescu-Roegen (1986) criticized Podolinsky's argument on similar grounds to those of Engels.

John Bellamy Foster

Further reading

Podolinsky 2016a, 2016b.

See also: Energy analysis, Emergy, Materialism.

References

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Foster, J.B. & Burkett, P. 2016. Marx and the Earth: An Anti-Critique. Chicago, IL: Haymarket Books.
Georgescu-Roegen, N. 1986. The entropy law and the economic process in retrospect. Eastern Economic Journal 12(1): 3–25.
Martínez-Alier, J. 1987. Ecological Economics. Oxford: Blackwell.
Martínez-Alier, J. & Naredo, J.M. 1982. A Marxist precursor of ecological economics. Journal of Peasant Studies 9(2): 207–24.
Marx, K. 1976. Capital, Volume 1: A Critique of Political Economy. B. Fowkes, translator. London: Penguin.
Podolinsky, S. 2016a. "Socialism and the unity of physical forces," pp. 243–61 in Marx and the Earth: An Anti-Critique. J.B. Foster & P. Burkett, eds. Chicago, IL: Haymarket Books.
Podolinsky, S. 2016b. "Human labour and the unity of force," pp. 262–87 in Marx and the Earth: An Anti-Critique. J.B. Foster & P. Burkett, eds. Chicago, IL: Haymarket Books.

Policymaker

A ubiquitous and therefore contested term (like that of a stakeholder), which generally refers to high-level decision-makers in the public sector. Some have often assumed them solely to be elected officials who vote on legislative proposals. However, the policy-making process's sectoral (subsystem) focus and its multi-level nature mean that power is often diffuse, resulting in decisions made by non-elected actors. Policy networks or traditional United States iron triangles (close networks of congressional committees, the bureaucracy, and interest groups) suggest actors' broader participation and substantive input, particularly in policy formulation and design.

Adam M. Wellstead

Further reading

Cairney 2020; Howlett et al. 2009.

See also: Power, Non-state actors, Stakeholder, Democracy.

References

Cairney, P. 2020. Understanding Public Policy: Theories and Issues, 2nd edn. London: Red Globe Press.
Howlett, M., Ramesh, M. & Perl, A. 2009. Studying Public Policy: Policy Cycles and Policy Subsystems, Vol. 3. Oxford: Oxford University Press.

Political ecology

Supra-disciplinary field of study combining critical perspectives from geography, anthropology, environmental humanities, decolonial thought, alternative development studies, cultural ecology, and insights from frontline, grassroots struggles of resistance to neocolonialist domination. Political ecology (PE) articulates and problematizes the intersections of people, place, nature, culture, and power, and provides conceptual lenses through which to view the role of institutional arrangements, actors, and power relations in socio-ecological distribution conflicts. Such conflicts, increasingly studied in ecological economics as environmental injustices, can be understood as occurring where issues of access to resources and/or exposure to the consequences of resource use overlap with potentially conflicted societal relations of, for example, class, gender, or ethnic identity. For ecological economics research, the intersection between social ecology and its core concept of social metabolism and PE has yielded particularly productive contributions.

The field centers two aspects: (1) a methodological choice of empirical field observation of biophysical and socio-economic processes in emergent, coevolving, dynamic interactions; and (2) an axiological choice of normative pragmatism to contribute to material and social change for historically underincluded, minoritized groups, towards collective liberation. The field also stands on two ontological claims: (1) climate chaos and other ecological problems are primarily caused by excessive production, consumption, and waste, at ever-expanding commodity frontier(s); an extremely unjust process that benefits very few, while eliminating the capacity to survive for millions; and (2) the "environment" is not only a fact of nature: it is also a fact of politics, cultural narrative, and collective imaginary, generally shaped by colonialist, hegemonic, violent norms of control and oppression. The field is evolving through a feminist turn, highlighting implications for critical power analysis of the complexities of socialized identity markers such as gender, race, class, and contextualized positionality. PE is also integrating pluralist modes of co-creating and legitimizing knowledge, as well as transcending binaries of "researcher" and "subject" through participatory methods. This set of lenses enables theorizing and attending to affective, embodied, and relational experiences of people with and in nature, place, community, and life pathways.

Nina L. Smolyar & Anke Schaffartzik

Further reading

Robbins 2019; Paulson & Gezon 2005; Harcourt & Nelson 2015; Rocheleau 2008; Temper et al. 2018; Martínez-Alier 2003; Scheidel et al. 2018.

See also: Ecological distribution conflicts, Violence in environmental conflict, Social justice, Environmental justice, Feminist political ecology, Feminist ecological economics, Ecofeminism, Social-ecological systems, Societal transformation.

References

Harcourt, W. & Nelson, I.L., eds. 2015. Practising Feminist Political Ecologies: Moving Beyond the "Green Economy." London: Zed Books.

Martínez-Alier, J. 2003. The Environmentalism of the Poor: A Study of Ecological Conflicts and Valuation. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Paulson, S. & Gezon, L.L. 2005. Political Ecology Across Spaces, Scales, and Social Groups. New Brunswick, NJ: Rutgers University Press.

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Rocheleau, D.E. 2008. Political ecology in the key of policy: from chains of explanation to webs of relation. Geoforum 39(2): 716–27.

Scheidel, A., Temper, L., Demaria, F. & Martínez-Alier, J. 2018. Ecological distribution conflicts as forces for sustainability: an overview and conceptual framework. Sustainability Science 13(3): 585–98.

Temper, L., Walter, M., Rodriguez, I. et al. 2018. A perspective on radical transformations to sustainability: resistances, movements and alternatives. Sustainability Science 13(3): 747–64.

Political economy

The integrated and interdisciplinary study of political and economic decision-making. Political economy analyzes the behavior of political agents who make decisions in the presence of socio-economic institutional opportunities and constraints. From its inception in the late 18th century until the "marginal revolution" of the 1870s, economics was known as political economy, and only by the early 1900s were the shorter terms economy and economic more commonly used. Political economists shared certain basic premises. Value was determined by counting the number of labor hours embodied in production, and the fate of a growing market economy would be a non-growing stationary state.

The modern use of the term "political economy" reflects the work of Karl Marx in the 1860s. Capital was not a thing, but the process of self-expanding value. The idea of steady state capitalism is oxymoronic. Marx analyzed a competitive economy, but by the late 19th century the major capitalist economies became dominated by monopoly. The tendency of a monopolized economy is toward stagnation, or slow growth.

The study of economic concentration is now a major focus of modern political economy, as is the ever-prominent role played by finance and debt in keeping the

economy from succumbing to stagnation. Political economy is useful for ecological economists because it poses the question of whether a capitalist economy can provide for a decent standard of living in the absence of economic growth. Also, a large literature on "ecological Marxism" has emerged in the 21st century.

KENT A. KLITGAARD

Further reading

Marx 1993; Baran & Sweezy 1966; Foster et al. 2010.

See also: Institutions, Economic institutions, Debt, Classical economics.

References

Baran, P.A. & Sweezy, P.M. 1966. Monopoly Capital: An Essay on the American Economic and Social Order. New York: Monthly Review Press.

Foster, J.B., York, R. & Clark, B. 2010. The Ecological Rift. New York: Monthly Review Press.

Marx, K. 1993. Capital, Vols I–III. London: Penguin.

Political-industrial ecology

A recent research approach developed by geographers and political ecologists that "entails an importing of method and an exporting of spatial sensitivity and critical political economy" (Newell & Cousins 2015, p. 721). The aim is to use quantitative methods from industrial ecology and social ecology to inform a radical critique of metabolic processes in terms of urban political ecology. The understanding of the urban metabolism of industrial-political ecology reaches this stage by combining an extensive Marxist apparatus, which combines socio-political dynamics with largely qualitative and spatialized methodological approaches by revealing the "hidden" flows of material and energy consumption. It is therefore a question of territorializing urban metabolism, in order, for example, to show the impact relationships in terms of environmental and social injustice.

JEAN-BAPTISTE BAHERS

Further reading

Pincetl & Newell 2017.

See also: Urban metabolism, Political ecology, Industrial ecology, Social ecology, Political economy, Environmental justice, Social justice.

References

Newell, J.P. & Cousins, J.J. 2015. The boundaries of urban metabolism: towards a political–industrial ecology. Progress in Human Geography 39: 702–28.

Pincetl, S. & Newell, J.P. 2017. Why data for a political–industrial ecology of cities? Geoforum 85: 381–91.

Pollutant

Any biological or chemical substance that is considered harmful to the air, water, land, animals, plants, or to human health. Usually defined by federal, state, or provincial law.

BARRY D. SOLOMON

Further reading

Tietenberg & Lewis 2018.

See also: Polluted, Pollution, Pollution abatement, Emissions, Effluent.

Reference

Tietenberg, T.H. & Lewis, L. 2018. "Economics of pollution control: an overview," pp. 333–56 in Environmental and Natural Resources Economics, 11th edn. New York: Routledge.

Polluted

Contaminated with pollution. Can refer to the air, water, or land.

BARRY D. SOLOMON

See also: Pollution, Pollutant, Pollution abatement, Emissions, Effluent.

Polluter pays principle

The commonly accepted practice that those who pollute should bear the cost of managing it to protect human health and the environment. In 1972 the Organisation for Economic Co-operation and Development (OECD) Council recommended that polluters should pay the costs of abating their own environmental pollution up to the emissions/pollution levels imposed by regulation or incentivized by environmental levies. Abatement may require filter installations, sanitation plants, or other add-on techniques; substitution of (more expensive) materials and fuels for (lower priced) dirtier versions, and so on. In a narrow polluter pays principle (PPP) definition only the abatement costs are considered.

A levy applied on the units of emissions/pollution puts an effective price on the non-abated emissions/pollution, with transfers of (considerable) revenue to the public treasury. The revenue may cover part, all, or more of the damage costs caused by the non-abated pollution. Some of the revenue may compensate victims. Paying for damage is the "extended PPP." A further extension would add payments for historical pollution.

Combining the precautionary principle with the PPP results in the precautionary polluter pays principle; potential polluters are mandated to take insurance or preventive measures for pollution that may occur in the future (for example, levies on purchased electronic appliances are saved in a fund earmarked for waste management of electronic material). The PPP has the strong appeal of justice: the one who causes the problems is made financially responsible. PPP is often difficult to apply in practice, as illustrated by the largely uncharged polluting of the atmosphere by greenhouse gas emissions.

Aviel Verbruggen

Further reading

Gaines 1991; OECD 1992.

See also: Externalities, Environmental externalities, Internalizing externalities, Pollution, Emissions, Pollution abatement, Precautionary principle, Extended producer responsibility.

References

Gaines, S.E. 1991. The polluter-pays principle: from economic equity to environmental ethos. Texas International Law Journal 26: 463–96.

OECD (Organisation for Economic Co-operation and Development). 1992. The Polluter Pays Principle: OECD Analyses and Recommendations. Paris: OECD.

Pollution

a. Any biological, physical, or chemical substance in gaseous, liquid, or solid form that is introduced into the environment and not part of its natural composition.
b. Any gaseous, liquid, or solid substance introduced into the environment in a concentration greater than its natural level, and which can cause harmful effects to the health of humans and/or plants and other animals.

Barry D. Solomon

Further reading

Hill 2020; Gani & Scrimgeour 2014.

See also: Emissions, Effluent, Polluted, Pollution prevention (P2), Pollution abatement, Environment, Environmental health, Natural.

References

Gani, A. & Scrimgeour, F. 2014. Modeling governance and water pollution using the institutional economic framework. Economic Modelling 42: 363–72.

Hill, M.H. 2020. Understanding Environmental Pollution, 4th edn. Cambridge: Cambridge University Press.

Pollution abatement

Any technology or measure that is used to reduce, control, or eliminate air, water, or land pollution and its impacts on the environment. Examples include sewage treatment plants, catalytic converters in automobiles,

buffer strips on farms, and flue gas desulfurization technology in coal-fired power plants.

BARRY D. SOLOMON

Further reading

Feenberg & Mills 1980; Jung et al. 1996; Smulders & Gradus 1996; Sidemo-Holm et al. 2018; Tietenberg & Lewis 2018.

See also: Pollution, Pollution prevention (P2), Best management practices (BMPs), Environmental management, Environmental restoration, Bioremediation, Climate change mitigation.

References

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Jung, C., Krutilla, K. & Boyd, R. 1996. Incentives of advanced pollution abatement technology at the industry level: an evaluation of policy alternatives. Journal of Environmental Economics and Management 30(1): 95–111.

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Tietenberg, T.H. & Lewis, L. 2018. "Economics of pollution control: an overview," pp. 333–56 in Environmental and Natural Resources Economics, 11th edn. New York: Routledge.

Pollution haven

A location that attracts pollution-intensive activity due to relatively less stringent environmental regulation. The weak form of this phenomenon is that areas with increased regulation will see at the margin a relocation of polluting activity to other locations, also known as the pollution haven effect. The strong form posits that the relocation will go disproportionately to locations with less regulation, also known as the pollution haven hypothesis. Relocation may also be mitigated by differences in local factor endowments and the capital intensity of the goods produced.

JOHN P. TANG

Further reading

Antweiler et al. 2001; Grossman & Krueger 1993; Tang 2015.

See also: Pollution, Porter hypothesis.

References

Antweiler, W., Copeland, B.R. & Scott, M. 2001. Is free trade good for the environment? The American Economic Review 91(4): 877–908.

Grossman, G.M. & Krueger, A.B. 1993. "Environmental impacts of a North American Free Trade Agreement," pp. 165–77 in The Mexico–U.S. Free Trade Agreement. P.M. Garber, ed. Cambridge, MA: MIT Press.

Tang, J.P. 2015. Pollution havens and the trade in toxic chemicals: evidence from U.S. trade flows. Ecological Economics 112: 150–60.

Pollution intensity

The ratio of pollution or emissions per unit of output. Also called emissions intensity. Pollution in the numerator is typically measured in physical units such as tons of greenhouse gases or sulfur dioxide. Output in the denominator might be measured in physical units such as kilowatt hours (Holland et al. 2020) or tons of steel, but is often reported in monetary units such as dollars or euros to facilitate comparisons between dissimilar activities.

Pollution intensity can be compared across manufacturers, industries, or jurisdictions (Cherniwchan et al. 2017). Sometimes pollution intensity is assessed for consumers, calculated as the pollution emitted while manufacturing each dollar of goods purchased (Levinson & O'Brien 2019). Changes in overall pollution intensity can be decomposed into those changes due to the composition of products manufactured and changes to the pollution intensity of individual industries (Shapiro & Walker 2018).

ARIK M. LEVINSON

Further reading

Barrows & Ollivier 2018; Levinson 2015.

See also: Pollution, Emissions, Greenhouse gases.

References

Barrows, G. & Ollivier, H. 2018. Cleaner firms or cleaner products? How product mix shapes emission intensity from manufacturing. Journal of Environmental Economics and Management 88: 134–58.

Cherniwchan, J., Copeland, B.R. & Taylor, M.S. 2017. Trade and the environment: new methods, measurements, and results. Annual Review of Economics 9: 59–85.

Holland, S.P., Mansur, E.T., Muller, N.Z. & Yates, A.J. 2020. Decompositions and policy consequences of an extraordinary decline in air pollution from electricity generation. American Economic Journal: Economic Policy 12(4): 244–74.

Levinson, A. 2015. A direct estimate of the technique effect: changes in the pollution intensity of US manufacturing 1990–2008. Journal of the Association of Environmental and Resource Economists 2(1): 43–56.

Levinson, A. & O'Brien, J. 2019. Environmental Engel curves: indirect emissions of common air pollutants. Review of Economics and Statistics 101(1): 121–33.

Shapiro, J.S. & Walker, R. 2018. Why is pollution from US manufacturing declining? The roles of environmental regulation, productivity, and trade. American Economic Review 108(12): 3814–54.

Pollution prevention (P2)

Any policy, program, process, or practice by a private firm that prevents, eliminates, or reduces the toxicity of pollution or wastes at the source prior to treatment, recycling, or disposal. Also called P2. In additional to its benefits to human health and the environment, P2 can often save money for private companies by avoiding more expensive pollution treatment, control, or disposal.

BARRY D. SOLOMON

Further reading

Freeman et al. 1992.

See also: Pollution, Pollution abatement, Pollution intensity, Waste management, Industrial ecology.

Reference

Freeman, H., Harten, T., Springer, J. et al. 1992. Industrial pollution prevention: a critical review. Journal of the Air and Waste Management Association 42(5): 618–56.

Pollution taxes

An environmental policy instrument that is a form of environmental taxes (sometimes also called green taxes). The main purpose of a pollution tax is to reduce environmental harm caused by air emissions, water pollution, waste disposal, or noise. The exception is greenhouse gas and sulfur dioxide (SO_2) taxes, which are often classified under energy taxes if the mineral oil tax rate is based on the carbon or sulfur content of the fuel (Eurostat 2013).

Taxes increase the cost to a polluter of generating pollution, providing incentives to develop new innovations and to adopt existing ones. The tax takes account of external environmental effects of economic and social activities, and thus creates fairer prices (getting the prices right) for activities, products, and services that pollute the environment. Increasing the prices of such commodities through pollution taxes is expected to reduce consumption and thus relieve some environmental pressure. Ideally, the tax is levied as directly as possible on the pollutant or action causing environmental damage (de Nevers 1977). The tax rate for polluting goods should vary according to the social costs and the elasticity of demand (Sandmo 1975).

Potential effects of such taxes should be measured against their environmental effectiveness and economic efficiency. An alternative to taxing environmental "bads" is to provide tax relief or subsidy for environmental "goods" (OECD 2011). Environmental taxes can help to relieve some of the burden of other taxes (for example, income taxes and social contributions) through ecological tax reform that allows the achievement of a double dividend.

OLGA KIUILA

Further reading

Enevoldsen 2005; Pearson 1995; Sterner 1990.

See also: Environmental taxes, Carbon taxes, Polluter pays principle, Double dividend, Environmental subsidies.

References

de Nevers, N. 1977. Air pollution control philosophies. Journal of the Air Pollution Control Association 27(3): 197–218.
Enevoldsen, M. 2005. The Theory of Environmental Agreements and Taxes. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.
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Sandmo, A. 1975. Optimal taxation in the presence of externalities. Swedish Journal of Economics 77(1): 86–98.
Sterner, T. 1990. An international tax on pollution and natural resources depletion. Energy Policy 18(3): 300–302.

Population

Statistics: a set of objects from which a sample is drawn for study.

Ecology: the number of individuals of a species (or otherwise defined group) that lives in a defined geographical area. Population ecology is a subfield of ecology that studies the dynamics of populations such as birth and death rates, migration patterns, and their interactions with their environment.

Economics and demography: the number of humans in some defined geographical area. Population economics, or demographic economics, applies economic analyses to the study of population size and dynamics. Population size also plays a central role in discussions around sustainability, at least since Thomas Malthus (1798). Yet, population management and control is often controversial for various reasons: aside from ethical and religious considerations, fertility rates drop with economic growth (e.g., Becker et al. 1990). Moreover, the distribution of environmental impacts is a more relevant policy dimension for sustainability; for example, the bottom half of the global income distribution is responsible for less than half the carbon emissions of the richest percentile (Gore 2020).

JOERI SOL

Further reading

Cohen 1998; Wells & Richmond 1995.

See also: Population density, Population aging, Population dynamics, Economic growth, Sustainability, Environmental impact assessment tools.

References

Becker, G.S., Murphy, K.M. & Tamura, R. 1990. Human capital, fertility, and economic growth. Journal of Political Economy 98(5, Part 2): S12–S37.
Cohen, J.E. 1998. How many people can the earth support? Bulletin of the American Academy of Arts and Sciences 51(4): 25–39.
Gore, T. 2020. Confronting Carbon Inequality: Putting Climate Justice at the Heart of the COVID-19 Recovery. oxfamilibrary.openrepository.com
Malthus, T.R. 1798. An Essay on the Principle of Population. Oxford: Oxford University Press.
Wells, J.V. & Richmond, M.E. 1995. Populations, metapopulations, and species populations: what are they and who should care? Wildlife Society Bulletin 23(3): 458–62.

Population aging

An increase in the proportion of older people relative to younger people, resulting from declines in child mortality, birth rates, and longer lifespans. Often misunderstood to be an inexorable decline in the productive capacity of a society, but once the demographic transition is complete, a new steady state is established in which able-bodied adults predominate.

Aging is commonly quantified by a rise in median age, or in "dependency ratio," being the ratio of people aged over 64 and/or under 15 to those aged 15–64. Its inverse, the "support ratio," is also commonly reported, particularly as "workers per retiree." All such measures are misused to imply macroeconomic strains.

To date, demographic aging has been accompanied by greater workforce participation, particularly of older cohorts, and lower unemployment and underutilization of workers, without diminishing the workforce. Likewise, since longevity has mostly extended healthy life more than the period of frailty, costs associated with health care and old-age care have risen less than measures of aging (Zweifel et al. 2004; Sanderson & Scherbov 2010). Sanderson et al. (2017) propose reporting "prospective age," being the median remaining life expectancy, in contrast to "retrospective age" (median age, that is, years lived in the past), to emphasize increasing longevity as a positive rather than a negative social change.

JANE N. O'SULLIVAN

See also: Population, Population dynamics, Demographic transition.

References

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Sanderson, W.C., Scherbov, S. & Gerland, P. 2017. Probabilistic population aging. PLoS ONE 12(6): e0179171.

Zweifel, P., Felder, S. & Werblow, A. 2004. Population ageing and health care expenditure: new evidence on the "red herring." Geneva Papers on Risk and Insurance 29: 652–66.

Population density

A common metric of the population size divided by the square kilometers or square miles of a geographic area, usually applied to the human population living in a specific land area (for example, a county, shire, state, province, nation, and so on). Population density is also measured for animal and plant species on land and in water bodies.

BARRY D. SOLOMON

Further reading

Drechsel et al. 2001.

See also: Population, Population dynamics.

Reference

Drechsel, P., Gyiele, L., Kunzer, D. & Cofie, O. 2001. Population density, soil nutrient depletion, and economic growth in sub-Saharan Africa. Ecological Economics 38(2): 251–8.

Population dynamics

The nature or description of demographic changes in a defined population (for both humans and other animals), including changes in age-specific and gender-specific death rates, migration rates, fertility rates, and resulting changes in age distribution, population size, and growth rate. The term has gained popular usage, particularly by the United Nations Population Fund, as a politically correct means to reference human population growth without mentioning it. Before human population growth became a taboo subject, the word "demography" sufficed to refer to all types of demographic change in aggregate.

JANE N. O'SULLIVAN

Further reading

UNFPA 2014.

See also: Demographic transition, Population, Population aging.

Reference

UNFPA (United Nations Population Fund). 2014. Population dynamics and policies. https://www.unfpa.org/resources/population-dynamics-and-policies.

Population viability analysis

See: Viability analysis.

See also: Population, Population dynamics.

Porter hypothesis

The hypothesis that more stringent environmental regulation promotes technological innovation that reduces the amount of toxic materials that are produced or processed. Innovation can reduce the cost of compliance to regulation (weak form), and in some cases may generate enough savings to exceed compliance costs (strong form). The adoption of less-polluting technologies, also known as the technique effect, can occur alongside changes in production scale or composition. This hypothesis was first formulated by Michael Porter and Claas van der Linde (1995).

JOHN P. TANG

Further reading

Antweiler et al. 2001; Wheeler 2002.

See also: Pollution, Pollution haven, Technological progress.

References

Antweiler, W., Copeland, B.R. & Scott, M. 2001. Is free trade good for the environment? American Economic Review 91(4): 877–908.
Porter, M.E. & van der Linde, C. 1995. Toward a new conception of the environment–competitiveness relationship. Journal of Economic Perspectives 9(4): 97–118.
Wheeler, D. 2002. Beyond pollution havens. Global Environmental Politics 2(2): 1–10.

Positional goods

A small number of goods that are valued based on how they are distributed among people. Positional goods are valued as a status symbol, and as such greatly exceed the market value of seemingly comparable goods. Examples include luxury automobiles, yachts, diamonds, rare art, real estate in highly desirable locations, brand name luxury handbags, Rolex watches, and vacations in remote or exotic locations. The term "positional good" was first used by Austrian-British financial journalist Fred Hirsch (1977), though it is based on the classic work of the American economist Thorstein Veblen (1899).

BARRY D. SOLOMON

Further reading

Linder 1970; Schneider 2016.

See also: Affluence, Affluenza, Market goods, Economic valuation techniques.

References

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Linder, S.B. 1970. The Harried Leisure Class. New York: Columbia University Press.
Schneider, M. 2016. The nature, history and significance of the concept of positional goods. History of Economics Review 45(1): 60–81.
Veblen, T. 1899. The Theory of Leisure Class. New York: Macmillan.

Positivism

Philosophy: a research approach and position in philosophy of science representing the classical scientific worldview (Harré 1972; Caldwell 1994).

Ontology: reality is believed to consist exclusively of discrete phenomena or events.

Epistemology: knowledge takes the form of general and context-independent laws about regularities between these phenomena or events that can be discovered by scientists via observation, allowing the prediction of the future. Scientific knowledge is restricted to facts that are rigorously separated from values or normative statements. All scientific concepts must relate to observation.

Methodology: research rests on quantitative data collection and interpretation.

There are multiple versions of positivism; for example: Auguste Comte's foundational and early account of positive sociology, logical empiricism by the Vienna Circle, among them Rudolf Carnap's model of inductive generalization, Carl Hempel's deductive-nomological model of explanation, or Karl Popper's critical rationalism establishing the hypothetico-deductive model of falsificationism.

ARMIN L. PULLER

See also: Epistemology, Empiricism, Quantitative analysis, Scientific method.

References

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Post-capitalist world(s)

An evocative, inspirational horizon as well as the "here and now" world governed by other-than-capitalist logics. Instead of an aspirational or a purist perspective vision that sees it as a world to come after capitalism has run its course, a post-capitalist world is enacted here and now, by political and economic forms that challenge the hegemony of capitalism as the only story or script that inscribes human lives. Post-capitalist vision, following Gibson-Graham's (2006) work, is about making visible (and expanding) the diversity of provisioning and (re)productive activities that exist despite capitalism.

Challenging a totalitarian view of the "capitalist economy," a post-capitalist world uses the method that works the cracks within capitalism through everyday actions and micro-practices of resistance, reimagination, and alternative doings (Temper et al. 2018) that unsettle the Eurocentric "one-world world" (Law 2015) based on limitless economic growth, capital accumulation, and individualism. Echoing the Zapatistas' vision of a "world where many worlds can fit," the post-capitalist world is a pluriverse that draws inspiration from different paths towards alternative futures that include community and solidarity economies, anarchism, socialism, post-development and decolonial practices, radical ecological democracy, degrowth, post-work, autonomous perspectives, among others (Chatterton & Pusey 2020). Some strands of post-capitalist debates see technological progress, mechanization, and automation as a way out of capitalism (Srnicek & Williams 2016), while others emphasize a "refusal" to capitalist work (Weeks 2016), different forms of "doing" (Holloway 2010), worlding and storying (Haraway 2016), restoration (Kimmerer 2013), "commoning" (Federici 2018), and alternative ways of being human, as critical to nurturing post-capitalist worlds.

Neera Singh

See also: Post-growth, Post-development, Degrowth, Democracy, Autonomous institution.

References

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Kimmerer, R.W. 2013. Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge and the Teachings of Plants. Minneapolis, MN: Milkweed Editions.

Law, J. 2015. What's wrong with a one-world world? Distinktion: Scandinavian Journal of Social Theory 16(1): 126–39.

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Temper, L., Walter, M., Rodriguez, I. et al. 2018. A perspective on radical transformations to sustainability: resistances, movements and alternatives. Sustainability Science 13(3): 747–64.

Weeks, K. 2016. "The problem with work," pp. 291–326 in Global Histories of Work. A. Eckert, ed. Berlin: De Gruyter Oldenbourg.

Post-development

An era or approach in which development would no longer be the central organizing principle of social life (Escobar 1995). Development is at the core of the Western imaginary and hegemony over the rest of the world. It holds two assumptions: (1) growth or progress should be able to continue indefinitely; and (2) constant growth of production will make the future self-evidently better. From a post-structuralist perspective, concepts are constructed within a particular history and culture. They are a social

construction to be deconstructed. Therefore, post-development aims to deconstruct development. The central questions here are: who has the power to define what the problem is (diagnosis), and how can it be solved (prognosis)? For instance, if the problem of poverty is framed as a lack of income, then the solution is economic growth. Post-development questions these kinds of framings that have become self-evident, necessary, and universal truth.

One could trace the history of the development concept from the inaugural speech of United States President Harry Truman in 1949, where he distinguished countries between developed and underdeveloped. Since then, the conceptualization of development in social sciences has seen three main moments: (1) modernization theory in the 1950s and 1960s, with its allied theories of growth; (2) Marxist-inspired dependency theory in the 1960s and 1970s; and (3) critiques of development as a cultural discourse since the 1990s. "Post-development" emerged from this last period. It is related to at least four other emerging imaginaries: of post-capitalism, post-growth/degrowth, post-patriarchy, and post-colonial.

Ecological economics contributed to post-development with an ecological critique of development in general, and economic growth in particular. These debates open the conceptual space for a pluriverse of alternatives to development, such as degrowth, buen vivir, and environmental justice (Beling et al. 2018).

Federico Demaria

Further reading

D'Alisa et al. 2014; Akbulut et al. 2019.

See also: Environmental justice, Degrowth, Agrowth, Buen vivir, Development, Poverty, Social constructionism.

References

Akbulut, B., Demaria, F., Gerber, J.F. & Martinez-Alier, J. 2019. Who promotes sustainability? Five theses on the relationships between the degrowth and the environmental justice movements. Ecological Economics 165: 106418.

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D'Alisa, G., Demaria, F. & Kallis, G. eds. 2014. Degrowth: A Vocabulary for a New Era. Abingdon: Routledge.

Escobar, A. 1995. Encountering Development. Princeton, NJ: Princeton University Press.

Post-growth

a. A set of normative conceptions concerning how economies should move beyond continual economic growth. As a normative concept, post-growth views contend that continued economic growth under the current dominant capitalist system is irreconcilable with ecological limits, and that future trajectories, defined by decreasing environmental impacts and increasing social welfare, are both possible and desirable alternatives.

b. An umbrella term that may be used to define any economic pathway or worldview not defined by, or dependent on, continual economic growth as measured by inflation adjusted gross domestic product (GDP). Common examples of post-growth futures include degrowth and steady state (no-growth) economics, which are often discussed in similar normative terms as above, but which in a broader sense may define any pathways with declining or non-growing GDP without necessarily assuming increases in other measures of well-being or environmental improvements.

Martin R. Sers

Further reading

Victor 2019; Hardt et al. 2020; Jackson 2021.

See also: Degrowth, Steady state economy, Agrowth, Post-development, Post-capitalist world(s).

References

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between embodied energy intensity and labour productivity. Sustainability 12(3): 962.
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Victor, P.A. 2019. Managing Without Growth: Slower by Design, Not Disaster, 2nd edn. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Post-Keynesian economics

Economics built on the seminal works of John Maynard Keynes (1936 [1973]) and Michał Kalecki (1954). Methodologically, it shares the five presuppositions of heterodox economics (Lavoie 2014): (1): the epistemology and the ontology are based on realism; (2) the concept of rationality assumes environment-consistent rationality and satisficing agents; (3) the applied method follows organicism and holism; (4) the economic core focuses on production and growth; and (5) regarding the political core, regulated markets and continuous state intervention into the economy are recommended.

Furthermore, five essential features specific to post-Keynesian economics can be highlighted (Hein 2017): (1) the focus on a monetary theory of production means that money is non-neutral in the short and long run with regard to employment, distribution, and growth; (2) the dominance of the principle of effective demand implies that investment generates saving, in the short and the long run; (3) the importance of the notion of fundamental uncertainty; (4) economic processes take place in historical and irreversible time, and are thus largely path dependent; concepts such as a NAIRU (non-accelerating-inflation-rate-of-unemployment) or potential growth are endogenous to the actual time path of the economy driven by effective demand; and (5) the importance of distributional issues and distribution conflict for economic outcomes.

Eckhard Hein

Further reading

Hein 2014; King 2015.

See also: Income distribution, Wealth distribution, Redistribution, Economic growth, Monetary policy, Heterodox economics.

References

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Kalecki, M. 1954: Theory of Economic Dynamics: An Essay on Cyclical and Long-run Changes in Capitalist Economy. London: Allen & Unwin.
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Lavoie, M. 2014. Post-Keynesian Economics: New Foundations. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Post-normal science

Introduced by philosophers Silvio Funtowicz and Jerome Ravetz (1990), an approach to science that makes systems uncertainties and decision stakes essential analytical elements. Post-normal science research focuses on a wide range of issues, including climate change, sustainability, and public governance of the natural environment (Strand 2017). The approach is underpinned by the observation that in "issue-driven science relating to environmental debates, typically facts are uncertain, values in dispute, stakes high, and decisions urgent" (Ravetz 1999, p. 649). Under such conditions, "normal science" (cf. Kuhn 1962 [2012]) is no longer held to be able to provide adequate inputs for policy processes.

Quality assurance is a key concept in post-normal science. The approach entails the use of an "extended peer community" that plays an active role in finding solutions to specific problems. Extended peer communities may include scientists and stakeholders as well as others with an interest in resolving a particular issue.

Hubert Buch-Hansen

See also: Uncertainty, Peer review process, Wicked problems.

References

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Ravetz, J.R. 1999. What is post-normal science. Futures 31: 647–53.
Strand, R. 2017. "Post-normal science," pp. 288–97 in Routledge Handbook of Ecological Economics. C.L. Spash, ed. Abingdon: Routledge.

Poverty

Economics: a state or condition in which a person or community lacks the financial resources to provide the necessities of life: food, safe and clean water, shelter, and clothing (Banerjee & Duflo 2011; Ravallion 2016). What the necessities of life are varies across countries and over time because they are socially determined. Poverty can be measured in absolute or relative terms. The amount of money needed to buy the basket of commodities necessary to satisfy the socially determined basic needs in a country at a certain time provides an absolute measure of poverty. The relatively poor are people who receive less than the minimum amount of income needed to maintain the average standard of living in the society that they live in.

Ecology: the interrelationship between poverty and ecology is complex. Ecological degradation has an impact on the level of income, and thus on the poverty level. On the other hand, the poor are forced to deplete resources to survive, and this degradation of the environment further impoverishes people (Ingram et al. 2012).

VICTOR A. BEKER

Further reading

Sen 1976.

See also: Income distribution, Economic inequality, Poverty trap, Multidimensional Poverty Index (MPI).

References

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Ravallion, M. 2016. The Economics of Poverty: History, Measurement, and Policy. Oxford: Oxford University Press.
Sen, A. 1976. Poverty: an ordinal approach to measurement. Econometrica 44(2): 219–31.

Poverty trap

Economics: a self-reinforcing and spiraling mechanism in which poverty forces people to remain poor. It is a vicious cycle that causes individuals, communities, regions, or entire economies to get stuck in extreme poverty, owing to abysmally low or downward spiraling incomes in real terms, making minimum standards of living unaffordable.

Sociology: a scenario created when low-income individuals or families living in poverty lose welfare or tax benefits when they secure employment or a higher salary, resulting in an overall worse economic condition because of the loss of their benefits. The social strata reinforce the perpetuation of the poverty trap.

Ecology: when extreme environmental degradation (which depletes production potential of agriculture and other natural resources) forces people to fall into and remain in poverty for a long time, owing to declining income in real terms leading to incessant stressed livelihoods.

AMITA R. SHAH

Further reading

Azariadis & Stachurski 2005; Katz 1989; Sachs 2006.

See also: Poverty, Multidimensional Poverty Index (MPI), Economic welfare, Total human welfare.

References

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Sachs, J.D. 2006. The End of Poverty: Economic Possibilities for Our Time. New York: Penguin Books.

Power

Physics: the amount of energy transferred or converted per unit time.

Social sciences: the ability to influence actions, beliefs, and behaviors of others. One can say that X has power over Y when X can get Y to do something that Y would not otherwise do (Dahl 2007). However, this is not the only way that power functions. For example, one may exercise power by influencing, shaping, or determining their desires, preferences, and thoughts (Lukes 2004), or setting the agenda or context that defines what is socially economically and politically possible for others (Hay 2002; Jessop 2005). This kind of power is more invisible, or subtle, compared to the first aspect of power, since it appears as if someone is choosing their behavior on their own.

Political science: having the political authority over the affairs of a people or political unit, granted by a constitution or legislation.

Hiroe Ishihara

See also: Energy, Power relations, Power differentials, Market power.

References

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Lukes, S. 2004. Power: A Radical View. New York: Macmillan International Higher Education.

Power differentials

The existence of imbalanced power relations, where power describes the ability to act or produce an effect on other people, narratives, policies, practices, or things. Power differentials are relational and manifest in various ways: between actors, in discourses and narratives, through structures and institutions, and in worldviews. For example, actor-oriented power differentials describe the ability of individuals or organizations to realize their will despite resistance from others. Discursive power differentials are exercised when actors, such as government agencies, corporations, or non-governmental organizations, produce discourses and narratives that serve their purposes, and coerce other groups to adopt and reproduce their discourses. Structural power differentials describe historically established social structures and institutions that shape and constrain the power of individuals. Ontological power differentials are exercised when one worldview (often Western) dominates over others. Unequal power differentials often perpetuate domination by one group over another, and repeatedly result in social and ecological exploitation.

Jessica L. Blythe

Further reading

Kish & Farley 2021; Svarstad et al. 2018.

See also: Power, Inequality.

References

Kish, K. & Farley, J. 2021. A research agenda for the future of ecological economics by emerging scholars. Sustainability 13(3): 1557.

Svarstad, H., Benjaminsen, T.A. & Overå, R. 2018. Power theories in political ecology. Journal of Political Ecology 25(1): 350–63.

Power relations

A relationship in which an individual or a group has an ability to order, command, direct, or influence others to behave in a certain way. For example, power relations exist between a military commander

and a soldier, as the military commander has the power to order the soldier to go to battle, even to die. However, the exercise of power is not always synonymous with violence or coercion (Elias 1978; Haugaard 2008). In this case of a commander and a soldier, a soldier may willingly follow the commander's orders, thinking that they are defending their country. Here, the subordinate, those whom the power is exercised over, considers the exercise of power by the dominant as legitimate and gives consent. At the same time, this is "contingent consent," in which individuals retain rights to rescind their consent (Gilbert 2006). Whenever the individuals rescind their consent, the power relations reveal the coercive aspect, forcing someone to do something that they do not otherwise desire to (Dahl 1957).

HIROE ISHIHARA

See also: Power, Power differentials.

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Elias, N. 1978. The Civilizing Process. Oxford: Blackwell.
Gilbert, M. 2006. A Theory of Political Obligation: Membership, Commitment, and the Bonds of Society. Oxford: Oxford University Press.
Haugaard, M. 2008. Power and habitus. Journal of Power 1(2): 189–206.

Pragmatism

Philosophy: a 19th-century school of thought most closely associated with the work of Charles Sanders Peirce and William James that regards conceptions of the world as closely tied to agency in the world. Originally used as a theory of meaning, over time it has become used in a broad range of interpretations.

Ecology: a stance in environmental ethics that moves from seeking intrinsic value in the natural environment to instrumental motivations of conservation, where valuing the environment becomes a response to our perception of and interaction with nature.

Economics: an interpretation of economic value that incorporates behavioral and cultural dimensions of value reaching beyond the rational actor paradigm of neoclassical economics. In ecological economics, the behavioral relevance of prior experience and emotive response in instrumental decision-making.

MATTHIAS KLAES

Further reading

James 1907; Weston 1985; Klamer 2003.

See also: Behavioral economics, Behavioral ecological economics, Warm glow effect, Environmental ethics, New environmental pragmatism, Human agency.

References

James, W. 1907. Pragmatism: A New Name for Some Old Ways of Thinking. New York: Longmans, Green & Co.
Klamer, A. 2003. A pragmatic view on values in economics. Journal of Economic Methodology 10(2): 191–212.
Weston, A. 1985. Beyond intrinsic value: pragmatism in environmental ethics. Environmental Ethics 7(4): 321–39.

Preanalytic vision

From Schumpeter (1954, p. 41), the starting point, basic assumptions, beliefs, theories, goals, and purposes of a scientific field.

Ecological economics: in contrast to the endless growth paradigm of mainstream economics, ecological economics begins by recognizing a series of immutable biophysical laws and realities. These include the laws of thermodynamics, and the fact that the macroeconomy is a subsystem of the ecosphere that is sustained by a metabolic throughput of matter-energy, starting with depletion of the finite ecosphere's low-entropy resources and ending with its pollution by resulting high-entropy wastes.

Ecological economics also stresses that there are four types of capital – manufactured, human, natural, and social; that there is limited substitutability between the forms of capital and between capital and other factors of production; and that human preferences

are not fixed (Costanza 2001). Furthermore, humans now live in a "full world" economics era, in contrast to the "empty world" era when classical and neoclassical economics were developed. Based on the biophysical constraints on the human economy, it follows that there is a point at which the growth of the macroeconomy becomes uneconomic, where the marginal utility from consuming goods and services is exceeded by the marginal disutility of additional consumption. This point is the optimal (sustainable) scale of the macroeconomy (Daly 1991, 1992).

BARRY D. SOLOMON

See also: Paradigm, Empty world, Full world, Sustainable scale, Optimal scale of the macroeconomy, Growth paradigm, Classical economics, Neoclassical economics.

References

Costanza, R. 2001. Visions, values, valuation, and the need for an ecological economic. BioScience 51(6): 459–68.

Daly, H.E. 1991. Towards an environmental macroeconomics. Land Economics 67(2): 255–9.

Daly, H.E. 1992. Allocation, distribution, and scale: towards an economics that is efficient, just, and sustainable. Ecological Economics 6: 185–93.

Schumpeter, J. 1954. History of Economic Analysis. London: Allen & Unwin.

Precautionary principle

A broad philosophical and legal approach to policy, action, or innovation that requires that for a suspected risk to public health or the environment, in the absence of adequate scientific knowledge, certainty, or consensus that the action is harmful, the burden of proof that it is not harmful falls on those taking or proposing the policy, action, or innovation. In these cases, caution, pausing, and further review are emphasized, and public participation in decision-making and the promotion of a wide range of alternatives (Kriebel et al. 2001). The principle was first suggested in France by Bernard de Bélidor (1729) in the context of civil engineering, though its modern usage dates to a translation of the German term *Vorsorgeprinzip*, in English the foresight principle, in the 1970s (O'Riordan & Cameron 1994).

The principle is that society should seek to avoid environmental damage by careful planning. Critics argue that the principle is too vague to be workable and that it can stifle progress and innovation. The principle has seen most applications in law and policy in the European Union (especially with respect to genetically modified organisms), in Germany, Sweden, and France, as well as to varying degrees in several international environmental treaties and agreements.

BARRY D. SOLOMON

Further reading

Foster et al. 2000.

See also: Public health, Ecosystem health, Environmental health, Ecohealth, Maximin, Risk, Pollution prevention (P2), Risk assessment, Risk aversion.

References

de Bélidor, B.F. 1729. La science des ingénieurs, dans la conduite des travaux de fortification et d'architecture civile, Paris: Chez Claude Jombert.

Foster, K.R., Vecchia, P. & Repacholi, M.H. 2000. Science and the precautionary principle. Science 288(5468): 979–81.

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O'Riordan, T. & Cameron, J. 1994. "The history and contemporary significance of the precautionary principle," pp. 12–30 in Interpreting the Precautionary Principle. T. O'Riordan & J. Cameron, eds. Abingdon, UK & New York, USA: Earthscan.

Preference endogeneity

According to a common assumption in neoclassical economics, preferences are characteristics of decision-makers that are exogenous (external) to the choice situation and stable over time. Both welfare and behavioral economists have criticized and challenged this assumption (Tversky & Thaler 1990; Sen 1973). It has been argued that preferences are developed and governed

by a diversity of elements in the social, cultural, economic, and legal environments (Palacios-Huerta & Santos 2004), and evolve over time in response to changes in the decision-making environment such as the policies or institutional arrangements (Bowles 1998; Becker & Mulligan 1997). Preferences can also change based on the effects of indoctrination, peers, and herding, among other factors (Acemoglu et al. 2015). If preferences are indeed a function of the choice situation that decision-makers are confronted with, then not only do decision-makers' preferences determine economic outcomes, but also the economic, social, legal, and cultural structure of society affect their preferences.

CAN LIU

Further reading

Danaf et al. 2020.

See also: Endogeneity, Endogenous growth model, Exogenous.

References

Acemoglu, D., Laibson, D. & List, J.A. 2015. Economics. New York: Pearson.

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Danaf, M., Guevara, A., Atasoy, B. & Ben-Akiva, M. 2020. Endogeneity in adaptive choice context: choice-based recommender systems and adaptive stated preferences surveys. Journal of Choice Modelling 34: 1–16.

Palacios-Huerta, I. & Santos, T.J. 2004. A theory of markets, institutions, and endogenous preferences. Journal of Public Economics 88(3–4): 601–27.

Sen, A. 1973. Behaviour and the concept of preference. Economica 40(159): 241–59.

Tversky, A. & Thaler, R.H. 1990. Anomalies: preference reversals. Journal of Economic Perspectives 4(2): 201–11.

Preference formation

The process by which preferences unravel by the interplay between individuals and their surroundings (Druckman & Lupia 2000). In this respect, preferences are not always stable, and they may change depending on the context. For example, ecological economists support the idea that deliberative processes provide the space for preference formation through social learning (Mavrommati et al. 2021; Kenter et al. 2016; Eriksson et al. 2019).

GEORGIA MAVROMMATI

Further reading

Murphy et al. 2017; Kenter et al. 2015.

See also: Preference heterogeneity, Preference endogeneity, Deliberative valuation, Social learning.

References

Druckman, J.N. & Lupia, A. 2000. Preference formation. Annual Review of Political Science 3: 1–24.

Eriksson, M., van Riper, C.J., Leitschuh, B. et al. 2019. Social learning as a link between the individual and the collective: evaluating deliberation on social values. Sustainability Science 14(5): 1323–32.

Kenter, J.O., O'Brien, L., Hockley, N. et al. 2015. What are shared and social values of ecosystems? Ecological Economics 111: 86–99.

Kenter, J.O., Bryce, R., Christie, M. et al. 2016. Shared values and deliberative valuation: future directions. Ecosystem Services 21(Part B): 358–71.

Mavrommati, G.M., Borsuk, M.E., Kreiley, A.I. et al. 2021. A methodological framework for understanding shared social values in deliberative valuation. Ecological Economics 190: 107185.

Murphy, M.B., Mavrommati, G., Mallampalli, V.R. et al. 2017. Comparing group deliberation to other forms of preference aggregation in valuing ecosystem services. Ecology and Society 22(4): 17.

Preference heterogeneity

The condition of apparently similar individuals having differing willingness to pay for goods and services. It begs the questions of why the demand profiles are different and what can be learned by associating demand profiles with underlying characteristics of the population. The existence of preference heterogeneity invites the researcher to delve

deeper and attempt to associate characteristics of the population with their preferences. One study identified preference heterogeneity in what people value about forests, ranging from availability of parking and picnic tables to particular tree species, long hiking trails, and presence of lakes and rivers. Further analysis linked a person's proximity to a forest with a preference for parking and picnic tables (Abildtrup et al. 2013).

BRENT M. HADDAD

Further reading

Garrod et al. 2012.

See also: Preference formation, Revealed preference methods, Contingent valuation method (CVM), Willingness to pay (WTP).

References

Abildtrup, J., Garcia, S., Olsen, S. and Stenger, A. 2013. Spatial preference heterogeneity in forest recreation. Ecological Economics 92: 67–77.

Garrod, G., Ruto, E., Willis, K. & Powe, N. 2012. Heterogeneity of preferences for the benefits of environmental stewardship: a latent-class approach. Ecological Economics 76: 104–11.

Preservation

The setting aside or maintenance of wilderness lands and their natural resources in pristine condition, largely free of human use and impacts. If human access is allowed to such areas, it is normally solely for the enjoyment of the natural beauty, serenity, and inspiration, and not for the extractive use of resources. The pioneer of the environmental preservation movement is usually considered to be John Muir, a Scottish naturalist and immigrant to the United States in the 19th century (Muir 1996; Holmes 1999; Worster 2008). Preservation contrasts with conservation, which allows for the reasonable use, extraction, and management of natural resources for the benefit of humans. Preservationists see nature and wild areas as having intrinsic value independent of their economic value to people.

BARRY D. SOLOMON

Further reading

McKibben 1989.

See also: Conservation, Nature, Naturalness, Intrinsic value, Extractivism.

References

Holmes, S. 1999. The Young John Muir: An Environmental Biography. Madison, WI: University of Wisconsin Press.

McKibben, B. 1989. The End of Nature. New York: Random House.

Muir, J. 1996. John Muir: His Life and Letters and Other Writings. T. Gifford ed. London, UK and Seattle, WA, USA: Mountaineer Books.

Worster, D. 2008. A Passion for Nature: The Life of John Muir. Oxford: Oxford University Press.

Prevention

Any action undertaken to avoid, preclude, or stop something from occurring. A preference for prevention in environmental policy, as opposed to mitigation, is the philosophy behind the precautionary principle and pollution prevention (P2).

BARRY D. SOLOMON

Further reading

Barrett & Segerson 1997.

See also: Precautionary principle, Pollution prevention (P2), Mitigation.

Reference

Barrett, J. & Segerson, K. 1997. Prevention and treatment in environmental policy design. Journal of Environmental Economics and Management 33(2): 196–213.

Price theory

See: Microeconomics.

See also: Transaction prices, Shadow price, Market, Market imperfections, Non-competitive market, Competitive market, Free market, Market failure, Labor markets.

Primary energy

Sources of energy in a form that are first accounted for in a statistical energy balance before any conversion or transformation to secondary energy sources. Examples include crude oil, dry natural gas, coal, uranium, biomass, falling and flowing water, geothermal, wind and solar energy.

BARRY D. SOLOMON

Further reading

Hall et al. 1986; Hall & Klitgaard 2018; Cleveland & Morris 2013.

See also: Energy, Secondary energy, Fossil fuels, Renewable energy.

References

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Hall, C.A.S., Cleveland, C.J. & Kaufmann, R. 1986. Energy and Resource Quality: The Ecology of the Economic Process. New York: Wiley-Interscience.

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Principal–agent problem

Conceptualized in the early to mid-1970s by the United States economists Stephen Ross (1973), and Michael Jensen and William Meckling (1976), it occurs when two parties (agent and principal) make an agreement according to which the agent works for the principal (in return for some incentives). Given the condition of asymmetric information and different interests between the parties, two problems arise: adverse selection and moral hazard; that is, the parties do not really know each other, and this might lead to a wrong choice and to misbehavior, cheating, and conflict of interest. Hence, the principal–agent problem generally results in agency costs that the principal might bear.

The principal–agent problem has applications in economics, and is especially applied in corporate governance, for instance shareholders (principal) versus management (agent); and in political studies, for instance voters (principal) versus politicians (agent). In ecological economics it has been applied to species and biodiversity conservation, and the exchange value of nature (Moyle 1998; Nuppenau 2002).

GIANDOMENICA BECCHIO

Further reading

Akerlof 1970; Grossbard & Hart 1983.

See also: Asymmetric information, Moral hazard.

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Moyle, B. 1998. Species conservation and the principal–agent problem. Ecological Economics 26(3): 313–20.

Nuppenau, E.-A. 2002. Towards a genuine exchange value of nature: interactions between humans and nature in a principal–agent framework. Ecological Economics 43(1): 33–47.

Ross, S. 1973. The economic theory of agency: the principal's problem. The American Economic Review 63(2): 134–9.

Principle of substitution

General: replacement of one thing with another within a system or process, without disruption or incoherence to that system or process, such as in an economic context the provision of goods or services.

Neoclassical and environmental economics: assumes that capital, labor, and material resources are substitute factors of production without constraints, and this idea is inherited with some modification in environmental economics and forms the concept of weak sustainability. If natural and human capital are substitutes, then depletion of given finite resources and degradation of ecosystems

have no intrinsic limits and global scarcity is not a constraint.

Ecological economics: natural capital is not a substitute for manufactured capital in production functions, but a complement or condition that must be preserved, and thus cannot be duplicated or replaced. This is the basis of strong sustainability. A further dividing line between branches of economics concerns whether nature should be conceptualized as capital at all, and valued for the purposes of its preservation.

Josh Moos & Jamie A. Morgan

Further reading

Daly 1995; O'Neill et al. 2008.

See also: Hartwick rule, Solow sustainability, Neoclassical economics, Production function, Limits to growth, Weak sustainability, Strong sustainability, Scarcity, Resource scarcity, Natural resource accounting, Manufactured capital, Natural capital.

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Prisoner's dilemma

An example of a game in game theory where two prisoners are faced with the decision to confess or not confess (Tucker 1983, p. 228). In this dilemma, two prisoners are charged with a violation of law and are held separately by the police. Each is told: if one confesses and the other does not, the former will be given a reward of one unit and the other will be fined two units. If both confess, each will be fined one unit. If neither confesses, both will go clear. In this game, the pure strategy to confess dominates the pure strategy not to confess for either prisoner. But herein lies the dilemma. Since the strategy to confess dominates the strategy to defect, the outcome obtained when both confess is worse for each than the outcome that they would have obtained had they both remained silent. This game illustrates a conflict between individual and group rationality. A group whose members pursue rational self-interest may end up worse off than a group whose members cooperate for the betterment of the whole (Kuhn 2019).

In ecological economics, a classical example of the prisoner's dilemma is the tragedy of the commons, as well as collective choice and sustainability problems more generally (Hardin 1968; Paavola & Adger 2005; Magli & Manfredi 2022).

Oluwaseun A. Odusola

Further reading

Oskamp & Perlman 1965; Shubik 1970.

See also: Game theory, Tragedy of the commons, Institutional economics, New institutional economics, Sustainability, Sustainable development.

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Private amenity value

Economics: beneficial aspects of land that may potentially provide a major source of land ecosystem services and environmental assets. Includes the private landowner consumption of services such as open space, recreation,

landscape, bequest options, social status, lifestyle, and the opportunity to engage in rural land activities (for example, ranching or hunting). Reveals the underlying motivations for keeping, buying, and managing a piece of land. Thus, private landowners obtain benefits from land ownership that go beyond income from marketed products. These landowners, often referred to as non-industrial landowners, are willing to forego commercial profits based on their land management and ownership preferences; in contrast to industrially oriented management (for example, agricultural plantations), in which commercial profit maximization prevails.

Landowners (potential sellers) who want to keep these amenities demand a higher price from potential buyers, increasing the land price. At the same time, if potential buyers expect to consume these amenities when acquiring the property, they will increase their bid to match the price demanded by sellers, and to compete with other potential amenity consumers. This has implications in terms of revealing ecosystem contribution to economic production if the value of private amenity consumption is overlooked, and from a management and conservation perspective.

Since the transaction value of the private amenities consumed by landowners is not directly observable, non-market product valuation methods can be used to simulate their demand, which can be elicited from real and simulated landowner investment and consumption decisions (Campos et al. 2009; Oviedo et al. 2022).

Pablo Campos Palacín

Further reading

Raunikar & Buongiorno 2006; Barton et al. 2019; Pattanayak et al. 2002.

See also: Amenity, Amenity value, Cultural services, Environmental income, Environmental asset.

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Raunikar, R. & Buongiorno, J. 2006. Willingness to pay for forest amenities: the case of non-industrial owners in the south central United States. Ecological Economics 56: 132–43.

Private goods

One of four main types of goods relevant to natural resource and environmental management: private goods, public goods, club goods (toll goods), and common pool resources (open access); defined by the relative ability of resource owners or appropriators to exclude other users (excludability), and the extent to which one individual's consumption reduces the amount of the resource available for other users (subtractability).

In contrast to public goods, private goods are both excludable and subtractable (or rivalrous) in consumption. Individuals in the conventional marketplace possess choices with respect to the kind and quality of private goods consumed. Information regarding quantity and quality is comparatively easy to measure and assess, while price and allocation decisions are determined primarily by market mechanisms.

Shana M. Starobin

Further reading

Ostrom 1990; Ostrom & Ostrom 1978.

See also: Goods, Public goods, Common pool resources.

References

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Ostrom, V. & Ostrom, E. 1978. "Public goods and public choices," pp. 7–49 in Alternatives for Delivering Public Services: Toward Improved Performance. E.S. Savas, ed. Boulder, CO: Westview Press.

Private property

A social and legal construct that establishes the right for a natural or non-governmental legal person to exclude the use and usufruct of a produced good, land, or other natural resource from others via property rights. Private property rights can be applied on non-physical goods such as information (that is, intellectual property). Contrary to private property is public property, which is owned by the state. In economics, a free market economy requires private property on final products as well as on manufactured capital, but not necessarily on natural resources, in order to achieve allocative efficiency (Fuders & Pastén 2020).

Felix Fuders

Further reading

Demsetz 1967; Stevenson 1991; Daly & Farley 2011.

See also: Property right, Public goods, Manufactured capital, Natural capital, Resources, Common property resources.

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Privatization

a. The selling or transfer of government-controlled or state-owned assets to the private sector.
b. Deregulation of heavily regulated private companies or industries. Economists often argue that privatization leads to increased economic efficiency.

Barry D. Solomon

Further reading

Vickers & Yarrow 1991.

See also: Private property, Private goods, Regulation.

Reference

Vickers, J. & Yarrow, G. 1991. Economic perspectives on privatization. Journal of Economic Perspectives 5(2): 111–32.

Procedural rationality

An emphasis on the rationality of the processes of decision-making, rather than the rationality of the outcome itself. Initiated by the work of Herbert Simon (1976), it is derived from the premise that the environment is complex and uncertain, and our computational capabilities limited; thus, arriving at a "rational" decision (in the sense of a truly optimal choice) is not possible. Given irreducible uncertainty and cognitive limitations, the processes by which policies are designed assume importance; this constitutes the rationale of ecological economics, which favors approaches based on processes and procedures conducive to drawing on different kinds of information (the preferences, values,

knowledge, and interests of different stakeholders) when making a political decision.

In addition to the implausibility of the omniscient agent assumption, procedural rationality argues in favor of deliberative decision-making mechanisms on the grounds that public reasoning through mutual understanding is a precondition for a healthy public sphere, where multidimensional interdependences at the economics–environment nexus can properly be managed.

FIKRET ADAMAN & PAT DEVINE

Further reading

Akbulut & Adaman 2020; Faucheux & Froger 1995; O'Connor et al. 1996; Özkaynak et al. 2012.

See also: Rationality, Bounded rationality, Deliberative democracy, Deliberative ecological economics, Uncertainty.

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Producer surplus

a. The additional benefits that producers (the owners and product providers) obtain when the price at which the producers would supply the product is lower than the market price.

b. The difference between the amount obtained in a market transaction and the minimum amount the producer is willing to accept.

Producer surplus is usually expressed by referring to a graph, though it can be expressed mathematically (Henderson & Quandt 1980). The supply curve represents the combination of prices and level of a = output the producer is willing to supply. The area below the market price line and above the supply curve indicates producer surplus. The concept is that there is a minimum total payment a manufacturer will accept, and anything above that is producer surplus.

In general, when other factors remain constant, an increase in the market price will increase producer surplus. Likewise, if a producer enjoys conditions such that their supply price or marginal cost decreases and nothing else changes, their producer surplus will increase. Alternatively, if demand suddenly falls and there are unsold goods such that producers can only sell some of the goods at lower market prices, then producer surplus will fall. The sum of the producer surplus of all manufacturers in a specific market equals the producer surplus of that entire market.

TERESA GHILARDUCCI

Further reading

Boulding 1945.

See also: Willingness to pay (WTP), Willingness to accept (WTA), Transaction prices, Consumer surplus.

References

Boulding, K.E. 1945. The concept of economic surplus. American Economic Review 35(5): 851–69.

Henderson, J.M. & Quandt, R.E. 1980. Microeconomic Theory: A Mathematical Approach, 3rd edn. New York: McGraw-Hill.

Production function

A formal specification of the relationship between output and inputs in an economic production process. In the conventional conception, the output comprises a conven-

tional good or service and the inputs consist of capital and labor. One of the most-used forms, though much criticized, is the Cobb–Douglas production function. Incorporating ideas from natural resource and environmental economics allowed for wastes as a joint product with produced output, and for resource inputs distinct from capital and labor, consistent with a broader ecological economics perspective (Mäler 1992).

The production function concept views production essentially as a linear throughput process, whereas ecological economics thinking sees this as circular and involving feedback mechanisms and an understanding of thermodynamics (Georgescu-Roegen 1971). Knowledge of the production function is useful for valuing environmental inputs used in production (Barbier 2007; Lynne et al. 1981). However, the correct formulation depends on whether the produced output is marketed or not. More recent extensions consider the concept of an ecological production function, where outputs are ecological goods and services and inputs are ecological services (Faber et al. 2021).

DUNCAN J. KNOWLER

Further reading

Barbier 2000; Barbier et al. 2021.

See also: Microeconomics, Cobb–Douglas production function, Throughput, Non-market value, Environmental goods and services, Ecosystem services.

References

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Productivity

The amount of output produced by a system per unit of input, per unit of time.

Ecology:

a. Primary productivity is the rate of biomass produced per unit area/volume by photoautotrophic (producer) organisms, such as plants. Primary productivity can be expressed as grams of dry organic matter, per square meter, per day.
b. Secondary productivity is the generation of biomass by heterotrophic (consumer) organisms, such as animals.

Neoclassical economics: productivity most commonly refers to "labor productivity" or "total factor productivity." Labor productivity is economic output per unit of labor. It is usually expressed as gross domestic product (GDP) in monetary terms (for example, dollars) per hour worked, per year. Total factor productivity is closely related to neoclassical production function theory and therefore typically explains economic output in terms of a weighted average of various factors of production (such as labor and capital).

Ecological economics: ecological economists also commonly refer to labor productivity and sometimes refer to total factor productivity. However, compared to conventional economists, ecological economists have more of a focus on the role of biophysical inputs (such as energy). Compared to conventional

economists, who typically treat productivity as a technical parameter of the economy, ecological economists are more likely to analyze the political context of productivity. Amongst ecological economists there are substantive debates around the role and desirability of productivity growth in terms of delivering well-being and environmental sustainability. This is particularly the case in post-growth and degrowth literatures.

Simon Mair

Further reading

Foster 2016; Isham et al. 2021; Jackson 2019; Keen et al. 2019; Solow 1957; Begon et al. 2014.

See also: Production function, Cobb–Douglas production function, Joint production, Net primary production (NPP), Degrowth, Post-growth, Energy, Capital, Labor theory of value.

References

Begon, M., Howarth, R.W. & Townsend, C.R. 2014. Essentials of Ecology. New York: Wiley.
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Isham, A., Mair, S. & Jackson, T. 2021. Worker wellbeing and productivity in advanced economies: re-examining the link. Ecological Economics 184: 106989.
Jackson, T. 2019. The post-growth challenge: secular stagnation, inequality and the limits to growth. Ecological Economics 156: 236–46.
Keen, S., Ayres, R. & Standish, R. 2019. A note on the role of energy in production. Ecological Economics 157: 40–46.
Solow, R. 1957. Technical change and the aggregate production function. Review of Economics and Statistics 39(3): 312–20.

Pro-environmental behavior (PEB)

a. Conduct and actions that directly or indirectly benefit or minimize harm to the natural environment, regardless of intention (Stern 2000). PEB includes behaviors that can reduce land, water, and air pollution, protect habitat and ecosystems, and mitigate climate change. Focusing on the consequences that behavior has on the environment is useful when researchers seek to identify and target impactful behaviors, which could result from a range of motivations (for example, people might take transit for convenience, not environmental motives).
b. Behavior that is undertaken with the goal of minimizing harm to or benefiting the environment, irrespective of its actual effects (Stern 2000). Defining PEB in terms of intention is useful for researchers interested in the processes that motivate people to help the environment, and when the actual effects of behaviors are unknown. PEB can be divided into two general types (Stern 2000): private sphere PEB and public sphere PEB. Private sphere PEB includes individual lifestyle choices and consumption decisions (for example, recycling and composting, living car-free, reducing consumption of goods and energy, eating a plant-based diet). Private sphere behaviors have received the most attention in research and public discourse. However, citing the need for more systemic change, some researchers are calling for increased attention to public sphere PEB (Fielding & Hornsey 2016). Public sphere PEB consists of civic engagement and environmental activism aimed at changing social structures and environmental policies (for example, voting based on environmental issues, writing letters to politicians, signing petitions, joining environmental groups, engaging in marches and protests, civil disobedience).

Annika E. Lutz, Caroline M.L. Mackay, Jonathan A. Mendel & Michael T. Schmitt

Further reading

Lange & Dewitte 2019; Steg & Vlek 2009.

See also: Pro-social behavior, Behavioral economics.

References

Fielding, K.S. & Hornsey, M.J. 2016. A social identity analysis of climate change and envi-

ronmental attitudes and behaviors: insights and opportunities. Frontiers in Psychology 7: 121.
Lange, F. & Dewitte, S. 2019. Measuring pro-environmental behavior: review and recommendations. Journal of Environmental Psychology 63: 92–100.
Steg, L. & Vlek, C. 2009. Encouraging pro-environmental behaviour: an integrative review and research agenda. Journal of Environmental Psychology 29(3): 309–17.
Stern, P.C. 2000. Toward a coherent theory of environmentally significant behavior. Journal of Social Issues 56(3): 407–24.

Profit maximizing

A reflection of the neoclassical economics perspective of the fiduciary responsibility of the firm (Carson 1993). The concept parallels the attribute of "insatiable appetite to consume" assumed for consumers. In both cases a utilitarian perspective related to satisfaction results in an amoral focus of benefits. In utilitarianism, the benefit of the individual is independent of the costs and benefits to other parties (Koplin 1963).

The application of profit maximization to firm activities results in abiding by the letter of regulation, but not necessarily the intention. As a result, profit maximization is aligned with negative externalities. For example, if there are no regulatory limits related to pollution, or no market costs attributed to discharges into a waterway, a firm may seek to reduce waste costs by disposing of waste products into the environment. This action aligns with profit maximization but results in costs to others: the environment, other species, and people.

Profit maximization is essentially constrained by regulation, which in turn mimics prevailing social norms. As social norms change, the defining attributes of profitability are also subject to modification (for example, inclusion of corporate social responsibility, operationalized sustainability).

MADHAVI VENKATESAN

See also: Neoclassical economics, Externalities, Environmental externalities, Utilitarianism.

References

Carson, T. 1993. Friedman's theory of corporate social responsibility. Business and Professional Ethics Journal 12(1): 3–32.
Koplin, H. 1963. The profit maximization assumption. Oxford Economic Papers New Series 15(2): 130–39.

Progress

Traditionally defined by economics to indicate technological development and the production of more and/or better goods and services, thus increasing labor and non-labor factor productivity. A broader societal view of progress considers it to mean a gradual, overall improvement in the human condition; that is, societal development, equality, and human welfare.

BARRY D. SOLOMON

Further reading

Stiglitz et al. 2009, p. 149.

See also: Progress indicators, Genuine progress indicator (GPI), Progressive, Technological progress, Productivity, Human development, Total human welfare.

Reference

Stiglitz, J.E., Sen, A. & Fitoussi, J.P. 2009. Report of the Commission on the Measurement of Economic Performance and Social Progress (CMEPSP), Paris. Available at http://www.stiglitz-sen-fitoussi.fr/en/documents.htm.

Progress indicators

Metrics that have been developed to determine real well-being in a society, largely based on dissatisfaction with gross domestic product (GDP) or gross national product (GNP) as inappropriate measures of economic welfare. These include: income and wealth equality; Human Development Index (HDI); genuine progress indicator (GPI); measure of economic welfare (MEW); index of sustainable economic welfare (ISEW); gross national well-being (GNW); OECD Better Life Index;

Happy Planet Index; and the Gross National Happiness Index (GNH) of Bhutan. These metrics, to widely varying degrees, incorporate environmental and social as well as economic costs and benefits of economic production. While usually calculated at the national level, progress indicators have also been estimated for smaller geographic areas.

BARRY D. SOLOMON

Further reading

Costanza et al. 2009.

See also: Progress, Genuine progress indicator (GPI), Human Development Index (HDI), Index of sustainable economic welfare (ISEW), Gross domestic product (GDP), Gross national product (GNP), Economic inequality.

Reference

Costanza, R., Hart, M., Talberth, J. & Posner, S. 2009. Beyond GDP: the need for new measures of progress. Pardee Paper No. 4, Boston, MA: Pardee Center for the Study of the Longer-Range Future.

Progressive

a. A tax system based on the taxpayer's ability to pay, with higher marginal tax rates on people with higher taxable incomes. A regressive tax system is the opposite, with a lower marginal tax rate on people with higher taxable incomes.
b. Progressive economics is a political and economic philosophy that challenges the laissez-faire and free market approach to economic policy, supporting a higher degree of government intervention in the economy to improve social justice and social welfare. Economic policies favored by progressives include higher taxes on large corporations, greater enforcement of antitrust laws, income redistribution aimed at reducing economic inequality, universal health care, increased access to public education, greater support for collective bargaining and workers' rights, an increased minimum wage rate, and significant action on climate change, among others. Progressive economic policies are strongest in Europe.

BARRY D. SOLOMON

Further reading

Young 1990; Sherman et al. 2008.

See also: Progress, Progress indicators, Genuine progress indicator (GPI), Free market, Laissez-faire economics, Economic inequality, Heterodox economics.

References

Sherman, H.J., Hunt, E.K., Nesiba, R.F. et al. 2008. Economics: An Introduction to Traditional and Progressive Views, 7th edn. Armonk, NY: M.E. Sharpe.

Young, H.P. 1990. Progressive taxation and equal sacrifice. American Economic Review 80(1): 253–66.

Property regimes

Land or environmental resource systems of ownership and possession, entailing rights and responsibilities, rules of transfer and dispossession between individuals, states, or groups with respect to land or other environmental resources. The discussion of property regimes is usually limited to "private" and "public," but there are also "common," "open range," and other property regimes. An imprecise designation of property regimes could create serious ecological damage because such mischaracterization becomes the source of controversial environmental economics, policy, and politics. For instance, the dichotomous treatment of property regimes into "private" or "common" has created confusion and analytical errors, as has the thinking that common property means "open range" property regimes or land with unregulated/open access, leading to much debate about the so-called "tragedy of the commons." Common property has, in practice, been effective in nourishing the environment, while private property, often presumed to be a superior property regime, has often led to much more destructive uses. There could be granular differences within and between property regimes. Distinctions that could make a difference to ecological

outcomes include whether common property is based on principles of "equal" or "joint" rights.

Analysis of property regimes usually involves some considerations about the state, market, and community in shaping nature, economy, and society, but these need not be considered in isolation. Even private property regimes rely on state guarantees or community recognition for security of use, possession, or ownership. Property regimes evolve over time, from internal processes of change, or external pressures, or a combination of forces. For this reason, while property regimes are usually said to establish property relations or even social relations, they are perhaps more accurately reflections of socio-ecological (property) relations.

Franklin Obeng-Odoom

Further reading

Bromley 1991; Hardin 1968; Obeng-Odoom 2021.

See also: Commons, the, Tragedy of the commons, Common property regimes, Private property, Property right, Open access, Open access regimes.

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Bromley, D.W. 1991. Environment and Economy: Property Rights and Public Policy. Oxford: Blackwell.

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Obeng-Odoom, F. 2021. The Commons in an Age of Uncertainty: Decolonizing Nature, Economy, and Environment. Toronto: University of Toronto Press.

Property right

a. A set of relationships involving an owner, the thing owned, and others. The relationships establish the nature and extent of ownership. Examples, referred to as the "sticks in a bundle" of property rights, include (from Honoré 1961) an owner's right to use, consume, modify, generate income, destroy, remove, and bequest the thing owned, and to exclude others from the same. The presence and extent of each right depends on its original justification (including, from Becker 1977, first occupancy, added labor, utility, liberty, virtue), existing law and social conditions, tradition, the nature of the thing owned, and ease of enforceability. Property rights place duties on others to act in ways that implement the rights. Property rights sometimes place duties on the owner to provide access and/or use rights to others, including rights of way, easements, viewsheds, and use rights to water. Weak property rights take the form of government-issued permits or licenses.

b. (From Bromley 1992) a claim to a benefit stream that some higher body—usually the state—will agree to protect through the assignment of duty to others who may covet, or somehow interfere with, the benefit stream.

Brent M. Haddad

Further reading

Hohfeld 1913.

See also: Public trust doctrine, Property regimes, Property systems.

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Bromley, D. 1992. The commons, common property, and environmental policy. Environmental and Resource Economics 2: 1–17.

Hohfeld, W.N. 1913. Some fundamental legal conceptions as applied in legal reasoning. Yale Law Review 23(1): 16–59.

Honoré, A. 1961. "Ownership," pp. 107–47 in Oxford Essays in Jurisprudence: A Collaborative Work. A.M. Guest, ed. London: Oxford University Press.

Property systems

The set of laws and practices that facilitate ownership. The systems include defining what is owned, the privileges and duties of ownership, how ownership is enforced, how transfers of ownership occur, and how disputes are settled. Property systems overlap with economic systems, such as markets, in the transfer of property; administrative

systems in the implementation of ownership; legal systems for enforcement and dispute resolution; and social systems for traditional practices surrounding use, extent of rights, and property disputes. Property systems influence both procedures and outcomes of ownership in terms of social equity, environmental impacts, and human health and longevity.

BRENT M. HADDAD

Further reading

Hohfeld 1913; Honoré 1961; Becker 1977; Bromley 1992.

See also: Property regimes, Property right, Commons, the.

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Becker, L. 1977. Property Rights: Philosophic Foundations. New York: Routledge & Kegan Paul.

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Pro-social behavior

The intention to benefit other individuals, the community, or society at large. Examples include donation, cooperation, altruistic behavior, reciprocity, inequity aversion, fairness, trust, adherence to social norms, empathy, truth-telling, helping, gift-giving, sharing, voting, participation in political and social movements, and protection of the environment. Pro-social behavior contrasts with purely self-interested behavior, which implies that individual decisions are made solely based on a private cost–benefit calculation, while pro-social behavior considers others' benefits as well. Adoption of pro-social behavior by a certain fraction of individuals in a community can increase average well-being (Bowles & Gintis 1998) and lead to improved outcomes in collective action dilemmas such as overexploitation of natural resources, climate change, and biodiversity loss.

PINAR ERTÖR-AKYAZI

Further reading

Bowles & Gintis 2002; Fehr et al. 2002.

See also: Pro-environmental behavior (PEB), Norms, Preference formation, Preference heterogeneity, Subjective preferences.

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Fehr, E., Fischbacher, U. & Gächter, S. 2002. Strong reciprocity, human cooperation, and the enforcement of social norms. Human Nature 13(1): 1–25.

Prospect theory

Introduced by psychologists Daniel Kahneman and Amos Tversky (1979), a descriptive model of decision-making under risk. It is based on the observation of pervasive effects (bias) in decision-making that are inconsistent with expected utility theory. In fact, individuals tend to underweight probable outcomes in comparison with more certain outcomes (the certainty effect). This bias leads to risk aversion in decisions involving sure gains and to risk-seeking in decisions involving sure losses. Furthermore, individuals are affected by the isolation effect; that is, they discard elements that are shared by all prospects under consideration. This further bias leads to inconsistent preferences when the same choice is presented differently. Decision weights may also be affected by other biases, such as ambiguity or vagueness and loss-aversion, that is, the pain of losing is stronger than the pleasure of gaining.

Further developments of prospect theory have been focused on the role of values that rule the assessment of gains and losses and the weighting of uncertain effects. Tversky and Kahneman (1992) presented a modified version of their model that employed

cumulative rather than separable decision weights (cumulative prospect theory). In economics, prospect theory has been applied to finance and insurance, consumption choice, and contract theory; it has been adopted to estimate the underweighting of opportunity costs, failure to ignore sunk costs, and regret. Prospect theory opened the fields of behavioral economics and experimental economics.

GIANDOMENICA BECCHIO

Further reading

Davis & Holt 2021; Thaler 2015.

See also: Rationality, Rational behavior, Rational choice, Risk, Uncertainty, Expected utility theory (EUT), Behavioral economics, Experimental economics.

References

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Thaler, R.H. 2015. Misbehaving: The Making of Behavioral Economics. New York: W.W. Norton & Company.

Tversky, A. & Kahneman, D. 1992. Advances in prospect theory: cumulative representation of uncertainty. Journal of Risk and Uncertainty 5: 297–323.

Prosperity

The lasting condition of thriving or flourishing within the limits of the planet without compromising the flourishing of other beings. In its sustainable form, prosperity takes account of our responsibilities to others. It requires material sufficiency as well as social and psychological well-being, rather than material abundance and monetary wealth (Jackson 2017). It must be disentangled from economic growth. As a cultural concept, it can have different meanings between and within cultures. Realizing such an understanding of prosperity may require the creation of a new framework of thought (Sardar 2008).

ANASTASIA LOUKIANOV

See also: Sufficiency, Well-being economy, Decoupling economic growth, Happiness, Buen vivir.

References

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Sardar, Z. 2008. Prosperity: a transmodern analysis. Think-piece for the SDC Seminar Visions of Prosperity. London: Sustainable Development Commission.

Protected areas

See: Conservation areas.

See also: Marine protected areas (MPAs).

Provisioning services

The material benefits provided to people from ecosystems, which are technically products. These include food, freshwater, biotic and abiotic renewable energy sources, raw materials, genetic resources, medicinal resources, and ornamental resources. Many, but not all, provisioning services are traded in markets (Haines-Young & Potschin-Young 2018).

BARRY D. SOLOMON

See also: Ecosystem services, Agricultural ecosystem services, Biotic resources, Abiotic resources, Genetic resources, Renewable energy.

Reference

Haines-Young, R. & Potschin-Young, M.B., 2018. Revision of the Common International Classification of Ecosystem Services (CICES V5.1): a policy brief. One Ecosystem 3: e27108.

Public goods

Economics: a good (or service) that has the dual properties of non-rivalry and non-excludability. Paul Samuelson is attributed with the first use of the concept, though his name for it was “collective consumption

good" (Samuelsson 1954). Thus, sometimes these goods are also called collective goods or social goods. Samuelson specified the publicness of the good by placing the entire good in the utility functions of all in a relevant group. Over time, adjectives such as pure, mixed, and congested were applied to the concept. "Pure" implies that all in a relevant group consume all the good (for example, national defense); "mixed" allows consumers to use part of the good privately while access remains public (for example, public education); and "congested" involves a capacity constraint by which potential consumers cannot gain access to the good (for example, a crowded public highway). A "free-rider" problem in funding non-excludable public goods outside of government is the possibility of individuals getting the good at no cost.

Ecological economics: ecological economists put a stronger emphasis on goods and services supplied by the natural environment (e.g., Swallow et al. 2018). Elements such as air, wild species, water, natural cycles, and climate are generally available for all to "consume." The preservation of this natural capital is thought to promote sustainability for humans and other species, subject to the laws of thermodynamics.

Civil society: a public good refers to the welfare of a group of citizens.

John A. Sorrentino

Further reading

Buchanan 1968; Grant & Langpap 2019.

See also: Non-rival resources, Non-excludable resource, Congestible public good, Market failure, Free rider, Environmental goods and services, Ecosystem services.

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Buchanan, J.M. 1968. The Demand and Supply of Public Goods. Chicago, IL: Rand-McNally.

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Samuelson, P.A. 1954. The pure theory of public expenditure. Review of Economics and Statistics 36(4): 387–89.

Swallow, S.K., Anderson, C.M. & Uchida, E. 2018. The bobolink project: selling public goods from ecosystem services using provision point mechanisms. Ecological Economics 143: 236–52.

Public health

The discipline and field of endeavor concerned with protecting, preserving, and promoting the health of people living now and in the future (Hanlon et al. 2012). The origins of organized public health lie in 19th-century urbanization and industrialization, with early efforts to control infectious diseases through the improvement of social conditions. Winslow's 1920 definition of public health remains widely accepted: "the science and art of preventing disease, prolonging life, and promoting health and efficiency through organized community effort" (Winslow 1920).

Public health is distinguished by its focus on the health of whole populations, as distinct from the focus of clinical health care on individual patients (Baum 2016). From its early concern with infectious diseases, public health has evolved to reflect changing risks from environmental factors, non-communicable diseases, health inequalities, and the social and commercial determinants of health (Baum 2016).

Public health research, practice, and policy increasingly recognize the profound importance of ecological determinants of and risks to health, including anthropogenic climate change (Hanlon et al. 2012), with a widening focus on the interconnectedness of human, animal, ecosystem, and planetary health (Hensher 2020).

Martin C. Hensher

See also: Human health, Planetary health, One health, Environmental health.

References

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Hanlon, P., Carlisle, S., Hannah, M. & Lyon, A. 2012. The Future Public Health. Maidenhead: Open University Press.

Hensher, M. 2020. "Human health and ecological economics," pp. 188–208 in Sustainable Wellbeing Futures: A Research and Action Agenda for Ecological Economics. R. Costanza, J.D. Erickson, J. Farley & I. Kubiszewski, eds.

Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.
Winslow, C.E.A. 1920. The untilled field of public health. Science 51(1306): 23–33.

Public–private partnerships

The long-term cooperative activities between the public and private actors to deliver public services and infrastructure (that is, buildings, water and sewerage systems, schools, hospitals, and so on) while sharing risks, costs, and resources (Khanom 2010). It is a tool of governance or management that involves either interorganizational or financial arrangements between corporations and governments.

SHAN ZHOU

See also: Governance, Adaptive governance, Local governance, Water governance.

Reference

Khanom, N.A. 2010. Conceptual issues in defining public–private partnerships (PPPs). International Review of Business Research Papers 6(2): 150–63.

Public trust doctrine

A requirement that the sovereign or state holds in trust designated resources for the people's benefit. The doctrine dates to Roman civil law and historically was codified in the Institutes of Justinian, which assured the citizens of Rome that:

> The following things are by natural law common to all—the air, running water, the sea, and consequently the seashore. No one therefore is forbidden access to the seashore, provided he abstains from injury to houses, monuments, and buildings generally; for these are not, like the sea itself, subject to the law of nations. (Moyle 1913, p. 35)

As applied through English common law and incorporated into United States common law, the public trust doctrine provides that navigable waters and the lands submerged by them are held in trust for the people's benefit, and establishes the public's right to enjoy fully public trust lands and waters for a wide variety of recognized public uses. The doctrine is not fixed or static, and is extended to meet changing conditions and public needs.

As societies advance, the list of assets that should belong to the people in common because the assets were inherited or created together, and therefore should be preserved in the common interest, has expanded to include: natural assets, for example undisturbed habitats, ecosystems, biological diversity, waste absorption capacity, nutrient cycling, flood control, pollination, raw materials, fresh water replenishment systems, soil formation systems, and the global atmosphere; and social assets such as the Internet, legal and political systems, universities, libraries, accounting procedures, science and technology, transportation infrastructure, the radio spectrum, city parks, and so on.

GARY FLOMENHOFT

Further reading

Sax 1970, 1980; Rose 1998.

See also: Common law, Common property resources, Commons, the.

References

Moyle, J.B. 1913. The Institutes of Justinian, 5th edn. Oxford: Clarendon Press.
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Punctuated equilibrium theory

A theory in evolutionary biology proposed by paleontologists Niles Eldredge and Stephen Jay Gould (1972) that suggests that biological species show little morphological change over their geological history once they appear

in the fossil record; rather than the steady and slow transformation presupposed by phyletic gradualism. For Eldredge and Gould, the degree of continuous change conventionally attributed to Darwin's theory of evolution could not actually be found in the fossil record; instead, stasis prevailed over the history of most species, rarely interrupted by punctuational change (Rhodes 1987). Under such a view, evolution is to be characterized by long periods of stability and stagnation in the morphology of a species, disrupted by short periods of rapid change during which new forms appear and bursts of speciation occur (Venditti & Pagel 2008).

ORIOL VALLÈS CODINA

See also: Darwinian theory, Evolutionary analysis, Fitness.

References

Eldredge, N. & Gould, S.J. 1972. "Punctuated equilibria: an alternative to phyletic gradualism," pp. 82–115 in Models in Paleobiology. T.J.M. Schopf, ed. San Francisco, CA: TJM Freeman, Cooper & Co.

Rhodes, F.H. 1987. Darwinian gradualism and its limits: the development of Darwin's views on the rate and pattern of evolutionary change. Journal of the History of Biology 20(2): 139–57.

Venditti, C. & Pagel, M. 2008. Speciation and bursts of evolution. Evolution: Education and Outreach 1(3): 274–80.

Purchasing power parity (PPP)

A theory which proposes that the nominal exchange rate between the currencies of two countries should be equal to the ratio of the aggregate price levels between the same two countries. While the theory goes back several centuries, the specific terminology was introduced by the Swedish economist Karl Gustav Cassel right after World War I (Cassel 1918). If this adjustment to exchange rates is not made, the purchasing power of the currencies in different countries will vary abroad. Based on PPP theory, the price of one good—for example, a McDonald's Big Mac hamburger—can be compared in different countries at the current exchange rate to determine whether a foreign currency is undervalued or overvalued relative to the United States dollar (Taylor & Taylor 2004).

In practice, PPP generally differs from existing exchange rates, especially due to lower prices for non-traded goods in developing countries, meaning that living standards in those countries will be underestimated based on current exchange rates, and a PPP adjustment is required.

BARRY D. SOLOMON & JONATHAN M. HARRIS

See also: Money, Monetary policy, Comparative advantage.

References

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Taylor, A.M. & Taylor, M.P. 2004. The purchasing power parity debate. Journal of Economic Perspectives 18 (4): 135–58.

Pure rate of time preference

The rate at which a person, firm, or government agency prefers goods and services in the present time over the future, independently of considerations of the productivity of alternative investments (the marginal opportunity cost or rate of return to investment capital) (Feldstein 1964). While the pure rate of time preference accounts for natural human impatience, the concept is contested and some scholars argue against using it in some contexts (or declining the value over time), such as a basis for the social discount rate in climate change and biodiversity policy where discounting weighs future generations lower than the present, despite the fact that the effects of climate change increasingly worsen over time (Cline 1992; Fearnside 2002; Spash 2002; Manne 1995; Fujii & Karp 2008; Anthoff et al. 2009).

BARRY D. SOLOMON

See also: Discounting, Social discount rate, Benefit–cost analysis (BCA), Net present value (NPV), Overlapping generations model.

References

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Feldstein, M.S. 1964. The social time preference discount rate in cost–benefit analysis. Economic Journal 74(294): 360–79.

Fujii, T. & Karp, L. 2008. Numerical analysis of non-constant pure rate of time preference: a model of climate policy. Journal of Environmental Economics and Management 56(1): 83–101.

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Spash, C.L. 2002. Greenhouse Economics: Values and Ethics. London: Routledge.

Q

Qualitative research

Compound noun. A form of empirical inquiry that uses non-numerical data and methods of analysis to answer research questions. Employed in a variety of social science disciplines without a unifying theory or practice. Qualitative research methods often emphasize interpretivism, context, participants' meanings, and researcher positionality. Examples include focus groups, interviews, participant observation, ethnography, content analysis, narrative analysis, and case studies. Qualitative research methods originated in anthropology, clinical psychology, and sociology.

Caitlin B. Morgan

Further reading

Aspers & Corte 2019; Corbin & Strauss 2008; Emerson et al. 2011; Guest et al. 2013; Merriam 2019; Ritchie et al. 2013.

See also: Quantitative analysis, Discourse analysis, Narrative, Induction.

References

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Merriam, S.B. 2019. "Introduction to qualitative research," pp. 3–18 in Qualitative Research in Practice: Examples for Discussion and Analysis, 2nd edn. S.B. Merriam & R.S. Grenier, eds. San Francisco, CA: Jossey-Bass.

Ritchie, J., Lewis, J., McNaughton Nicholls, C. & Ormston, R. 2013. Qualitative Research Practice: A Guide for Social Science Students and Researchers, 2nd edn. Los Angeles, CA: SAGE.

Quality of life (QoL)

a. Subjective meaning: the extent to which people are satisfied with their lives or with various aspects of their lives that are relevant to their overall satisfaction. Related to subjective well-being (SWB), life-satisfaction, fulfillment, happiness, welfare, utility. Measured directly by asking people to self-report their level of satisfaction. Inter-city QoL rankings—which emphasize local determinants of subjective QoL (that is, amenities) rather than subjective QoL itself—are typically obtained by using market data and hedonic pricing methods, but they then rely on the neoclassical assumption that people are compensated in local housing and labor markets for differences that affect their QoL.
b. Objective meaning: the extent to which human needs are fulfilled from an objective perspective. Related to human well-being and human development. Assessment is based on lists of human needs (or QoL dimensions) and the measurement of personal resources (for example, income), human functionings (for example, health conditions), and/or capabilities (for example, capability to move in the public space, see Sen 1993) that enable them to be met. These measures are usually combined into a composite indicator.
c. Integrative meaning: "the extent to which human needs are fulfilled in relation to

personal or group perceptions of subjective well-being" (Costanza et al. 2007, p. 269). This definition, developed by ecological economists, articulates objective and subjective assessments of the degree of satisfaction of human needs in several life domains, and subjective assessments of the importance of each domain for overall SWB.

YVES SCHAEFFER

Further reading

Ahmadiani & Ferreira 2019; Biagi et al. 2018; Maddison et al. 2020; Nussbaum & Sen 1993.

See also: Subjective well-being, Life satisfaction, Happiness, Welfare, Utility, Human development, Amenity, Hedonic pricing method.

References

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Biagi, B., Ladu, M.G. & Meleddu, M. 2018. Urban quality of life and capabilities: an experimental study. Ecological Economics 150: 137–52.

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Maddison, D., Rehdanz, K. & Welsch, H., eds. 2020. Handbook on Wellbeing, Happiness and the Environment. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Nussbaum, M.C. & Sen, A., eds. 1993. The Quality of Life. Oxford: Clarendon Press.

Sen, A.K. 1993. "Capability and well-being," pp. 30–53 in The Quality of Life. M. Nussbaum & A. Sen, eds. Oxford: Clarendon Press.

Quantitative analysis

Any of a large range of research techniques that use mathematical and/or statistical measurement, modeling, and analysis.

BARRY D. SOLOMON

See also: Models and modeling, Econometrics, Multivariate statistical techniques, Complex systems modeling, Dynamic models, System dynamics models, Bioeconomic modeling, Spatial modeling, Systems-oriented simulation models, Agent-based modeling (ABM).

Quasi-option value

The benefit that can be achieved by gaining an improved understanding of uncertain and irreversible future outcomes. It is the value of information that can achieved by postponing a decision. It was first developed as a concept by Arrow and Fisher (1974) in the context of decision-making where a development option will have an environmental impact that is uncertain and irreversible. Quasi-option value considers the prospect of a delay in making a decision being able to allow for an improvement in knowledge regarding the environmental outcome. The inclusion of a quasi-option value in a benefit–cost analysis does not necessarily require the decision to be delayed, but does require recognition of the prospect of a delay that would enable more and improved information to be gathered.

JEFF W. BENNETT

Further reading

Conrad 1980.

See also: Option value, Uncertainty, Irreversibility, Precautionary principle, Benefit–cost analysis (BCA).

References

Arrow, K. & Fisher, A. 1974. Environmental preservation uncertainty and irreversibility. Quarterly Journal of Economics 88(2): 312–19.

Conrad, J. 1980. Quasi option value and the expected value of information. Quarterly Journal of Economics 94(4): 813–20.

R

Race to the bottom

A theory that predicts state behavior in the context of regulatory competition. The term itself has been traced back to United States Supreme Court Justice Louis Brandeis, who in 1933 in a dissenting opinion on *Liggett Co. v. Lee* claimed that as states competed to establish attractive rules for company incorporation "the race was one not of diligence but of laxity." Under the condition of interstate or international competition, governments have incentives to adopt increasingly weak regulatory standards to attract foreign businesses (Porter 1999).

Strategic governments relax their regulatory frameworks to gain a competitive advantage over other states. If all governments behave accordingly, state behavior triggers an undercutting competition that continues until the regulatory level of the least stringent state is achieved. In essence, the "race to the bottom" theory argues that regulatory competition produces market failures that result in suboptimal policy outcomes. Cooperation and collective decision-making provide opportunities to overcome situations of undercutting regulatory competition and to agree upon common regulatory frameworks for the benefit of the public good.

THOMAS DIETZ

Further reading

Revesz 1992; Konisky 2007.

See also: Regulation, Governance, Market failure.

References

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Revesz, R.L. 1992. Rehabilitating interstate competition: rethinking the "race-to-the-bottom" rationale for federal environmental regulation. NYU Law Review 67: 1210–54.

Radical ecological economics

An examination of the relationship between society and the planet from the perspective of communities. Radical ecological economics (REE) offers an alternative to the dominant, market-based analytical approach and goes further than the critical school of ecological economics that identifies thousands of struggles worldwide for environmental justice against the inroads of global capitalism. Instead, it focuses on the way communities organize themselves to develop autonomous governance structures and productive systems to attend to their basic needs while caring for their territories. It identifies ways in which peoples are explicitly organizing to build convivial societies in the face of external forces that threaten their integrity and control their resources to advance the global process of capital accumulation.

By incorporating alternative cosmogonies into the analysis, REE examines the ways in which different value systems affect people's behavior and their relationships to nature. These worldviews explicitly accord substantial importance to the collective processes that permit individuals the realization of their potential and their uniqueness when given the opportunity to contribute to the community's well-being. REE differs from other approaches by formulating strategies that communities implement to minimize their impact on their territories, creating a balanced social metabolism. It identifies the "commu-

nitarian subjects" engaged in ambitious projects to thrive on the margins of the dominant international systems, asserting their autonomy for self-government, while developing local alliances, and international networks for mutual support. This involves a deliberate consideration of the metabolic process from appropriation to excretion (involving production, distribution, and consumption) to minimize the deleterious effects.

David P. Barkin

Further reading

Barkin et al. 2012; Barkin et al. 2020; Barkin & Sánchez 2020.

See also: Ecological economics, Autonomous institution, Bottom-up approaches, Social metabolism, Societal transformation.

References

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Barkin, D., Ortega, M.F., Saldaña Guillen, M. et al. 2020. Construyendo una economía ecológica radical para la autonomía local. Polis 19(56): 72–86.

Barkin, D. & Sánchez, A. 2020. The communitarian revolutionary subject: new forms of social transformation. Third World Quarterly 41(8): 1421–41.

Rational behavior

a. Individual behavior that satisfies several internally consistent axioms (for example, transitivity, completeness, independence).
b. Going back to Paul Samuelson's (1938) revealed preference theory, individual behavior that aims at maximization of (expected) utility, where utility is defined in terms of self-interested preferences. Preferences are assumed to be complete, fully formed, and independent. Also called the *Homo economicus* model. Formalized by von Neumann and Morgenstern (1944).
c. In the context of collective action, game theory, and social choice, behavior that leads to a Pareto-optimal allocation of resources. Social dilemmas arise when individually rational behavior (b) leads to collectively irrational outcomes.

Bartosz Bartkowski

Further reading

Herfeld 2020; Sen 1977; Simon 1955.

See also: Bounded rationality, *Homo economicus*, Collective action, Consumer sovereignty, Game theory, Rational choice, Individual choice, Collective choice, Pareto optimality, Expected utility theory (EUT).

References

Herfeld, C. 2020. The diversity of rational choice theory: a review note. Topoi 39(2): 329–47.

Samuelson, P.A. 1938. A note on the pure theory of consumer's behaviour. Economica 5(17): 61–71.

Sen, A. 1977. Rational fools: a critique of the behavioural foundations of economic theory. Philosophy and Public Affairs 6(4): 317–44.

Simon, H.A. 1955. A behavioral model of rational choice. Quarterly Journal of Economics 69(1): 99–118.

von Neumann, J. & Morgenstern, O. 1944. Theory of Games and Economic Behavior. Princeton, NJ: Princeton University Press.

Rational choice

A way of describing human behavior. The origin of rational choice theory within economics is rooted in the marginalist revolution in the late 19th century and was introduced by classical economists such as William Stanley Jevons (1871), but it was systematized in the 1930s by Lionel Robbins (1932) and in the 1960s–1970s by the economists of the Chicago School, such as Gary Becker (1981). It assumes that, given the available information, human beings are rational agents, able to maximize their expected utility function by making their choice that results in outcomes lined up with their own self-interest.

From a technical point of view, rational choice theory assumes that human preferences may be ranked, as they are based on four axioms: completeness, transitivity, continuity, and non-satiation, according to Pareto's definition of preferences (Pareto

1971). It implies that the final benchmark of any individual and social choice is efficiency: when economic agents are driven by self-interest and make rational choices, society performs better. It is adopted by neoclassical economics to describe individual choice and social phenomena under the condition of scarcity of means and given ends. It has become increasingly employed in other social sciences to explain social phenomena such as elections, legislation, and interest groups. Many heterodox economic theories criticize rational choice theory and consider it either unable or only partially able to describe individual as well as social behavior.

GIANDOMENICA BECCHIO

Further reading

Mele & Rawling 2004.

See also: Rationality, Utility, Welfare economics, Bounded rationality.

References

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Pareto, V. 1971. Manual of Political Economy. A.S. Schwier, trans. New York: A.M. Kelley.
Robbins, L. 1932. An Essay on the Nature and Significance of Economic Science. London: Macmillan.

Rationalism

See: Rationality.

See also: Rational behavior, Rational choice, Bounded rationality, Modernity.

Rationality

General: the capacity to act by following logical reasoning and knowledge, which is consistent with the structure of the human mind. In a narrow sense, it is a procedure of problem-solving that excludes any form of emotions and passions as well as instincts. In a broader sense it includes any practice that influences human behavior. The analysis of human rationality was introduced by Greek philosophers such as Plato and Aristotle, and enriched since then by scholars of any discipline. Max Weber (1978) identified four kinds of rationality: practical (an attempt to consider the best means to achieve an end); theoretical (an attempt to understand the world in terms of models); substantive (an attempt to make values consistent in the problem-solving process); and formal (a set of rules, laws, and regulations that are applied by organizations).

Economics: rationality may be intended as full, bounded, or ecological. Full rationality, adopted by neoclassical economics, presumes perfect knowledge and complete information; while bounded rationality, introduced by Herbert Simon (1957), includes descriptive, normative, and prescriptive accounts of effective behavior that reject the assumptions of full rationality. Ecological rationality considers human rationality as a form of heuristics, that is, an effect of the adaptive fit between the human mind and the environment (Gigerenzer et al. 1999).

GIANDOMENICA BECCHIO

Further reading

Kahneman & Tversky 2000.

See also: Rational choice, Bounded rationality, Prospect theory, Heuristic.

References

Gigerenzer, G., Todd, P. & ABC Research Group, eds. 1999. Ecological Rationality: Intelligence in the World. New York: Oxford University Press.
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Weber, M. 1978. Economy and Society, Vol. 1. G. Roth & C. Wittich, eds. Berkeley, CA: University of California Press.

Rawlsian ethics

In his *Theory of Justice*, John Rawls (1971, p. 109) presented a diagram of practical philosophy. Practical reasoning can take routes towards axiology, deontology, and a concept of moral worth. Deontology divides into three lines: institutions, commitments, and the law of nations. This explanation indicates that "Rawlsian ethics" would be more than Rawls's elaborated theory of justice and rests on the metaethical method of reflective equilibrium. To Rawls, all persons have moral beliefs, which must be corrected by principles stemming from ethical theories. Sometimes beliefs and principles are in accordance, sometimes they diverge, sometimes they clash. The method of reflective equilibrium is about mutual corrections in search of coherence.

Rawls's convictions stem from the Western revolutionary ideas of freedom, equality, solidarity, and the pursuit of happiness. He also believes that life prospects should not be determined by contingencies of birth. His theory of justice brings beliefs and principles into equilibrium via the device of the original position. This position is designed as a veil of ignorance by which all individual traits of persons are covered. Principles being adopted by risk-averse and mutually disinterested persons under such a veil are seen as fair. Such persons would adopt principles of freedom, equality, and solidarity. Risk-averse persons under the veil wish to avoid a horrible way of life at the worst position, within a system of cooperation. They have the incentive to opt for a principle guaranteeing a decent way of life at such position. This "principle of difference" gives a rationale in favor of a welfare state. According to Rawls, a principle of fair savings that holds within a chain of generations would also be adopted. Rawls supposes that persons under the veil are contemporaries acting as representatives of family lines. A better solution supposes that persons do not know their position within the chain of generations. If savings includes stocks of natural capital, this principle can be specified as a fair bequest package of "strong" sustainability (Ott 2014). If these four principles are fully institutionalized, a society is well ordered.

KONRAD OTT

See also: Justice, Institutions, Fair bequest package, Deontological, Welfare, Natural capital, Strong sustainability, Maximin.

References

Ott, K. 2014. Institutionalizing strong sustainability: a Rawlsian perspective. Sustainability 6(2): 894–912.

Rawls, J. 1971. A Theory of Justice. Oxford: Clarendon Press.

Real interest rate

The interest rate that an investor, lender, or saver receives after adjusting for inflation. This amount measures the compensation to lenders for the expected losses due to the time value of money, a risk component reflecting potential default and regulatory changes, while excluding the expected inflation rate. If the nominal interest rate and inflation rate are low, this can be expressed as the Fisher (1907) equation (named for economist Irving Fisher):

$$r = i - \pi$$

where r = the real interest rate, i = the nominal interest rate and π = the inflation rate.

On an economy-wide level a common index of inflation is used such as the gross national (or domestic) product implicit price deflator or the rate of change in the Consumer Price Index. For purposes of benefit–cost analysis conducted for government policy-making, a government agency commonly dictates the real interest rate to be used by analysts, which may or may not reflect a true social discount rate.

BARRY D. SOLOMON

Further reading

Common & Stagl 2005.

See also: Interest rate policy, Monetary policy, Benefit–cost analysis (BCA), Discounting, Social discount rate, Pure rate of time preference, Inflation, Risk.

References

Common, M. & Stagl, S. 2005. Ecological Economics: An Introduction. Cambridge: Cambridge University Press, pp. 300–304.

Fisher, I. 1907. The Rate of Interest. New York: Macmillan.

Realism

An epistemological position arguing that knowledge production refers to an external reality existing independently and prior to ongoing scientific investigation. Contra relativism, it advocates the position that the sciences can produce true and objective knowledge. Contra phenomenalism, it asserts that objects exist in themselves, and that reality cannot be reduced to sense-data.

The nature, elements, and properties of this objectively existing reality are conceptualized in different realist ontologies: for example, "naïve realism" reduces reality to mind-independent objects that are directly perceivable; "scientific realism" states that reality extends to unobservable entities and defends the possibility of sciences to produce knowledge about them; "flat realism" asserts that all entities of reality possess the same ontological status; and "depth realism" argues that reality has depth and its elements are characterized by hierarchies and dependencies, stratification, and emergence (as advocated by critical realism). All realist ontologies reject ontological idealism, claiming that reality is a mental construct.

ARMIN L. PULLER

Further reading

Lawson 1997; Mäki 2012; Spash 2012.

See also: Critical realism, Epistemology, Scientific method, Emergence and Emergent properties.

References

Lawson, T. 1997. Economics and Reality. London: Routledge.

Mäki, U. 2012. "Realism and antirealism about economics," pp. 3–24 in Handbook of the Philosophy of Science, Vol. 13: Philosophy of Economics. U. Mäki, ed. Amsterdam: Elsevier.

Spash, C.L. 2012. New foundations for ecological economics. Ecological Economics 77: 36–47.

Reallocation

a. A change in ownership or use-rights. Reallocation can occur through market exchange, government intervention, individual contracting, inheritance, or donation, among other methods. It can be voluntary or coerced. It can range from complete transfer of all rights to a transfer of use-rights. Often used with reference to water rights transfers. Even water conservation is a form of reallocation, because one individual uses less water so that another can consume more.
b. A transfer of spending from one purpose to another, often in the context of government budgets.

BRENT M. HADDAD

Further reading

Garrick et al. 2009; Llop 2013.

See also: Allocation, Resource allocation, Ownership, Market, Property right, Intertemporal allocation.

References

Garrick, D., Siebentritt, M., Aylward, B. et al. 2009. Water markets and freshwater ecosystem services: policy reform and implementation in the Columbia and Murray–Darling Basins. Ecological Economics 69(2): 366–79.

Llop, M. 2013. Water reallocation in the input–output model. Ecological Economics 86: 21–27.

Rebound effect

A situation in which planned or pursued environmental benefits from a new technology or organizational practice are not realized or remain smaller than expected because of the underestimated or ignored implications of external factors (Hertwich

2005). Also known as the "take-back effect" and the "Khazzoom–Brookes postulate." For example, a new technology or increased use of recycled raw materials may increase the material efficiency of textile production, but environmental benefits therby gained may be diminished or completely lost if the overall consumption of textiles continues to grow or if the recycling process requires a large amount of additional energy production (Levänen et al. 2021). Also occurs when the monetary savings from increased use of energy efficiency or conservation leads to increased energy consumption. In addition to increased consumption or use of resources, rebound dynamics can relate to other system-level factors such as changes in pricing, availability, and demand for goods and services (Figge & Thorpe 2019).

Jarkko Levänen

Further reading

Grepperud & Rasmussen 2004; Ottelin et al. 2020; Sorrell & Dimitropoulos 2008.

See also: Jevons paradox.

References

Figge, F. & Thorpe, A.S. 2019. The symbiotic rebound effect in the circular economy. Ecological Economics 163: 61–9.

Grepperud, S. & Rasmussen, I. 2004. A general equilibrium assessment of rebound effects. Energy Economics 26(2): 261–82.

Hertwich, E.G. 2005. Consumption and the rebound effect: an industrial ecology perspective. Journal of Industrial Ecology 9(1–2): 85–98.

Levänen, J., Uusitalo, V., Härri, A. et al. 2021. Innovative recycling or extended use? Comparing the global warming potential of different ownership and end-of-life scenarios for textiles. Environmental Research Letters 16: 054069.

Ottelin, J., Cetinay, H. & Behrens, P. 2020. Rebound effects may jeopardize the resource savings of circular consumption: evidence from household material footprints. Environmetal Research Letters 15: 104044.

Sorrell, S. & Dimitropoulos, J. 2008. The rebound effect: microeconomic definitions, limitations and extensions. Ecological Economics 65(3): 636–49.

Reciprocity

Anthropology: the non-market exchange of goods or labor. Reciprocity can take on several forms, including balanced reciprocity, which consists of bartering; generalized reciprocity, which reflects gift-giving without the expectation of immediate reward; and negative reciprocity, which involves giving something with the expectation of receiving something more valuable in return.

Economics: individuals' tendency to respond to another party's actions with an equivalent action, including to reward another party's favorable actions and punish their unfavorable ones based on the perceived favorability of those actions, and not as the result of some agreed-upon or expected exchange.

International relations and trade: the granting of mutual benefits and concessions, and sanctions and restrictions between states.

Kate M. Laffan

Further reading

Fehr & Gächter 2000; Falk & Fischbacher 2006; Kolm 2006; Heins et al. 2018.

See also: Trust, Asymmetric information, Risk aversion, Expected utility theory (EUT).

References

Falk, A. & Fischbacher, U. 2006. A theory of reciprocity. Games and Economic Behavior 54(2): 293–315.

Fehr, E. & Gächter, S. 2000. Fairness and retaliation: the economics of reciprocity. Journal of Economic Perspectives 14(3): 159–81.

Heins, V.M., Unrau, C. & Avram, K. 2018. Gift-giving and reciprocity in global society: introducing Marcel Mauss in international studies. Journal of International Political Theory 14(2): 126–44.

Kolm, S.C. 2006. "Reciprocity: its scope, rationales, and consequences," pp. 371–541 in Handbook of the Economics of Giving, Altruism and Reciprocity, Vol. 1. S.-C. Kolm & J.M. Ythier, eds. Amsterdam: North-Holland.

Recycling

Any process that converts waste materials, energy, human labor, and perhaps chemical additives into a material suitable for reuse as an input into the production of a final consumable good. With reducing and reusing, recycling is often considered an essential component to achieving a circular or sustainable economy.

Recycling is incentivized via market signals wherever the market price of the recycled material exceeds the costs of all inputs necessary to the recycling process (Baumol 1977). Recycling also occurs in response to government incentives and mandates such as taxes on waste disposal, subsidies paid for recycled materials, and standards that require final consumable goods to contain a minimum level of recycled material content (Kinnaman 2005). Recycling has also been promoted by private industry. For example, the plastics industry in the United States created a numbering system inside the chasing arrows symbol to help consumers identify and hopefully recycle the various types of plastic. These promotional efforts were implemented to help the plastics industry avoid a public ban on plastic packaging materials.

THOMAS C. KINNAMAN

Further reading

Kinnaman et al. 2014; Kinnaman 2006.

See also: Sustainable recycling, Sustainable waste disposal, Waste management, Circular economy.

References

Baumol, W.J. 1977. On recycling as a moot environmental issue. Journal of Environmental Economics and Management 4(1): 83–7.

Kinnaman, T.C. 2005. Why do municipalities recycle? B.E. Journal of Economic Analysis and Policy 5(1): 1–23.

Kinnaman, T.C. 2006. Examining the justification for residential recycling. Journal of Economic Perspectives 20(4): 219–32.

Kinnaman, T.C., Yamamoto, M. & Shinkuma, T. 2014. The socially optimal recycling rate. Journal of Environmental Economics and Management 68(1): 54–70.

REDD (Reducing Emissions from Deforestation and forest Degradation)

An international policy mechanism that seeks to contribute to climate change mitigation by paying entities in the global South for avoided deforestation or avoided forest degradation, to reduce net greenhouse gas emissions globally. It was first proposed at the Conference of the Parties (COP11) of the United Nations Framework Convention on Climate Change (UNFCCC) in Montréal in 2005, and has since evolved into REDD+, which includes "the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries" (Pistorius 2012, p. 638).

REDD+ can be thought of as a payment for ecosystem services scheme (Corbera 2012), providing financial incentives for the ecosystem service of carbon storage and sequestration, though other co-benefits may also be considered, for example for biodiversity conservation (Turnhout et al. 2017). Funding for REDD+ may emerge from cap-and-trade or voluntary carbon markets, or from multilateral or bilateral donations and public funds (Schulz 2020).

CHRISTOPHER SCHULZ

Further reading

Maniatis et al. 2019; May et al. 2011; Visseren-Hamakers et al. 2012.

See also: Climate change mitigation, Forest conservation, Carbon market, Commodification of nature, Payment for ecosystem services (PES).

References

Corbera, E. 2012. Problematizing REDD+ as an experiment in payments for ecosystem services. Current Opinion in Environmental Sustainability 4(6): 612–19.

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55. Bogor, Indonesia: Center for International Forestry Research (CIFOR).
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Schulz, C. 2020. "Carbon markets and forest conservation in the Brazilian Amazon," pp. 43–6 in Building a Sustainable Future in Brazil: Environment, Development, and Climate Change. A. Prusa & A.E. Smith, eds. Washington, DC: Brazil Institute, Wilson Center.
Turnhout, E., Gupta, A., Weatherley-Singh, J. et al. 2017. Envisioning REDD+ in a post-Paris era: between evolving expectations and current practice. Wiley Interdisciplinary Reviews: Climate Change 8(1): e425.
Visseren-Hamakers, I.J., Gupta, A., Herold, M. et al. 2012. Interdisciplinary perspectives on REDD+. Current Opinion in Environmental Sustainability 4(6): 587–9.

Redistribution

Economics: the process of transferring something from a person or group of people to other people to increase social justice; for example, through progressive taxation, anti-poverty programs, unemployment insurance or other transfer payments, or land reform. Such policies redistribute income or wealth in a society.

Barry D. Solomon

Further reading

Tullock 2013.

See also: Progress, Progressive, Transfers, Social justice.

References

Tullock, G. 2013. Economics of Income Redistribution. Dordrecht: Springer.

Reductionism

a. A belief that a phenomenon can be understood by examining its parts and their interaction. On the one hand, reductionist thinking helps to sort out a complex topic and identify its dynamics. On the other hand, the process of identifying parts can leave out important aspects and yield an oversimplified and inaccurate description of the whole. "Reductionist" thinking is often used as a pejorative, with the alternative being holism.
b. A belief that certain foundational sciences, such as mathematics and physics, have the power to explain phenomena found in other sciences, including social sciences. Norgaard (2013, p. xxi) describes the policy advice resulting from reductionist methods as "partly correct but wholly wrong," in the sense that the method misses unintended consequences such as global warming caused by industrial activity. Engineering has identified productive industrial methods but was unable to predict the meteorological and social consequences of its broader impacts. An alternative to reductionism is interdisciplinarity, which assumes that disciplines have analytical tools and explanatory powers that are distinct from the foundational sciences and that are needed in combination to understand complex socio-ecological challenges.

Brent M. Haddad

Further reading

Balany & Halog 2021.

See also: Holistic approach, Atomism, Emergence and emergent properties, Applied systems analysis, Interdisciplinary, Unintended consequences.

References

Balanay, R. & Halog, A. 2021. A review of reductionist versus systems perspectives towards "doing the right strategies right" for circular economy implementation. Systems 9(2): 38.
Norgaard, R. 2013. "Embracing fewer answers," Preface 2 in K. Farrell, T. Luzzati & S. van den Hove, eds. Beyond Reductionism: A Passion for Interdisciplinarity. London: Routledge.

Regenerative capacity

Economics:

a. The capacity of an economy or type of economic activity to restore, renew, or revitalize natural capital (Raworth 2017).
b. The capacity of an economy as a living system to promote and sustain human prosperity and well-being (Fullerton 2015).

Ecology:

a. The ability of an ecological system to maintain a healthy state and to evolve (Brown et al. 2018).
b. The self-renewal capacity of agricultural and natural systems, with the aim of reactivating ecological processes damaged or overexploited by human activity (Morseletto 2020, p. 769).

BARRY D. SOLOMON

Further reading

Lovins et al. 2018.

See also: Restoring natural capital (RNC), Ecological restoration, Environmental restoration, Circular economy, Well-being economy.

References

Brown, M., Haselsteiner, E., Apró, D. et al., eds. 2018. Sustainability, Restorative to Regenerative. COST Action CA16114 RESTORE, Working Group One Report: Restorative Sustainability. https://www.eurestore.eu/wp-content/uploads/2018/04/Sustainability-Restorative-to-Regenerative.pdf.

Fullerton, J. 2015. Regenerative Capitalism: How Universal Principles and Patterns will Shape Our New Economy. Stonington, CT: Capital Institute.

Lovins, L.H., Wallis, S., Wijkman, A. & Fullerton, J. 2018. A Finer Future: Creating an Economy in Service to Life. Gabriola Island, Canada: New Society Publishers.

Morseletto, P. 2020. Restorative and regenerative: exploring the concept in the circular economy. Journal of Industrial Ecology 24: 763–73.

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Regional analysis

See: Regional science.

See also: Regional economics.

Regional economics

A subdiscipline of economics which, along with urban economics, regional science, and economic geography, incorporates the dimension of "space" into analysis of the workings of the market. It is organized into two main branches:

a. Location theory, first developed in the early 1900s, which addresses the economic mechanisms that distribute activities in space and explains the locational choices of firms and households. In location theory, space is interpreted as the distance between places or economic activities.
b. Regional growth (and development) theory, which focuses on spatial aspects of economic growth and the territorial distribution of income. In regional growth theories, the concept of space evolved. At the beginning in the early 1950s, space was associated with an administrative region, or more generally to a subnational area. Since the mid-1970s, space has been interpreted as "territory", that is, as an independent production factor and a generator of advantages for the firms situated within it.

ROBERTA CAPELLO

Further reading

Hoover 1948; Isard 1956; McCann 1998; Capello 2015.

See also: Regional environmental planning, Regional science, Urban economics, Geography.

References

Capello, R. 2015. Regional Economics, 2nd edn. London: Routledge.

Hoover, E.M. 1948. The Location of Economic Activity. New York: McGraw-Hill.

Isard, W. 1956. Location and Space-Economy: A General Theory Relating to Industrial

Location, Market Areas, Land Use, Trade and Urban Structure. New York: Technology Press of MIT and John Wiley & Sons.
McCann, P. 1998. The Economics of Industrial Location: A Logistics-Costs Approach. Heidelberg: Springer.

Regional environmental planning

The process of decision-making to carry out land development on a supra-local scale. Environmental planning in general endeavors to manage relationships that exist within and between natural systems and human systems. In a narrow understanding, environmental planning as such aims to conserve and protect cultural and natural landscapes with a high emphasis on the ecological nature and values of landscapes. Environmental planning is concerned with the impact of land use, development, and subdivision on the natural environment, including land, water, flora, and fauna, to achieve sustainable outcomes.

Regional environmental planning encompasses areas such as land use, air pollution, noise pollution, wetlands, endangered species habitat, flood zone susceptibility, coastal zone erosion, and visual studies, among others. In a wider understanding, regional planning is an inherent part of regional environmental planning and therefore includes the planning of natural resource management and integrated land use, socio-economics, transportation, infrastructure, economics, and housing characteristics in a region.

Meike Levin-Keitel

Further reading

von Haaren et al. 2019; Marshall 1993; Baldwin 2019.

See also: Land use planning, Urban planning, Regional science, Environmental management.

References

Baldwin, J.H. 2019. Environmental Planning and Management. London: Routledge.
Marshall, T. 1993. Regional environmental planning: progress and possibilities in Western Europe. European Planning Studies 1(1): 69–90.
von Haaren, C., Lovett, A.A. & Albert, C. 2019. Landscape Planning with Ecosystem Services. Theories and Methods for Application in Europe. Dordrecht: Springer.

Regional science

A field of social sciences that uses quantitative analysis to study problems at the regional, urban, or rural level as well as internationally. Thus, a broad definition of region is used as regional analysis can be applied at a range of spatial scales. Also, regional boundaries are not static, and depend on the problem being studied. Contributors include urban and regional economists, economic geographers, urban and regional planners, among others. The field was formally founded by Walter Isard in the early 1950s (Isard, 1956, 1960). The first academic department of regional science opened at the University of Pennsylvania in 1958, though it closed in 1993.

Regional scientists have studied a large variety of social, economic, political, and behavioral phenomena that have a spatial dimension (Isserman 2001). The main topics of study in the field have included industrial and urban location theory and modeling, interindustry analysis, methods of regional and spatial analysis, transportation, human migration, land use and urban and regional development, regional policy, environmental and ecological analysis, and natural resource management.

Barry D. Solomon

See also: Input–output (I–O) analysis, Environmentally extended input–output analysis (EE–IOA), Regional economics, Urban economics, Geography.

References

Isard, W. 1956. Location and Space-Economy: A General Theory Relating to Industrial Location, Market Areas, Land Use, Trade and Urban Structure. New York: Technology Press of MIT and John Wiley & Sons.
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Technology Press of MIT and John Wiley & Sons.
Isserman, A. 2001. "Regional science," pp. 12930–35 in International Encyclopedia of the Social & Behavioral Sciences. N.J. Smelser & P.B. Baltes, eds. Oxford: Pergamon Press.

Regulating services

The category of ecosystem services that provides benefits to people by moderating critical natural phenomena. These include climate regulation and natural carbon storage, water and air purification, crop pollination, decomposition of contaminants, and erosion, flood, and disease control. The Common International Classification of Ecosystem Services (CICES) now combines regulating and maintenance ecosystem services (Haines-Young & Potschin-Young 2018).

BARRY D. SOLOMON

See also: Ecosystem services, Climate, Climate change, Climate regulation, Carbon sequestration, Agricultural ecosystem services, Common International Classification of Ecosystem Services (CICES), Maintenance services.

Reference

Haines-Young, R. & Potschin-Young, M.B., 2018. Revision of the Common International Classification of Ecosystem Services (CICES V5.1): a policy brief. One Ecosystem 3: e27108.

Regulation

Economics: the most common and widespread environmental policy instrument, which sets emission, effluent, or pollution control standards or targets, compliance schedules, and penalties and fines for nonattainment. Sometimes called direct regulation or command-and-control regulation. Standards can be set for ambient environmental quality in the air, water, or land; or end-of-pipe control technology for industrial facilities, other buildings, or mobile sources.

Although direct environmental regulations have generally been effective, they can also be costly since they do not provide any incentive for exceeding the standards or targets. In addition, direct regulations generally do not allow for flexibility for how or where to reduce emissions or pollution most cost-effectively in regulated facilities, and are often approved with political loopholes. As a result, sometimes environmental regulations have been supplemented with incentives to reward firms for surpassing regulatory mandates.

Ecology: ecosystems and individual species such as plants, trees, bees, and other pollinators as well as bacteria contribute to the regulation of air quality, water purification, soil erosion, flood control, crop pollination, disease control, carbon storage, and even climate regulation (Hein et al. 2006).

BARRY D. SOLOMON

Further reading

Brunel & Levinson 2013; Fiorino 2006; Kubasek & Silverman 2013.

See also: Environmental policy instruments, Regulatory capture, Regulating services, Climate regulation.

References

Brunel, C. & Levinson, A. 2013. Measuring environmental regulatory stringency. OECD Trade and Environment Working Papers 2013/05, Paris.
Fiorino, D.J. 2006. The New Environmental Regulation. Cambridge, MA: MIT Press.
Hein, L., van Koppen, K., de Groot, R.S. & van Ierland, E. 2006. Spatial scales, stakeholders and the valuation of ecosystem services. Ecological Economics 57(2): 209–28.
Kubasek, N. & Silverman, G. 2013. Environmental Law, 8th edn. Upper Saddle River, NJ: Pearson.

Regulatory capture

Neoclassical economics and political science:

a. The process through which special interests (for example, regulated monopolies) influence state intervention in any of its forms, such as taxation, licensing and approvals, foreign and monetary policymaking, and research and development (R&D) laws (from Dal Bó 2006).

b. The outcome of a state institution (for example, regulatory agency) being influenced to produce interventions that are in favor of its regulated special interests and that may potentially harm the public interest. The theory of regulatory capture was originally developed in the 1950s and 1960s, and most significantly advanced in the 1970s by George Stigler (1971) and later expanded by Sam Peltzman (1976).

YUHAO BA

Further reading

Laffont & Tirole 1991; Carpenter & Moss 2013.

See also: Regulation, Non-state actors, Institutions.

References

Carpenter, D. & Moss, D.A., eds. 2013. Preventing Regulatory Capture: Special Interest Influence and How to Limit it. New York: Cambridge University Press.

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Laffont, J.J. & Tirole, J. 1991. The politics of government decision-making: a theory of regulatory capture. Quarterly Journal of Economics 106(4): 1089–1127.

Peltzman, S. 1976. Toward a more general theory of regulation. Journal of Law and Economics 19(2): 211–40.

Stigler, G.J. 1971. The theory of economic regulation. Bell Journal of Economics and Management Science 2(1): 3–21.

Regulatory taking

A governmental regulation that limits the use of private property to such an extent that the property owner is significantly deprived of economic value of the property. A representative example is an environmental regulation that severely restricts land use. A principle subsequently follows that the government is legally obliged to pay compensation for the losses because the regulation, although serving public purposes, effectively "takes" part of the owner's property. This is strictly based on the reasoning that legal property consists of numerous entitlements, thus compelling the government to pay for the restrictions on entitlements that it unilaterally imposed on property owners.

In contrast, there is a public interest rationale for paying no compensation if the regulation involves the state's exercise of police power, or if the losses are only partial and the social gains significant. Many environmental regulations require some limits on uses of property (for example, restrictions on polluting a stream that flows through a private property). Therefore, the question of when a regulation effectively results in a government taking that requires the payment of just compensation has been a contentious issue in many jurisdictions around the world for the last century.

ILJOONG KIM & JONATHAN M. HARRIS

Further reading

Epstein 1985; Fischel 1995.

See also: Eminent domain, Property right, Regulation.

References

Epstein, R. 1985. Private Property and the Power of Eminent Domain. Cambridge, MA: Harvard University Press.

Fischel, W. 1995. Regulatory Takings: Law, Economics, and Politics. Cambridge, MA: Harvard University Press.

Relationality

A mode of understanding the identity, function, or meaning of a human or non-human entity through its relationships and interactions with others. As an analytic, relationality means focusing less on the traditional objects of study, but rather on the relations between them. In contrast to the norms of sustainability and resilience, which focus on the workings and properties of a system, relationality focuses on the connectedness of entities within a system; for example, in a resource management plan, ensuring that no one is excluded from the process (Lejano 2019). This idea has also been used to characterize resource management regimes that are governed not only by formal or informal

rules and rights, but also by the working and reworking of relationships among actors.

RAUL P. LEJANO

Further reading

Walsh et al. 2021.

See also: Relational values, Community, Networks.

References

Lejano, R.P. 2019. Relationality and social–ecological systems: going beyond or behind sustainability and resilience. Sustainability 11(10): 2760.

Walsh, Z., Böhme, J. & Wamsler, C. 2021. Towards a relational paradigm in sustainability research, practice, and education. Ambio 50(1): 74–84.

Relational values

The virtues, principles, and preferences associated with relationships between humans and nature, or among humans that involve nature (Muraca 2016). They include values such as reciprocity, care, and kinship. The relational values concept questions the established dichotomy of reasons to value the environment: intrinsic value (value in and of itself) versus instrumental value (value for what it provides to humans) (Chan et al. 2016).

The concept resonates with diverse perspectives that foreground the importance of relationality and relationship in human experience, and the lack of stark separation between people and nature (notably, feminist, indigenous, and decolonial perspectives). The concept thus has crucial implications for epistemic justice (that is, acknowledging different ways of knowing and relating to the world). Philosophical details of relational values include that they are not solely instrumental (though they may have instrumental elements; see Himes & Muraca 2018), and that they are non-substitutable (because what matters is the relationship itself, as opposed to only what it provides; see Chan et al. 2018).

RACHELLE K. GOULD

See also: Relationality, Intrinsic value, Bequest value, Altruistic value, Threatened species value, Existence value, Environmental justice.

References

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Muraca, B. 2016. Relational values: a Whiteheadian alternative for environmental philosophy and global environmental justice. Balkan Journal of Philosophy 8: 19–38.

Relative vs. absolute scarcity

Neoclassical economics focuses on the relative scarcity of economic goods and services, while classical economics and ecological economics emphasize the absolute scarcity of certain goods (Baumgärtner et al. 2019).

Neoclassical economics: market goods and services are scarce relative to their substitutes, which is reflected in their opportunity cost and price. In addition, perfect substitutability between factors of production is usually assumed in most production functions. Neoclassical views on relative scarcity were influenced by classical economist David Ricardo's observation that farmland varies in quality.

Classical economics: Thomas Robert Malthus introduced the idea of absolute scarcity of natural resources in the late 1700s, as an immutable physical limitedness that is subject to increasing demands from human societies (Scoones et al. 2019). In particular, he argued that since the human population expands geometrically, while food production and other natural resource supplies grow only linearly, food would eventually exhibit

absolute scarcity and the human population would eventually decline as a result.

Ecological economics: most ecological economists believe that scarcity is socially constructed, but also that natural capital provides humans with many environmental goods and services for which there are no substitutes. Thus, they generally find the classical economics treatment of scarcity more useful than its treatment in neoclassical economics. As such, they generally agree with the insights from the Club of Rome's classic study, *The Limits to Growth* (Meadows et al. 1972). This led to many ecologists and some economists in the 1960s and 1970s being called "neo-Malthusians" (Lipton 1989). Ecological economists note that natural resources such as groundwater can be irreversibly lost, and many species of plants and animals are facing extinction, while numerous others have already gone extinct in our lifetimes. Consequently, many ecological economists study non-market valuation of natural capital and environmental goods and services, though others reject such monetization as meaningless (e.g., Norton 2015).

Barry D. Solomon

Further reading

Wagner & Newman 2013.

See also: Scarcity, Scarcity value, Scarcity rent, Social construction of scarcity, Natural capital, Environmental goods and services, Limits, Limits to growth, Neo-Malthusian.

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Relativism

Philosophy of science: refers to a moral or philosophical position which asserts that there is no absolute and universal truth, but that the point of view which one can develop varies according to historical, social, and cultural conditions. The relativist doctrine has often been opposed by those who see science as an activity of unveiling universal truths, and who therefore criticize the relativist point of view as scientifically flawed (Boghossian 2006). In contrast, one can mention the "strong programme" of David Bloor and his colleagues at the Science Studies Unit of the University of Edinburgh, who insist on the fact that all scientific truth is contingent (Barnes & Bloor 1982). According to this position, since any process of knowledge production is dependent on the conditions of its acquisition, that undertaken by people in society is a process systematically limited by our senses as well as by our collective beliefs, and is not capable of reaching absolute certainties.

Ecological economics: the relativist position is not used as an explicit standard-bearer and some of the authors in the field distance themselves from any overly absolute form of relativism (Kallis & Norgaard 2010; Spash 2012). However, if the relativistic attitude starts from the time that one rejects any form of universalism, then one can conceive of the idea that the recognition of value pluralism is a form of relativism. Similarly, Ostrom's rejection of "one-size-fits-all" solutions (Ostrom 2010) shows that, in the governance of common pool resources, one should be wary of universal solutions.

Olivier Petit

See also: Critical realism, Pluralism, Coevolution, Common pool resources.

References

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Ostrom, E. 2010. Beyond markets and states: polycentric governance of complex economic systems. American Economic Review 100(3): 641–72.

Spash, C.L. 2012. New foundations for ecological economics. Ecological Economics 77: 36–47.

Remuneration

The total compensation provided to workers or management. Includes not only salaries and wages, but also any fringe benefits such as bonuses, commissions, health insurance, stock options and dividends, company cars, mobile phones, retirement packages, and so on. Remuneration can also be made in the form of freshwater, food, and other ecological resources (Matete & Hassan 2004).

Barry D. Solomon

See also: Labor markets, Labor theory of value.

Reference

Matete, M. & Hassan, R. 2004. An ecological economics framework for assessing environmental flows: the case of inter-basin water transfers in Lesotho. Global and Planetary Change 47 (2–4): 193–200.

Renewable energy

Useful energy collected from sources that are naturally replenished on time scales less than or approximately equal to an average human lifetime. Examples include sunlight, wind, rain, waves, tides/ocean currents, and geothermal heat (Usher 2019). The first four of these come directly or indirectly from the Sun. Tidal power and ocean currents are based on the motion of the Earth–Moon system as well as the Sun, while geothermal heat is derived from the subsurface of the Earth. Fossil fuels, which are only created or replenished over millions of years, are not renewable energy.

Renewable energy sources and their conversion technologies are generally regarded as having low environmental impacts and, especially, low life-cycle greenhouse gas emissions. Exceptions include large-scale hydroelectric dams that flood densely vegetated valleys, becoming substantial emitters of the greenhouse gas methane, and bioenergy produced in environmentally damaging ways such as by clearing native forests to grow oil palm plantations, or by using fossil fuels to distill alcohol fuel produced from biomass. However, biomass residue, for example, from the corn, wheat, and sugarcane industries, is generally regarded as renewable. A related term, "alternative energy," is rapidly being superseded as renewable energy becomes mainstream and replaces investment in fossil fuels.

Mark O. Diesendorf

Further reading

REN21 2020.

See also: Renewable resource, Sustainable energy, Biofuel, Bioenergy.

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Usher, B. 2019. Renewable Energy: A Primer for the Twenty-First Century. New York: Columbia University Press.

Renewable resource

Any natural resource that can be naturally replenished at a rate faster than it is used by humans. Examples include sunlight, air, wind, biomass, and geothermal energy. Some renewable resources can be depleted on a local scale depending on the rate of use, such as fish, freshwater, agricultural crops, and forest resources (Hilborn et al. 1996).

Renewable resources are sometimes called flow resources.

BARRY D. SOLOMON

Further reading

Walters 1986; Swallow 1990.

See also: Flows, Biomass, Forest resources, Food system, Agroecology, Water resources, Sustainable yield, Maximum sustainable yield, Non-renewable resource.

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Rent

Classical economics:

a. The returns to land as a factor of production. This concept of rent was used by Adam Smith, David Ricardo, and Karl Marx.
b. Income extracted through control of scarce or monopolized assets. This concept of rent emerged in the late 19th century with the realization that surplus payments analogous to "land rents" could accrue to any economic agent in control of resources (or attributes) that are inelastic in supply; that is, whose supply is relatively insensitive to changes in demand.

Neoclassical economics: the return to any agent of production greater than that required to keep it in its present employment; or, synonymously, income more than opportunity cost/transfer price. This concept of rent can be traced to Joan Robinson (1933) and is dominant among neoclassical economists. Land rents only classify as rents under this definition if they exceed payments that could be demanded in the next most profitable deployment of the land. Rents conceived in this way can be minimized through competition. Some theorists, following Alfred Marshall (1890), prefer the term "quasi-rents" to refer to surplus incomes extracted through control of assets that are only temporarily inelastic. Significant rent-bearing assets include land, minerals, patents, financial assets, data, and infrastructure for the provision of utilities, transport, and communications. Rents are typically contrasted with incomes that are earned through productive labor or innovation (UNCTAD 2017, p. 120). Some ecological economists warn that rent extraction will be a major cause of inequality as resource constraints tighten, and call for changes to the ownership and governance of rent-bearing assets (Stratford 2020).

BETH STRATFORD

See also: Scarcity rent, Rent-seeking behavior, Natural resource rents, Opportunity cost, Land economics, Geonomics.

References

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Rent-seeking behavior

a. The socially unproductive use of time and resources to seek benefit from political or administrative public policy decisions, but also more generally involving quests for benefits from anybody, usually studied in the context of contests for favors. Benefits are called "rents" in being obtained through unearned privilege and not productive effort. The origin of the concept is Tullock (1967). The concept met with ideological opposition (Hillman & Ursprung 2016) in portraying

governments as subject to influence in creating and assigning unearned benefits.
b. Application: the concept has been widely applied (e.g., Congleton & Hillman 2015).
c. Social costs of rent-seeking behavior: depend *inter alia* on how the identity of successful rent seekers is determined (Hillman & Riley 1989), whether a rent is divisible (Long & Vousden 1987), and whether the rent is a personal or group benefit (Ursprung 1990); social costs include resources used in contesting a rent by successful and unsuccessful rent seekers, and in countering rent seekers (Appelbaum & Katz 1986), for example when environmentalists oppose lax environmental standards sought by producers.
d. Corruption: can be involved (Aidt 2016), but rent-seeking behavior is consistent with politicians' legal prerogatives through public policy.
e. Political incentives to create contested rents (Gradstein & Konrad 1999): can be for reasons of political support (as in Hillman 1982), or for politicians to benefit directly from rents created (as in Grossman & Helpman 1994).
f. Conspicuousness: there are political and personal incentives for rent-seeking behavior to be hidden (Tullock 1989).

ARYE L. HILLMAN

See also: Rent, Scarcity rent, Regulatory capture.

References

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Ursprung, H.W. 1990. Public goods, rent dissipation, and candidate competition. Economics and Politics 2(2): 115–32.

Replacement cost

A revealed preference method to determine the cost that would have to be paid to replace an asset in the present time. In ecological economics, the use of the replacement cost method requires that it is possible to find a substitute for an environmental good or ecosystem service, and that the replacement provides functions that are equivalent in magnitude and quality to what is being replaced. This condition is frequently not fulfilled in the real world. For example, it has been shown in the case of lost pollination services from honeybees that pollen dusting as a replacement for insect pollination was ineffective, leading to underestimation of wild pollinator service value (Allsopp et al. 2008). If no perfect substitute exists it may be possible to find a close substitute (Sundberg 2004).

BARRY D. SOLOMON

See also: Revealed preference methods, Economic valuation techniques, Ecosystem services.

References

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Sundberg, S. 2004. Replacement costs as economic values of environmental change: a review of and application to Swedish sea trout habitats. Beijer Discussion Papers Series No. 184. Stockholm: Beijer International Institute of Ecological Economics, Royal Swedish Academy of Sciences.

Reserves

Economics: the portion of the total resource base of a mineral or energy resource that has been located with certainty and that can be economically recovered and used with currently available technology. Since natural resources are subject both to depletion through exploitation and to continuous exploration and new discovery, the quantity of reserves changes over time, and can increase over time especially as technology improves. Ecology: an area protected against illegal hunting, and economic growth and development (game reserves or wildlife reserves); or illegal fishing, and economic growth and development (marine reserves).

Barry D. Solomon

Further reading

Neumayer 2000; Lee & De Preez 2016; Armstrong 2007.

See also: Resources, Technological change, Technological progress, Marine protected areas (MPAs), Conservation areas.

References

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Neumayer, E. 2000. On the methodology of ISEW, GPI and related measures: some constructive suggestions and some doubt on the "threshold" hypothesis. Ecological Economics 34(3): 347–61.

Resilience

The capacity of a system to successfully buffer, absorb, or adapt to change or disturbances to persist across time. Metaphorically, resilience can be thought of as elasticity or the ability to bend but not break. Economically, resilience has properties of a positive externality and a public good that the market may lack incentive to supply (Stanley 2020). The measurement of resilience is traditionally defined in two narrower ways, which arose from the assumptions of their originating disciplines:

a. Engineering resilience, also called "bounce-back resilience." The time taken to return (bounce back) to an existing equilibrium following a perturbation. Similar to traditional neoclassical economic approaches, this definition focuses on maintaining an optimum steady state through continuous efficiency of function, maximizing rate of recovery, and avoiding different or novel equilibria (Allen et al. 2019).
b. Ecological resilience, also called social-ecological resilience. The amount of stress that can be absorbed before a system redefines its behavior (Holling 1973). Unlike engineering resilience, ecological resilience does not require continued functioning in the same way: in this definition systems are allowed to reorganize, adapt, or transform their functions, structures, processes, attributes, or feedbacks to survive and recover, so long as they maintain some discernible continuity in their core identities across time. Arising out of complex systems thinking by C.S. Holling that assumes a non-linear world characterized by multiple stable states, resilience is the key property that mediates transitions between these states. Ecological resilience can be applied equally to human systems such as economies as well as natural systems: the word "ecological" here has become a catch-all term for complex systems in general.

Conrad B. Stanley

Further reading

Wieland & Durach 2021; Knudsen et al. 2018.

See also: Panarchy theory, Ecosystem resilience, Economic resilience, Urban resilience, Rural resilience, Ecological perturbation, Disturbance, Ecosystem persistence, Externalities.

References

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Wieland, A. & Durach, C.F. 2021. Two perspectives on supply chain resilience. Journal of Business Logistics 42(3): 315–22.

Resource allocation

The apportioning, allotting, dividing up, or assigning of scarce resources between competing or alternative uses, such as to produce different goods and services, or for the use of technologies based on various factors of production, to satisfy human wants and needs. Neoclassical economics focuses on market allocation and the price system in the interest of economic efficiency. Markets are the most common allocation mechanism in use. Ecological economics recognizes that other forms of allocation are possible or may even be desirable. Alternative forms of allocation include central planning, political decisions, random selection, "first come, first served," negotiation, and so on.

Barry D. Solomon

Further reading

Daly 1992.

See also: Pareto optimality, Allocation, Intertemporal allocation.

Reference

Daly, H.E. 1992. Allocation, distribution, and scale: towards an economics that is efficient, just, and sustainable. Ecological Economics 6: 185–93.

Resource base

Ecology: the natural resources (material and energetic; renewable and non-renewable) that humans and other species can consume to sustain their lives. The term can be specified with further ones (social metabolism, environmental sustainability), and with ecological indicators to measure the limits of the resource base of a given system (for example, carrying capacity, ecological footprint, material and energy flows, human appropriation of net primary production, planetary boundaries).

Economics: the term "resource-based economy" is used to describe:

a. The national economies of countries highly dependent on exporting natural resources (especially oil and gas).
b. The envisioned forms of a future sustainable economy of the post-industrial society (based on cooperation, resource sharing, smart and sustainable resource use).

In the resource-based view of the firm (Barney 1991) the competitive advantage is assessed through the resources a firm possesses, combines, and applies (natural and other resources, including knowledge). In the contrasting market-based view, the situation and position in the market is seen as determining the success of a firm.

Karl Bruckmeier

Further reading

González de Molina & Toledo 2014; Hackett 2016; Armstrong & Shimizu 2007.

See also: Carrying capacity, Ecological footprint, Human appropriation of net primary production (HANPP), Social-ecological systems.

References

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resource-based view of the firm. Journal of Management 33(6): 959–86.
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Hackett, S.C. 2016. Environmental and Natural Resources Economics: Theory, Policy, and the Sustainable Society. London: Routledge.

Resource consumption

a. The conversion of raw materials to final products, wastes, and residues, based on biophysical laws (Martin et al. 2016).
b. Exergy loss of natural resources, measured through life-cycle assessment (Ayres et al. 2006; Goßling-Reisemann 2008).
c. The difference between the closing and opening period accountings of environmental assets or resource stocks, based on economic ecosystem accounting (Caparrós et al. 2003).

Barry D. Solomon

See also: Resource efficiency, Economic ecosystem accounting, Environmental asset, Biophysical constraints on human activity, Biophysical economics, Exhaustible resource theory, Exergy, Life-cycle assessment (LCA), Carrying capacity.

References

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Martin, J.-L., Maris, V. & Simberloff, D.S. 2016. The need to respect nature and its limits challenges society and conservation science. Proceedings of the National Academy of Sciences of the United States of America 113(22): 6105–12.

Resource depletion

Ecology:

a. The rate of the use/consumption of a resource type exceeds the rate of its replacement/replenishment. Based on the resource type, there are various distinctions of depletion, such as: defaunation (depletion of wildlife: faunal resources), deforestation (depletion of floral resources), groundwater (aquifer depletion), soil erosion, and so on.
b. Indirect depletion caused by pollution or contamination of resources, for example, water resources or soil.

Economics: mostly used for farming, fishing, mining, water, soil, and fossil fuels consumption. It is crucial to categorize resources into renewable and non-renewable. For renewable resources, depletion is the portion of the harvesting, logging, catching, or other exploitation, above the sustainable level (replenishment rate) of the resource stock. For non-renewable resources, it is the quantity of resources extracted, compared to the (estimated) available resource stock that is not able to be renewed, at least at a rate comparable with human use and time scale (EEA 2021; Cleveland & Morris 2009).

Panos Kalimeris

Further reading

Hotelling 1931; Dasgupta & Heal 1974.

See also: Natural resource depletion, Resource scarcity, Renewable resource, Non-renewable resource, Hotelling model.

References

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Resource efficiency

Ecological economics: useful material output divided by material input (Dahlström & Ekins 2005, p. 173), or a measure of economic output (Bassi et al. 2021). A key element of the above definition is the meaning of "resources," which refers to aspects in the natural world that have the capacity to produce goods and services: biomass, metals, non-metallic minerals, energy, water, minerals, biotic and abiotic resources (EC 2011; UNEP 2017). Resources are usually measured in a physical unit, for instance mass, volume, length, or area.

Business economics: the term "eco-efficiency" has been used as a synonym for resource efficiency or "doing more with less resources" (EEA 1999). Rosenberg (1976) noted a wide range of efficiency measures to exploit natural resources, including: raising output per unit of resource input, raising the productivity of the process of exploration and resource discovery, raising the productivity of the extractive process, the development of techniques for the exploitation of lower-grade or other more abundant resources, or technologies for the reuse of materials otherwise going to waste. Therefore, it is assumed that organizations increase their resource efficiency when they reduce the quantity of resources needed to offer the same or improved products and/or services.

Fernando Díaz López

See also: Efficiency, Eco-efficiency, Economic efficiency, Energy efficiency, Productivity, Exploitation, Extractivism.

References

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Resource management

Decision-making over time regarding the use of a form of energy or matter that can be used to achieve a desired goal or improve or even maximize human welfare (Mitchell 2019). As such, the concept is anthropocentric. There are many types of resources such as humans, equipment, money, and natural resources. Among natural resources there are renewable resources (for example sunlight, fish, forests, hydropower), non-renewable resources (for example, petroleum, natural gas, minerals), and contingent (not yet commercially recoverable) resources (for example, agriculture, wild species). A portion of non-renewable resources are also contingent resources.

Natural resource management is related to sustainable development in that non-renewable resources may become exhausted without considering the welfare of future generations, and contingent resource

uses may exceed critical limits, preventing the renewal of the resource for the welfare of future generations. Natural resource management is inherently political, as certain resource uses may favor the interests of some groups over others, both within a generation and between generations. One result of this is the movement toward co-management of natural resources, which involves the sharing of powers and responsibility between government and local resource users (Berkes et al. 1991; Plummer & Fitzgibbon 2004).

KRISTINE M. GRIMSRUD

Further reading

Field 2015.

See also: Ecosystem management, Ecosystem approach to management (EAM), Adaptive ecosystem management, Environmental management, Fisheries management, River basin management, Watershed management, Integrated water resources management (IWRM), Demand management, Forest conservation, Renewable resource, Non-renewable resource, Fossil fuels, Safe minimum standard (SMS).

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Plummer, R. & Fitzgibbon, J. 2004. Co-management of natural resources: a proposed framework. Environmental Management 33: 876–85.

Resource regimes

See: Property regimes.

See also: Common property regimes, Open access regimes, Resources, Resource management, Resource allocation.

Resource rents

See: Natural resource rents.

See also: Rent.

Resources

a. Materials available in the environment that help to supply human wants and needs, and thus a socially constructed term. Often called natural resources.
b. Anything of value to people, including workers and other people.
c. The portion of the total non-renewable resource base of a mineral or energy resource that has been located with less certainty than reserves, and which might be recovered and used in the future. The petroleum or uranium resource bases, for example, are thus larger than their respective bases of reserves. Resource recovery may not be economical today. Since natural resources are subject to continuous exploration, the quantity of resources changes over time.

BARRY D. SOLOMON

Further reading

Wellmer 2008; Meinert et al. 2016.

See also: Reserves, Renewable resource, Non-renewable resource, Technology.

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Wellmer, F.-W. 2008. Reserves and resources of the geosphere, terms so often misunderstood. Is the life index of reserves of natural resources a guide to the future? Zeitschrift der Deutschen Gesellschaft für Geowissenschaften 159(4): 575–90.

Resource scarcity

Economics:

a. Unavailability of a natural resource in an amount required to maintain a desired level of consumption. Absolute (or Malthusian) resource scarcity may occur in the absence of alternatives to the natural resources essential for human life, such as potable water. Relative (or Ricardian) scarcity means that a resource is scarce relative to other inputs, and the price of this resource rises relative to that of other inputs (Barbier 2021).
b. A factor essential for the economic evaluation of a natural resource with limited availability. Resource scarcity is rewarded in the market economy by a scarcity rent that compensates for the user cost of consumption of an exhaustible or renewable resource (Randall 2021). If the scarcity rent is unobservable, the resource scarcity factor is measured, albeit imperfectly, as the resource price or by means of the industry-wide extraction cost function (Halvorsen & Smith 1991).

Ecology: resource scarcity refers to the limited capacity of natural capital to absorb anthropogenic impacts on the environment and to provide valuable environmental services. Relative scarcity of natural capital means that human-made capital can substitute for these services under natural capital depletion to ensure weak sustainability, implying that future generations are not made worse off. Absolute resource scarcity is reflected in the strong sustainability view that essential Earth system processes place absolute limits on the expansion of global human activity and populations, which are determined by the planetary boundaries (Steffen et al. 2015).

GEORGY TROFIMOV

Further reading

Barnett & Morse 1963; Krautkraemer 1998.

See also: Resources, Scarcity indicators, Reserves, Resource depletion, Natural resource depletion, Relative vs. absolute scarcity, Scarcity rent, Resource management, Natural capital, Sustainability, Weak sustainability, Strong sustainability.

References

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Steffen, W., Richardson, K., Rockström, S. et al. 2015. Planetary boundaries: guiding human development on a changing planet. Science 347(6223): 1259855.

Respiration

The biochemical process by which an organism exchanges oxygen and carbon dioxide with its environment. For organisms without lungs, such as plants and fish, the process works differently than in humans. As plants absorb atmospheric carbon dioxide and water for growth, they release oxygen through their leaves. Fish use their gills to exchange dissolved oxygen and carbon dioxide in water. Ecosystem respiration is the sum of all respiration occurring in a specific ecosystem.

BARRY D. SOLOMON

Further reading

Buenstorf 2000.

See also: Ecosystem, Evolutionary analysis.

Reference

Buenstorf, G. 2000. Self-organization and sustainability: energetics of evolution and implications for ecological economics. Ecological Economics 33(1): 119–34.

Restoration

See: Ecological restoration, Environmental restoration.

See also: Restoration ecology, Ecosystem, Ecosystem management.

Restoration ecology

The branch of ecological science that provides concepts, models, methodologies, and tools for the practice of ecological restoration. It also benefits from direct observation of and participation in restoration practice (Gann et al. 2019).

James C. Aronson, Adam T. Cross, Neva R. Goodwin & Laura Orlando

See also: Ecological restoration, Restoring natural capital (RNC).

Reference

Gann, G.D., McDonald, T., Walder, B. et al. 2019. International principles and standards for the practice of ecological restoration. Restoration Ecology 27(S1): S1–S46.

Restoring natural capital (RNC)

The replenishment of natural capital stocks to improve long-term human well-being and ecosystem health (Aronson et al. 2007). Without natural capital there is no flow of ecosystem services; thus, human well-being is directly diminished when stocks of natural capital are degraded. Reversing such losses may be achieved through ecological investment and restoration and other ecological improvements in agriculture, urbanization, industrial activities, and other areas where people interact with the natural world.

James C. Aronson, Adam T. Cross, Neva R. Goodwin & Laura Orlando

See also: Natural capital, Investment, Ecological restoration, Restoration ecology, Environmental restoration.

Reference

Aronson, J., Milton, S.J. & Blignaut, J.N. 2007. "Restoring natural capital: definitions and rationale," pp. 3–8 in Restoring Natural Capital: Science, Business and Practice. J. Aronson, S.J. Milton & J.N. Blignaut, eds. Washington, DC: Island Press.

Return on investment (ROI)

A popular though simple financial metric used in business to determine the attractiveness of an investment over time. ROI is an easy way to relate profits to capital investment, and to compare several alternative investment options in a portfolio in terms of economic efficiency. An ROI should be evaluated over the lifetime of an investment, as well as for a single time period. There are two common ways to calculate ROI:

$$\text{ROI} = \frac{R - I}{C} \times 100\%$$

$$\text{ROI} = \frac{N}{C} \times 100\%$$

Where R = final value of investment, I = initial value of investment, N = net return on investment, and C = cost of investment.

The ROI is easier to calculate than net present value (NPV), with the latter more likely to be used in a benefit–cost analysis (BCA) conducted by a government agency A limitation of the ROI metric is that it does not fully capture the short-term or long-term importance, value, or risks associated with natural and social capital (Sroufe 2018, p. 268).

Barry D. Solomon

See also: Investment, Net present value (NPV), Benefit–cost analysis (BCA).

Reference

Sroufe, R. 2018. Integrated Management: How Sustainability Creates Value for any Business. Bingley, UK: Emerald Publishing.

Revealed preference methods

Techniques used to determine the value or price of goods and services, including non-market environmental and ecological values, based on market pricing information and data. These methods include the hedonic pricing method, travel-cost method, and the defensive expenditures or averting behavior method. Revealed preference methods allow ecological economists and others to indirectly determine the value of environmental or ecological goods and services from goods related in consumption that are traded in a market, such as housing, water, and recreation. In these cases, the environmental or ecological goods and services are implicitly traded in these markets. Economists generally consider revealed preference methods to be more accurate than stated preference methods because of the reliance of revealed preference methods on real market behavior.

BARRY D. SOLOMON

Further reading

Adamowicz et al. 1994; Whitehead et al. 2008.

See also: Hedonic pricing method, Travel cost method, Defensive expenditures, Stated preference methods.

References

Adamowicz, W., Louviere, J. & Williams, M. 1994. Combining revealed and stated preference methods for valuing environmental amenities. Journal of Environmental Economics and Management 26(3): 271–92.

Whitehead, J.C., Pattanayak, S.K., Van Houtven, G.L. & Gelso, B. 2008. Combining revealed and stated preference data to estimate the nonmarket value of ecological services: an assessment of the state of the science. Journal of Economic Surveys 22(5): 872–908.

Reversibility

The ability to maintain and to restore the functional performance of a system. The crucial terms in the definition require case-specific elaboration, starting by delineating the considered "system." Reversibility is substantiated on three aspects: (1) time horizon (for example, duration of effects); (2) revoking costs for stopping or reversing an adverse course; (3) substitutability of benign options for periled ones.

Substitutability is the preponderant feature of reversibility beyond revocability. Both concepts are confused by neoclassical economics by assuming unlimited substitutability, what amounts to a blind eye for (ir) reversibility. Substitutability is grading along assigned weights, either to strict identity or to functional performance of a valued system. For example: the identity of a human being is irreversibly lost at death; however, natural death of individual identities is part of the functional performance of the human species. The three constituent aspects are ordered variables. Hence, reversibility is also gradable from flexibility, over rigidity, to preclusion, with irreversibility as a radical absorbing antonym. According to the definition of reversibility, the term "irreversibility" should not be used lightly. However, it is alarming when unique, non-substitutable, life-essential systems deteriorate with little ability to maintain and restore their functional performance. Climate change and biodiversity loss are two prime cases.

AVIEL VERBRUGGEN

Further reading

Verbruggen 2013.

See also: Irreversibility, Substitutability, Carrying capacity.

Reference

Verbruggen, A. 2013. Revocability and reversibility in societal decision-making. Ecological Economics 85: 20–27.

Ricardian land

The indestructible and non-depletable characteristics of land. Refers to land and its economic properties as a surface area, site, location, physical structure, or substrate only, independent of its fertility, nutrients, and minerals or energy resources. Named for the classical economist David Ricardo. According to Ricardo, since land is a gift of nature and has no supply price or cost of production, the entire economic return from land is rent (Ricardo 1971). While within the same generation Ricardian land is both rival and excludable, between generations it is non-rival.

BARRY D. SOLOMON

Further reading

Marshall 1890; Samuleson 1959.

See also: Rent, Excludability, Excludable good, Rivalness, Rival resource, Non-rival resources, Scarcity rent, Land use designations.

References

Marshall, A. 1890. Principles of Economics. London: Macmillan & Company.

Ricardo, D. 1971. Principles of Political Economy, R.M. Hartwell, ed. Baltimore, MD: Penguin Books.

Samuelson, P.A. 1959. A modern treatment of the Ricardian economy: I. The pricing of goods and of labor and land services. Quarterly Journal of Economics 73(1): 1–35.

Ricardian scarcity

Named after the classical economist David Ricardo, refers to the idea that farmland and other natural resources decrease in quality over time as they are exploited.

GEORGY TROFIMOV

See also: Scarcity, Resource scarcity, Relative vs. absolute scarcity, Social construction of scarcity, Scarcity rent, Malthusian scarcity.

Richness

Ecology: The number of different species that exists in a specific ecological community, ecosystem, landscape, or region.

See also: Species richness.

Economics: The quality or state of being rich or having significant wealth.

BARRY D. SOLOMON

See also: Species, Fitness, Wildlife conservation, Darwinian theory, Wealth, Virtual wealth.

Rights

A moral or legal entitlement to (not) have or (not) do something. They are socially constructed institutions that can be authorized and enforced by a court or some other formal or informal social authority. Because the creation of rights also establishes corresponding duties and responsibilities, the assertion of a right has the capacity to assert a claim that is enforceable against others.

JULIA TALBOT-JONES

Further reading

Cole & Grossman 2002; Commons 1968; Hohfeld 1913.

See also: Institutions, Property right, Human rights, Environmental rights, Indigenous rights.

References

Cole, D.H. & Grossman, P.Z. 2002. The meaning of property rights: law versus economics? Land Economics 78(3): 317–30.

Commons, J.R. 1968. Legal Foundations of Capitalism. Madison, WI: University of Wisconsin Press.

Hohfeld, W.N. 1913. Some fundamental legal conceptions as applied in judicial reasoning. Yale Law Review 23(1): 16–59.

Risk

a. The possibility or probability of suffering harm, injury, or disease, or experiencing otherwise negative or undesirable consequences from an activity.
b. The exposure to the possibility of injury or loss.
c. The effects of uncertainty on the achievement or experience of human or group objectives. For example: exposure to high levels of lead may cause weakness, anemia, and kidney and brain damage; in the United States (US) the risk each year of the average driver dying because of injuries sustained in a car crash is 1 in 77; and 1 in 2 women and 1 in 3 men in the US face the risk of developing cancer within their lifetime.

BARRY D. SOLOMON

Further reading

Davies 1996; Landis & Wiegers 1997.

See also: Risk perception, Risk aversion, Risk assessment, Uncertainty, Monte Carlo simulation, Maximin, Minimax regret criterion.

References

Davies, J.C. 1996. Comparing Environmental Risks: Tools for Setting Government Priorities. New York: Routledge.

Landis, W.G. & Wiegers, J.A. 1997. Design considerations and a suggested approach for regional and comparative ecological risk assessment. Human and Ecological Risk Assessment 3(3): 287–97.

Risk assessment

A technique to assess the human health, ecological, accident, or failure risk of a chemical product, process, facility, policy, or project. In most applications, toxicological laboratory analyses and bioassays, or ecological field studies, or engineering assessments are involved.

Human health: the process usually involves four steps: hazard identification, dose–response assessment, exposure assessment, and risk characterization. Dose–response can be expressed as a no-observed-effect level, no-observed-adverse-effect level, lowest-observed-adverse-effect level, incidence per unit of exposure, and in other ways.

Ecological: the process also involves four steps: problem formulation for the affected plants, animals, and technologies; exposure assessment; ecological health effects assessment; and risk characterization.

Technological: for industrial facilities, five steps are usually involved: system description, identification of the technological hazard, analysis of the probability of system failure, risk rating and recommended actions, and resolution or reduction of the risk, if possible.

Risk characterization or rating thus conveys the risk assessor's judgment on the nature and presence or absence of risks, how the assessment was made, uncertainties, and policy choices. It is usually expressed as the probability of cancer, death, or other adverse health effects, system failure, or accident based on exposure to a chemical or operation of a technology. Thus, this information is used to determine how to manage a risk or technology based on some standard or frame of reference for acceptable risk.

BARRY D. SOLOMON

Further reading

Covello & Merkhoher 1993; Ostrom & Wilhelmsen 2019; Simon 2020; Bahr 2014.

See also: Risk, Risk aversion, Risk perception, Technology, Technological change.

References

Bahr, N.J. 2014. System Safety Engineering and Risk Assessment: A Practical Approach, 2nd edn. Boca Raton, FL: CRC Press.

Covello, V.T. & Merkhoher, M.W. 1993. Risk Assessment Methods: Approaches for Assessing Health and Environmental Risks, 3rd edn. New York: Springer.

Ostrom, L.T. & Wilhelmsen, C.A. 2019. Risk Assessment: Tools, Techniques, and their

Applications, 2nd edn. Hoboken, NJ: John Wiley & Sons.
Simon, T.W. 2020. Environmental Risk Assessment: A Toxicological Approach, 2nd edn. Boca Raton, FL: CRC Press.

Risk aversion

Economics: an attitude towards risk characterized by preference of (more) certain outcomes against less certain ones with an equal expected monetary payoff (itself a function of the payoff from each outcome and the probability associated with them). In the language of expected utility theory, the utility function of a risk-averse economic agent is concave: as wealth increases, additional marginal utility decreases.

Ecology:

a. Aversion to chemical, biological, or physical risks to living organisms and ecosystems posed by human intervention; a type of environmental risk aversion (Fairman et al. 1998).
b. The slow growth of juvenile primates is a response to the ecological risks of predation and starvation that they experience (Janson & Van Schaik 1993).

Aja Ropret Homar

Further reading

Arrow 1965; Von Neumann & Morgenstern 1947.

See also: Risk, Risk neutrality, Uncertainty, Expected utility theory (EUT).

References

Arrow, K.J. 1965. "The theory of risk aversion," Chapter 2 in Aspects of the Theory of Risk Bearing. Helsinki: Yrjö Jahnsson Saatio.
Fairman, R., Mead, C.D. & Williams, W.P. 1998. Environmental Risk Assessment: Approaches, Experiences and Information Sources. Copenhagen: European Environment Agency.
Janson, C.H. & Van Schaik, C.P. 1993. "Ecological risk aversion in juvenile primates: slow and steady wins the race," pp. 57–76 in Juvenile Primates: Life History, Development, and Behavior. M.E. Pereira & L.A. Fairbanks, eds. New York: Oxford University Press.
Von Neumann, J. & Morgenstern, O. 1947. Theory of Games and Economic Behavior, 2nd rev. edn. Princeton, NJ: Princeton University Press.

Risk neutrality

Indifference between certain and uncertain outcomes with equal expected payoffs (monetary or otherwise). Risk neutrality indicates a risk-aversion parameter equal to 1 and is captured by a linear utility function. For example, in terms of environmental risk, a risk-neutral farmer makes decisions to maximize his present value of the net income stream or other benefits that derive from farming land.

Aja Ropret Homar

Further reading

De Pinto et al. 2013; Von Neumann & Morgenstern 1947.

See also: Risk, Risk aversion, Uncertainty.

References

De Pinto, A., Robertson, R.D. & Obiri, B.D. 2013. Adoption of climate change mitigation practices by risk-averse farmers in the Ashanti Region, Ghana. Ecological Economics 86: 47–54.
Von Neumann, J. & Morgenstern, O. 1947. Theory of Games and Economic Behavior, 2nd rev. edn. Princeton, NJ: Princeton University Press.

Risk perception

Psychology: an individual's subjective judgment and assessment of the level of risk associated with a particular event that might cause immediate or long-term undesirable consequences. It results from cognitive processes used to cope with complex situations (heuristics). Can be measured and predicted through psychometric scaling methods (Fischhoff et al. 1978). Factors such as the degree of familiarity with the hazard and the dread feeling directly influence the perception of individ-

uals about the seriousness and acceptability of risks.

Sociology: shared values and beliefs about risks as constituted in a social and cultural context. People's judgment and assessment towards risks will depend on how they are socially constructed. Socio-political institutions and cultural values influence the way in which people interpret and make sense of risk.

BEATRIZ M. SAES

Further reading

Slovic 1987; Douglas & Wildavsky 1982.

See also: Risk, Risk assessment, Heuristic.

References

Douglas, M. & Wildavsky, A. 1982. Risk and Culture: An Essay on the Selection of Technical and Environmental Dangers. Berkeley, CA: University of California Press.

Fischhoff, B., Slovic, P., Lichtenstein, S. et al. 1978. How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. Policy Sciences 9(2): 127–52.

Slovic, P. 1987. Perception of risk. Science 236 (4799): 280–85.

Risk premium

The difference between the expected return on a security or portfolio and the riskless rate of interest (the certain return on a risk-less security). The underlying reason for this is the idea that there should be a higher expected return or premium for bearing risk (Goetzmann & Ibbotson 2006, pp. 3, 7).

From the equity side, the risk could be: credit risk, the risk that the asset does not perform as expected; liquidity risk, the risk that the asset cannot be transformed to cash quickly; market risk, and so on (Society of Actuaries n.d.). From the lending side, a risk premium is the additional interest rate or return lenders ask from their borrowers. A high-risk premium can occur if lenders believe that borrowers are likely to default and not pay back loans; if lenders are risk-averse; and/or if financial intermediaries are reducing lending because of fear of bankruptcy (Blanchard 2021, p. 132).

OLUWASEUN A. ODUSOLA

See also: Risk, Risk aversion, Risk perception.

References

Blanchard, O. 2021. Macroeconomics, 8th edn. Hoboken, NJ: Pearson.

Goetzmann, W.N. & Ibbotson, R.G. 2006. The Equity Risk Premium: Essays and Explorations. Oxford: Oxford University Press.

Society of Actuaries. n.d. Risk premium. Actuarial toolkit. https://actuarialtoolkit.soa.org/tool/glossary/risk-premium.

Rivalness

An intrinsic characteristic of some resources in which its use or consumption by one person reduces the amount available for everyone else. Rivalness increases as resources become scarcer, which can potentially create a negative feedback loop of exploitation of scarce resources for economic gains at the expense of natural capital.

MARCELLO HERNÁNDEZ-BLANCO

Further reading

Daly & Farley 2011.

See also: Rival resource, Fund-service resources, Non-rival resources, Scarcity, Resource scarcity.

Reference

Daly, H.E. & Farley, J. 2011. Ecological Economics: Principles and Applications, 2nd edn. Washington, DC: Island Press.

Rival resource

A resource that when used by one person limits the use by another person, and therefore it also reduces the quantity of the resource available for others. All stock-flow resources (that is, provisioning services) are rival. For example, fisheries compete for ever-decreasing fish stocks, a rival resource

that when it is extracted from the ocean is no longer available for other fishermen.

MARCELLO HERNÁNDEZ-BLANCO

Further reading

Hernández-Blanco & Costanza 2019; Costanza et al. 2014; Daly & Farley 2011.

See also: Rivalness, Ecosystem services, Stocks, Flows, Fund-service resources, Provisioning services, Non-rival resources.

References

Costanza, R., Cumberland, J.H., Daly, H. et al. 2014. An Introduction to Ecological Economics, 2nd edn. Boca Raton, FL: CRC Press.

Daly, H.E. & Farley, J. 2011. Ecological Economics: Principles and Applications, 2nd edn. Washington, DC: Island Press.

Hernández-Blanco, M. & Costanza, R. 2019. "Natural capital and ecosystem services," pp. 254–68 in The Routledge Handbook of Agricultural Economics. G.L. Cramer, K.P. Paudel & A. Schmitz, eds. London: Routledge.

River basin management

One of the models of water management on an international level (Molle 2008). This was institutionalized at least a century ago, but many authors (for example, the French geographer Philippe Buache in the 18th century) had already been recommending for a long time that natural boundaries (mountains, watersheds) be used to establish political and economic borders. His definition of the river basin as "the set of all the slopes on which fall the waters that converge to a same river or creek" could still apply today.

The institutionalization of river basin management based on watersheds or catchment areas has undergone interesting developments in Europe, with the experience of the Genossenshaft in the Ruhr at the beginning of the 20th century, and the institution of the confederaciones hidrográficas in 1926 in Spain. In the United States, the Tennessee Valley Authority was created in the 1930s to manage water as a multifunctional resource. These different experiences originated from issues related to drainage, hydroelectric production, irrigation, and freshwater pollution. Thus, it is well documented that the river basin is at least as much a political territory as a natural territory.

Today, the adoption of water management at the level of river basins is recognized as one of the essential ingredients of the water management package, based on the participation of users and the use of economic instruments, within the framework of integrated water resources management discourse carried out by the major international institutions or within the framework of European water policy, among others.

OLIVIER PETIT

Further reading

Carr 2015; Molle 2009; Petit & Baron 2009.

See also: Groundwater governance, Stakeholder participation, Market-based instruments, Integrated water resources management (IWRM), Common pool resources.

References

Carr, G. 2015. Stakeholder and public participation in river basin management—an introduction. WIREs Water 2(4): 393–405.

Molle, F. 2008. Nirvana concepts, narratives and policy models: insights from the water sector. Water Alternatives 1(1): 131–56.

Molle, F. 2009. River-basin planning and management: the social life of a concept. Geoforum 40(3): 484–94.

Petit, O. & Baron, C. 2009. Integrated water resources management: from general principles to its implementation by the state. The case of Burkina Faso. Natural Resources Forum 33(1): 49–59.

Royalties

Payments made by firms to fossil fuel, mineral, forestry, and some water resource owners based on license agreements for the right to use their assets and extract or process the resources. The asset owners may be government agencies, private firms, or households. Royalties can be charged three ways: (1) profit based: based on net cash flow or some other measure of project profitability; (2) *ad valorem*: output-based, as a percentage of the value of production; or (3) specific, or

unit-based: which is levied as a set charge per physical unit of production.

BARRY D. SOLOMON

Further reading

Brown et al. 2016; Kinnaman 2011; Blignaut & Hassan 2002.

See also: Fossil fuels, Forest resources, Water resources, Natural resource rents.

References

Blignaut, J.N. & Hassan, R.M. 2002. Assessment of the performance and sustainability of mining sub-soil assets for economic development in South Africa. Ecological Economics 40(1): 89–101.

Brown, J.P., Fitzgerald, T. & Weber, J.G. 2016. Capturing rents from natural resource abundance: private royalties from U.S. onshore oil and gas production. Resource and Energy Economics 46: 23–38.

Kinnaman, T.C. 2011. The economic impact of shale gas extraction: a review of existing studies. Ecological Economics 70(7): 1243–49.

Rural livelihoods

The capabilities, assets (stores, resources, claims, and access), and activities that rural people require for their means of living (FAO 2003). The concept is frequently coupled to poverty and food security in poor countries. On the one hand, "rural" is understood as the space where diverse economic activities such as agriculture, livestock, forestry, fisheries, mining, tourism, and a wide range of non-agricultural occupations take place, and where their communities live. On the other hand, "livelihood" refers to (from Chambers & Conway 1992) an integrating concept in which capabilities and equity are both the ends and the means of living.

IKER ETXANO

Further reading

Ellis 2000; Scoones 1998.

See also: Sustainable agriculture, Food security, Poverty, Rural transformation, Sustainable livelihoods, Sustainable tourism, Sustenance.

References

Chambers, R. & Conway, G. 1992. Sustainable rural livelihoods: practical concepts for the 21st century. IDS Discussion Paper 296. Brighton: Institute of Development Studies.

Ellis, F. 2000. Rural Livelihoods and Diversity in Developing Countries. Oxford: Oxford University Press.

FAO (Food and Agriculture Organization of United Nations). 2003. Enhancing Support for Sustainable Rural Livelihoods. COAG/2003/7. Rome: FAO.

Scoones, I. 1998. Sustainable rural livelihoods: a framework for analysis. IDS Working Paper 72. Brighton: Institute of Development Studies.

Rural resilience

The capacity over time of individuals, households, communities, or other aggregate units living in rural areas to withstand a myriad of shocks and stressors, return to their previous levels of food security and well-being after experiencing an adverse event, and thrive in the face of risk and uncertainty. For instance, a rural household can be considered resilient to environmental change if it consistently manages to cope with climatic shocks by successfully adapting to them, and avoids long-lasting adverse welfare consequences. As people's livelihoods in rural areas often rely on fragile equilibria and depend upon natural resources and agriculture, the notion of rural resilience is inextricably linked to the concepts of vulnerability to poverty and food insecurity, climate change adaptation, and rural development.

MARCO LETTA

Further reading

Barrett & Constas 2014; Barrett et al. 2021; FAO 2018.

See also: Climate change adaptation, Food insecurity, Food security, Resilience, Rural transformation.

References

Barrett, C.B. & Constas, M.A. 2014. Toward a theory of resilience for international development applications. Proceedings of the National

Academy of Sciences of the United States of America 111(40): 14625–30.
Barrett, C.B., Ghezzi-Kopel, K., Hoddinott, J. et al. 2021. A scoping review of the development resilience literature: theory, methods and evidence. Applied Economics and Policy Working Paper Series, No. 3/2021, Cornell University, Ithaca, NY.
FAO (Food and Agriculture Organization of the United Nations). 2018. The State of Food Security and Nutrition in the World 2018: Building Climate Resilience for Food Security and Nutrition. http://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1152267/.

Rural transformation

Refers to collective, social efforts that re-embed the positive and negative externalities of rural economies into local and regional democratic procedures. This is accomplished by addressing interrelated problems of rural areas, such as: demographic change and emigration, deterioration of public infrastructure, economic decline and outflow of capital, and degradation of the natural environment. Such processes can lead to a decrease of communities' capabilities to self-govern, and to repression of liberal and pluralistic values. Successful cases tend to emerge from pragmatic coalitions between local government, the private sector, and civil society organizations. These cases address concrete local manifestations of such problems with local resources, while often drawing inspiration and knowledge from other places. Over time, several such initiatives converge to diverse rural economies. Examples are short food supply chains, energy autonomy networks, complementary currencies, and ecosystem governance programs.

Jan-Tobias Doerr

Further reading

Long & Douwe van der Ploeg 1994; Pike et al. 2007; Hassanein 2003; Doerr & Taylor Aiken 2021; Coenen et al. 2012.

See also: Rural livelihoods, Sustainable livelihoods, Rural resilience, Sustainability transition.

References

Coenen, L., Benneworth, P. & Truffer, B. 2012. Toward a spatial perspective on sustainability transitions. Research Policy 41(6): 968–79.
Doerr, J.-T. & Taylor Aiken, G. 2021. Transformative pragmatism: how a diversity of Leitbilder is harnessed for rural transformation in Réiden, Luxembourg. Environmental Policy and Governance 31(3): 237–48.
Hassanein, N. 2003. Practicing food democracy: a pragmatic politics of transformation. Journal of Rural Studies 19(1): 77–86.
Long, A. & Douwe van der Ploeg, J. 1994. "Endogenous development: practices and perspectives," pp. 1–6 in Born from Within: Practice and Perspectives of Endogenous Rural Development. J. Douwe van der Ploeg & A. Long, eds. Essen: Uitgeverij Koninklije Van Gorcum.
Pike, A., Rodríguez-Pose, A. & Tomaney, J. 2007. What kind of local and regional development and for whom? Regional Studies 41(9): 1253–69.

S

Safe minimum standard (SMS)

A collective choice rule to preserve a minimum level or safe standard of a renewable resource unless the social costs of doing so are "intolerable," "unacceptable," or "excessive" (Berrens et al. 1998, p. 147). Sometimes considered an alternative to benefit–cost analysis. Developed by natural resource economist Siegfried von Ciriacy-Wantrup (1952), the concept focuses flow resources that might be irreversibly damaged and hence destroyed in case their use transgresses a critical zone that is characterized by (strong) uncertainty (Bishop 1978; Seidl 2017). Examples for such flow resources are animal and plant species, scenic resources, land, and storage capacity of groundwater basins (Solomon et al. 2004).

The major objective of the concept is to retain economic possibilities to halt a decreasing resource flow that may involve irreversibility. Irreversibility can be economic and biological. The former sets in earlier than the latter. Economic irreversibility is relative and depends on "technology, wants and social institutions," whereas biological irreversibility is absolute. Conservation policy permits reaching a maximum social net revenue in resource utilization over time. This means that resource use is far from excluded, but it must be secured in the long term. The means for such a policy are broad, and involve societal practices (for example, routines, habits, knowledge) and institutional settings (for example, property, tenancy, taxes), which led Ciriacy-Wantrup to consider conservation as cheap.

The original concept involved a critical institutional analysis, normative decisions, and adaptive management (Seidl & Tisdell 2001). Economists have tried to overcome the institutional and normative elements by applying game theory, benefit–cost analysis, and cost-effectiveness analysis. However, strong uncertainty and the valuation problem could not be overcome. The concept of SMS inspired the precautionary principle and planetary boundaries concepts and is frequently invoked, yet in conservation economics the broad approach as proposed and developed by Ciriacy-Wantrup has rarely been applied.

Irmi Seidl

See also: Conservation, Biodiversity conservation, Wildlife conservation, Adaptive ecosystem management, Institutional analysis, Precautionary principle, Game theory, Benefit–cost analysis (BCA), Cost-effectiveness analysis (CEA).

References

Berrens, R.P., Brookshire, D.S., McKee, M. & Schmidt, C. 1998. Implementing the safe minimum standard approach: two case studies from the US Endangered Species Act. Land Economics 74(2): 147–61.

Bishop, R.C. 1978. Endangered species and uncertainty: the economics of a safe minimum standard. American Journal of Agricultural Economics 60(1): 10–18.

Ciriacy-Wantrup, S. von 1952. Resource Conservation: Economics and Policies. Berkeley, CA: University of California Press.

Seidl, I. 2017. "Addressing strong uncertainty: safe minimum standards," pp. 278–87 in The Routledge Handbook of Ecological Economics: Nature and Society. C.L. Spash, ed. Abingdon: Routledge.

Seidl, I. & Tisdell, C. 2001. Neglected features of safe minimum standard: socio-economic and institutional dimensions. Review of Social Economy 59(4): 418–42.

Solomon, B.D., Corey-Luse, C.M. & Halvorsen, K.E. 2004. The Florida manatee and eco-tourism: toward a safe minimum standard. Ecological Economics 50: 101–15.

Satisficing

a. A decision-making strategy that involves searching through the available alternatives to choose an option that is good enough. The view that economic decision-makers adopt satisficing rather than optimizing behaviors was introduced into the economics literature by Herbert Simon (1955). Simon rejected the neoclassical concept of "economic man," which assumes that economic decision-makers are omniscient, supposes that decision-making is a costless process, and that optimal economic decisions are made given these conditions. He argued that due to limits to the exercise of rationality (bounded rationality), namely the presence of uncertainty and the cost of decision-making itself, individuals do not optimize. Instead, they only seek satisfactory outcomes because of their decisions. For example, their search for an outcome may terminate as soon as they find a satisfactory one.
b. The idea that individuals ought to limit their levels of income and consumption to support ecological and environmental sustainability. It is claimed that most individuals can still have satisfactory levels of income and consumption if they do so (Daly 1980). Sahlins (1972) has argued that the members of some early hunting and gathering tribes were economic satisficers and that they were very content with their economic lot. This, for example, may help to explain the long-term sustainability of the economies of early Australian Aboriginal tribes (Tisdell 2018).

Clement A. Tisdell

Further reading

Tisdell 2021.

See also: Bounded rationality, Consumer sovereignty, *Homo economicus*, Sufficiency.

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Saturation

Chemistry: the maximum amount of a solute that can be dissolved in a solvent under specified conditions of temperature and pressure. This was the original definition of the term.

Economics: a situation where a product or market good or service has been fully distributed to meet the demand within a specific market area, which is usually geographical (Applebaum & Cohen 1961). When a market is saturated, for example eCommerce, no more customers can be found until the needs or tastes of the existing customers change (for example, for easier or faster service, or eCommerce for a new product) or new consumers enter the market.

Ecology:

a. The maximum number of animal species that can live together in an area of "uniform type," though this is very difficult to determine in the natural world (Elton 1950, pp. 17–22). While the total number of species in a guild has an upper limit, the composition could be highly variable among and within communities or assemblages over time (Olivares et al. 2018).
b. The equilibrium state in the number of species in a uniform area (MacArthur & Wilson 1967, p. 176).

Barry D. Solomon

See also: Market, Market goods, Species, Community.

References

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Say's law

Popularly, though inaccurately, known as "supply creates its own demand," or more generally as "Say's law of markets" based on the writings of Jean-Baptiste Say during the classical economics period. Baumol (1977) argued that there were at least eight Say's laws. The popular version of Say's law was promoted and criticized by John Maynard Keynes. He considered the full-employment implication of Say's law to be widely accepted among neoclassical economists during his time and a basis for laissez-faire macroeconomic policy, which he resoundingly rejected.

Say's law can be more properly stated that in a market economy all goods and services are produced for exchange with other goods and services, and in the process enough real income is created to purchase the economy's entire output (Blaug 1997). Thus, the total supply of goods and services in a market economy must equal the total demand derived from consumption in any given time period. If true, Say's law would seem to rule out any long-term and significantly high unemployment and "general glut" in aggregate production (the term "general glut" was introduced by classical economist Thomas Robert Malthus to describe an economic slump caused by excessive productive capacity and insufficient demand). Most leading contemporary economists reject Say's law, and some such as Paul Krugman argue the opposite: that is, that demand creates its own supply, especially during recessions (Krugman 2015).

BARRY D. SOLOMON

See also: Classical economics, Laissez-faire economics.

References

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Krugman, P.A. 2015, November 3. Demand creates its own supply. New York Times. https://krugman.blogs.nytimes.com/2015/11/03/demand-creates-its-own-supply/.

Scarcity

Neoclassical economics: an individual has virtually unlimited wants, but command over limited resources, and therefore all resources are scarce (Daoud 2011). Because of scarcity, all resources have a price, and prices are governed by markets.

Ecological economics: biophysical limits along with previous abundance and demand determine scarcity for specific resources and natural capital, not market mechanisms.

Ecology: the relationship between a population's wants W for a resource and the existence of that resource R in a particular history h and geography g (Daoud 2018). These wants are either essential (for example, food) or non-essential. Their essentialism is a function of mainly biological, social, and cultural mechanisms. Likewise, the existence of a resource is a function of various ecological, economic, technological, and cultural mechanisms. For each h and g, if the quantity of wants exceeds the number of available resources, that is, $W > R$, then scarcity is present. For $W < R$, abundance exists; and for $W = R$, sufficiency is present. A limited resource is different from a scarce resource. While a limited resource means that there is a finite existence of a resource with no reference to wants W, a scarce resource can only become scarce when evaluated in reference to W.

The dynamics of scarcity, abundance, and sufficiency (SAS): Daoud (2017, 2010) provides a synthesis of how individuals influence W and R to create, maintain, or manipulate scarcity. They use entitlements to enable or block others to access existing resources. Even though abundant resources exist, individuals will experience artificial scarcity because of a lack of entitlements (Daoud 2015).

ADEL DAOUD

Further reading

Daly 1974; Baumgärtner et al. 2006; Sen 1981; Xenos 1989.

See also: Abundance, Sufficiency, Scarcity indicators, Social construction of scarcity, Resources.

References

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Sen, A.K. 1981. Poverty and Famines: An Essay on Entitlement and Deprivation. Oxford: Oxford University Press.

Xenos, N. 1989. Scarcity and Modernity. London: Routledge.

Scarcity indicators

Neoclassical economics: most neoclassical economists have argued that price is the best indicator of natural resource scarcity (Fisher 1979; Slade 1982), while some have argued for unit costs, total extraction costs, natural resource rents, rental rates, royalties, and elasticities of substitution (Barnett & Morse 1963; Brown & Field 1979; Devarajan & Fisher 1982; Farzin 1995).

Ecological economics: ecological economists have criticized economic indicators of scarcity (e.g., Norgaard 1990), and some have favored a biophysical model of scarcity and energy-based indicators (Cleveland et al. 1984; Cleveland & Stern 1998).

BARRY D. SOLOMON

See also: Scarcity, Indicators, Scarcity rent, Scarcity value, Economic indicators, Resource scarcity, Relative vs. absolute scarcity, Social construction of scarcity.

References

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Devarajan, S. & Fisher, A.C. 1982. Exploration and scarcity. Journal of Political Economy 90(6): 1279–90.

Farzin, Y.H. 1995. Technological change and the dynamics of resource scarcity measures. Journal of Environmental Economics and Management 29(1): 105–20.

Fisher, A.C. 1979. "Measures of natural resource scarcity," pp. 249–75 in Scarcity and Growth

Reconsidered. V.K. Smith, ed. Baltimore, MD Johns Hopkins University Press.
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Slade, M.E. 1982. Trends in natural-resource commodity prices: an analysis of the time domain. Journal of Environmental Economics and Management 9: 122–37.

Scarcity rent

A category of rent where surplus income is extracted through control of scarce resources or assets. A resource is scarce if demand exceeds supply (Farzin 1992). The scarcity may be imposed by nature, or created through social or economic institutions, such as cartels, trade sanctions, intellectual property, or carbon markets with limited permits or allowances. Whoever controls the scarce resource has additional bargaining power, which is the source of the scarcity rent.

BETH STRATFORD

See also: Rent, Natural resource rents, Land economics, Geonomics.

Reference

Farzin, Y.H. 1992. The time path of scarcity rent in the theory of exhaustible resources. Economic Journal 102(413): 813–30.

Scarcity value

Neoclassical economics:

a. Extraction and consumption of a resource, good, or service in limited supply reduces its future availability and generates costs related to its increased scarcity. If availability is suppressed, the relative price will rise above the marginal production cost. The notion is frequently defined as the opportunity cost of reducing the stock of a scarce resource by one unit, or the additional value that could be reaped by relaxing scarcity at the margin. Scarcity value can apply to both exhaustible resources (for example, petroleum) and renewable resources in short supply (for example, water). In theory, perfect competition ensures that market prices encapsulate both marginal extraction costs and scarcity value (also called "scarcity rent"). Efficient markets are supposed to signal increasing scarcity value of a resource under depletion with rising prices.
b. Some goods draw part of their value from not being widely consumed, for example, positional goods or congestible goods. The diamonds–water paradox illustrates scarcity value, since diamonds are not a biological necessity but have high value due to their scarcity; while water, which is a biological necessity, used to have a low value because of its abundance. In the 21st century this paradox has been turned on its head. Because of population growth, climate change, and excess withdrawals by agriculture, water is increasingly scarce. On the other hand, technological innovation in synthetic diamonds has eroded monopoly power in the diamond industry and prices have fallen.

Ecological economics: a fundamental concept in illustrating that non-market goods—for example, ecological services—have value derived from their usefulness and scarcity. For example, the total economic value of a forest is not determined by just the market value of its wood, but by the value of all its ecological services. There is scarcity value associated with the resource rent, or the opportunity cost of extracting the resource, but non-market values are not included in the price.

JAMES R. KAHN & PHILIPPE P. ROMAN

Further reading

Hotelling 1931; Barnett & Morse 1952; Robertson & Taylor 1957; Krautkraemer 1998; Hirsch 1977; Rahman 2015; Bryan et al. 2018; Zetland 2021.

See also: Scarcity rent, Natural resource rents, Social construction of scarcity, Exhaustible resources, Congestible public good, Positional goods, Total economic value (TEV).

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Robertson, H.M. & Taylor, W.L. 1957. Adam Smith's approach to the theory of value. Economic Journal 67(266): 181–98.
Zetland, D. 2021. The role of prices in managing water scarcity. Water Security 12: 100081.

Scenario

A postulated sequence of events used to describe, explore, and communicate how the future may unfold. Starting from a defined initial situation for a specific region and thematic focus, scenarios investigate the future by reflecting on an internally consistent set of assumptions about key drivers and their relationships.

Common scenario typologies are based on: (1) the type of question addressed when referring to future change (that is, reference, explorative, normative); (2) the epistemology underlying the scenario exercise (that is, problem-focused, actor-focused, reflexive interventionist); (3) the rationale for engaging stakeholders in scenario development (that is, cognitive, constructive, political); (4) the form used to describe how the future may unfold (that is, qualitative, semi-quantitative, quantitative); (5) the time horizon considered (that is, short-term, mid-term, and long-term) and the direction of time (that is, projective and prospective); (6) the level of spatial aggregation or spatial extent (that is, micro, meso, and macro or global, continental, national, and regional); and (7) the breadth of the scenario topic (that is, sectoral versus multi-sectoral).

Hermine Mitter

Further reading

Alcamo 2008; Börjeson et al. 2006; Elsawah et al. 2020; Mietzner & Reger 2005; O'Neill et al. 2017; Rounsevell & Metzger 2010; Swart et al. 2004; Wilkinson & Eidinow 2008; Zurek & Henrichs 2007.

See also: Pathway, Energy pathways, Plausible.

References

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Zurek, M.B. & Henrichs, T. 2007. Linking scenarios across geographical scales in international environmental assessments. Technological Forecasting and Social Change 74(8): 1282–95.

Scientific method

An observation-based, empirical approach to understanding natural and physical phenomena that was first developed in the 17th century. Following initial observations, one forms questions and posits possible answers/explanations, often in the form of hypotheses. One then gathers additional data and performs measurements and experiments or mathematical analysis to assess the extent to which the data are consistent with the hypotheses, which may result in revisions to the hypotheses. Based on the results, one reaches conclusions about the nature of the phenomenon being studied.

Among the assumptions underlying the scientific method are that there is a physical reality (a belief known as scientific materialism) that human senses can reliably evaluate. Debates emerged in the 20th century over the range of proper application of the scientific method, and whether it can arrive at truth statements, or only conclude that a theory is not false based on the data considered (Popper 1968 [1959]). It has also been criticized by those who argue that scientific truth is contextual and can only be understood in terms of the extant reigning scientific paradigm (Kuhn 1970 [1962]), or that rhetorical argument is more powerful than truth emerging from the scientific method in motivating policy action (Poitras 2021). While the scientific method plays a significant role in ecological economics, there is also space for both qualitative and quantitative analysis, value pluralism, and critical institutionalism as practiced by social ecological economists (Spash 2021).

BRENT M. HADDAD

Further reading

Gauch 2012.

See also: Empiricism, Quantitative analysis, Qualitative research, Social ecological economics.

References

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Kuhn, T. 1970 [1962]. The Structure of Scientific Revolutions, 2nd edn. Chicago, IL: University of Chicago Press.
Poitras, G. 2021. Rhetoric, epistemology and climate change economics. Ecological Economics 184: 106985.
Popper, K. 1968 [1959]. The Logic of Scientific Discovery. New York: Harper & Row.
Spash, C.L. 2021. Social ecological economics. SRE—Discussion Paper, 06/2021. WU Vienna University of Economics and Business, Vienna.

Secondary energy

Sources of energy that result from the conversion or transformation of primary energy sources. Examples include petroleum products such as gasoline, diesel and jet fuel, synthetic oil and gas derived from coal, heat, electricity, hydrogen, and biofuels such as ethanol, biodiesel, biogas, and methanol.

BARRY D. SOLOMON

Further reading

Cleveland and Morris 2013.

See also: Energy, Primary energy.

Reference

Cleveland, C.J. & Morris, C., eds. 2013. Handbook of Energy Volume I. Waltham, MA: Elsevier.

Self-determination

The process by which an entity can freely make decisions about its well-being without outside interference. First expressed in relation to free will, and later state sovereignty, the concept of self-determination has most recently evolved to have application to specific groups of peoples, including indigenous peoples and minorities, and nature.

JULIA TALBOT-JONES

Further reading

Emerson 1971; Hobbes 1651; Philpott 2015; Talbot-Jones & Bennett 2019.

See also: Rights.

References

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Hobbes, T. 1651. Leviathan. London: Dent.
Philpott, D. 2015. In defense of self-determination. Ethics 105(2): 352–85.
Talbot-Jones, J. & Bennett, J. 2019. Toward a property rights theory of legal rights for rivers. Ecological Economics 164: 106352.

Self-organization

See: Spontaneous order.

See also: Institutions, Autonomous institution, Social institutions, Pareto efficiency.

Self-selection bias

Selection bias is created when a sample of units of observation used in statistical analysis is not representative of the larger population being studied. It can be caused by a variety of phenomena including non-random sampling and non-random attrition (loss of participants). Self-selection bias—also known as volunteer response bias—is selection bias that arises when units of observation with characteristics that affect an outcome of interest are allowed to disproportionately self-select into the sample. For example, in a study of the environmental preferences of university students, such bias would arise if the study sample were comprised of all students volunteering to participate and those with "green" preferences disproportionately volunteered.

Allen Blackman

Further reading

Heckman 1990; Lavrakas 2008.

See also: Quantitative analysis, Population.

References

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Lavrakas, P.J., ed. 2008. Encyclopedia of Survey Research Methods, Vol. 1. Thousand Oaks, CA: SAGE Publications.

Sensitivity analysis

The process of testing the robustness of the results of a mathematical model to alternative assumptions. Sensitivity analysis allows a researcher to reduce uncertainty in a study. By testing a model with different observations, input parameters, or policy scenarios, the effects on model projections, forecasts, or predictions can be determined. Sensitivity analysis is an essential component of mathematical modeling and can strengthen the value and usefulness of ecological economics models to users, and help to increase the understanding and credibility of results. The amount of sensitivity analysis that is needed will be based on expert or professional judgment.

Barry D. Solomon

Further reading

Andriantiatsaholiniana et al. 2004; Mattila et al. 2013.

See also: Models and modeling, Scenario, Multivariate statistical techniques.

References

Andriantiatsaholiniana, L.A., Kouikoglou, V.S. & Phillis, Y.A. 2004. Evaluating strategies for sustainable development: fuzzy logic reasoning and sensitivity analysis. Ecological Economics 48(2): 149–72.
Mattila, T., Koskela, S., Seppälä, J. & Mäenpää, I. 2013. Sensitivity analysis of environmentally extended input–output models as a tool for building scenarios of sustainable development. Ecological Economics 86: 148–55.

Separability

Mathematics: a simplifying property that allows, when applicable, the decoupling of variables on which functions describing phenomena depend, for example, in differential equations such as those regulating wave propagation and heat conduction, or potentials that generate a physical field of forces (Kelley 2017).

Neoclassical economics: an important concept in production theory, motivated by the desire to conceptualize the optimization of production decisions by stages.

a. Primal separability of production factor i and j from k exists where factor k's intensity does not affect the ease of substitution—measured in terms of the marginal rate of substitution—between i and j (Leontif 1947; Sono 1945).
b. Dual separability: on the basis of a twice differentiable cost function $C(Y, p_1, p_2 \ldots, p_u)$ with non-vanishing first and second partial derivatives, two factors i and j are defined to be dually separable from factor k if and only if the Leontief–Sono separability condition is valid (Frondel & Schmidt 2004).

Ecological economics: ecological economists are skeptical of the separability assumption and commonly note that everything is connected to something else in ecological systems, natural capital frequently cannot be substituted for by manufactured capital, and often manufactured capital not for labor, and energy is especially not separable from other production factors (Stern 1997).

MASSIMO SCALIA

See also: Differential equation, Substitutability, Capital substitution, Principle of substitution, Weak sustainability, Strong sustainability, Energy.

References

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Stern, D.I. 1997. Limits to substitution and irreversibility in production and consumption: a neoclassical interpretation of ecological economics. Ecological Economics 21(3): 197–215.

Service economy

a. An economy where the dozen or more service sectors play a growing and dominant, if not the largest, role in value added output and employment, typically for a country. The service sectors grew in importance in most countries during the second half of the 20th century and into the 21st century (Witt & Gross 2020). The service sectors are sometimes also called the "tertiary sector."
b. An economy where many product offerings also have a significant service component. For example, service provision is an important part of computer, cellphone, and copier businesses, as well as for other office equipment and home appliances.

BARRY D. SOLOMON

Further reading

Wölfl 2005.

See also: Services, Spheres of economic activity.

References

Witt, U. & Gross, C. 2020. The rise of the "service economy" in the second half of the twentieth century and its energetic contingencies. Journal of Evolutionary Economics 30: 231–46.
Wölfl, A. 2005. The service economy in OECD countries: OECD/Centre d'études prospectives et d'informations internationals. OECD Science, Technology and Industry Working Papers, No. 2005/03. Paris: OECD Publishing.

Services

Economics: a market transaction or activity in one of the service sectors of an economy, or in the informal sector, where no physical goods are exchanged between the buyer and seller. Services are the many activities that provide value to the buyer without the transfer of physical goods between the parties, and may include energy savings, thermal and visual comfort, and shelter. There are over a dozen service sectors of the economy (Triplett & Bosworth 2004). While goods can be returned to the seller, services once delivered cannot be returned.

Ecology: ecosystem services refer to a large range of welfare-enhancing benefits provided to people from the natural environment and healthy ecosystems (Farley 2012).

BARRY D. SOLOMON

See also: Service economy, Informal sector, Ecosystem services, Natural capital, Material services, Energy services.

References

Farley, J. 2012. Ecosystem services: the economics debate. Ecosystem Services 1(1): 40–49.

Triplett, J.E. & Bosworth, B.P. 2004. Productivity in the U.S. Services Sector: New Sources of Economic Growth. Washington, DC: Brookings Institution Press.

Shadow price

The additional value of a unit of a commodity, often of capital, to social well-being. It is also known as "accounting price" (Dasgupta 2009). If the commodity is marketable, the shadow price may equal its market price, but generally they are not equal, especially in the presence of market failure or externalities. In particular, the shadow price of natural capital typically surpasses its market price, because the latter only captures the value of provisioning services, and often misses its regulating, cultural, and maintenance (supporting) services.

The shadow price of a capital asset is a function of all capital assets, highlighting the importance of the relative scarcity, substitutability, and complementarity of, say, natural capital to produced manufactured capital. Crucially, it also depends on the underlying institutions, so that the shadow price of a hectare of forest, for example, differs under different management regimes.

Formally, the shadow price of a commodity can be expressed as the partial derivative of the objective function with respect to the commodity, given future socio-economic pathways. This can be shown to be equal to the sum of income gain and capital gain, discounted with an effective discount rate (Fenichel & Abbott 2014). In a steady state, where capital assets and their shadow prices are constant, it is also equal to the net present value of the income stream that the unit of capital good yields in the future.

RINTARO YAMAGUCHI

Further reading

Arrow et al. 2012.

See also: Capital, Manufactured capital, Natural capital, Capital substitution, Market failure, Externalities.

References

Arrow, K.J., Dasgupta, P., Goulder, L.H. et al. 2012. Sustainability and the measurement of wealth. Environmental and Development Economics 17(3): 317–53.

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Fenichel, E.P. & Abbott, J.K. 2014. Natural capital: from metaphor to measurement. Journal of the Association of Environmental and Resource Economists 1(1–2): 1–27.

Silviculture

The science and art of controlling the growth, composition, structure, health, and quality of forests and other woodlands for timber production (Ashton & Kelty 2018).

BARRY D. SOLOMON

See also: Forestry, Forest resources, Forest conservation.

Reference

Ashton, M.S. & Kelty, M.J. 2018. The Practice of Silviculture: Applied Forest Ecology, 10th edn. Hoboken, NJ: John Wiley & Sons.

Simulation modeling

See: Systems-oriented simulation models, Agent-based modeling (ABM).

See also: Monte Carlo simulation.

Sinks

Areas of the biosphere that receive flows of throughput wastes, minerals, and greenhouse gases (Hamilton 2020). If not overwhelmed, environmental sinks may be able to regenerate wastes back to useable resources through a variety of biogeochemical processes. In the case of some greenhouse gases and minerals, such as carbon dioxide, methane, nitrogen, and sulfur, if not trapped or destroyed some of the gases also cycle back from their sinks to sources or to the atmosphere (Canu et al. 2015). Sinks are generally not owned as private property and thus do not have property rights, except for some forests, soils, and wetlands (Byström et al. 2000; Olschewski & Benítez 2005).

BARRY D. SOLOMON

See also: Biosphere, Sources, Waste absorption capacity, Greenhouse gases, Carbon capture, Carbon sequestration, Nutrient cycling, Material cycling.

References

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Hamilton, C. 2020. "Foundations of ecological economics," pp. 35–64 in Human Ecology, Human Economy: Ideas for an Ecologically Sustainable Future. M. Diesendorf & C. Hamilton, eds. London, UK and New York, USA: Routledge.

Olschewski, R. & Benítez, P.C. 2005. Secondary forests as temporary carbon sinks? The economic impact of accounting methods on reforestation projects in the tropics. Ecological Economics 55(3): 380–94.

Smart city

An efficient and sustainable urban center that provides a high quality of life to its inhabitants through the optimal management of its resources and systems (Cavillo et al. 2016). Such cities make use of advanced integrated materials, sensors, electronics, and networks that are interfaced with computerized systems comprised of databases, tracking, and decision-making algorithms (Hall et al. 2000).

BARRY D. SOLOMON

Further reading

Shelton et al. 2015.

See also: Sustainable cities and communities, Urban planning, Urban unsustainability.

References

Cavillo, C.F., Sánchez-Miralles, A. & Villar, J. 2016. Energy management and planning in smart cities. Renewable and Sustainable Energy Reviews 55: 273–87.

Hall, R.E., Bowerman, B., Braverman, J. et al. 2000. The vision of a smart city. Second International Life Extension Technology Workshop, Paris.

Shelton, T., Zook, M. & Wiig, A. 2015. The "actually existing smart city." Cambridge Journal of Regions, Economy and Society 8(1): 13–25.

Social capital

The set of the actual or potential resources that individuals, groups, and communities have access to because of their network of relationships. At the individual level, social capital can be interpreted as a purposeful investment in social relationships, with expected returns in terms of access to tangible and intangible

resources. At the group level, social capital is an emerging property of social structure that both facilitates interactions among individuals and favors the functioning of communities, groups, and societies because of trust, shared norms, and reciprocity.

There are three forms of social capital: (1) "bonding social capital" refers to relationships with friends and family (that is, strong ties); (2) "bridging social capital" captures relationships with acquaintances and distant individuals (that is, weak ties); and (3) "linking social capital" refers to vertical relationships between individuals and groups occupying different strata of society.

Francesca Giardini

Further reading

Adler & Kwon 2002; Bourdieu 1986; Coleman 1998; Lin 2002; Putnam 1995.

See also: Social structures, Social order, Social institutions, Trust, Reciprocity, Human capital.

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Putnam, R.D. 1995. Bowling alone: America's declining social capital. Journal of Democracy 6(1): 65–78.

Social constructionism

An orientation to knowledge that focuses on how individuals and groups develop and assign meaning, including what is considered to be scientific knowledge. Knowledge and its validity can be understood in a sociological context, not based on foundational, permanent forms of proof. According to Taylor (2000, p. 508), social constructions are "ideological packages expressing bodies of thought that change over time and according to the actors developing the paradigms." Individuals and groups develop shared meanings based on their positionality (race, gender, class, and other factors), including access to power. With respect to science, as Weinberg (2014, p. 17) explains, fixed universal rules do not link language or the mind with a "preformed natural world."

By emphasizing positionality, access to power, and the desire for social validation as core elements in the creation of knowledge and in knowledge itself, social constructionism can illuminate how these factors contribute to injustices, such as environmental injustice (Taylor 2000). Social constructionism also has been extensively applied by ecological economists to natural resources, scarcity, and especially narratives of water scarcity (see, e.g., Aguilera-Klink et al. 2000; Otero et al. 2011).

Brent M. Haddad

Further reading

Kuhn 1962.

See also: Scientific method, Social construction of scarcity, Development, Resources, Scarcity, Justice, Environmental justice.

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Taylor, D.E. 2000. The rise of the environmental justice paradigm: injustice framing and the social construction of environmental dis-

courses. American Behavioral Scientist 43(4): 508–80.
Weinberg, D. 2014. Contemporary Social Constructionism: Key Themes. Philadelphia, PA: Temple University Press.

Social construction of scarcity

a. The fact (sometimes called "social scarcity") that resource scarcity is not merely physical or "natural," but is shaped by socio-political forces, most often in socially uneven ways.
b. The socio-political process that is conducive to this matter of fact. Though not restricted to this topic (see, e.g., Vikström 2016), the social construction of scarcity has been extensively used to document water issues: how socio-political choices contribute to turn water into a scarce resource (Aguilera-Klink et al. 2000) and how "narratives of scarcity" (Mehta 2001) are used to justify certain development paths (see, e.g., Crow-Miller 2015) and uneven allocation of water to different actors pursuing antagonistic ends (see, e.g., Otero et al. 2011).

Contrary to neoclassical economists who tend to define scarcity as the tension between unlimited wants and limited means to fulfill them, some ecological economists have long viewed scarcity as a concept in need of deconstruction and denaturalization (Aguilera-Klink et al. 2000). Instead of seeing desires (and to some extent needs) and means to fulfill them as "natural" exogenous variables, it is justified to regard them as contested, malleable, and constantly coevolving constructs (Kallis & Norgaard 2010). Though useful if interpreted with caution, most indicators of scarcity refer to a matter of fact that tends to obscure differential access to the resource according to power, financial means, political connections, and so on (scarcity is not lived in an even manner by different people); and eco-social dynamics that led to the current situation (most resources depicted as "scarce" or places depicted as "resource-scarce" could have a different status under different socio-political conditions).

PHILIPPE P. ROMAN

Further reading

Kaika 2003.

See also: Scarcity, Scarcity value, Power, Coevolution.

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Vikström, H., 2016. A scarce resource? The debate on metals in Sweden 1870–1918. Extractive Industries and Society 3: 772–81.

Social cost

Neoclassical economics: the total private cost, plus external costs of an economic activity or transaction (Pindyck & Rubinfeld 2018).

Ecological economics: Often considered to be the external cost of an economic activity or transaction alone (Soares & Porto 2009; Pindyck 2022).

SERGIO L. FRANKLIN JR

See also: Externalities, Environmental externalities, Total economic value (TEV).

References

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Pindyck, R.S. & Rubinfeld, D.L. 2018. Microeconomics, 9th edn. New York: Pearson.
Soares, W.L. & Porto, M.F. 2009. Estimating the social cost of pesticide use: an assessment from acute poisoning in Brazil. Ecological Economics 68(10): 2721–28.

Social discount rate

Economics and finance:

a. The appropriate interest rate to account for the effect of timing on the value to society of monetary costs and benefits.
b. A mathematical (accounting) method to adjust monetary values that have occurred in the past or will occur in the future, to present value from the perspective of society in annual terms. It accounts for time preference and opportunity cost to society of costs and benefits with respect to when they occur. Provides a basis to assess trade-offs involving differences of timing of outcomes.
c. The interest rate that adjusts a future or past monetary value so that society is indifferent to an equivalent present cost or benefit. This is as opposed to a private discount rate relevant to only an individual's or individual institution's objectives (including firms).

Since a social discount rate generally assumes less substitutability of outcomes (for example, less substitution between financial capital and natural capital than a private financial perspective), and accounts for outcomes of relevance to future generations rather than only consumption by the current generation, it tends to be a lower rate than financial market interest rates (and private discount rates), and involves less reduction in value for future outcomes (costs and benefits). Risk and uncertainty of future outcomes should generally be addressed separately (in terms of probabilities of future outcomes) rather than used to adjust social discount rates applied to future values.

Mark C. Buckley

Further reading

EPA 2014; Caplin & Leahy 2004; Gowdy & Erickson 2005.

See also: Discounting, Real interest rate, Net present value (NPV), Time preference, Pure rate of time preference, Benefit–cost analysis (BCA), Risk, Uncertainty.

References

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Social ecological economics

An interdisciplinary, heterodox, emergent paradigm, emphasizing that consumer theory should be consistent with actual human behavior, and production theory should be consistent with biophysical laws (Gowdy & Erickson 2005a, 2005b; Spash 2011, 2013; Spash & Guisan 2021). Social ecological economics also recognizes that the world is inherently unstable, ever-changing, uncertain, and unpredictable. Also, it accepts that there are multiple perspectives on environmental problems, and a role for both qualitative and quantitative knowledge (that is, value pluralism), value conflicts, and critical institutionalism (Spash 2020).

Social ecological economics was developed in part as a response to the trend for expressing values of nature predominantly in economic and monetary terms (Spash & Aslaksen 2015). Fundamentally, social ecological economics seeks to address issues of ethics, injustice, and social inequity inherent in current environmental problems with a need for fundamental changes in the structure of economic systems and human behavior (Spash 2013, p. 358).

Barry D. Solomon

Further reading

Buchs et al. 2020.

See also: Social-ecological systems, New resource economics, New environmental pragmatism, Methodological pluralism, Incommensurable values, Multi-criteria assessment, Deliberative multi-criteria analysis.

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Spash, C.L. 2013. The shallow or the deep ecological economics movement? Ecological Economics 93: 351–62.

Spash, C.L. 2020. A tale of three paradigms: realizing the revolutionary potential of ecological economics. Ecological Economics 169: 106518.

Spash, C.L. & Guisan, A.O.T. 2021. A future social-ecological economics. Real-World Economics Review 96: 203–16.

Spash, C.L. & Aslaksen, I. 2015. Re-establishing an ecological discourse in the policy debate over how to value ecosystems and biodiversity. Environmental Management 159: 245–53.

Social-ecological systems

Human societies are embedded in the biosphere, interconnected by a series of complex adaptive systems and subsystems comprised of energy and matter that ultimately make up social-ecological systems (SES). The social component of human activities includes the economy, technology, politics, and culture, while the ecological component refers to the biosphere and its global ecosystems on which the social system ultimately depends on to exist.

Elinor Ostrom (2009) proposed a general framework to analyze SES that has influenced the field of ecological economics, because it seeks to foster transdisciplinary collaboration to inform a governance system to protect open-access resources in a way that respects the spatial and temporal context-specific dynamics of diverse SES. SES are dynamic, and this requires acknowledging uncertainty and non-linearity as we seek to understand their interconnections, cross-scaled dynamics, systemic tipping points, and transformational change to foster resilience and real sustainable development (Reyers et al. 2018). Recently, the emerging understanding of tipping points and planetary boundaries has reinvigorated ecological economists working on a paradigm shift in economic thinking to address the root causes of unsustainability that threaten the long-term well-being of SES (Rockström et al. 2009; Steffen et al. 2015).

Rigo E.M. Melgar

See also: Social ecology, Coupled human and natural systems, Human–nature relationships, Interconnectedness, Tipping point, Resilience, Transdisciplinarity, Social ecological economics.

References

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Rockström, J., Steffen, W., Noone, K. et al. 2009. Planetary boundaries: exploring the safe operating space for humanity. Ecology and Society 14(2): 32.

Steffen, W., Richardson, K., Rockström, J. et al. 2015. Planetary boundaries: guiding human development on a changing planet. Science 347(6223): 1259855.

Social ecology

a. A highly dynamic and diverse academic field drawing from both social and natural sciences (Fischer-Kowalski 2015; Haberl et al. 2016; Stokols 2017). The underlying paradigm of this field is viewing human social and natural systems as interacting and coevolving over time, with causality working in both directions: societies colonize natural systems, extract

resources, create wastes and emissions, and need to organize themselves to be able to do so. Social ecology considers the metabolism of societies, with energy and material flows required for societal reproduction, with land use and food production, the environmental impacts of human activities, regulation, governance, and transformation. It offers a conceptual approach to society–nature coevolution that covers historical and current development processes and future sustainability transitions.

b. A political theory primarily associated with Murray Bookchin and elaborated over his body of work (e.g., Bookchin 1996; Biehl & Bookchin 1997). He presents a utopian philosophy of human evolution that combines the nature of biology and society into a third "thinking nature" beyond biochemistry and physiology, which he argues is a more complete, conscious, ethical, and rational nature. His core argument is that human domination and destruction of nature follows from social domination between humans. The transformation to an equitable, free society is a prerequisite to solving the ecological crisis.

Marina Fischer-Kowalski

Further reading

Bookchin 1982.

See also: Human ecology, Industrial ecology, Social-ecological systems, Social metabolism.

References

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Stokols, D. 2017. Social Ecology in the Digital Age: Solving Complex Problems in a Globalized World. London: Academic Press.

Social equity

The concept of fairness and justice as social policy. Generally understood to have at least three dimensions: recognition, procedure, and distribution. Distributional equity focuses on the allocation of costs, benefits, risks, and responsibilities. Procedural equity focuses on issues of participation and inclusiveness in decision-making. Equity in recognition focuses on ensuring that the values, beliefs, cultures, and identities of stakeholders are respected. Although similar to the concept of "equality," social equity is concerned with whether people get a "fair share" rather than an "equal share." Given that a "fair share" is a normative concept that may vary across cultures and individuals, what is equitable is context-dependent.

Bosco Lliso

Further reading

McDermott et al. 2013; Pascual et al. 2014; Friedman at al. 2018.

See also: Justice, Social justice, Just distribution, Distributive justice, Intragenerational equity, Stakeholder participation.

References

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Pascual, U., Phelps, J., Garmendia, E. et al. 2014. Social equity matters in payments for ecosystem services. BioScience 64(11): 1027–36.

Social forestry

See: Community forestry.

See also: Forestry, Forest conservation, Forest resources, Silviculture, Deforestation, Common property resources.

Social institutions

Groups of people with similar norms who come together to serve a common purpose and exhibit a regular, stable, valued, recurring pattern of behavior through collective action. The five main categories of social institutions are the family, education, economy, religion, and political. Other important social institutions include law, health care, science, and the mass media (Knight & Sened 1998; Bowles et al. 2003).

Barry D. Solomon

See also: Institutions, Collective action, Autonomous institutions, Economic institutions.

References

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Knight, J. & Sened, I., eds. 1998. Explaining Social Institutions. Ann Arbor, MI: University of Michigan Press.

Social justice

The viewpoint that all people deserve equal economic, social, and political rights and opportunities. Several applications of the term exist.

Environmental justice: the benefits of ecosystem health and the harms of environmental pollution and degradation are equitably and ethically distributed among groups of people, stratified by relative presence or absence of political, economic, and cultural power, and by differentiated histories of exploitation and exclusion. A heuristic: equity = equality + reparations.

Ecological justice: the human species is displaced from the apex of the hierarchy as the only species of moral concern and is properly re-placed into the ecological web of interdependent living and non-living ecological beings. All components of ecosystems and all humans need each other to thrive within the limits of ecosystems, on whose health and resilience humanity wholly depends. Collective solidarity for communal life and well-being springs from harmonizing and centering loving relationships across all dimensions of difference.

Ecological economics:

a. Justice is delimited by nature's finite "resources" and biological rates of regeneration, and in turn, delimits human-made economic and political systems.
b. A term gesturing to paradigm analysis as an integral part of the ecological economics discourse to situate work within sociological paradigms; not just biophysical limits to growth, but also an emphasis on using critical systems theory to more accurately: (1) define complex problems with the boundaries, facts, and values involved; (2) determine influential and sometimes hidden sources of power and knowledge; and (3) design, iterate, and implement solutions via participatory methods with those who are most effected (Kish et al. 2021).

Nina L. Smolyar

Further reading

Akomolafe & Benavides n.d.; Barry 2005; Tuck & Yang 2012; Huber 2019; Hickel 2018.

See also: Justice, Inequality, Inequity, Environmental justice, Climate justice, Ecological justice, Political ecology, Societal transformation, Critical theory, Incommensurable.

References

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.bayoakomolafe.net/post/the-times-are-urgent-lets-slow-down.
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Huber, M.T. 2019. Ecological politics for the working class. Catalyst 3(1): 7–45.
Kish, K., Mallery, D., Yahya Haage, G. et al. 2021. Fostering critical pluralism with systems theory, methods, and heuristics. Ecological Economics 189: 107171.
Tuck, E. & Yang, K.W. 2012. Decolonization is not a metaphor. Decolonization: Indigeneity, Education & Society 1(1): 1–40.

Social learning

a. Process of change in practices and action on the level of collective actors or even in a society that is based on newly acquired knowledge, a change in predominant value structures, or of social norms, which results in practically sizeable outcomes.
b. Societal learning and change is about changing relationships in profound ways and producing innovation to address chronic problems and develop new opportunities. These are not just interpersonal relationships, but relationships between large sections of society (Waddell 2017).
c. Change in understanding that goes beyond the individual to become situated within wider social units or communities of practice through social interactions between actors within social networks. In resilience thinking, learning is given a central role in the adaptive cycle. The adaptive cycle is a conceptual model of the dynamics and resilience of ecological, social, and social-ecological systems. In different stages of the cycle, learning plays different roles: in the "front loop," learning is associated with incremental, optimization-type innovation to enable further growth, whereas in the "back loop," it is associated with more radical types of innovation in response to crises in the system. A third, "transformational" type of learning occurs when learning outcomes, innovations developed during the back loop at lower levels of the social-ecological system, are taken up in the front loop at a higher level (de Kraker 2017, p. 101).

Psychology: processes where people learn from one another, via observation, imitation, and modeling (Bandura 1977).

Education: transformative and transgressive processes of change that are disruptive with current (educational) practices and require co-learning in multi-voiced and multi-actor formations (Lotz-Sisitka et al. 2015).

Bernd Siebenhüner

Further reading

Reed et al. 2010; Siebenhüner et al. 2016; Wals 2007.

See also: Societal transformation, Stakeholder participation, Participatory modeling, Resilience, Adaptive capacity, Institutional change.

References

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Wals, A.E., ed. 2007. Social Learning Towards a Sustainable World. Wageningen: Wageningen Academic Publishers.

Social metabolism

A methodology to understand the relationships between social and productive activities and the planetary ecosystem. Karl Marx (1875) first formally analyzed the interchange of products and energy between town and country based on the early work of Justus von Liebig; both labor and nature contributed value in the production process. This complex, dynamic interchange of matter and energy involves both nature-imposed conditions and human actions that transform this process.

Henri Lefebvre's original observation that "the umbilical cord that tied society to nature was badly severed" has now been generalized to a broad condemnation of the self-destructive effects resulting from the progressive but unconstrained tendency of capitalism to push its productive forces forward (Lefebvre 2016). This leads to the profound global environmental crisis that society presently suffers, characterized as a "metabolic rift."

The methodology examines the growing exchanges of energy and materials with the environment. It is particularly valuable because it focuses on the role of social organization (for example, governance) during the diverse stages of material and energy flows, from appropriation (input) to excretion (output). Between these points, intermediate flows, occurring in the "entrails" of society, transformation, consumption, and distribution, are essential parts of the process.

DAVID P. BARKIN

Further reading

Fischer-Kowalski 1997; Foster et al. 2010; Fuente-Carrasco et al. 2019; Martínez-Alier et al. 2010.

See also: Metabolic rift, Material flow analysis, Urban metabolism, Multi-scale integrated analysis of societal and ecosystem metabolism (MuSIASEM).

References

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Social opportunity cost (SOC)

A method to estimate the social discount rate (SDR), for use mainly in benefit–cost analysis. It assumes that the government raises funds to finance a project or policy by issuing debt. This causes a marginal increase in interest rates, which in turn impinges upon three other variables: it encourages private saving at the expense of consumption; it crowds out private investment; and it attracts foreign lending that crowds out net exports. The SDR estimated through the SOC approach consists of the opportunity cost of each of these three variables, weighted by the proportion of government funds sourced from each of them, in turn derived from the interest rate elasticity of supply and demand of each of them. The method originates from the writings of Harberger (1972). Lind (1990) extended the original formulation to include foreign lending. The SOC is but one of the leading methods to estimate the SDR. The main alternative is the social time preference (STP) approach, whereby the government is assumed to raise funds through taxation.

DORAMAS JORGE-CALDERÓN

Further reading

Burgess & Zerbe 2011; Moore et al. 2013.

See also: Social discount rate, Benefit–cost analysis (BCA), Interest rate policy, Pure rate of time preference.

References

Burgess, D.F. & Zerbe, R.O. 2011. Appropriate discounting for benefit–cost analysis. Journal of Benefit–Cost Analysis 2(2): 1–20.

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Lind, R.C. 1990. Reassessing the government's discount rate policy in light of new theory and data in a world economy with a high degree of capital mobility. Journal of Environmental Economics and Management 18(2, Part 2): S8–S28.

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Social order

The totality of structured human interrelationships and institutions in a society or part of it, and how they work together to maintain the status quo. Social order can include the prevailing economic structure or system; for example, capitalist social order, socialist social order, and so on. A stable social order is based on human nature, and is maintained based on a social contract, whereby certain laws and rules are generally adhered to, and common norms, beliefs, and values are maintained (Cooley 1964). It is hierarchical in the sense of a pyramid whereby a limited number of people hold more power than others, although despite superficial social consensus and stability there may be hidden crises.

Research shows that order can originate from non-linear chaos (Cramer 1988). General order is defined by entropy as a measure of disorder. It has been argued that since entropy in closed systems increases forever, social order will continually decrease, which would create a forever-degenerating society (Rifkin & Howard 1980). But human society is not a closed system, which must be described by the theory of dissipative structure (Prigogine & Stengers 1984), and there are a variety of complex internal interactions. Under this condition there is the possibility of entropy decreasing (Chang 2015, 2020), which may produce new order. The development of human society is not always pessimistic.

Yi-Fang Chang

See also: Social structures, Entropy, Dissipative structure, Human nature.

References

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Rifkin, J. & Howard, T. 1980. Entropy: A New World View. New York: Viking Books.

Social provisioning

a. The process of securing flows of essential goods and services (for example, housing, health care, education, transportation, utilities) for the purpose of meeting material and cultural needs of human groups. Collectively organized in different ways according to prevailing norms governing production, distribution, and consumption: market-based, state-led, co-operative, family-based, and so on.
b. A method of inquiry into evolving economic processes as socially and environmentally embedded phenomena (Jo 2011).
c. The main object of economic science (Gruchy 1987).

Marco Vianna Franco

Further reading

Lee & Jo 2011; Jo & Todorova 2018; Power 2004.

See also: Sustenance, Informal sector, Feminist ecological economics, Provisioning services, Universal basic services (UBS).

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Power, M. 2004. Social provisioning as a starting point for feminist economics. Feminist Economics 10(3): 3–19.

Social sciences

The study of societies and their institutions, and the behaviors and relationships among individuals and processes within those societies. The main examples are sociology, cultural anthropology, archaeology, human geography, linguistics, political science, psychology, economics, regional science, history, library science, media studies, and sustainability studies.

BARRY D. SOLOMON

Further reading

Hunt & Colander 2016.

See also: Economic institutions, Social institutions, Geography, Geonomics, Political economy, Regional science, Sustainability, Sustainable development.

Reference

Hunt, E.G. & Colander, D.C. 2016. Social Science: An Introduction to the Study of Society, 16th edition. New York, USA and London, UK: Routledge.

Social structures

Organized, patterned sets of social relationships or arrangements in which members of the society or groups are variously implicated (Merton 1968). They correspond to the structure of social action (Parsons 1968), and are sometimes defined simply as patterned social arrangements. Social structures and their properties are consistent with structuralism and structural functionalism in philosophy and modern sociology. Social structures are widespread, and include many aspects and levels, from different communities to governments at all levels, from schools and social groups to markets, and more.

All social structures must be based on some social order and rules. A well-known theory of social structure is the dissipative structure theory, and a mathematical method of investigation is fractal geometry. A structure–function–result (SFR) mode of sociology has been proposed (Chang 2013), and may extend to ecology, in which the structure of a system determines the system function and the evolution mechanism, and feedback modifies the structure.

YI-FANG CHANG

Further reading

Turner 2003.

See also: Social order, Social capital, Dissipation, Dissipative structure.

References

Chang, Y.F. 2013. Structure–function–result mode in sociology, hypercycle and knowledge economic theory. International Journal of Modern Social Sciences 2(3): 155–68.

Merton, R.K. 1968. Social Theory and Social Structure. New York: Free Press.

Parsons, T. 1968. The Structure of Social Action. New York: Free Press.

Turner, J.H. 2003. The Structure of Sociological Theory, 7th edn. Belmont, CA: Wadsworth Publishing.

Social welfare function

A fundamental, though abstract, and mathematical concept from welfare economics

and social choice theory for the comparative evaluation of social alternatives. The function depends on individual well-being based on either individual preferences or utilities based on each individual's consumption and work, and an interpersonal ethical value judgment on how the individual utility levels or preferences affect social welfare. This value judgment was originally assumed to be made by an external agent or institution, an assumption that was later relaxed by Kenneth Arrow and which led to his "impossibility theorem" for which he won the Sveriges Riksbank Prize in Economic Sciences in 1972. Three main approaches to developing a social welfare function were developed: Bergson–Samuelson (Bergson 1938; Samuelson 1947), Arrovian (Arrow 1963), and Sen (1970). Sen's approach criticized his predecessors based on his argument that utility is not a true indicator of well-being.

BARRY D. SOLOMON

See also: Welfare economics, Utility, Total human welfare, Subjective well-being, Well-being economy.

References

Arrow, K.J. 1963. Social Choice and Individual Values, 2nd edn. New Haven, CT: Yale University Press.

Bergson, A. 1938. A reformulation of certain aspects of welfare economics. Quarterly Journal of Economics 52(2): 310–34.

Samuelson, P.A. 1947. Foundations of Economic Analysis. Cambridge, MA: Harvard University Press.

Sen, A.K. 1970. Collective Choice and Social Welfare. San Francisco, CA: Holden-Day.

Societal transformation

Large-scale processes of fundamental change in social, political, and socio-ecological systems that affect major aspects of how human societies function. Societal transformations involve shifting interactions, dynamics, and relationships among communities at different scales, or different sectors, bioregions, and states. Occurs in a context of complexity and wicked problems. Transformation means fundamental shifts that are broad in that they impact many people or other-than-human entities, alter core structures and relationships, and occur at multiple scales or in multiple subsystems in each context.

Key levels of change (from Geels & Schot 2007) include regimes, defined as sets of rules linked by social networks, landscapes, or the environment in which regimes exist; and niches or relatively small, protected spaces where innovations can emerge and develop. Transformational changes can involve core purposes, key metrics for assessment and evaluation, core values, and the logic or mindset of participants in a system, as well as operating practices and power dynamics.

Societal transformation involves finding key leverage points for change (from Meadows 1999), which most powerfully involves mindset change and the ability to transcend how system participants understand the system: its paradigm. Other powerful change levers for societal transformation include shifts in the system's goals, structure, and rules.

SANDRA WADDOCK

Further reading

Westley et al. 2011; Waddock et al. 2015.

See also: Sustainability transition, Energy transition, Rural transformation, Social-ecological systems, Complexity theory, Bioregionalism, Wicked problems, Tipping point.

References

Geels, F.W. & Schot, J. 2007. Typology of sociotechnical transition pathways. Research Policy 36(3): 399–417.

Meadows, D. 1999. Leverage Points: Places to Intervene in a System. Harland, VT: Sustainability Institute.

Waddock, S., Dentoni, D., Meszoely, G. & Waddell, S. 2015. The complexity of wicked problems in large scale change. Journal of Organizational Change Management 28(6): 993–1012.

Westley, F., Olsson, P., Folke, C. et al. 2011. Tipping toward sustainability: emerging pathways of transformation. Ambio 40(7): 762–80.

Soil conservation

The protection of soil from wind and water erosion, and other types of degradation or deterioration on agricultural lands, for example, reduced fertility and productivity from overusage, salinization, acidification, and chemical contamination. As a result, soil conservation also requires careful management of the watershed and water usage. Soil conservation methods include crop rotation, cover cropping, strip cropping, cross-slope farming, reduced-tillage or no-till farming, composting, mulching, better nutrient management, and adding windbreaks and buffer strips, among others.

BARRY D. SOLOMON

Further reading

Blanco & Lai 2008.

See also: Soil fertility, Soil health, Nutrient retention, Sustainable agriculture.

Reference

Blanco, H. & Lal, R. 2008. Principles of Soil Conservation and Management. Dordrecht: Springer.

Soil fertility

The ability or capacity of soils to sustain agricultural plant growth by providing essential nutrients and favorable chemical, physical, and biological characteristics as habitat (FAO 2021). Fertile soils contribute to soil health, soil conservation, and food security. Sources of soil nutrients are primarily various kinds of fertilizers. The essential nutrients are often divided into macro and micro. Macronutrients include nitrogen, potassium, phosphorous, calcium, sulfur, and magnesium. Micronutrients include iron, boron, chlorine, copper, manganese, molybdenum, and zinc.

BARRY D. SOLOMON

Further reading

Havlin et al. 2013; Troeh & Thompson 2005.

See also: Soil health, Soil conservation, Nutrient retention, Food security, Food insecurity.

References

FAO (Food and Agriculture Organization of the United Nations). 2021. Soil fertility. https://www.fao.org/global-soil-partnership/areas-of-work/soil-fertility/en/.

Havlin, J.L., Tisdale, S.L., Nelson, W.L. & Beaton, J.D. 2013. Soil Fertility and Fertilizers: An Introduction to Nutrient Management, 8th edn. New York: Pearson.

Troeh, F.R. & Thompson, L.M. 2005. Soils and Soil Fertility, 6th edn. Ames, IA: Blackwell.

Soil health

The capacity of soil to function as a living ecosystem that supports and sustains terrestrial life (Lehmann et al. 2020). Components of soil health include the physical, chemical, hydrological, and biological characteristics of soil, and the interactions among them. Healthy soil is maintained by a complex web of microbial organisms, plants, and animals, both below and above ground. The health of the soil influences critical processes such as nutrient cycling, water filtration and retention, and carbon sequestration.

ADAM T. CROSS, NEVA R. GOODWIN, LAURA ORLANDO & JAMES C. ARONSON

See also: Soil conservation, Soil fertility, Abiotic resources, Biotic resources, Ecosystem health.

Reference

Lehmann, J., Bossio, T.A., Kögel-Knabner, I. & Rillig, M.C. 2020. The concept and future prospects of soil health. Nature Reviews Earth and Environment 1: 544–53.

Solow sustainability

The possibility of maintaining or increasing the intertemporal level of consumption thanks to the substitution of manufactured capital for natural resources (Solow 1974), which is named after the neoclassical economist Robert Solow. This kind of substitution is formalized in a neoclassical growth model

based on an aggregate production function. The substitution mechanism involves changes in the composition of output, the type of resources, or the technologies used to transform them. More generally, Solow's approach has been a major influence behind the notion of weak sustainability, which assumes the possibility of substituting human-made (manufactured) capital for natural capital (Solow 1993). However, ecological economists have strongly criticized this perspective for its lack of consideration of the physical limits to substitution (Daly 1997).

QUENTIN COUIX

Further reading

Couix 2019.

See also: Weak sustainability, Strong sustainability, Intergenerational equity, Manufactured capital, Natural capital, Capital substitution, Substitutability, Decoupling economic growth.

References

Couix, Q. 2019. Natural resources in the theory of production: the Georgescu-Roegen/Daly versus Solow/Stiglitz controversy. European Journal of the History of Economic Thought 26(6): 1341–78.

Daly, H.E. 1997. Georgescu-Roegen versus Solow/Stiglitz. Ecological Economics 22(3): 261–6.

Solow, R.M. 1974. Intergenerational equity and exhaustible resources. Review of Economic Studies 41: 29–45.

Solow, R.M. 1993. An almost practical step toward sustainability. Resources Policy 19(3): 162–72.

Sources

a. The points of origin of environmental pollution, residues, wastes, and greenhouse gases. Categories include mining, industry, electric and gas utilities, buildings, motor vehicles, agriculture, and forests. Air pollution can be classified as stationary, mobile, area (for example, agricultural, cities, wood-burning fireplaces), and natural sources (for example, wildfires, wind-blown dust, volcanoes); while water pollution can be classified as point or non-point sources.
b. The point of origin of usable raw materials that provide throughput for the economy, most of which returns to the environment as wastes or residues. Sources are generally owned as private or public property.

BARRY D. SOLOMON

Further reading

Sagoff 1995; Paavola & Adger 2005; Canu et al. 2015.

See also: Pollution, Private property, Property right, Utility, Fossil fuels, Common property, Common property resources, Property systems, Property regimes, Common property regimes, Sinks.

References

Canu, D.M., Ghermandi, A., Nunes, P.A.L.D. et al. 2015. Estimating the value of carbon sequestration ecosystem services in the Mediterranean Sea: an ecological economics approach. Global Environmental Change 32: 87–95.

Paavola, J. & Adger, W.N. 2005. Institutional ecological economics. Ecological Economics 53(3): 353–68.

Sagoff, M. 1995. Carrying capacity and ecological economics. BioScience 45(9): 610–20.

Spaceship Earth

A metaphor first used by Henry George (1879, Book IV, Ch. 2) to represent the natural planetary limits of life on Earth. The term was later revived and popularized by Kenneth Boulding (1966), Buckminster Fuller (1969), and the Club of Rome (Meadows et al. 1972) to represent limits to economic growth.

BARRY D. SOLOMON

See also: Limits, Limits to growth, Biosphere.

References

Boulding, K.E. 1966. "The economics of the coming spaceship Earth," pp. 3–14 in Environmental Quality in a Growing Economy.

H. Jarrett, ed. Baltimore, MD: Resources for the Future/Johns Hopkins University Press.
Fuller, R.B. 1969. Operating Manual for Spaceship Earth. Carbondale, IL: Southern Illinois University Press.
George, H. 1879. Progress and Poverty. An Inquiry into the Causes of Industrial Depressions and of Increase of Want with Increases in Wealth: The Remedy. New York: Doubleday, Page & Company.
Meadows, D., Meadows, D., Randers, J. & Behrens III, W.W. 1972. The Limits to Growth. Washington, DC: Potomac Associates / Universe Books.

Spatial analysis

The empirical inquiry into the geographical characteristics of socio-ecological systems. The key objective is the identification and articulation of geographical patterns (Dale & Fortin 2014) in one or more variables of interest: how the system's components are arranged in geographical space and across spatial scales; how they relate to and interact with each other at a given moment or through time; flows of or between the components, including their networks; and ways to measure, verify, represent, and visualize the above.

Spatial analysis is achieved by a variety of analytical techniques and tools, drawing significantly from geographical information systems and computation (Grekousis 2020). Waldo Tobler's first law of geography (everything is related to everything else, but near things are more related than distant things) is a cornerstone of spatial analysis but, increasingly, geographical space has been broadened to include non-Euclidean definitions, as have the notions of location and time to include inquiry into four modes of space–time interaction: synchronous presence, asynchronous presence, synchronous telepresence, and asynchronous telepresence (Miller 2004).

ATHANASIOS VOTSIS

See also: Spatial modeling, Spatial dynamics, Spatial heterogeneity.

References

Dale, M.R.T. & Fortin, M.-J. 2014. Spatial Analysis: A Guide for Ecologists. Cambridge: Cambridge University Press.
Grekousis, G. 2020. Spatial Analysis Methods and Practice. Cambridge: Cambridge University Press.
Miller, H.J. 2004. Tobler's first law and spatial analysis. Annals of the Association of American Geographers 94(2): 284–9.

Spatial dynamics

All ecosystems and many economic systems manifest spatially. Understanding spatial dynamics is essential to understanding the dynamics of ecosystems and many elements of economic systems. For example, consider the predator–prey relationships involving the fluctuating populations of foxes and hares. It is easy to imagine how this dynamic system may have an essential spatial element to it. Consider a confined space in which there were X foxes and Y hares. It is possible to imagine that the foxes could eat all the hares and both populations would reach zero. The more "natural" manifestation of this is that hares get to a sufficiently low population density that, through their wits and scarcity, they survive to breed back. Space can operate in the opposite way with fisheries. Fish stocks can be depleted to a point below their critical depensation point in which the population is destined to go extinct. Part of the reason for this is that they become so spatially scarce that they cannot find "partners" to breed with (Liermann 2001).

A common practice in ecological economics involves the economic valuation of ecosystem services. One approach involves "benefits transfer" by which an established economic value of a particular ecosystem service in one geographic location is used to value the same ecosystem services elsewhere. Accounting for spatial dynamics in ecosystem service valuation can be complicated, but is sometimes necessary because of real spatial variation in the phenomena being considered. For example, consider an evaluation of the economic value of "storm protection services" provided by coastal wetlands (Costanza et al. 2008). Estimating the value of storm protection services requires

the acquisition, representation, and analysis of several datasets that can vary spatially and temporally.

PAUL C. SUTTON

See also: Spatial analysis, Spatial modeling, Dynamic systems, Fisheries management, Benefit transfer.

References

Costanza, R., Pérez-Maqueo, O., Martinez, M. et al. 2008. The value of coastal wetlands for hurricane protection. Ambio 37(4): 241–8.

Liermann, H. 2001. Depensation: evidence, models and implications. Fish and Fisheries 2(1): 33–58.

Spatial heterogeneity

Ecology:

a. The variability present in a specific area, depending on the scale, in terms of topology, soil type, climate, resources, and so on.
b. The distribution of plants and animal species. Can be measured by the biodiversity or by the distribution of the population of a given species.

Economics:

a. The concentration and diversification of economic activities and prices, ecosystem services, non-market values, human happiness and life satisfaction, and so on. Can be measured by the type and amount of sectoral production, income distribution, degree of urbanization, and so on, in a specific period. This variation needs to be adjusted for when an analysis uses the benefit transfer method.
b. Spatial heterogeneity determines economic specialization and trade, which translates into fluxes of money, and throughputs of materials and energy.

TIZIANO DISTEFANO

Further reading

Pickett & Cadenasso 1995; Geoghegan et al. 1997; Shaver 2005; Distefano et al. 2019.

See also: Commodity trade, Biodiversity, Heterogeneity, Preference heterogeneity, Throughput, Benefit transfer.

References

Distefano, T., Chiarotti, G., Laio, F. & Ridolfi, L. 2019. Spatial distribution of the international food prices: unexpected heterogeneity and randomness. Ecological Economics 159: 122–32.

Geoghegan, J., Wainger, L.A. & Bockstael, N.E. 1997. Spatial landscape indices in a hedonic framework: an ecological economics analysis using GIS. Ecological Economics 23(3): 251–64.

Pickett, S.T. & Cadenasso, M.L. 1995. Landscape ecology: spatial heterogeneity in ecological systems. Science 269(5222): 331–4.

Shaver, G.R. 2005. "Spatial heterogeneity: past, present, and future," pp. 443–9 in Ecosystem Function in Heterogeneous Landscapes. G.M. Lovett, C.G. Jones, M.G. Turner & K.C. Weathers, eds. New York: Springer.

Spatial modeling

A distinct subset—in terms of analytical aims—of spatial analysis. While many approaches of spatial analysis typically focus on the elucidation of geographical patterns in a socio-ecological system, spatial modeling aims at the explanation of those patterns (Dale & Fortin 2014) through developing and testing quantitative or qualitative representations of the underlying rules. Thus, while spatial modeling benefits from the descriptive capacities of spatial analysis, it is an advanced stage of it, in which the goal is hypothesizing and testing a model of the rules governing the spatial behavior of a socio-ecological system, including formalization of causal relationships. The developed model is typically utilized in exploring or simulating the implications of such rules in different contexts; for instance, what-if analysis and scenario development and exploration. Key methods typically utilized in spatial modeling are spatial econometrics and geostatistics (Kelejian & Piras 2017) and, increasingly,

complexity approaches, such as agent-based modeling (Hamill & Gilbert 2016).

ATHANASIOS VOTSIS

See also: Spatial analysis, Spatial dynamics, Spatial heterogeneity, Econometrics, Agent-based modeling (ABM).

References

Dale, M.R.T. & Fortin, M.-J. 2014. Spatial Analysis: A Guide for Ecologists. Cambridge: Cambridge University Press.

Hamill, L. & Gilbert, N. 2016. Agent-Based Modelling in Economics. Chichester: John Wiley & Sons.

Kelejian, H. & Piras, G. 2017. Spatial Econometrics. Cambridge, MA: Academic Press.

Species

Ecology: the basic unit of classification and taxonomic rank in biology of related organisms that share common characteristics and are capable of interbreeding. A species is also a unit of biodiversity. Some species are also classified by subspecies, while over time in rare cases closely related species can hybridize.

BARRY D. SOLOMON

Further reading

De Queiroz 2007; Callaghan et al. 2021.

See also: Indicator species, Keystone species, Alien species, Invasive species, Species richness, Abundance, Metapopulation, Endangered species, Biodiversity.

References

Callaghan, C.T., Nakagawa, S. & Cornwall, W.K. 2021. Global abundance estimates for 9,700 bird species. Proceedings of the National Academy of Sciences of the United States of America 118(21): e2023170118.

De Queiroz, K. 2007. Species concepts and species delimitation. Systematic Biology 56(6): 879–86.

Species richness

The number of different species existing in a particular ecological community, ecosystem, landscape, or region, irrespective of their population size or distribution, or whether the species are endemic, alien, or invasive (Gotelli & Colwell 2001, 2011; Waide et al. 1999).

BARRY D. SOLOMON

See also: Species, Biodiversity, Biodiversity conservation, Wildlife conservation, Darwinian theory.

References

Gotelli, N.J. & Colwell, R.K. 2001. Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. Ecology Letters 4(4): 379–91.

Gotelli, N.J. & Colwell, R.K. 2011. "Estimating species richness," pp. 39–54 in Biological Diversity: Frontiers in Measurement and Assessment. A. Magurran & B. McGill, eds. Oxford: Oxford University Press.

Waide, R.B., Willig, M.R., Steiner, C.F. et al. 1999. The relationship between productivity and species richness. Annual Review of Ecology and Systematics 30: 257–300.

Spheres of economic activity

The core, public purpose, and business spheres (Goodwin et al. 2018, pp. 47–57). The core is comprised of households, families, and community groups and refers to typically small-scale economic activities that take place largely without the use of money; for example, raising families, preparing meals, and voluntary activities. The public purpose sphere includes government agencies, charities, religious and professional groups, and international organizations such as the United Nations, World Bank, and the Organisation for Economic Co-operation and Development. The business sphere encompasses companies that produce goods and services for profit and is by far the largest of the three. Sometimes a fourth sphere is also recognized—the informal sector—which is

small and operates outside of government regulation and oversight.

BARRY D. SOLOMON

See also: Economics, Microeconomics, Macroeconomics, Economic institutions, Institutional economics, New institutional economics, Informal sector.

Reference

Goodwin, N., Harris, J.M., Nelson, J.A. et al. 2018. Microeconomics in Context, 4th edn. New York & London: Routledge.

Spontaneous order

An order that emerges as result of the voluntary activities of individuals, which is not intentionally designed (Sugden 1989; Luban 2020). An influential concept in social theory, attributed to the work of Friedrich Hayek (Hayek 1988), Spontaneous order is also sometimes called self-organization. Organizations can be a part of spontaneous orders, but the reverse is not true. For example, organizations may be created and designed by humans; however, spontaneous order is defined as the result of human actions, not of human design.

In the context of both social and biological systems, spontaneous order may be reflected as swarm intelligence (Tao 2018), in which individuals follow simple rules, but the resulting group behavior can be surprisingly complex and remarkably effective. In social systems, spontaneous order consists of a set of competitive equilibria among self-interested individuals who follow the given "rules of the game," which is most likely to evolve and survive under natural selection (Alchain 1950). In this regard, different rules of the game would cause different types of spontaneous order. For instance, if an economic society obeys the equal-opportunity rules, the resulting spontaneous order is reflected as exponential income distribution; while if an economic society obeys the law of the jungle, the resulting spontaneous order is reflected as a Pareto optimal distribution (Tao 2016; Tao et al. 2019).

YONG TAO

See also: Institutions, Autonomous institution, Social institutions, Pareto efficiency.

References

Alchain, A.A. 1950. Uncertainty, evolution, and economic theory. Journal of Political Economy 58(3): 211–21.

Hayek, F.A. 1988. The Fatal Conceit. London: Routledge.

Luban, D. 2020. What is spontaneous order? American Political Science Review 114: 68–80.

Sugden, R. 1989. Spontaneous order. Journal of Economic Perspectives 3(4): 85–97.

Tao, Y. 2016. Spontaneous economic order. Journal of Evolutionary Economics 26: 467–500.

Tao, Y. 2018. Swarm intelligence in humans: a perspective of emergent evolution. Physica A 502: 436–46.

Tao, Y., Wu, X., Zhou, T. et al. 2019. Exponential structure of income inequality: evidence from 67 countries. Journal of Economic Interaction and Coordination 14: 345–76.

Sraffian economics

An economic school of thought that emerged through the contributions of the Italian economist Piero Sraffa. Sraffa moved to Cambridge after publishing an influential critique of Alfred Marshall's economic theory. At Cambridge, Sraffa contributed to further debates and critiques, while also editing the completed works of David Ricardo.

Sraffian economics rose after Sraffa (1960) published his book *Production of Commodities by Means of Commodities: Prelude to a Critique of Economic Theory*, which has been subject to various interpretations, also considering the (yet) unpublished Sraffa Papers kept at the Wren Library, Trinity College, Cambridge. Sraffa's 1960 book provided a theoretical basis for a critique of marginalist economic theory (understood as the dominant form of modern economics stemming from the marginalist revolution, and often called neoclassical economics), which was pursued through the Cambridge Controversies in the Theory of Capital. While initial interest in Sraffa's book came from its role as a theoretical basis for a critique in marginalist economics, the more constructive aspect of Sraffa's book has been interpreted as a revival of classical political economy

(Meek 1961), understood as a circular conception of the economy, in opposition to the linear conception of marginalist theory.

NUNO O. MARTINS

See also: Sraffian models, Neo-Ricardian.

References

Meek, R. 1961. Mr. Sraffa's rehabilitation of classical economics. Scottish Journal of Political Economy 8: 119–36.

Sraffa, P. 1960. Production of Commodities by Means of Commodities: Prelude to a Critique of Economic Theory. Cambridge: Cambridge University Press.

Sraffian models

Economic models based on Sraffa (1960). Sraffa presented circular models of the economy inspired by the contributions of the physiocrats and the classical political economists, which stand in contrast to the linear models advanced in modern economic theory (following the marginalist revolution). In Sraffa's models only objective entities are represented, such as the quantities produced and used in production (and in one specification of his equations, the quantity of labor time is also represented).

Sraffa's models differ from most models used in modern economic theory not only because of the absence of non-objective entities (such as subjective preferences), but also because both the inputs and the outputs of Sraffa's models are exogenous variables which, together with either the rate of profits or the wage, constitute the basic data for determining prices and either the wage or the rate of profits (depending on which one of them is not used as data initially). Both inputs and outputs are exogenous variables, thus the quantities of inputs are not represented as a causal factor of the quantities of outputs.

NUNO O. MARTINS

See also: Sraffian economics, Neo-Ricardian, Physiocrats, Circular economy.

Reference

Sraffa, P. 1960. Production of Commodities by Means of Commodities: Prelude to a Critique of Economic Theory, Cambridge: Cambridge University Press.

Stability

Mathematics:

a. Attribute of a dynamical system concerning the tendency of variables to remain within certain bounds, as opposed to shifting to fluctuate around some new values or exhibiting fluctuations of ever-increasing size. A system is said to have global stability if, following a perturbation of any size, variables eventually return to their previous ranges of fluctuation. A system is said to be in a state of local stability if this happens only for perturbations of variables within certain ranges.
b. As above, except when global stability variables evolve towards a single fixed point when not being perturbed, and when local stability variables evolve towards a given fixed point if they lie within ranges, known collectively as the basin of attraction of the fixed point.

Ecology: capability of an ecosystem to return to its usual range of fluctuations after a perturbation, and to not undergo unexpected large changes in its characteristics over time.

Economics: a scenario in which macroeconomic fluctuations are likely to remain within reasonable bounds for the foreseeable future; for example, with low likelihood of a large recession, high inflation, or a financial crisis.

ADAM B. BARRETT

Further reading

Barrett 2018; May & McLean 2007; Minsky 1986; Sayama 2015.

See also: Perturbation, Ecological perturbation, Climate instability.

References

Barrett, A.B. 2018. Stability of zero-growth economics analysed with a Minskyan model. Ecological Economics 146: 228–39.

May, R. & McLean, A. 2007. Theoretical Ecology: Principles and Applications. Oxford: Oxford University Press.

Minsky, H.P. 1986. Stabilizing an Unstable Economy. New York: McGraw-Hill.

Sayama, H. 2015. Introduction to the Modeling and Analysis of Complex Systems. Geneseo, NY: Open SUNY.

Stakeholder

a. Organized groups that are or will be affected by, or that have an interest in, the outcome of a decision (NRC 2008).
b. Any individual or group who can affect or is affected by the achievement of an organization's objectives (Freeman 1984).

Nuno Videira

Further reading

Reed et al. 2009.

See also: Stakeholder participation, Stakeholder analysis.

References

Freeman, R.E. 1984. Strategic Management: A Stakeholder Approach. Boston, MA: Pitman Publishing.

NRC (National Research Council). 2008. Public Participation in Environmental Assessment and Decision Making. Panel of Public Participation in Environmental Assessment and Decision Making. T. Dietz & P.C. Stern, eds. Committee on the Human Dimensions of Global Change. Division of Behavioral and Social Sciences and Education. Washington, DC: National Academies Press.

Reed, M., Graves, A., Dandy, N. et al. 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. Journal of Environmental Management 90(5): 1933–49.

Stakeholder analysis

The investigation of the beliefs, influences, roles, and links between different people or organizations who have an interest ("stakeholders") in an issue, place, or system. Stakeholder analysis may have many aims and use many different tools, and is used within and beyond ecological economics. In the ecological context, its aims may include measuring changes in community support for a particular activity, understanding the motivations of landholders so that they can be influenced to adopt a particular practice, or quantifying the value of ecosystem services to stakeholders. Its tools may include both qualitative methods (for example, interviews and surveys) and/or quantitative methods (for example, willingness-to-pay exercises or quantitative questionnaires, followed by statistical analysis or modeling). Often, stakeholder analysis uses the techniques and terminology of marketing or social sciences.

Steve J. Sinclair

Further reading

Aaltonen 2011; Prell et al. 2009.

See also: Stakeholder, Stakeholder participation, Participatory modeling, Networks, Bayesian belief networks.

References

Aaltonen, K. 2011. Project stakeholder analysis as an environmental interpretation process. International Journal of Project Management 29: 165–83.

Prell, C., Hubacek, K. & Reed, M. 2009. Stakeholder analysis and social network analysis in natural resource management. Society and Natural Resources 22: 501–18.

Stakeholder participation

Any mechanism or process to engage stakeholders in assessment, planning, policy-making, management, monitoring and/or evaluation of environmental and sustainability issues (from NRC 2008). Stakeholder participation is advocated for three fundamental reasons: normative (for example, enrichment through individual and social learning), sub-

stantive (for example, improved understanding of complex issues), and instrumental (for example, promoting collaboration for policy implementation) (Blackstock et al. 2007). Understanding who participates, how participation is promoted, and what is achieved when stakeholders engage in decision processes affecting social-ecological systems, are relevant questions in ecological economics studies (Blackstock 2017).

NUNO VIDEIRA

Further reading

Beierle & Cayford 2002.

See also: Stakeholder, Participatory modeling, Stakeholder analysis, Social-ecological systems.

References

Beierle, T.C. & Cayford, C. 2002. Democracy in Practice: Public Participation in Environmental Decisions. New York: Routledge.

Blackstock, K.L. 2017. "Participation in the context of ecological economics," pp. 341–50 in Routledge Handbook of Ecological Economics: Nature and Society. C.L. Spash, ed. London: Routledge.

Blackstock, K.L., Kelly, G. & Horsey, B. 2007. Developing and applying a framework to evaluate participatory research for sustainability. Ecological Economics 60: 726–42.

NRC (National Research Council). 2008. Public Participation in Environmental Assessment and Decision Making. Panel of Public Participation in Environmental Assessment and Decision Making. T. Dietz & P.C. Stern eds. Committee on the Human Dimensions of Global Change. Division of Behavioral and Social Sciences and Education. Washington, DC: National Academies Press.

Stated preference methods

Techniques used to determine the value or price of environmental or ecological goods and services based on questions about hypothetical situations. The main stated preference methods are contingent valuation, choice experiments, and conjoint analysis. In a contingent valuation study, survey respondents are asked directly how much they would be willing to pay to avoid a hypothetical environmental or ecological degradation, or to be compensated for the degradation, or to support an environmental or ecological improvement. In choice experiments and conjoint analysis, the valuation is uncovered indirectly from survey responses. Economists generally consider revealed preference methods to be more accurate than stated preference methods because of the reliance of revealed preference methods on real market behavior.

BARRY D. SOLOMON

Further reading

Adamowicz et al. 1994; Whitehead et al. 2008.

See also: Contingent valuation method (CVM), Choice experiments, Conjoint analysis, Revealed preference methods.

References

Adamowicz, W., Louviere, J. & Williams, M. 1994. Combining revealed and stated preference methods for valuing environmental amenities. Journal of Environmental Economics and Management 26(3): 271–92.

Whitehead, J.C., Pattanayak, S.K., Van Houtven, G.L. & Gelso, B. 2008. Combining revealed and stated preference data to estimate the nonmarket value of ecological services: an assessment of the state of the science. Journal of Economic Surveys 22(5): 872–908.

State of nature

A conceptual starting point for several treatises providing moral justifications for limited government. The state of nature is an era before the establishment of society in which no law exists, or only limited natural law such as a right of self-preservation, and in Thomas Hobbes's (1651) famous phrase, life is "solitary, poor, nasty, brutish, and short." People exchange some freedom for the protection of shared government to overcome the pitfalls of the state of nature. Later, David Hume (1739) characterized the state of nature as "a mere philosophical fiction" that serves to launch a sequence of inferences about how society should be organized. "Nature" here does not refer to natural ecosystems but

rather to conditions experienced by people in the absence of government.

Brent M. Haddad

Further reading

Locke 2013.

See also: Nature, Human nature, Governance.

References

Hobbes, T. 1651. Leviathan, E. Curley, ed. 1994. Indianapolis, IN: Hackett Publishing Co.
Hume, D. 1739. A Treatise of Human Nature. London: John Noon.
Locke, J. 2013. "Two treatises of government, 1689," pp. 43–6 in The Anthology of Citizenship: A Reader. S. Lazard, ed. Oxford: Wiley Blackwell.

Static

Economics:

a. For any economic quantity, rate, metric, or index that, for a time, is (approximately) constant; for example, capital and/or consumer production (and/or factors of), supply, demand, population, prices, wages, cost, profit, debt, (un) employment, interest rate, gross domestic product (GDP), Gini index, market.
b. Proportions that, for a time, remain (approximately) unchanged; for example, supply and demand in a stable equilibrium, input–output scenarios for firms, regions, or economies.
c. (From Frisch 1936 and Samuelson 1947) comparative statics, of equilibria.
d. An economy, when the GDP is used to define "economic growth" and GDP is (approximately) constant in time.
e. In (economic) equilibrium theory, a mathematical limit (with respect to time) that is stable.
f. An economic model for which time is held constant; or, over a small increment in time.
g. An economic model for which rates, or patterns of rates, do not depend on time.
h. Any economic objects, habits, tastes, technologies, resources, structures, or processes that, in principle, might change in time but do not.
i. Efficiency (as distinct from dynamic), in neoclassical theory.

Ecological economics:

a. For an approximately constant rate of flows and stocks of built and/or human and/or social, and/or natural capital.
b. An approximately constant flow-fund through an economy.
c. All or some of a–b, especially in a steady state economy that is in ecological and economical equilibrium. (Note that it is possible for the GDP to be static while the economy is stagnant, is otherwise dysfunctional, or while consumption of natural resources and/or population growth are not sustainable.)

Terrance J. Quinn

Further reading

Frisch 1992; Daly 2015.

See also: Stationary state, Steady state, Steady state economy, Circular economy, Flow-fund theory of production.

References

Daly, H. 2015. From Uneconomic Growth to a Steady-State Economy. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.
Frisch, R. 1936. On the notion of equilibrium and disequilibrium. Review of Economic Studies 3(2): 100–105.
Frisch, R. 1992. Statics and dynamics in economic theory. Structure Change and Economic Dynamics 3(2): 391–401.
Samuelson, P.A. 1947. Foundations of Economic Analysis. Cambridge, MA: Harvard University Press.

Stationarity

Economics: no systematic change exists in the mean and variance of the investigated time series, and the calculated covariance between two periods depends on the distance

between these two periods, not the period in which it was calculated.

Ecological economics:

a. Stationarity properties of a series are utilized to determine whether the variables converge or diverge over time. If the series are stationary, it is determined that the series tend to converge.
b. (From Yilanci et al. 2019) stationarity analyses are also used in the ecological economics literature to determine whether the shocks applied to the series are permanent or temporary. If the series are stationary, this tends to be mean-reverting and the impacts of shocks are temporary.

ALI EREN ALPER

Further reading

Ulucak & Apergis 2018; Yilanci & Pata 2020; Gujarati 1999.

See also: Non-stationarity, Stationary state, Convergence, Divergence.

References

Gujarati, D.N. 1999. Basic Econometrics. New York: McGraw-Hill.
Ulucak, R. & Apergis, N. 2018. Does convergence really matter for the environment? An application based on club convergence and on the ecological footprint concept for the EU countries. Environmental Science & Policy 80: 21–7.
Yilanci, V., Gorus, M.S. & Aydin, M. 2019. Are shocks to ecological footprint in OECD countries permanent or temporary? Journal of Cleaner Production 212: 270–301.
Yilanci, V. & Pata, U.K. 2020. Are shocks to ecological balance permanent or temporary? Evidence from LM unit root tests. Journal of Cleaner Production 276: 124294.

Stationary state

The conceptual predecessor of the steady state economy, which was originally discussed in the classical economics period but without a precise definition (Robbins 1930).

a. An economy that has evolved into an equilibrium state where population growth ceases, property rights in land and labor are so completely respected that they need not be enforced, and profits, rent, and wages remain constant forever (Mill 1848).
b. An economic condition where capital accumulation (net investments) and interest rates fall to a minimum or to nil, and may approach full employment (Pigou 1943; Usher 1989).

MASSIMO SCALIA

Further reading

Georgescu-Roegen 1977; Scalia et al. 2020.

See also: Steady state, Steady state economy, Evolutionary economics, Evolutionary analysis, Equilibrium.

References

Georgescu-Roegen, N. 1977. The steady state and ecological salvation: a thermodynamic analysis. BioScience 27: 266–70.
Mill, J.S. 1848. The Principles of Political Economy. London: John W. Parker.
Pigou, A.C. 1943. The classical stationary state. Economic Journal 53(212): 343–51.
Robbins, L. 1930. On a certain ambiguity in the conception of stationary equilibrium. Economic Journal 40: 194–214.
Scalia, M., Angelini, A., Farioli, F. et al. 2020. An ecology and economy coupling model: a global stationary state model for a sustainable economy in the Hamiltonian formalism. Ecological Economics 172: 106497.
Usher, D. 1989. The dynastic cycle and the stationary state. American Economic Review 79(5): 1031–44.

Status seeking

Economics:

a. (From Veblen 1912) to achieve a higher social status and be recognized by one's peers, people consume conspicuous goods, which are luxuries that denote status.
b. (From Frank 1999) as the super-rich become richer and buy more luxury goods to achieve higher status, everyone else must increase their consumption to maintain their status in a competitive

race resulting in wasteful consumption that does not make people happier or healthier.
c. (From Brown 1994) consumption consists of basics, variety, and status, with status consumption marking one's social position through showiness or exclusion. Status-seeking behavior causes wasteful consumption that does not increase social welfare (Brekke et al. 2003).

Ecology:

a. The wasteful consumption of luxury goods and competitive overconsumption from status seeking adds to humanity's consumption, increasing pollution (Howarth 1996), and exceeding what the planet can regenerate; that is, the human population's ecological footprint exceeds the region's biocapacity.
b. Wasteful consumption and overconsumption hamper attainment of the United Nations Sustainable Development Goal 12 (ensure sustainable consumption and production patterns).
c. Biologist Edward Wilson argued that natural selection produces status-seeking behavior because animals tend to have more surviving offspring when they increase their status in their social group (Wilson 1975).

Clair Brown

Further reading

Nguyen-Van & Pham 2013.

See also: Affluence, Affluenza, Positional goods, Inequality, Economic inequality, Social welfare function, Ecological footprint, Biocapacity, Overshoot, Sustainable Development Goals (SDGs), Fitness.

References

Brekke, K.A., Howarth, R.B. & Nyborg, K. 2003. Status-seeking and material affluence: evaluating the Hirsch hypothesis. Ecological Economics 45(1): 29–39.
Brown, C. 1994. American Standards of Living: 1918–1988. Cambridge, MA: Blackwell Publishers.
Frank, R.H. 1999. Luxury Fever: Why Money Fails to Satisfy in An Era of Excess. New York: Free Press.
Howarth, R.B. 1996. Status effects and environmental externalities. Ecological Economics 16(1): 25–34.
Nguyen-Van, P. & Pham, T.K.C. 2013. Endogenous fiscal policies, environmental quality, and status-seeking behavior. Ecological Economics 88: 32–40.
Veblen, T. 1912. The Theory of the Leisure Class. London: Macmillan Co.
Wilson, E.O. 1975. Sociobiology: The New Synthesis. Cambridge, MA: Belknap Press of Harvard University Press.

Steady state

Systems theory: refers to variables in a system that remain constant over time.

Economics: the term "steady state" (or steady-state) is used in two literatures to study: (1) long-run economic growth; and (2) institutional requirements to achieve a non-growing economy. Economic growth models (e.g., Solow 1956; Swan 1956) describe long-run economic growth rates with capital accumulation, population growth, and technological progress. These models have their theoretical roots in neoclassical economic theory, where economic growth remains theoretically possible even when resources become increasingly (relatively) scarce because of substitution possibilities in the assumed production functions (for example, Cobb–Douglas).

Ecological economics: a steady state economy as first formulated by Daly (1974) starts from the notion of absolute scarcity of all resources, and aims to stabilize the population size and stocks of physical assets at a desirable level below the carrying capacity of an environment, that is, leaving slack. Steady state economics is part of ecological economics and advocates distinguishing between economic growth and development; while a steady state economy prohibits growth of physical wealth, it allows for improvements in maintenance of this physical wealth or improvement in the utility derived from these assets.

Joeri Sol

See also: Steady state economy, Carrying capacity, Development, Economic development, Economic growth, Ecological economics, Neoclassical eco-

nomics, Production function.

References

Daly, H.E. 1974. The economics of the steady state. American Economic Review 64(2): 15–21.
Solow, R.M. 1956. A contribution to the theory of economic growth. Quarterly Journal of Economics 70(1): 65–94.
Swan, T.W. 1956. Economic growth and capital accumulation. Economic Record 32(2): 334–61.

Steady state economy

Ecological economics: a non-growing, non-receding economy that fits within the carrying capacity of the ecosystem supporting it. A steady state economy has a stabilized or fluctuating level of physical throughput and, *ceteris paribus*, is indicated by a stabilized or fluctuating gross domestic product (GDP), entailing stabilized population and per capita production and consumption of goods and services. A steady state economy is, nearly by definition, a sustainable economy; however, and theoretically, a short-term steady state economy may temporarily exceed or overshoot the long-term carrying capacity, in which case degrowth is required to achieve a long-term steady state economy.

The concept of a steady state economy in ecological economics can be distinguished from the neoclassical "steady-state economy" because the latter may be growing or receding if the factors of production remain stable in proportion. The ecological steady state economy may be seen as a special case of the neoclassical steady-state economy, but in ecological economics the non-hyphenated "steady state economy" also has policy implications, as "state" modifies economy and "steady" modifies state. The ideal steady state economy exists at an optimal size; non-optimal steady states are either too crowded or too sparse to maximize social welfare.

Brian Czech

Further reading

Daly 2014; Daly & Farley 2011; Czech 2006.

See also: Steady state, Stationary state, Throughput, Carrying capacity, Overshoot, Degrowth, Optimal scale of the macroeconomy.

References

Czech, B. 2006. "Steady state economy," in Encyclopedia of Earth. A. Jorgensen, J. Hammock, T. Tietenberg et al., eds. Washington, DC: National Council for Science and the Environment. https://editors.eol.org/eoearth/wiki/Steady_state_economy.
Daly, H.E. 2014. From Uneconomic Growth to a Steady State Economy. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.
Daly, H.E. & Farley, J. 2011. Ecological Economics: Principles and Applications, 2nd edn. Washington, DC: Island Press.

Stock-flow consistent models

A type of macroeconomic model predicated on the integration of an economy's balance sheet entries (stocks) with the financial transactions (flows) between the sectors of the economy. The core feature of stock-flow consistent (SFC) models is the transactions-flow matrix, which records the transactions between each sector and the changes in each sector's assets and liabilities constructed so that all rows and columns sum to zero. This zero-sum principle captures the requirement that all flows in an SFC model are accounted for and that "everything comes from somewhere and everything goes somewhere" (Godley & Lavoie 2007). SFC models are also notable for their often detailed integration of financial sector considerations, as compared to neoclassical macroeconomic models. Though SFC models have historically been utilized by post-Keynesian economists, they have become a core component of the emerging school of ecological macroeconomics.

Martin R. Sers

Further reading

Jackson & Victor 2020; Nikiforos & Zezza 2017.

See also: Ecological macroeconomics, Post-Keynesian economics, Post-growth, Degrowth.

References

Godley, W. & Lavoie, M. 2007. Monetary Economics: An Integrated Approach to Credit, Money, Income, Production and Wealth. New York: Palgrave Macmillan.

Jackson, T. & Victor, P.A. 2020. The transition to a sustainable prosperity—a stock-flow-consistent ecological macroeconomic model for Canada. Ecological Economics 177: 106787.

Nikiforos, M. & Zezza, G. 2017. Stock-flow consistent macroeconomic models: a survey. Working Paper No. 891, Levy Economics Institute of Bard College, Annandale-on-Hudson, NY.

Stocks

Economics:

a. A type of securities that represents the ownership shares of a corporation. Also known as an equity.
b. The total quantity of capital at any given point in time.

Ecology:

a. Subpopulations of a fish species found in a specific geographic region. Farm animals are often called livestock, as well as animals kept privately or raised for personal use or for pleasure.
b. The amount of carbon stored in vegetative biomes such as aquatic, forest, grassland, desert, and tundra.

BARRY D. SOLOMON

Further reading

Michie 2006; Garafalo & Yamarik 2002; Edwards et al. 2004; Fourqurean et al. 2012.

See also: Non-renewable resource, Renewable resource, Fossil fuels, Capital stock, Fishery resources, Fisheries management, Carbon stock, Biome.

References

Edwards, S.F., Link, J.S. & Roundtree, B.P. 2004. Portfolio management of wild fish stocks. Ecological Economics 49(3): 317–29.

Fourqurean, J.W., Duarte, C.M., Kennedy, H. et al. 2012. Seagrass ecosystems as a globally significant carbon stock. Nature Geoscience 5: 505–9.

Garafalo, G.A. & Yamarik, S. 2002. Regional convergence: evidence from a new state-by-state capital stock series. Review of Economics and Statistics 84(2): 316–23.

Michie, R.C. 2006. The Global Securities Market: A History. Oxford, UK and New York, USA: Oxford University Press.

Strategic decision-making

An approach to business management in which the short-term interests of a firm fade into the background, giving way to its long-term goals, interests, and vision. Unlike tactical decision-making, aimed at solving current business problems, strategic decision-making is aimed at determining the long-term priorities of the enterprise and creating a strategy for its development in the target market. In the digital economy, artificial intelligence (AI)-based business management automation tools are becoming increasingly available. They are especially useful for strategic decision-making, as they allow a firm to systematically consider and deeply analyze the entire set of conditions and market alternatives to achieve maximum efficiency of business management. In strategic decision-making, objectivity is especially important (neutralization of the influence of the "human factor" on the decisions made), which digital technologies in management also help to facilitate.

ELENA G. POPKOVA

Further reading

Nauhaus et al. 2021; Novikov 2021; Popkova et al. 2019; Pozdnyakova et al. 2017; Robinson et al. 2021.

See also: Sustainable business, Management science, Business innovation, Corporate social responsibility.

References

Nauhaus, S., Luger, J. & Raisch, S. 2021. Strategic decision making in the digital age: expert sen-

timent and corporate capital allocation. Journal of Management Studies 58(7): 1933–61.
Novikov, D. 2021. Models of strategic decision-making under informational control. Mathematics 9(16): 1889.
Popkova, E.G., Chesnokova, A.V. & Morozova, I.A., eds. 2019. Specifics of Decision Making in Modern Business Systems: Regularities and Tendencies. Bingley, UK: Emerald Publishing.
Pozdnyakova, U.A., Popkova, E.G., Kuzlaeva, I.M. et al. 2017. "Strategic management of clustering policy during provision of sustainable development," pp. 413–21 in Integration and Clustering for Sustainable Economic Growth: Contributions to Economics. E.G. Popkova, V.E. Sukhova, A.F. Rogachev et al., eds. Cham: Springer.
Robinson, D.K.R., Schoen, A., Larédo, P. et al. 2021. Policy lensing of future-oriented strategic intelligence: an experiment connecting foresight with decision-making contexts. Technological Forecasting and Social Change 169: 120803.

Stressors

Entities, processes, or events that perturb the normal structure or functioning of a system or a system component. Stressors may have beneficial or detrimental consequences, though the term is most frequently used in the context of the latter.

NICHOLAS D. ROXBURGH

Further reading

Orr et al. 2020.

See also: Perturbation, Ecological perturbation, Disturbance, Ecosystem structure and function.

Reference

Orr, J.A., Vinebrooke, R.D., Jackson, M.C. et al. 2020. Towards a unified study of multiple stressors: divisions and common goals across research disciplines. Proceedings of the Royal Society B 287(1926): 20200421.

Strong sustainability

A much contested and often misunderstood term because it is not a type of sustainability as such but a view of what is needed to achieve sustainability, which itself is most often defined as "non-declining human well-being over time" (Pearce et al. 1994). Pearce et al. (1989, p. 127) originated "strong sustainability," but their definition was to preserve total natural capital, which implied valuing all separate forms of natural capital monetarily. A widely accepted, ecological-economic definition now would be that it "requires a subset of total natural capital be preserved in physical terms so that its functions remain intact. This is so-called 'critical' natural capital (CNC)" (Dietz & Neumayer 2007, p. 619). Deciding what this subset should be in practice depends on the region being considered, is always very difficult, and is mostly unfalsifiable because the far future is unknown.

A CNC example could be limiting global warming to 2°C or less. Strong sustainability is essentially a view about substitutability because the opposing, standard-economic, weak sustainability paradigm "assumes that ... manufactured ... or human capital ... [is limitlessly] substitutable for natural capital" (Ayres et al. 2001, pp. 157–58). In theory, this clash of paradigms can be resolved by noting that low substitutability between capitals implies both minimum limits on capitals, and monetary values for inter-capital substitutions within those limits.

JOHN C.V. PEZZEY

See also: Natural capital, Substitutability, Weak sustainability, Capital substitution.

References

Ayres, R.U., van den Bergh, J.C.J.M. & Gowdy, J.M. 2001. Strong versus weak sustainability: economics, natural sciences, and "consilience." Environmental Ethics 23: 155–68.
Dietz, S. & Neumayer, E. 2007. Weak and strong sustainability in the SEEA: concepts and measurement. Ecological Economics 61: 617–26.
Pearce, D.W., Atkinson, G.D. & Dubourg, W.R. 1994. The economics of sustainable devel-

opment. Annual Review of Energy and the Environment 19: 457–74.
Pearce, D., Markandya, A. & Barbier, E.B. 1989. Blueprint for a Green Economy. London: Earthscan.

Structural change

A change or shift in the way a market or economy operates. Structural change is typically brought on by major changes in technology, product characteristics, production and consumption, scale of operation, the price of capital and labor, knowledge and information, and geographic location.

JOHN M. POLIMENI

Further reading

Fisher 1939; Clark 1940; Kuznets 1973; van Neuss 2019.

See also: Technological change, Technological progress, Economies of scale.

References

Clark, C. 1940. The Conditions of Economic Progress. New York: Macmillan.
Fisher, A.G.B. 1939. Primary, secondary and tertiary production. Economic Record 15(28): 24–38.
Kuznets, S. 1973. Modern economic growth: findings and reflections. American Economic Review 63(3): 247–58.
van Neuss, L. 2019. The drivers of structural change. Journal of Economic Surveys 33(1): 309–49.

Subjective preferences

A term used to designate the mental state of human beings. Subjective preferences started to enter gradually into the analytical scheme of economic theory, in order not only to express the subjective effort involved in production, but also to designate the motivation for purchasing a given product. After the marginalist revolution of the 1870s, subjective preferences started to be represented more systematically through the utility of purchasing a given commodity, while the effort undertaken in production also started to be represented in terms of the disutility of labor.

Neoclassical economists such as Arthur Cecil Pigou (1920) used the notion of utility to engage in the analysis of human welfare, noting the tendency for utility to decrease as income increases, which means that redistribution increases overall utility. Other economists, such as Lionel Robbins (1932), interpreted utility as an irreducibly subjective phenomenon, which cannot be compared across individuals, while paving the way for the use of the ordinal approach to utility, where utility levels reflect merely the preference order, but not the exact intensity of the subjective preference, as in a cardinal approach to utility. Recent studies in neuroscience have tried to find the neuronal correlates of mental states to provide an objective basis for understanding mental phenomena such as subjective preferences.

NUNO O. MARTINS

See also: Utility, Preference heterogeneity, Preference endogeneity, Preference formation, Lexicographic preferences.

References

Pigou, A.C. 1920. The Economics of Welfare. London: Macmillan.
Robbins, L. 1932. An Essay on the Nature and Significance of Economic Science. London: Macmillan.

Subjective well-being

Self-assessment of one's momentary or general mental state. It has two dimensions: (1) pleasure, which goes back to Jeremy Bentham's notion of hedonism; and (2) purpose, which goes back to Aristotle's notion of the virtuous life. These two dimensions can be measured in two ways: (1) as cognitive evaluations (for example, by asking people about their general life satisfaction or feeling of purpose in life, or about their satisfaction or feeling of purpose in specific life domains); and (2) as affective experiences (for example, by asking people about their momentary happiness or purpose). While evaluations are mostly measured using surveys, experiences

are often measured using tools such as the day reconstruction method (DRM) or experience sampling method (ESM). For environmental valuation, life satisfaction, as a global evaluative measure of subjective well-being, is most often used.

CHRISTIAN KREKEL

Further reading

Diener et al. 2002; Dolan & Kudrna 2016.

See also: Life satisfaction, Quality of life (QoL), Happiness, Objective well-being, Well-being economy.

References

Diener, E., Lucas, R.E. & Oishi, S. 2002. "Subjective well-being: the science of happiness and life satisfaction," pp. 463–73 in Handbook of Positive Psychology. C.R. Snyder & S.J. Lopez, eds. Oxford: Oxford University Press.

Dolan, P. & Kudrna, L. 2016. "Sentimental hedonism: pleasure, purpose, and public policy," pp. 437–52 in Handbook of Eudaimonic Well-being. J. Vittersø, ed. Cham: Springer.

Subjectivity

The quality of a person's judgment being based on personal feelings, opinions, perspectives, beliefs, and tastes rather than objective reality. This quality results in personal bias as well as individuality, and is the opposite of objectivity. Subjectivism is a philosophical doctrine which holds that all knowledge is subjective and based on personal experience, and that there is no objective truth.

BARRY D. SOLOMON

Further reading

Horwitz 1994.

See also: Subjective preferences, Objectivity, Epistemology, Epistemological bias.

Reference

Horwitz, S. 1994. "Subjectivism," pp. 17–22 in The Elgar Companion to Austrian Economics. P.J. Boettke, ed. Aldershot, UK and Brookfield, VT, USA: Edward Elgar Publishing.

Subsidies

Payments or tax reliefs that governments grant individuals or firms to induce them to consume or produce particular goods (for example electric cars), to stimulate research and development (for example for "green" products), to protect industries in their infant state (for example, renewable energies and battery technologies), and essential economic activities (for example, agriculture in general, and organic farming in particular) from international competition, and to promote social justice (for example, through co-financing of public transportation or through child benefits). These examples show that subsidies can play an important role in environmental policy aiming at curbing pollution and achieving sustainable development, especially as subsidies usually generate less political resistance as compared to environmental regulations and environmental taxes.

There are also widespread "bad" or "perverse" subsidies (for example, tax deductions for fossil fuels, or government expenditures for keeping non-competitive or ecologically harmful industries alive). Beyond that there are many other problems with subsidies: they run the risk of distorting the price system and of undermining the conditions of fair competition in international trade, thus thwarting economic efficiency; financing them through taxes causes economic losses (that is, "excess burdens"); using government debt instead causes financial obligations for future generations; the design of subsidy schemes that are well targeted and without deadweight effects is difficult; providing subsidies tends to foster rent-seeking behavior of the beneficiaries and may create an entitlement mentality, which makes it difficult to abolish subsidies after they have fulfilled their purpose.

WOLFGANG BUCHHOLZ

Further reading

Myers & Kent 1998; Strand 2016; Rodrik 2014; Mazzucato 2021.

See also: Environmental subsidies, Environmental taxes, Pollution taxes, Carbon taxes, Green industrial policy.

References

Mazzucato, M. 2021. Public Purpose: Industrial Policy's Comeback and Government's Role in Share Prosperity. Cambridge, MA: MIT Press.

Myers, N. & Kent, J. 1998. Perverse Subsidies: How Tax Dollars Can Undercut the Environment and the Economy. Washington, DC: Island Press.

Rodrik, D. 2014. Green industrial policy. Oxford Review of Economic Policy 30(3): 469–91.

Strand, J., ed. 2016. The Economics and Political Economy of Energy Subsidies. Cambridge, MA: MIT Press.

Subsistence

The state of having what a person needs to stay alive over time, but no more than that. In subsistence economies such as those based on hunting, gathering, or pastoralism, economic surplus is minimal and only used to exchange basic goods such as food and clothing (Sahlins 1974). The historical development of the social division of labor enabled societies to produce a surplus product above their basic needs for survival, so that they could sustain the livelihood of the non-productive members of society. The existence of an economic surplus implies social conflict over its distribution, which unfolds based on the dominant mode of production (slavery, feudalism, or capitalism). The concept of subsistence is foundational in classical political economy as based in the labor theory of value, as it allows the definition of economic surplus and exploitation.

Oriol Vallès Codina

Further reading

Bowles et al. 2018; Foley 1986; Polanyi et al. 1957.

See also: Consumer surplus, Producer surplus, Political economy, Labor theory of value, Sustenance.

References

Bowles, S., Edwards, R. & Roosevelt, F. 2018. "The surplus product: competition, command, and change," pp. 67–88 in Understanding Capitalism: Competition, Command, and Change, 4th edn. New York: Oxford University Press.

Foley, D.K. 1986. "The theory of capital and surplus value," pp. 31–48 in Understanding Capital: Marx's Economic Theory. Cambridge, MA: Harvard University Press.

Polanyi, K., Arensberg, C. & Pearson, H., eds. 1957. Trade and Market in the Early Empires: Economies in History and Theory. New York: Free Press.

Sahlins, M. 1974. Stone Age Economics. London: Routledge.

Substitutability

a. For consumer goods and services, the ability of one good or service to be substituted for another, with little or no change in utility. Examples could include pens and pencils, coffee and tea, meat and fish, and two different brands of soap or toothpaste.
b. In the case of economic production functions, the ability of different factors of production to be exchanged for one another. While neoclassical economics commonly assumes perfect substitutability between factor inputs, ecological economists argue that there is limited substitutability between, for example, natural capital and energy, and manufactured capital and labor (Stern 1997).

Barry D. Solomon

See also: Principle of substitution, Substitution effects, Capital substitution, Complementarity.

Reference

Stern, D.I. 1997. Limits to substitution and irreversibility in production and consumption: a neoclassical interpretation of ecological economics. Ecological Economics 21(3): 197–215.

Substitution effects

a. The impacts that occur when consumers change a buying decision. Emergence of a lower-cost version of a product might

prompt the switch. Impacts include changes in where industrial production occurs, who is employed, and the environmental impacts of production, especially if the price drop is caused by reduced investment in pollution abatement.

b. Evidence of a willingness to trade off one good for a similar good in response to changes in price, relative scarcity, or other factors. A study by Morse-Jones et al. (2012) identified limited and specific willingness to substitute some forms of tropical rainforest wildlife for others in a willingness-to-pay survey of United Kingdom residents, while other forms of wildlife showed no substitution effect.

BRENT M. HADDAD

See also: Principle of substitution, Substitutability, Income effects, Externalities, Environmental externalities, Complementarity.

Reference

Morse-Jones, S., Bateman, I., Kontoleon, A. et al. 2012. Stated preferences for tropical wildlife conservation amongst distant beneficiaries: charisma, endemism, scope and substitution effects. Ecological Economics 78: 9–18.

Succession

Ecology: the process of change in an ecosystem following a perturbation or disturbance (Egerton 2015).

Economics: the orderly passage of private property, assets, and power from one entity to another in business or personal affairs (Huson et al. 2004; Mishra et al. 2010).

BARRY D. SOLOMON

See also: Ecological succession, Private property, Power.

References

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Sufficiency

a. In development and justice discourses understood as distributive justice ("sufficientarianism"), defining a minimum requirement of income or resource access within pluralist lifestyles (Kanschik 2016).

b. Sufficiency as a limit (maximum consumption) and an alternative to efficiency was promoted in the early 2000s, for example by Thomas Princen. His concept is based on the absolute size of inputs and output, limiting production by restricting extraction from the environment to what it can support. Sufficiency should replace efficiency as the organizing principle of society (Princen 2005).

c. Sufficiency as a solution: dematerialization and climate change can be achieved by lifestyle change, permitting a good life with less consumption. The suitability for low-income groups has been disputed, and severe limitations in an unchanged socio-economic environment have been demonstrated (Speck & Hasselkuss 2015).

d. Sufficiency as demand-side management. Most climate scenarios today mention consumption change, but do not include it in their models and scenarios. Scholars have shown that the emissions reduction potentials on the demand side equal those on the supply side if properly activated (Wachsmuth & Duscha 2019). They can skim off the efficiency surplus leading to rebound effects, thus making efficiency effective.

e. Sufficiency as the opposite of "faster, higher, further" (a political use of the term in ecological economics, and among non-governmental organizations)

includes a focus on human socio-cultural and psychological needs, deceleration, stress reduction, good work, equity, and less but better consumption. It is considered a key element of a deeper transformation of the industrial consumer society, with changing orientations, regulations, infrastructures, norms, practices (Rijnhout & Mastini 2018).

JOACHIM H. SPANGENBERG

Further reading

Spangenberg & Lorek 2019.

See also: Sustainable consumption, Demand management, Rebound effect, Energy self-sufficiency, Food self-sufficiency.

References

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Spangenberg, J.H. & Lorek, S. 2019. Sufficiency and consumer behaviour: from theory to policy. Energy Policy 129: 1070–79.
Speck, M. & Hasselkuss, M. 2015. Sufficiency in social practice: searching potentials for sufficient behavior in a consumerist culture. Sustainability: Science, Practice and Policy 11(2): 14–32.
Wachsmuth, J. & Duscha, V. 2019. Achievability of the Paris targets in the EU—the role of demand-side-driven mitigation in different types of scenarios. Energy Efficiency 12(2): 403–21.

Supply

Neoclassical economics: economics is sometimes summarized as the science for optimally allocating scarce resources. In this context "supply" refers to the total amount of a good or service available to consumers. When "supplies" are large and in excess of demand, the resource in question does not garner much economic attention; for example, the supply of the carbon dioxide (CO_2) absorbing capacity of the atmosphere did not typically garner much attention with respect to economic allocation analysis until the 1990s.

Ecological economics: one area in which ecological economics differs from traditional neoclassical economics is in determining what resources are in scarce supply. Traditional economics typically regards the environment in a very vague way. The environment typically simply "supplies" the raw materials for our economy. Ecological economics regards the environment as a store of natural capital, which provides a supply of ecosystem services to humans through interactions with social, human, and manufactured capital. The supply of ecosystem services is decreasing (Costanza et al. 2014), while the global gross domestic product (GDP) is growing. One thrust of ecological economics is fostering a broader awareness of what resources are in scarce supply, and what should be done about it.

PAUL C. SUTTON

Further reading

Samuelson et al. 2019.

See also: Peak oil supply, Commodity supply chain, Supply chain management, Resources, Scarcity, Demand, Natural capital.

References

Costanza, R., de Groot, R., Sutton, P. et al. 2014. Changes in the global value of ecosystem services. Global Environmental Change 26: 152–8.
Samuelson, P.A., Nordhaus, W.D., Chaudhuri, S. & Sen, A. 2019. Economics, 20th edn. New Delhi: McGraw-Hill.

Supply chain management

The coordination of upstream and downstream relationships with suppliers and customers to deliver superior and timely customer value at less cost (Christopher 2016). Supply chains historically described the coordinated, often multi-firm, steps of acquiring and assembling materials into a final product, and delivering the product to end-users. Their management increasingly involve the integration of: (1) environmental concerns into each stage of

the supply chain to reduce material flows and the negative implications of production and consumption processes (green or sustainable supply chain management); and (2) reverse flows of used products and materials back to the originator (closed loop or circular supply chain management).

BENJAMIN H. LOWE

Further reading

Lambert & Cooper 2000; Seuring & Müller 2008; Genovese et al. 2017.

See also: Commodity supply chain, Green supply chains, Value chain analysis.

References

Christopher, M. 2016. Logistics and Supply Chain Management. Harlow, UK: Pearson.

Genovese, A., Acquaye, A.A., Figueroa, A. & Lenny Koh, S.C. 2017. Sustainable supply chain management and the transition towards a circular economy: evidence and some applications. Omega 66(B): 344–57.

Lambert, D.M. & Cooper, M.C. 2000. Issues in supply chain management. Industrial Marketing Management 29(1): 65–83.

Seuring, S. & Müller, M. 2008. From a literature review to a conceptual framework for sustainable supply chain management. Journal of Cleaner Production 16(15): 1699–1710.

Supporting services

One of the original four main categories of ecosystems that benefit people, as proposed by the Millennium Ecosystem Assessment (2005). However, supporting services are intermediate, such as primary production, oxygen production, soil formation and retention, nutrient cycling, water cycling, and habitat provision, and may be redundant with regulating services in some categories. Since these services provide the basis for services in the other ecosystem service categories, and to prevent double counting in service audits and valuations, programs such as the Economics of Ecosystems and Biodiversity (TEEB) and the Common International Classification of Ecosystem Services (CICES) do not recognize the term "supporting services" (Kumar 2010). The CICES instead recommends the use of the term "maintenance services" to better connect this category with regulating services (Haines-Young & Potschin-Young 2018).

BARRY D. SOLOMON

See also: Maintenance services, Millennium Ecosystem Assessment, Common International Classification of Ecosystem Services (CICES).

References

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Kumar, P. ed. 2010. The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. London, UK and Washington, DC, USA: Earthscan.

Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-Being: Synthesis. Washington, DC: Island Press.

Surprise

The emotion experienced when current events, facts, or information do not conform to previously established beliefs or states of mind. Surprise can be experienced individually (relative to others) or in a collective fashion (in absolute terms). The individual act of learning a new idea surprises the learner but not the instructor. On the other hand, the generation of new technologies or knowledge has the potential to prompt collective surprise. Novelty cannot be predicted (from Shackle 1972). Surprise is the primal mechanism whereby the mind copes with a fundamentally uncertain reality where novelty occurs.

The acquisition and generation of new information, and the uncovering and learning of new logical linkages, creates puzzles and paradoxes that challenge the perception of what is considered possible. Surprise prepares the mind for the acceptance of the unexpected and opens it for creativity. It allows for the consideration of possibilities beyond what is deemed probable or logical. The analysis of surprise aims at understanding the character of decisions and actions that engender novelty. Surprise is common, may be positive or negative in character, and plays

a fundamental role in ecosystems, climate change, and biodiversity (King 1995).

ANDRES F. CANTILLO

See also: Tipping point, Complexity theory.

References

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Sustainability

The goal of a process called "sustainable development" (Costanza 1991; Common & Perrings 1992). Metaphorically, sustainability is the distant mountain we must climb, and sustainable development is a pathway to the summit. Authors coming from an environmental science perspective generally consider that sustainability, like sustainable development, has three aspects: ecological or environmental, social, and economic. One conception illustrates these as three partially overlapping circles, with "true" sustainability represented by the central region where all three circles overlap (Figure 17). A "stronger" conception assigns priorities to these aspects by illustrating them as three concentric circles, with the outer being ecological, the middle one being social, and the innermost one being economic (Figure 18). Both conceptions recognize implicitly that there does not have to be a trade-off between the three aspects. However, conceptions arising from neoliberal economics generally allow natural capital to be replaced with human-made capital.

The concept of sustainability (e.g., Klauer et al. 2017) has become crucial for addressing central problems of modern societies. It is particularly concerned with the question of whether humanity's influence on the natural foundations of life could lead to a long-term threat to the well-being or even the survival of human beings.

MARK O. DIESENDORF, MALTE M. FABER & MARC FRICK

See also: Sustainable development, Strong sustainability, Weak sustainability, Holling sustainability, Solow sustainability, Sustainability science, Sustainability assessment, Sustainability metrics, Sustainability transition.

References

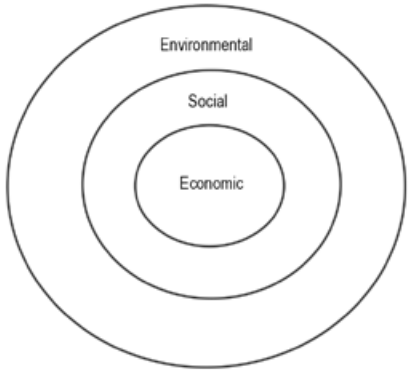
Common, M. & Perrings, C. 1992. Towards an ecological economics of sustainability. Ecological Economics 6: 7–34.

Costanza, R., ed. 1991. Ecological Economics: The Science and Management of Sustainability. New York: Columbia University Press.

Klauer, B., Manstetten, R., Petersen, T. et al. 2017. Sustainability and the Art of Long-Term Thinking. London: Routledge. (German edition 2013: Die Kunst langfristig zu denken. Nomos Verlag Baden-Baden.)

Source: Mark Diesendorf (author).

Figure 17 *A weak conception of sustainability, with "true" sustainability represented by the central region where all three circles overlap*



Source: Mark Diesendorf (author).

Figure 18 *A stronger conception of sustainability as the economy nested in society and the environment*

Sustainability assessment

A complex appraisal method to assess the alignment of decisions (*ex ante*) or outcomes (*ex post*) to sustainability goals, organized within a normative framework encompassing at least three dimensions (environmental, social, and economic) across multiple spatial and temporal scales (Sala et al. 2015). The normative framework is derived from the definition of sustainability, which is value-laden and differs across disciplines and socio-cultural context. Ecological-economic interpretations emphasize biophysical boundaries, value pluralism, and interactions between the socio-economic subsystem and biosphere, whereas conventional economics emphasizes weak sustainability, value monism, and non-declining (discounted) welfare over time (Patterson et al. 2017). Choice of indicators and methods for assessing each dimension is thus complicated by ontological and epistemic considerations, highlighting the need for participation and pluralism alongside expert input (for example, by adopting a post-normal science perspective).

MICHAEL CURRAN

Further reading

Pintér et al. 2012.

See also: Indicators, Sustainability metrics, Integrated assessment model, Triple bottom line (TBL), Weak sustainability, Strong sustainability.

References

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Pintér, L., Hardi, P., Martinuzzi, A. & Hall, J. 2012. Bellagio STAMP: principles for sustainability assessment and measurement. Ecological Indicators 17: 20–28.

Sala, S., Ciuffo, B. & Nijkamp, P. 2015. A systemic framework for sustainability assessment. Ecological Economics 119: 314–25.

Sustainability assessment tools

Decision supporting tools that are used in the context of a sustainability assessment for the evaluation of criteria reflecting one or more sustainability dimensions, or for covering any of the requirements (normative, systemic, transdisciplinary, strategic) (Troullaki et al. 2021) of a sustainability assessment process. The term has been used interchangeably in the literature to denote hierarchically different elements, such as frameworks, methodologies, methods, models, software, or indicators (Sala et al. 2015). Tools may vary

in focus, for example, in terms of the spatial and temporal scale, the temporal perspective (*ex ante*, *ex post*), the area of applicability, and the sustainability dimensions they cover.

Ecological economics critiques bring to the fore value judgments embedded in tools regarding the interpretation and operationalization of sustainability, which have practical and ethical implications for the decision-making process. Therefore, the choice of the assessment tool (Gasparatos & Scolobig 2012) and decisions made in the development of a tool (de Olde et al. 2017) need to be transparent, relevant to the decision-making context, and when possible made with the involvement of concerned stakeholders.

Katerina Troullaki

Further reading

Ness et al. 2007; Bebbington et al. 2007; Singh et al. 2009.

See also: Sustainability assessment, Impact assessment, Environmental impact assessment tools, Integrated assessment model.

References

Bebbington, J., Brown, J. & Frame, B. 2007. Accounting technologies and sustainability assessment models. Ecological Economics 61(2–3): 224–36.

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Gasparatos, A. & Scolobig, A. 2012. Choosing the most appropriate sustainability assessment tool. Ecological Economics 80: 1–7.

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Singh, R.K., Murty, H.R., Gupta, S.K. & Dikshit, A.K. 2009. An overview of sustainability assessment methodologies. Ecological Indicators 9(2): 189–212.

Troullaki, K., Rozakis, S. & Kostakis, V. 2021. Bridging barriers in sustainability research: a review from sustainability science to life cycle sustainability assessment. Ecological Economics 184: 107007.

Sustainability metrics

Quantitative assessments of a product, person, company, city, region, or country's performance against a particular sustainability definition. Therefore, the metric needs to declare the observable sustainability definition against which the object is being evaluated. For instance, if the definition is "living within the means of ecosystem regeneration," then a metric that compares the aggregate human ecological footprint to biocapacity, or biomass removal against net primary productivity, could be meaningful choices, with a requirement that some regeneration needs to be left for wild species if biodiversity is also preserved. Or if the definition embraces integrity of the biosphere, then one can compare human use of essential biosphere components against critical thresholds in each component, as in the case of planetary boundaries. In all three cases, demand must be less, or significantly less, than regeneration as a minimum condition for sustainability. Metrics could also be focused on a particular subsystem, such as a forest or a fishing ground, where harvest is compared with regeneration. The landscape of metrics is described in various handbooks including Atkinson et al. (2014), Bell and Morse (2018), Fogel et al. (2012), and Lawn (2005).

Many definitions of sustainability are unspecific (such as the Brundtland definition of sustainable development), which in turn makes metrics for such vague definitions problematic. Various multidimensional indices exist that sometimes are called sustainability metrics, such as the environmental performance index (Wendling et al. 2020). But that may be a misnomer as they are not based on an observable definition. Therefore, they are arbitrary constructs, and are merely a reflection of their architects' preferences rather than an actual, empirical description. Such arbitrary indices may be useful heuristics if all users agree that their aggregation criteria match with their own preferences.

Mathis Wackernagel & David Lin

Further reading

World Commission on Environment and Development 1987; IUCN et al. 1991.

See also: Sustainability, Sustainable development, Ecological footprint, Biocapacity, Biodiversity,

Biosphere, Biomass, Net primary production (NPP), Human appropriation of net primary production (HANPP), Planetary health, Heuristic.

References

Atkinson, G., Dietz, S., Neumayer, E. & Agarwala, M., eds. 2014. Handbook of Sustainable Development, 2nd rev. edn. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Bell, S. & Morse, S., eds. 2018. Routledge Handbook of Sustainability Indictors. London: Routledge.

Fogel, D., Fredericks, S., Spellerberg, I. & Butler Harrington, L.L., eds. 2012. Berkshire Encyclopedia of Sustainability, Volume 6: Measurements, Indicators, and Research Methods for Sustainability. Great Barrington, MA: Berkshire Publishing.

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World Commission on Environment and Development. 1987. Our Common Future. Oxford: Oxford University Press.

Sustainability science

A transdisciplinary field of research that emerged in 2001, which addresses the interactions between humans and the natural world as these interactions pertain to problems of sustainability and sustainable development. A relatively new branch of science, drawing from the fields of environmental science, ecology, sustainable development, and economics.

LAURA SCHMITT OLABISI

Further reading

Clark 2007; Kates 2011; Kates et al. 2001.

See also: Sustainability, Sustainable development.

References

Clark, W.C. 2007. Sustainability science: a room of its own. Proceedings of the National Academy of Sciences of the United States of America 104(6): 1737–38.

Kates, R.W. 2011. What kind of a science is sustainability science? Proceedings of the National Academy of Sciences of the United States of America 108(49): 19449–50.

Kates, R.W., Clark, W.C., Corell, R. et al. 2001. Sustainability science. Science 292(5517): 641–42.

Sustainability transition

The long-term transformation of a society towards more sustainable production, consumption, and social relations. Overall, one can define this transition as a society pursues sustainability goals in social, environmental, and economic dimensions (see UN 2015). In the social dimension, targets such as inequality reduction should be pursued. In the environmental dimension, lower carbon emissions and a higher share of environmentally friendly activities should be pursued. In the economic dimension, higher productivity and better exports may be targets. It demands innovation in the public and private sectors to drive a structural change in different economies (Fagerberg 2018). This transition requires new technologies, but also a strong policy effort to foster structural change in the economic and productive structure, and also in the society's routines and cultural practices (Schilling et al. 2018).

JOAO PAULO BRAGA

See also: Sustainability, Sustainable development, Societal transformation, Structural change.

References

Fagerberg, J. 2018. Mission (im)possible? The role of innovation (and innovation policy) in supporting structural change and sustainability transitions. Working Papers on Innovation

Studies 20180216, Centre for Technology, Innovation and Culture, University of Oslo.
Schilling, T., Wyss, R. & Binder, C.R. 2018. The resilience of sustainability transitions. Sustainability 10(12): 4593.
UN. 2015. Resolution adopted by the General Assembly on 25 September 2015. 70.1. Transforming our world: the 2030 Agenda for Sustainable Development. https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E.

Sustainable agriculture

A set of agricultural practices (plant growing and/or animal breeding) to produce foodstuffs or fibers, in sufficient amounts in terms of energy and nutritious food to sustain healthy life, while: (1) limiting the consumption of natural resources in term of quantity, quality, soil, and water *in primis*; (2) minimizing the environmental impacts of the whole agricultural sector, from reducing the use of agrochemicals and adopting "integrated pest management," to using cover and nitrogen-fixing crops, to reducing waste along the food chain; (3) favoring the resilience of the agroecosystem by preserving key agroecological functions and services, and locally suitable varieties; (4) contributing to a range of public goods and services, such as clean water, wildlife and habitats, carbon sequestration, flood protection, groundwater recharge, landscape amenity value, and leisure/tourism; and (5) being socially and economically fair to farmers, as exacerbating economic pressures on farmers may result in them adopting damaging farming practices.

Being multifunctional, sustainable agriculture should account for its whole contributions to society, its cultural dimension, and risk perception (for example, food security in poor rural communities in the global South versus economic profitability in the global North). Power asymmetries should be addressed to avoid inhibiting organizational diversity and the plurality of agricultural practices. Vernacular agricultural knowledge (for example, conservation of local varieties, landraces, farming practices, ecological knowledge) and the culture they are embedded in should be preserved, as it represents a significant reservoir of knowledge than may help to foster agricultural resilience and respond to future unknown challenges.

GAËL PLUMECOCQ & TIZIANO GOMIERO

Further reading

FAO 2021; Gliessman 2015; McIntyre et al. 2009; Poore & Nemecek 2018; Pretty 2008.

See also: Sustainable food system, Agroecology, Integrated pest management (IPM), Amenity value, Agricultural ecosystem services, North–South relations, Power differentials, Resilience.

References

FAO (Food and Agriculture Organization of the United Nations). 2021. Sustainable Food and Agriculture. https://www.fao.org/sustainability/resources/publications/en/.
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Poore, J. & Nemecek, T. 2018. Reducing food's environmental impacts through producers and consumers. Science 360(6392): 987–92.
Pretty, J. 2008. Agricultural sustainability: concepts, principles and evidence. Philosophical Transactions of the Royal Society B 363(1491): 447–65.

Sustainable business

The wedding of two seemingly incompatible value systems: sustainability and for-profit enterprise. It is rooted in the belief from the 1990s onwards, developed by business scholars, consultants, corporate reformers, and a segment of environmentalists, that the private sector can play a transformative role in creating a sustainable society. It is summed up by the ideal, articulated by Paul Hawken, that "the ultimate purpose of business is not, or should not be, simply to make money. Nor is it merely a system of making and selling things. The promise of business is to increase the general wellbeing of humankind through service, a creative invention and ethical philosophy" (Hawken 1993, p. 155).

The idea also took on greater methodological rigor and specificity with the emergence and rapid institutional acceptance of the "triple bottom line" (Elkington 1998), which created an accounting system that valued, all at once, social, ecological, and financial well-being.

By the early 21st century, sustainable business was held up as a vehicle for a kind of "third industrial revolution" (Hawken et al. 1999; Rifkin 2011); one that would value "natural capital," and draw on the prodigious wealth and agility of the private sector to initiate a transformation away from fossil fuels and ecological destruction, and towards clean energy and environmental sustainability. The idea of sustainable business has also benefited from a growing number of metrics, indicators, and certifications that have brought greater precision to the concept. In the face of ongoing climate change, environmental destruction, social inequality, and the various refugee and social crises of the 21st century, the idea of sustainable business is frequently challenged by ecological economists, environmentalists, social critics, and degrowth scholars, who argue that growth-oriented, deregulated, fossil-fueled, consumer society is inherently unsustainable (Daly & Farley 2011; D'Alisa et al. 2015), despite the efforts of some corporations to evolve the practices and purpose of business.

JEREMY L. CARADONNA

See also: Triple bottom line (TBL), Natural capital, Degrowth, Objective well-being, Indicators, Well-being economy, Genuine progress indicator (GPI), Index of sustainable economic welfare (ISEW), Life-cycle assessment (LCA).

References

D'Alisa, G., Demaria, F. & Kallis, G. 2015. Degrowth: A Vocabulary for a New Era. New York: Routledge.

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Elkington, J. 1998. Accounting for the triple bottom line. Measuring Business Excellence 2(3): 18–22.

Hawken, P. 1993. The Ecology of Commerce: A Declaration of Sustainability. New York: HarperCollins Publisher.

Hawken, P., Lovins, A.B. & Lovins, L.H. 1999. Natural Capitalism: The Next Industrial Revolution. London: Earthscan.

Rifkin, J. 2011. The Third Industrial Revolution: How Lateral Power is Transforming Energy, the Economy, and the World. New York: Macmillan.

Sustainable cities and communities

a. Cities and communities in which improvement in the quality of human life is achieved in harmony with improving and maintaining the health of ecological systems.
b. Cities and communities that improve the local quality of life through urban planning and management, including ecological, cultural, political, institutional, social, and economic components, without leaving a burden on future generations.
c. Cities and communities that make development choices that respect the relationship between their economy, ecology, and equity. Sometimes also called green cities or eco-friendly cities.

The United Nations Sustainable Development Goal 11, established in 2015, seeks to "make cities and human settlements inclusive, safe, resilient, and sustainable." Seven outcome targets were established: safe and affordable housing, affordable and sustainable transport systems, inclusive and sustainable urbanization, protection of the world's cultural and natural heritage, reduction of the adverse effects of natural disasters, reduction of the environmental impacts of cities, and to provide access to safe and inclusive green and public spaces. Various indexes, ratings, and ranking systems have identified the most sustainable cities with varying results, though European cities dominate. Among the cities that have appeared at or near the top of these lists are: Copenhagen, Stockholm, Helsinki, Oslo, Berlin, Zurich, Frankfurt, London, Madrid, Vienna, Amsterdam, Singapore, Vancouver, Canberra, and Brisbane (Akande et al. 2019; Shmelev 2019; Sáez et al. 2020).

BARRY D. SOLOMON

Further reading

Rees & Roseland 1991.

See also: Sustainability, Sustainable development,

Sustainable Development Goals (SDGs), Urban planning, Smart city, Sustainable transportation, Resilience, Sustainability metrics.

References

Akande, A., Cabral, P., Gomes, P. & Casteleyn, S. 2019. The Lisbon ranking for smart sustainable cities in Europe. Sustainable Cities and Society 44: 475–87.

Rees, W.E. & Roseland, M. 1991. Sustainable communities: planning for the 21st century. Plan Canada 31(3): 15–25.

Sáez, L., Heras-Saizarbitoria, I. & Rodríguez-Núñez, E. 2020. Sustainable city rankings, benchmarking and indexes: looking into the black box. Sustainable Cities and Society 53: 101938.

Shmelev, S.E., ed. 2019. Sustainable Cities Reimagined: Multidimensional Assessment and Smart Solutions. London: Routledge.

Sustainable consumption

The use of goods and services in ways that minimize environmental impacts and ensure that needs can be met for present and future generations (Seyfang 2009; Middlemiss 2018). Sustainable consumption is a market-based tool for meeting environmental goals, which treats the individual consumer as the driving force of market transformation. Consumers are exhorted to "do their bit" as ecological citizens by incorporating both social and environmental concerns when making purchasing decisions.

The term entered the international policy arena in United Nations (UN) Agenda 21 (1992) and is now included in the UN Sustainable Development Goals (SDG 12). Academics distinguish between weak and strong forms of sustainable consumption; the former involves making incremental shifts in consumption patterns that largely maintain the status quo, and the latter entails absolute reductions in consumption levels through lifestyle changes such as downsizing and abstemiousness (Schroeder & Anantharaman 2017, p. 4).

Sherilyn MacGregor

Further reading

Hayward & Roy 2019.

See also: Sustainable Development Goals (SDGs), Strong sustainability, Weak sustainability, Ecological citizenship, Pro-environmental behavior (PEB), Environmental ethics.

References

Hayward, B. & Roy, J. 2019. Sustainable living: bridging the North–South divide in lifestyles and consumption debates. Annual Review of Environment and Resources 44(1): 157–75.

Middlemiss, L. 2018. Sustainable Consumption: Key Issues. London: Earthscan/Routledge.

Seyfang, G. 2009. The New Economics of Sustainable Consumption. Basingstoke: Palgrave Macmillan.

Schroeder, P. & Anantharaman, M. 2017. "Lifestyle leapfrogging" in emerging economies: enabling systemic shifts to sustainable consumption. Journal of Consumer Policy 40(1): 3–23.

Sustainable design

A design that applies environmental principles to create portable devices and services from recycled, recyclable, and renewable materials to conserve natural resources, safeguard the environment, and ensure energy efficiency. By minimizing the negative impacts that human activities have on the planet, human–computer interaction (HCI) experts and researchers can create good technological design to meet the needs of businesses and individuals without compromising the needs of the next generation.

Tomayess Issa

Further reading

Jaffe et al. 2020; Issa & Isaias 2022; Soden et al. 2021.

See also: Sustainability, Eco-design, Sustainable business, Business innovation.

References

Issa, T. & Isaias, P. 2022. Sustainable Design: HCI, Usability and Environmental Concerns. London: Springer-Verlag.

Jaffe, S.B., Fleming, R., Karlen, M. & Roberts, S.H. 2020. Sustainable Design Basics. New York: John Wiley & Sons.

Soden, R., Pathak, P. & Doggett, O. 2021. "What we speculate about when we speculate about

sustainable HCI," pp. 188–98 in ACM SIGCAS Conference on Computing and Sustainable Societies (COMPASS '21), June 28–July 2, 2021, Virtual Event, Australia. New York: Association for Computing Machinery.

Sustainable development

Sometimes called ecologically sustainable development, sustainable development is conflated with "sustainability" by some authors, although a more precise approach is to regard sustainability as the goal or destination of "sustainable development." The best-known definition is "development that meets the needs of the present, without compromising the ability of future generations to meet their own needs" (WCED 1987). However, this raises more questions than it answers: Does development necessarily entail economic growth? What are genuine needs as opposed to wants? Would an ecocentric concept be preferable to an anthropocentric one?

Nowadays there are hundreds of different definitions. Some approaches attempt to focus the concept by setting out principles and goals, such as intergenerational and intragenerational (social) equity or justice, the conservation of biodiversity and ecosystem integrity, the precautionary principle, community participation in decision-making, and improvement of individual and community well-being. Lack of precision in the definitions and the use of the concept by vested interests to justify continuing environmentally damaging activities have led to critiques of the concept (e.g., Beder 1993).

Others see sustainable development as a contestable concept that, by its nature, cannot be defined in a precise manner, like justice and freedom. The meaning of such concepts emerges from continuing discussion and debate. Many authors consider that sustainable development, like sustainability, has three aspects or components: ecological or environmental, social, and economic. Definitions that emphasize economic development and allow trade-offs between natural and human capital are described by some as "weak" sustainable development, for example if a forest is sacrificed to build a mine. Definitions that give priority to environmental protection are described as "strong," for example, types of economic and social development that protect and restore the natural environment and social justice.

Mark O. Diesendorf

Further reading

Diesendorf 2020.

See also: Sustainability, Strong sustainability, Weak sustainability, Intragenerational equity, Precautionary principle, Biodiversity conservation, Well-being economy.

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Sustainable Development Goals (SDGs)

Seventeen interlinked goals for 2030 established by the United Nations in 2015 (UN 2015), which succeeded the Millennium Development Goals (MDGs). SDG 1: End poverty in all its forms everywhere. SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture. SDG 3: Ensure healthy lives and promote well-being for all at all ages. SDG 4: Ensure inclusive and equitable education and promote lifelong learning opportunities for all. SDG 5: Achieve gender equality and empower all women and girls. SDG 6: Ensure availability and sustainable management of water and sanitation for all. SDG 7: Ensure access to affordable, reliable, sustainable, and modern energy for all. SDG 8: Promote sustained, inclusive, and sustainable economic growth, full and productive employment and decent work for all. SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation. SDG 10: Reduce income inequality within and among countries. SDG 11: Make

cities and human settlements inclusive, safe, resilient, and sustainable. SDG 12: Ensure sustainable consumption and production patterns. SDG 13: Take urgent action to combat climate change and its impacts by regulating emissions and promoting development in renewable energy. SDG 14: Conserve and sustainably use the oceans, seas, and marine resources for sustainable development. SDG 15: Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation, and halt biodiversity loss. SDG 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable, and inclusive institutions at all levels. SDG 17: Strengthen the means of implementation and revitalize the global partnerships for sustainable development.

BARRY D. SOLOMON

See also: Sustainable development, Environmental indicators, Millennium Development Goals (MDGs).

Reference

United Nations (UN). 2015. Resolution adopted by the General Assembly on 25 September 2015, Transforming our world: the 2030 Agenda for Sustainable Development, A/RES/70/1. New York: United Nations.

Sustainable development indicators

See: Environmental indicators.

See also: Indicators, Sustainable development, Sustainable Development Goals (SDGs).

Sustainable energy

Energy for sustainable development and for a sustainable society. Has very low adverse environmental and human health impacts, is affordable, reliable, accessible, and compatible with a socially just society. Many authors consider that it can be provided by a combination of renewable energy supply with the reduction of unnecessary or wasteful energy demand. The latter can be achieved by improved efficiency of generation, conversion, and use of energy to provide existing energy services, together with behavior change to reduce the demand for energy services. Some authors believe that nuclear energy should also be considered a sustainable energy source, though this view is frequently contested.

MARK O. DIESENDORF

Further reading

Chu & Majumdar 2012; Popkova & Sergi 2021; Tester et al. 2012.

See also: Sustainable development, Renewable energy, Energy efficiency, Energy access, Energy services.

References

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Popkova, E.G. & Sergi, B.S. 2021. Energy efficiency in leading emerging and developed countries. Energy 221(9): 119730.

Tester, J.W., Drake, E.M., Driscoll, M.J. et al. 2012. Sustainable Energy: Choosing Among Options, 2nd edn. Cambridge, MA: MIT Press.

Sustainable energy assessment models

Mathematical and computational models used to determine the growth in the use of sustainable energy sources through analysis of policy scenarios. Most such models assess the potential for increased use of renewable energy sources, and in some cases also nuclear energy, at the national level. Sustainable energy assessment models are also used for regional and global assessments, such as for scenarios supporting studies of the Intergovernmental Panel on Climate Change (IPCC). The greatest use of such models is to analyze scenarios for the reduction of greenhouse gas emissions, a principal advantage of renewable and nuclear energy sources.

Sustainable energy assessment modeling began in the 1980s and 1990s and has increased in popularity in the last decade or so. Several categories of these models can be identified. Popular bottom-up optimization models such as MARKAL and MESSAGE focus on technological change in energy supply and the use of dynamic linear programming to find least-cost solutions (Morris et al. 1991; Gielen & Changhong 2001; Messner et al. 1996). Other computation modeling approaches include agent-based modeling, network-based modeling (Yoro et al. 2021), biophysical modeling (Dale et al. 2012; King 2020), integrated assessment energy-climate models (Loulou & Labriet 2008; Shukla & Chaturvedi 2013), and bottom-up energy system models linked to top-down macroeconomic models (Messner & Schrattenholzer 2000; Chai & Zhang 2010).

BARRY D. SOLOMON

See also: Sustainable energy, Renewable energy, Models and modeling, Impact assessment models, Integrated assessment model, Greenhouse gases, Intergovernmental Panel on Climate Change (IPCC).

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Shukla, P.R. & Chaturvedi, V. 2013. Sustainable energy transformations in India under climate policy. Sustainable Development 21(1): 48–59.

Yoro, K.O., Daramola, M.O., Sekoai, P.T. et al. 2021. Update on current approaches, challenges, and prospects of modeling and simulation in renewable and sustainable energy systems. Renewable and Sustainable Energy Reviews 150: 111506.

Sustainable food system

Refers to three fundamental dimensions linking food production, processing, and consumption in a long-term perspective: the biophysical (biodiversity, living processes, resource use, soil health, ecological sustainability, nutrition, and so on); the economic (for example, power and control exerted along the food chain, criteria of distribution of added value); and the socio-cultural (for example, community values, local traditions). Therefore, a "sustainable food system is one that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised" (FAO 2018, p. 1).

A sustainable food system is rooted in sustainable agriculture. It is based on short-distribution supply chains to generate a fair distribution of the added values (addressing food sovereignty across scales). It promotes behaviors such as reducing animal consumption and food waste, while minimizing food losses. A sustainable food system builds relationships and defines rules according to sustainability principles, addressing all the aspects of food production, processing, and consumption (complex and interwoven), and their actors (farmers, suppliers, brokers, processors, distributors, consumers, researchers, third-party certifiers, policymakers).

Four key ethics principles guide the sustainability of food systems: health (biophysical sustainability), ecology (sustainable agroecological management), fairness (fair relationships), and care (precautionary and responsible management) (IFOAM 2021). Sustainable food systems, while addressing

agroecological sustainability, food security, fairness, and consumer choice, should also spur social awareness about human ecology, foster social participation and gender equality, and preserve cultural identity, in how food is both produced and consumed (alimentary regimes).

Gaël Plumecocq & Tiziano Gomiero

Further reading

Gaitán-Cremaschi et al. 2019; Howard 2021; Poore & Nemecek 2018; Springmann et al. 2018.

See also: Sustainability, Sustainable agriculture, Food system, Food security, Food self-sufficiency, Agroecology, Sustainable livelihoods, Power, Social metabolism.

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Sustainable livelihoods

a. Means of living that can be consistent and resilient in the long term, ensuring the satisfaction of households and individual material and non-material needs. Examples can be found in traditional lifestyles, based on farming, husbandry, fishing, and housing with a close and direct management of local natural resources. According to Chambers and Conway (1991), sustainable livelihoods potentially assist in two main aims: (1) environmental: enhancing the local and global assets on which livelihoods depend, favoring the provision of other livelihoods; and (2) social: coping and recovering from stress and shocks, and guaranteeing maintenance for future generations. This definition transcends a biased connotation of livelihood as merely to have a job and access to monetary rents. The first institutional appearance of this notion was at the 1992 Earth Summit held in Rio de Janeiro (Morse & McNamara 2013).

b. An operational tool and strategical approach, promoted by intergovernmental organizations, non-governmental organizations, and research institutes, designed to contribute to poverty reduction in third world communities (Brocklesby & Fisher 2003). A sustainable livelihood approach can challenge the hegemonic understanding of development (Sneddon 2000), assessing new initiatives, and reassessing existing activities in order to fit with daily experiences of local communities (Ashley & Carney 1999).

Francisco J. Toro

See also: Sustainable development, Post-development, Matrix of human needs, Human needs assessment, Resilience, Economic resilience.

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and Practice. Heidelberg, Germany; New York, USA; London, UK: Springer.
Sneddon, C.S. 2000. "Sustainability" in ecological economics, ecology and livelihoods: a review. Progress in Human Geography 24(4): 521–49.

Sustainable manufacturing

The creation of manufactured products through economically efficient processes that are non-polluting or minimize negative environmental impacts, conserve energy and natural resources, and are safe and healthy for employees, communities, and consumers (OECD 2009; EPA 2021).

BARRY D. SOLOMON

Further reading

Garetti & Taisch 2012; Rosen & Kishawy 2012; Joung et al. 2013; Stock & Seliger 2016.

See also: Sustainable design, Eco-design, Eco-innovation, Eco-efficiency, Industrial ecology, Sustainable business, Circular economy, Sustainable recycling, Sustainable consumption.

References

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Stock, T. & Seliger, G. 2016. Opportunities of sustainable manufacturing in Industry 4.0. Procedia CIPR 40: 536–41.

Sustainable mobility

See: Sustainable transportation.

See also: Land use planning, Urban planning.

Sustainable production

See: Sustainable manufacturing.

See also: Sustainable design, Eco-design, Eco-innovation, Eco-efficiency, Industrial ecology, Sustainable business, Circular economy, Sustainable consumption.

Sustainable recycling

Reuse of material resources that improves the overall sustainability as compared to a situation where recycling would not occur. While increased recycling is often associated with the improved sustainability, recycling does not automatically lead to environmental, social, or economic improvements, and there are also thermodynamical limits to increased recycling (Reuter 2011). Sustainability of recycling needs to be assessed as a combination of environmental, social, and economic impacts originating in recycling activity, and these impacts should be evaluated from the perspective of overall resource management. Due to natural, socio-cultural, and political factors, opportunities and limitations for recycling vary between the geographical contexts, which must be considered in sustainability assessments (Levänen et al. 2018).

JARKKO LEVÄNEN

Further reading

Levänen 2015.

See also: Recycling, Waste management, Sustainable waste disposal, Resource management, Circular economy.

References

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of industrial recycling in Finland. Journal of Cleaner Production 87: 542–9.
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Reuter, M.A. 2011. Limits of design for recycling and "sustainability": a review. Waste and Biomass Valorization 2: 183–208.

Sustainable scale

The highest level of material throughput that remains sustainable, based on biophysical limits. The sustainable scale is found at the level of economic throughput that is identical to the regeneration rate of ecosystems affected by the throughput in question. Any further increase in throughput beyond this scale is unsustainable. Ensuring a sustainable scale requires observing three rules (Santa-Barbara et al. 2005): (1) we harvest renewable resources below the natural regeneration rates of all critical ecosystem services associated with the specific throughput activities; (2) we maintain our rate of throughput so that their emissions or wastes do not exceed the rates that can be absorbed or broken down by natural processes in a meaningful time span; (3) any use of non-renewable resources should be coupled with investment in replacing the non-renewable resource with renewable alternatives, or coupling the non-renewable usage with a renewable offset.

Barry D. Solomon

See also: Optimal scale of the macroeconomy, Sustainable yield, Maximum sustainable yield.

Reference

Santa-Barbara, J., Czech, B., Daly, H.E. et al. 2005. "Sustainable scale in environmental education: three rules, two perspectives, one overriding policy objective, and six cultural shifts," in Proceedings of the Centre for Environment Education 2005 Conference, Ahemedabad, Gujurat, India.

Sustainable Society Index (SSI)

A multidimensional sustainability metric used to measure and monitor economic, social, and environmental performance in a variety of countries. It has been implemented since 2006 by the Sustainable Society Foundation (the Netherlands) and is published bi-annually (SSI 2021). The index groups variables into three well-being dimensions and is calculated for over 150 countries. The human well-being dimension groups variables in the categories "basic needs," "personal development and health," and "well-balanced society," such as education and income distribution. The environmental well-being dimension groups variables in the categories "natural resources" and "climate and energy," such as energy use and consumption. The economic well-being dimensions groups variables in the categories "transition" and "economy," such as gross domestic product and organic farming. The index weighs 21 different indicators (variables) to reflect their relative importance in the SSI to reach an overall score that ranges from 0 to 10.

Joao Paulo Braga

Further reading

Witulski & Dias 2021.

See also: Indicators, Environmental indicators, Economic indicators, Sustainability, Sustainability transition, Objective well-being, Well-being economy, Human Development Index (HDI), Matrix of human needs, universal basic services (UBS).

References

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Witulski, N. & Dias, J.G. 2021. The Sustainable Society Index: its reliability and validity. Ecological Indicators 114: 106190.

Sustainable tourism

a. Tourism which is in a form that can maintain its viability in an area for an indefinite period.
b. Tourism which is developed and maintained in an area (for example, a community, an environment) in such a manner and at such a scale that it remains viable over an indefinite period, and does not degrade or alter the environment (both human and physical) in which it exists to such a degree that it prohibits the successful development and well-being of other activities and processes.

RICHARD W. BUTLER

Further reading

Butler 1993, 2017, 2018.

See also: Economic resilience, Ecosystem resilience, Sustainable development.

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Sustainable transportation

Refers to forms of mobility that are not environmentally, economically, or socially detrimental. It stresses pollution reduction, full cost analysis, and pricing, addressing equity through removing mobility barriers for physically, socially, and economically disadvantaged or underserved populations, as well as promoting healthy mobility activities such as walking and cycling (Banister 2008; Schiller & Kenworthy 2018). It stresses lower-energy or "soft path" approaches including non-motorized forms, as well as substituting transit and intercity passenger rail for trips that might otherwise be taken by automobile or commercial aviation. Sometimes also called "sustainable mobility."

Many researchers and analysts in this field prefer to characterize, rather than narrowly define, this field in terms of its many dimensions and facets. Several also point to the inseparability of mobility and land use planning and configurations. It is often fruitful to compare such characterizations with the dominant business as usual (BAU) mobility and urban planning practices and paradigms. Especially useful are comparisons between various cities and urban regions, undertaken at regional, national, or even global levels. Such analyses compare the amounts of travel undertaken by different transport modes related to differing land use and transportation policies, planning, and configurations.

PRESTON L. SCHILLER

Further reading

Lovins 1977; OECD 1996.

See also: Land use planning, Urban planning.

References

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Sustainable waste disposal

Wastes that are appropriately reused, recycled, collected, transported, intermediately treated, and finally disposed of based on a life-cycle perspective to avoid any potential damage to future generations and the environment. All the processes should be designed in line with the best available technology (BAT) and optimized to minimize the potential environmental/ecological/social impacts under the constraint of available financial resources. Meanwhile, societal and ecological justice should be considered. In addition, the property of waste should reflect the contemporary lifestyle and technological level of a society. Therefore, sustainable waste disposal (SWD) would be a type of complex system engineering. SWD might be of low risk in urban and rural areas, while highly risky in war-torn regions.

YU-CHI WENG

Further reading

Cossu 2009a, 2009b; Takatsuki 2013.

See also: Waste management, Waste absorption capacity, Benefit–cost analysis (BCA), Life-cycle assessment (LCA).

References

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Cossu, R. 2009b. From triangles to cycles. Waste Management 29(12): 2915–17.
Takatsuki, H. 2013. Waste problems and our lifestyle. Waste Management 33(11): 2145–6.

Sustainable yield

Output from a renewable resource that, under current levels of extraction, would be expected to be produced and available indefinitely. For an aquifer it would be the level of water that can be extracted per unit of time that does not exceed the recharge rate into the aquifer. For a forest, it would be the amount of timber that could be harvested on an ongoing basis, forever.

R. QUENTIN GRAFTON

Further reading

Maimone 2004; Kalf & Woolley 2005; Karp & Shield 2008.

See also: Sustainable yield, Maximum sustainable yield, Groundwater governance, Forest conservation.

References

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Maimone, M. 2004. Defining and managing sustainable yield. Groundwater 42(6): 809–14.

Sustenance

a. Any means of support, maintenance, and subsistence for life and health.
b. Basic quantity of food and drink that is required to provide nourishment for humans, other animals, or plants to remain alive and healthy.
c. The financial means of livelihood.

BARRY D. SOLOMON

Further reading

d'Arge 1994; Hukkinen 1995.

See also: Subsistence, Food security, Material services, Universal basic services (UBS).

References

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Hukkinen, J. 1995. Corporatism as an impediment to ecological sustenance: the case of Finnish waste management. Ecological Economics 15(1): 59–75.

System dynamics models

Continuous simulation models based on hypothesized relations across activities and processes used to understand the behavior of complex dynamic systems. In the 1950s, MIT's Jay Forrester developed the system dynamics simulation modeling language while trying to understand the complexity of industrial economic systems. Forrester's basic system dynamics language is based on general systems thinking. It models the positive and negative feedback loop structures of a system by using nodes made up of stocks, constants, and variables connected through arrows to show the relationships between the nodes, table functions (a type of constant), and time delays.

In 1972, Forrester's students Donella Meadows, Dennis Meadows, Jørgen Randers & William Behrens III used the first computers to simulate the system dynamics of the world's "limits to growth" models as part of a report to the Club of Rome to show how exponential economic and population growth were incompatible with an ever-decreasing supply of resources and an ever-increasing pollution (Meadows et al. 1972; see also Meadows et al. 2004). The "limits to growth" models were foundational to the development of ecological and biophysical economics because they showed that the economic growth paradigm that arose from the 1950s could not be sustained in the long term, and it needed to be transformed to something that the biosphere could sustain (Ekins 1993; Bardi 2011; Hall & Klitgaard 2018). Meadows (2008) presented a straightforward guide of how systems dynamics language and models can be used to address and solve real problems involving complex system dynamics. Recently, system dynamic modeling continues to be applied to understand the complex dynamics of biophysical limits to economic growth such as the energy and material requirements for a global energy transition away from fossil fuels, to address depletion and climate concerns (e.g., Capellán-Pérez et al. 2019).

RIGO E.M. MELGAR

See also: Dynamic systems, Dynamic models, Coupled system dynamics, Limits to growth.

References

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Meadows, D.H., Randers, J. & Meadows, D.L. 2004. The Limits to Growth: The 30-Year Update. London: Routledge.

System of Environmental–Economic Accounting (SEEA)

See: System of National Accounts (SNA).

See also: Environmental accounting, Economic ecosystem accounting.

System of Environmental–Economic Accounting—Ecosystem Accounting (SEEA-EA)

See: Economic ecosystem accounting.

See also: System of National Accounts (SNA), Natural resource accounting.

System of National Accounts (SNA)

Economics:

a. Total income accounts of society generated by economic activities in the national/subnational territory in the accounting period (McElroy 1976; Stone 1984), considered by ecological economists and others to be incomplete and inconsistent. Omits the economic activities that do not supply any final product consumption or that do not contain manufactured costs from ecosystem accounting. The purchased manufactured costs generated by the activities omitted are directly allocated to the activities that benefit from them in the ecosystem economic accounts. The commercial final product consumptions are valued at market prices. Non-commercial final products consumed and accumulated (own account manufactured gross capital formation) are valued at their cost, except for animal gross capital formations that are valued at imputed market prices.
   The SNA attributes the final products of market and non-market economic activities generated to the institutional sectors of corporations and general government (European Commission et al. 2009, Table 2.13; Campos et al. 2021, Table 3). The aim is to measure a narrow total national income as the net value added (NVA), labeled also as net domestic product, comprised of employee compensation, net operating surplus, and net mixed income. The standard NVA inconsistency with total income is due to the omission of economic activities such as natural growth, environmental consumption of fixed assets, the inclusion of depletion and the omission of capital gain, except for manufactured consumption of fixed capital valued at replacement price, and the omission of the government net operating surplus (NRC 1999).
b. The United Nations has attempted to improve upon the SNA by developing a System of Environmental–Economic Accounting (SEEA), which is "a framework that integrates economic and environmental data to provide a more comprehensive and multipurpose view of the interrelationships between the economy and the environment and the stocks and changes in stocks of environmental assets, as they bring benefits to humanity" (UN n.d. 2012).

Pablo Campos Palacín

See also: Economic ecosystem accounting, Environmental accounting, Agroforestry Accounting System (AAS).

References

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Systems analysis

See: Applied systems analysis.

See also: Coupled human and natural systems, Dynamic systems, Complex systems modeling, Systems-oriented simulation models.

System scale and hierarchy

The conceptualization of multiple types of systems operating at relatively distinct levels of detail for different scientific or managerial—or both—purposes. At a particular scale, one system comprises interacting subsystems from the lower level and is itself a component of a larger system from the higher level. For example, the number of species in an ecosystem is influenced by the spatial resolution of the species occurrence data. A hierarchical representation of species occurrence envisions limited species as smaller, nested sub-ecosystems within a larger system having more extensive biodiversity. Similarly, economic product markets and systems operate and interact at different scales, from the local to the global.

ZHENGYUAN GAO

Further reading

O'Neill et al. 1989; Norton 2011.

See also: Ecological indicators, Ecosystem structure and function, Ecosystem functional diversity, Multi-scale integrated analysis of societal and ecosystem metabolism (MuSIASEM), Hierarchy.

References

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O'Neill, R.V., Johnson, A.R. & King, A.W. 1989. A hierarchical framework for the analysis of scale. Landscape Ecology 3: 193–205.

Systems-oriented simulation models

Computational models that simulate the evolution of a complex system over time to explore or predict its behavior or system-level outcomes. They are often used to study the implications of an intervention or change to the system or to understand how structural features of the system determine its behavior. Models can be of different types:

1. Agent-based or individual-based models represent the system through autonomous agents, such as humans or organisms, that are situated in an environment. Rules of interactions between agents, and between agents and their environment (formulated as computer algorithms or difference equations) determine how the system evolves from a set of initial conditions. The model is simulated and emerging system-level outcomes, and the processes that generated them, are analyzed.
2. System dynamics models represent the system through aggregated stocks, such as a fish stock or the population of adopters, and the flows between them. The system evolves according to rules that specify how stock levels change (formulated as difference or differential equations). Initial conditions are specified, the model is simulated, and the resulting system-level outcomes such as changes in stock levels or equilibria of the system are analyzed.

MAJA SCHLÜTER

Further reading

Schlüter et al. 2021; Lade et al. 2021.

See also: Agent-based modeling (ABM), System dynamics models, Differential equation, Dynamic systems, Social-ecological systems, Stocks, Flows.

References

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Schlüter, M., Lindkvist, E., Wijermans, N. & Polhill, G. 2021. "Agent-based modelling," pp. 383–97 in The Routledge Handbook of Research Methods for Social-Ecological Systems. R. Biggs, A. de Vos, R. Preiser et al., eds. London: Routledge.

T

Tariff

Economics: a tax or duty levied on a good imported into a country. A unit, specific, or quantity tariff is a fixed charge per unit of the good that is imported, while an *ad valorem* tariff is levied as a percentage of the market value of the imported good. Governments impose tariffs to protect domestic industries, remedy trade distortions, and to increase revenues.

Public utilities: a schedule of electric, gas, solid waste, or water and wastewater rates and other customer charges used to determine the total sales price offered by a utility company to different customer classes, depending on consumption levels. A popular policy instrument in many countries to promote the production and use of renewable electricity is called a feed-in tariff, which provides a guaranteed, above-market price to producers by a long-term contract (Ponta et al. 2018). The goal is to provide long-term price certainty to renewable energy producers through cost-based purchase prices while guaranteeing access to the electric grid.

BARRY D. SOLOMON

Further reading

Batra et al. 1998; Margolis et al. 2005.

See also: Trade liberalization, Commodity trade, World Trade Organization (WTO), Renewable energy, Utility, Environmental policy instruments.

References

Batra, R., Beladi, H. & Frasca, R. 1998. Environmental pollution and world trade. Ecological Economics 27(2): 171–82.

Margolis, M., Shogren, J.F. & Fischer, C. 2005. How trade politics affect invasive species control. Ecological Economics 52(3): 305–13.

Ponta, L., Raberto, M., Teglio, A. & Cincotti, S. 2018. An agent-based stock-flow consistent model of the sustainable transition in the energy sector. Ecological Economics 145: 274–300.

Technocracy

The governance or control of society by technical experts. The term was first used by William H. Smythe, a California engineer, in 1919. Where methodology is concerned, some paradigms are closer to technocracy in their orientation, while other approaches attempt to contribute to a strengthened democracy. In neoclassical economics, benefit–cost analysis (BCA) exemplifies a technocracy-oriented method, while essential aspects of democracy are respected in positional analysis (Brown et al. 2017). BCA attributes a role to the analyst as technical expert. There is an idea of correct market prices (actual or hypothetical) to be used in aggregation of costs and benefits for each alternative considered. The analyst claims the ability to identify the best option from a societal perspective. Some politicians and other actors may share the values built into BCA, but others question the specific market-oriented ideas of progress.

Positional analysis is built on a different idea of economics as "multidimensional management of limited resources in a democratic society" (Söderbaum 2019, p. 22). Non-monetary impacts are considered separately from monetary impacts, and issues of inertia—for example, irreversibility—are seriously addressed. The role of the analyst is to illuminate an issue in a many-sided way for politicians and other actors who differ with respect to values and ideological orientation. The ranking of alternatives will then be a matter of ideological orientation. A many-sided analysis of alternatives of choice and impacts is carried out and the analyst interacts with stakeholders and other actors. In BCA the analyst determines not

only the correct method but also the correct ideology.

PETER SÖDERBAUM

See also: Democracy, Deliberative democracy, Benefit–cost analysis (BCA), Participatory modeling.

References

Brown, J., Söderbaum, P. & Dereniowska, M. 2017. Positional Analysis for Sustainable Development: Reconsidering Policy, Economics and Accounting. London: Routledge.

Söderbaum, P. 2019. Reconsidering economics in relation to sustainable development and democracy. Journal of Philosophical Economics 13(1): 19–38.

Technological change

The gradual process of research, development, and improvement in technology, which leads to increased economic efficiency, labor productivity, and economic growth. However, its impacts can be negative as well as positive. Joseph Schumpeter divided technological change in a free market into the three separate processes of invention, innovation, and diffusion (Schumpeter 1942). It varies from the minor to the revolutionary, and results from competition in market economies. Technological change can also be categorized as either new functions, or the same process or a new process for an existing function (Røpke 2001).

While technological change has been a topic of concern in economics since Adam Smith and is traditionally assumed in most time series models of the economy, ironically it is typically not addressed or explained in economic models, since it is generally considered to be exogenous or automatic. In contrast, engineering analyses, and bottom-up energy assessments, and some climate change mitigation models, explicitly examine technological change. The latter approaches are more recent and model technological change endogenously, and are sometimes called technological change modeling (Romer 1990; Bouwman et al. 2006; Keary 2016). Even so, while technological change is readily applied to environmental problems such as pollution, resource depletion, and overpopulation, since these are human enterprises they have social and institutional limitations (Bella 1979).

BARRY D. SOLOMON

See also: Technology, Technological progress, Technological optimism vs. technological pessimism, Technological lock-in.

References

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Keary, M. 2016. The new Prometheans: technological optimism in climate change mitigation modelling. Environmental Values 25(1): 7–28.

Romer, P.M. 1990. Endogenous technological change. Journal of Political Economy 98: 71–78.

Røpke, I. 2001. New technology in everyday life—social processes and environmental impact. Ecological Economics 38(3): 403–22.

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Technological lock-in

Innovation studies consider technological lock-ins as emergent properties of a set of interacting systemic features resulting from past historical incidents (Arthur 1989), and which are mostly an *ex post* and exogenous explanation of lock-ins. Ecological economics analysis of lock-ins departs from this analysis, advancing an *ex ante* explanation (Befort 2021). On the one hand, actors choose between possible techno-economic combinations depending on the trajectories they belong to. This influences the knowledge they can use, and the type of demand that actors can address with their products. On the other hand, actors produce narratives promising to unlock their lock-ins to satisfy an expected functionality in their attempt to impose framings. This creates systemic barriers to alternatives, locking innovation in a paradigm. Hence, the development of promises is about developing credibility and legitimacy in order to unlock lock-ins that are both social and technological, that is, partici-

pating in an ecological transition, along with localized technological progress.

NICOLAS BEFORT

Further reading

Antonelli 2008; Unruh 2002.

See also: Business innovation, Green innovations, Eco-innovation, Technological change, Carbon lock-in, Exogenous.

References

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Arthur, B.W. 1989. Competing technologies, increasing returns, and lock-in by historical events. Economic Journal 99: 116–31.
Befort, N. 2021. The promises of drop-in vs. functional innovations: the case of bioplastics. Ecological Economics 181: 106886.
Unruh, G.C. 2002. Escaping carbon lock-in. Energy Policy 30: 317–25.

Technological optimism vs. technological pessimism

Opposing beliefs, ethos, or dogmas among economists on the role of technology development in solving environmental and other societal problems. Most neoclassical economists tend to be technological optimists (e.g., Nordhaus et al. 1973; Solow 1974); while most ecological economists tend to be technological pessimists, which is sometimes also called prudent pessimism (Costanza 1989; Daly 1996; Huesemann 2001; Hornborg 2014). Extreme technological pessimists are often considered neo-Malthusians.

These opposing views on technology were epitomized by the famous 1980 bet between Julian Simon and Paul Ehrlich on whether the real price of a basket of five mineral resources would rise or fall in price over the next decade, based on the competing forces of scarcity and technological progress. While Simon won the bet, in hindsight if the data were examined over a century or more, Ehrlich would have won (Kiel et al. 2010).

BARRY D. SOLOMON

Further reading

Bella 1979; Krier & Gillette 1985.

See also: Technological progress, Technological change, Neo-Malthusian, Limits to growth.

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Solow, R.M. 1974. The economics of resources or the resources of economics. American Economic Review 64(2): 1–14.

Technological progress

A change in technology that improves social well-being. Includes invention, adoption, or improvement of technology. New technologies come from the scientific community, private firms, and practical experimentation. There are five main types of technological progress: (1) productivity: an increased output per unit of work time, leading to economic wealth and more leisure time; (2) efficiency: greater output per unit of input, leading to a reduction of demand for inputs; (3) quality: includes durability, ease of use, aesthetics, and similar elements that increase product value; (4) knowledge: technologies that create new knowledge through open

share; and (5) risk: the potential for future losses (technologies can reduce risk—such as energy storage—and can also introduce new risks, for example climate change).

Modern technologies ideally should not worsen environmental problems. The environmental consequences of human activity are frequently affected by technological change, and environmental policy interventions can create constraints and incentives that have significant effects on the path of technological progress (Jaffe et al. 2002). Providing incentives to develop environmentally friendly technologies is one focus of environmental policy. The basic method to measure technological progress is total factor productivity (the ratio of output to input). Implementation of a new technology may create both winners and losers. The exponential growth of new technologies has been observed over the last half-century.

OLGA KIUILA

Further reading

Solow 1957; Hall & Rosenberg, 2010; Spacey 2017.

See also: Technology, Technological change, Technological optimism vs. technological pessimism, Pollution abatement.

References

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Jaffe, A.B., Newell, R.G. & Stavins, R.N. 2002. Environmental policy and technological change. Environmental and Resource Economics 22: 41–70.

Solow, R.M. 1957. Technical change and the aggregate production function. Review of Economics and Statistics 39(3): 312–20.

Spacey J. 2017. 7 types of technological progress. Simplicable. https://simplicable.com/new/technological-progress.

Technology

a. Application of scientific knowledge and developments for practical purposes, especially in industry, but in all spheres of human activity.

b. Methods, techniques, systems, skills, processes, equipment, and machinery developed from the application of scientific knowledge.

BARRY D. SOLOMON

Further reading

Smalls & Jollands 2006; Rennings 2000; Greenwood & Holt 2008.

See also: Industrial economics, Technological progress, Technological change, Technological lock-in, Technological optimism vs. technological pessimism, Technocracy.

References

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Rennings, K. 2000. Redefining innovation—eco-innovation research and the contribution from ecological economics. Ecological Economics 32(2): 319–32.

Smalls, B. & Jollands, N. 2006. Technology and ecological economics: Promethean technology, Pandorian potential. Ecological Economics 56(3): 343–58.

Teleology

General:

a. From the Greek words *telos*, "end" and *logos*, "reason"; literally, the study of goals.

b. A mode of explanation in which something is explained by the end to which it contributes (purpose, end, goal, or function).

Philosophy of biology/science: in ancient philosophy, in particular Aristotle, teleology was a matter of ontology: reality can be understood and explained by the final cause (for example, everything strives to perfection). Everything, including change, can be explained as being goal-oriented (contrary to, for example, arbitrary or efficient). Such teleological notions still play a role in biological sciences, where they potentially conflict with

evolutionary theory, which refers to efficient causes rather than to final causes or goals.

Political/ethical theory: in ethics, political theory, and economics, teleology refers primarily to teleological ethics, also known as consequentialist ethics. Consequentialism is the view that normative properties depend only on the value of the consequences (for example, pleasure, happiness, utility); in contrast to deontological ethics (from the Greek *deon*, "duty"), where normative properties of an action are independent of the consequences (for example, lying is bad, independently of its effects). The most well-known variant of consequentialism is utilitarianism, defined (from Kymlicka 2002, p. 10) as the idea "that the morally right act or policy is that which produces the greatest happiness for the members of society," or simply the idea that utility should be maximized. Utilitarianism is seen by many as the normative assumption of welfare economics.

STIJN NEUTELEERS

Further reading

Smart & Williams 1973; Walsh 2008; Allen & Neal 2020.

See also: Utilitarianism, Utility, Consequentialism, Deontological, Welfare economics.

References

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Walsh, D.M. 2008. "Teleology," pp. 113–37 in Oxford Handbook of the Philosophy of Biology. M. Ruse, ed. Oxford: Oxford University Press.

Temporal dynamics

Ecology: refers to any patterns or processes of change, growth, or activity that all ecosystems undergo. Until the last quarter of the 20th century, ecosystems were understood to be in a steady state of dynamic equilibrium or homeostasis (Rohde 2006). In such a balance of nature, all the interactions between their component species balanced each other, so that their populations were roughly stable around their average values, while only one among many competitive species could prevail (Kricher 2009).

More recently, ecosystems came to be increasingly seen as periodically subject to threshold and transient dynamics, as well as exogenous and endogenous disturbances, characterized as driver–response relationships that moved them away from their initial state (Ryo et al. 2019). The capacity of an ecosystem to absorb disturbances and remain close to its steady state is called ecological resilience; the ease or difficulty with which it can deviate from equilibrium is its resistance.

ORIOL VALLÈS CODINA

Further reading

Rau et al. 2018.

See also: Dynamic systems, System dynamics models, Equilibrium, Disturbance, Ecological perturbation, Resilience, Ecosystem resilience, System scale and hierarchy, Complexity theory, DPSIR (Drivers-Pressures-State-Impact-Response) framework.

References

Kricher, J. 2009. The Balance of Nature: Ecology's Enduring Myth. Princeton, NJ: Princeton University Press.

Rau, A.L., von Wehrden, H. & Abson, D.J. 2018. Temporal dynamics of ecosystem services. Ecological Economics 151: 122–30.

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Ryo, M., Aguilar-Trigueros, C.A., Pinek, L. et al. 2019. Basic principles of temporal dynamics. Trends in Ecology and Evolution 34(8): 723–33.

Territorial ecology

An emerging French research field that gathers urbanists, economists, historians, and environmental scientists who want to question territorial metabolism as much as their spatial-temporal determinants. Territorial ecology is "considered in a spatial context and that takes into account the stakeholders

and, more generally, the agents involved in material flows, questions their management methods and considers the economic and social consequences of these flows" (Barles 2010, p. 443). It thus aims, from a historical perspective, to characterize local socio-ecological regimes, the expression of which is territorial metabolism here conceived as the product of the intertwining of natural (or physical) processes, including natural cycles such as those of water, carbon, nitrogen, and so on, and of techniques stemming from human societies.

Jean-Baptiste Bahers

Further reading

Barles 2015.

See also: Urban metabolism, Social ecology, Stakeholder, Stakeholder analysis, Material flow analysis.

References

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Barles, S. 2015. The main characteristics of urban socio-ecological trajectories: Paris (France) from the 18th to the 20th century. Ecological Economics 118: 177–85.

Theory of the second best

Sometimes called the general theory of second best, second-best theorem, or the second-best solution, the optimal, that is, welfare-maximizing and hence economically efficient allocation of resources (production inputs) under constraints that hinder the achievement of the (socially optimal) first-best solution that would be achieved without any constraints.

Mathematically, when at least one of the first-best optimality conditions cannot be fulfilled, the second-best solution can be "achieved only by departing from all other optimum conditions" (Lipsey & Lancaster 1956, p. 12). Politically, in the presence of market failures, such as environmental externalities, a second-best solution results from the optimal adjustment of the available policy instruments when "jurisdictional limitations, political constraints, incomplete information or prohibitive transaction and compliance costs" (Fischer et al. 2021, p. 12; see also Rodrik 2008) prevent policymakers from achieving the first-best solution by restricting the set of available policy instruments.

Michael Hübler

See also: Efficiency-based arguments, Market failure.

References

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Lipsey, R.G. & Lancaster, K. 1956. The general theory of second best. Review of Economic Studies 4(1): 11–32.

Rodrik, D. 2008. Second-best institutions. American Economic Review 98(2): 100–104.

Third party

Economics: a person or organization besides the two principal parties to an economic transaction or business agreement who has a lesser interest in the transaction (Edwards-Jones et al. 2000, pp. 13–35). A third party can also be a mediator of a business dispute, or a broker in an emissions trading system.

Environmental economics: a third party can be a person or firm who suffers a negative environmental externality such as air pollution from a nearby paper mill, or a positive environmental externality such as free pollination services for an apple orchard due to the presence of nearby honeybee keeping.

Barry D. Solomon

See also: Transaction costs, Emissions trading, Externalities, Environmental externalities.

Reference

Edwards-Jones, G., Davies, B. & Hussain, S.S. 2000. Ecological Economics: An Introduction. London: Blackwell Science.

Threatened species value

Economics: the simulated transaction value of the passive use service (existence value) of the preservation of a wild biological species threatened with extinction (Campos et al. 2020). The economic service of existence value can only be revealed by species threatened with extinction. The demand for a "preservation service" is revealed/stated in people experiencing increased welfare by contributing to the prevention or mitigation of the extinction of any unique biological species by its mere existence. The demand for preservation of threatened biodiversity is commensurable as a transaction value by consumers' marginal willingness to pay.

Consumers may reveal/state an exchange value that is lower than the cost of preserving the threatened species with extinction. In this situation the policymaker's decision, representing the unborn future generations, can lawfully impose on current consumers a total income loss in the current period. The political decision is based on the precautionary principle, subject to a tolerable social cost. The demand for the service of a unique biological species variety does not depend on its characteristics, and therefore all species threatened with extinction have the same existence price revealed/declared by the consumer (Norton 1987). By means of service consumption valuation methods without market prices, the simulated transaction price of the preservation service of a biological species common to the total set of threatened species in a delimited natural area can be estimated.

PABLO CAMPOS PALACÍN

Further reading

Krutilla 1967; Richardson & Loomis 2009; Kant 1785 [1997]; Campos et al. 2019; Díaz et al., 2020.

See also: Non-use value, Existence value, Revealed preference methods, Stated preference methods, Transaction prices, Precautionary principle, Biodiversity, Wildlife conservation, Welfare.

References

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Norton, B.G. 1987. Why Preserve Natural Variety? Princeton, NJ: Princeton University Press.

Richardson, L. & Loomis, J. 2009. The total economic value of threatened, endangered and rare species: an updated meta-analysis. Ecological Economics 68(5): 1535–48.

Threshold

A variable level in a system, the crossing of which changes the system dynamics from one domain of interest to another. A threshold effect is a radical change in the system dynamics when the threshold is crossed. For example, the biomass of a species and the concentration of chemical substances can be used to measure the threshold of an ecosystem. The distance between the current and threshold level of a variable can be a measure of resilience. In ecological-economic systems, a threshold is not independent of economic systems; the interactions between ecological and economic systems dynamically and endogenously determine the threshold. For example, how the market responds to the scarcity of fish affects the threshold level of fish biomass. The term "ecological economic threshold" differentiates itself from an eco-

logical notion of a threshold or an ecological threshold (Uehara 2013).

TAKURO UEHARA

See also: Resilience, Ecosystem resilience, Integrated ecological–economic systems, Threshold hypothesis.

Reference

Uehara, T. 2013. Ecological threshold and ecological economic threshold: implications from an ecological economic model with adaptation. Ecological Economics 93: 374–84.

Threshold hypothesis

As formulated by Manfred Max-Neef (1995, p. 117), it stipulates that "economic growth brings about an improvement in the quality of life but only up to a point beyond which, if there is more economic growth, the quality of life may begin to deteriorate." Max-Neef drew on early empirical work on alternative measures of economic welfare (MEWs) in the 1990s which showed that the environmental and social costs of additional economic activities were outweighing the benefits in terms of increased levels of consumption. As a result, the threshold hypothesis is like Herman Daly's concept of uneconomic growth (Daly 1999).

The threshold hypothesis has been challenged based on methodological choices in the design of early MEWs, and recent MEW studies are undecided on the presence of a threshold point for economic welfare (Neumayer 2000; Lawn & Clarke 2010; Van der Slycken & Bleys 2020). Key influencing methodological factors include the decreasing marginal utility of consumption, and the increasing costs of long-term environmental degradation (Niccolucci et al. 2007).

BRENT BLEYS

Further reading

Armiento 2018.

See also: Measures of economic welfare, Uneconomic growth.

References

Armiento, M. 2018. The Sustainable Welfare Index: towards a threshold effect for Italy. Ecological Economics 152: 296–309.

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Lawn, P. & Clarke, M. 2010. The end of economic growth? A contracting threshold hypothesis. Ecological Economics 69(11): 2213–23.

Max-Neef, M. 1995. Economic growth and quality of life: a threshold hypothesis. Ecological Economics 15: 115–18.

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Niccolucci, V., Pulselli, F.M. & Tiezzi, E. 2007. Strengthening the threshold hypothesis: economic and biophysical limits to growth. Ecological Economics 60(4): 667–72.

Van der Slycken, J. & Bleys, B. 2020. A conceptual exploration and critical inquiry into the theoretical foundation(s) of economic welfare measures. Ecological Economics 176: 106753.

Throughput

An entropic process in the biosphere and a concept describing Earth's anthropogenic metabolic flow. It refers to objects that travel through the human sphere, entering as (low-entropy) resources (or natural capital), such as wood, coal, and precious metals, and exiting as (high-entropy) waste to air, land, and water. These objects are commonly defined as either "matter" and/or "energy," and thence the terms "matter-energetic throughput" and "material throughput" are used. If the analysis of the metabolic flow (input–output) is limited to an economic unit—for example, a firm, a household, or a national economy—then the term "economic throughput" is used. Owing to human embeddedness in nature, every human act (for example, a new product or service) requires matter-energy and alters the amount and quality of throughput. The greater the

throughput, the greater the amount of high entropy.

PASI HEIKKURINEN

Further reading

Georgescu-Roegen 1975; Daly 1996; Heikkurinen 2019.

See also: Entropy, Entropy law, Linear throughput, Material flow accounts, Material flow analysis, Anthropogenic, Degrowth, Bioeconomics.

References

Daly, H.E. 1996. Beyond Growth: The Economics of Sustainable Development. Boston, MA: Beacon Press.

Georgescu-Roegen, N. 1975. Energy and economic myths. Southern Economic Journal 41(3): 347–81.

Heikkurinen, P. 2019. Degrowth: a metamorphosis in being. Environment and Planning E: Nature and Space 2(3): 528–47.

Time horizon

a. The duration over which some economic outcomes occur or are planned/expected to occur, including in cost–benefit analysis studies. The choice and analysis of the time horizon is thus of key importance for economic modeling. Paying attention to a model's timescale allows one to assess how quickly or slowly its major variables are predicted to change over time. As noted by Atkinson (1969, p. 137): "If we throw away information about the time dimension, we are reducing still further our limited understanding of the relationship between these models and the real world."
b. In accounting and finance, the period over which an asset is expected to be held. Since assets have different maturity dates, default risks, and depreciation rates, the decision of the time horizon is of key importance for the computation of present and future values, as well as for risk assessment.

ETTORE GALLO

Further reading

Robinson 1980; Sato 1963.

See also: Time preference, Net present value (NPV), Benefit–cost analysis (BCA), Risk assessment.

References

Atkinson, A.B. 1969. The timescale of economic models: how long is the long run? Review of Economic Studies 36(2): 137–52.

Robinson, J. 1980. Time in economic theory. Kyklos 33(2): 219–29.

Sato, R. 1963. Fiscal policy in a neo-classical growth model: an analysis of time required for equilibrating adjustment. Review of Economic Studies 30(1): 16–23.

Time preference

a. An index of the intertemporal marginal rate of substitution between present and future consumption (Becker & Mulligan 1997). According to this view, the rate of time preference depends on how impatient the individuals who make up society are, as well as on their heterogeneity (for example, by income, social class, education, tastes and culture).
b. Austrian School economists understand time preference as the degree to which people prefer present to future satisfaction (Rothbard 2000). According to this view, the interactions of individual time preference schedules will determine and be equal to the interest rate. Since individuals always prefer to consume the same good sooner, rather than later, this view implies that the rate of time preference—and thus the interest rate—will always be positive.

ETTORE GALLO

Further reading

Fisher 1930.

See also: Time horizon, Pure rate of time preference, Preference heterogeneity, Discounting, Real interest rate, Austrian School of economics.

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Becker, G.S. & Mulligan, C.B. 1997. The endogenous determination of time preference. Quarterly Journal of Economics 112(3): 729–58.

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Rothbard, M.N. 2000. America's Great Depression, 5th edn. Auburn, AL: Ludwig von Mises Institute.

Tipping point

Given some system, the point or threshold in the system control parameter which, when exceeded by a small quantitative amount, will trigger a process of non-linear change in a crucial system feature, inevitably effecting an often permanent qualitative system state change (Figure 19). The stability of this new system state is qualitatively different when compared with the former, and the state-stabilizing feedbacks are fundamentally altered from the previous state.

Tipping points are associated with tipping elements, which refer to subsystems in which a small change or intervention can lead to large changes at the macroscopic level and drive the whole system to a new basin of attraction. Exact quantifications of the relationship between big and small, however, are rare, as are empirical examples (Figure 20). There has been considerable concern about possible tipping points in the global climate system; for example, the sudden release of large quantities of methane from Arctic soils, potentially greatly accelerating the process of climate change.

Jordan P. Everall, Ilona M. Otto & Jonathan M. Harris

Further reading

Lenton et al. 2008; Milkoreit et al. 2018.

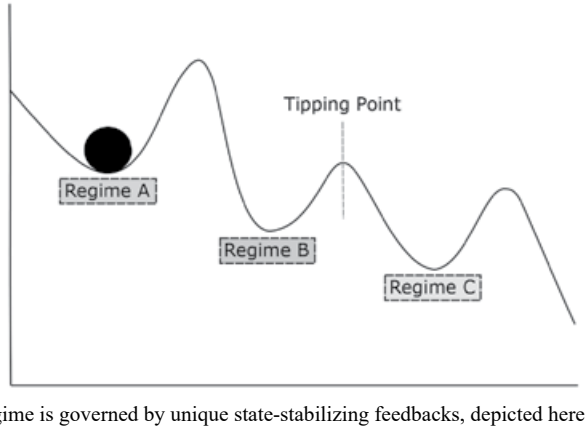
See also: Non-linear, Climate change.

References

Lenton, T.M., Held, H., Kriegler, E. et al. 2008. Tipping elements in the Earth's climate system. Proceedings of the National Academy of Sciences of the United States of America 105(6): 1786–93.

Milkoreit, M., Hodbod, J., Baggio, J. et al. 2018. Defining tipping points for social-ecological systems scholarship—an interdisciplinary literature review. Environmental Research Letters 13(3): 033005.

Otto, I.M., Donges, J.F., Cremades, R. et al. 2020. Social tipping dynamics for stabilizing Earth's climate by 2050. Proceedings of the National Academy of Sciences of the United States of America 117(5): 2354–65.



Note: Each basin or regime is governed by unique state-stabilizing feedbacks, depicted here as the steepness of the basin walls or the curve.
Source: Authors.

Figure 19 *Typical "ball and cup" depiction of tipping points on a stability landscape, with the current system state designated by the ball*

Intervention type	Small effect	Big effect
Small intervention	An incremental change, e.g., a town mitigation plan	A tipping effect, e.g., feed-in tariffs in the German "Energiewende"
Big intervention	Inefficient interventions, e.g., the European Carbon Emission Trading scheme leading to a marginal reduction of greenhouse gas emission due to leakage effects	An elephant effect, e.g., reducing the Earth's carbon burden by means of solar radiation management geoengineering

Source: Otto et al. 2020.

Figure 20 *Illustrative examples of intervention-and-effect relationships in the context of climate change mitigation (Otto et al. 2020)*

Toll goods

See: Club goods.

See also: Excludability, Excludable good, Non-rival resources, Public goods.

References

Martínez-Alier, J. 2002. The Environmentalism of the Poor: A Study of Ecological Conflicts and Valuation. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Sundaram, J.K. & Chowdhury, A. 2012. Is Good Governance Good for Development? New York: Bloomsbury Publishing.

Top-down approaches

Policy strategies implemented by institutions at the level of the state, be it local, regional, national, or international. They are based on homogenous governance models which presume that a single policy is suitable for all segments of a society, and applicable for differing ecosystems. These approaches emerged as part of a systematization of "good governance" that were an integral part of the implementation of neoliberal economic policies in the last decades of the 20th century. They call for a reduction in the oversight processes characteristic of other models of accountability. Top-down approaches are unabashedly a class project that argues in favor of individual freedom and the virtues of privatization.

David P. Barkin

Further reading

Martínez-Alier 2002; Sundaram & Chowdhury 2012.

See also: Institutions, Governance, Neoliberalism, Bottom-up approaches.

Total allowable catch (TAC)

An aggregate quota and policy instrument that limits the fish catch in a specific geographic area for each fishing season or year. Fishery scientists determine the TAC based on fishery management plans employing normal population dynamics and viability analyses. TACs are usually expressed in tonnes of live weight equivalent, but may also be set in terms of numbers of fish. The quota is allocated among individual operators in a variety of ways.

Barry D. Solomon

Further reading

Karagiannakos 1996; Dewees 1998; Emery et al. 2014.

See also: Total allowable commercial catch (TACC), Individual transferable quotas (ITQs), Fisheries management, Fishery, Fishery resources, Maximum sustainable yield, Viability analysis, Environmental policy instruments.

References

Dewees, C.M. 1998. Effects of individual quota systems on New Zealand and British Columbia fisheries. Ecological Applications 8(S1): S133–38.

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Karagiannakos, A. 1996. Total allowable catch (TAC) and quota management in the European Union. Marine Policy 20(3): 235–48.

Total allowable commercial catch (TACC)

a. Total allowable catch (TAC) for a fish species in a specific geographic area minus the number of fish allowed to be taken by indigenous groups and recreational fishers. Fishery scientists determine the TAC based on fishery management plans using viability analyses and normal population dynamics.
b. A policy instrument that sets a quota to limit the TACC in a specific geographic area during a fishing season or year. TACCs are usually expressed in tonnes of live weight equivalent, but may also be set in terms of numbers of fish. The quota is allocated among individual commercial fishers in several ways.

BARRY D. SOLOMON

Further reading

Dewees 1998.

See also: Total allowable catch (TAC), Individual transferable quotas (ITQs), Fisheries management, Fishery, Fishery resources, Maximum sustainable yield, Viability analysis, Environmental policy instruments.

Reference

Dewees, C.M. 1998. Effects of individual quota systems on New Zealand and British Columbia fisheries. Ecological Applications 8(S1): S133–38.

Total economic value (TEV)

An all-encompassing measure of the economic value of an environmental asset (good), attribute (natural capital), or ecosystem service. The main division of the categories of economic value is use versus non-use (passive use) value. Use value includes actual use of the environmental good or service in question, planned use, or possible use. It is sometimes divided into direct and indirect use value. Possible use is also called option value, which is the willingness to pay (WTP) value someone places on preserving the possible future use; for example, a future visit to a national park.

Non-use value includes existence value (stewardship, deep ecology, and WTP estimates can reflect the notion of intrinsic value), altruistic value (current generation), and bequest value (for the enjoyment of future generations). Among the categories of non-use value, it is usually difficult or impossible to separate the subcategories. For all these types of values there need to be rigorous valuation techniques to estimate the value of benefits. Also, it may be difficult to separate someone's use from non-use valuation, as the value of one may affect the value of the other. Thus, it is risky to estimate non-use value in isolation.

BARRY D. SOLOMON

Further reading

Randall & Stoll 1983; Bergstrom et al. 1990.

See also: Environmental asset, Natural capital, Ecosystem services, Willingness to pay (WTP), Economic valuation techniques, Deep ecology, Altruism, Existence value, Intrinsic value, Option value, Bequest value, Environmental stewardship.

References

Bergstrom, J.C., Stoll, J.R., Titre, J.P. & Wright, V.L. 1990. Economic value of wetlands-based recreation. Ecological Economics 2: 129–47.

Randall, A. & Stoll, J.R. 1983. "Existence value in a total valuation framework," pp. 265–74 in Managing Air Quality and Scenic Resources at National Parks. R. Rowe & L. Chestnut, eds. Boulder, CO: Westview Press.

Total human welfare

Economics (from Stahel 2020):

a. The main aim of the economic process as stated by Aristotle, who defined the oikonomy as "the art of living and living well."
b. The degree to which humans or communities can afford to enjoy the necessities, conveniences, and amusements of human life, as defined by Adam Smith and classic English political economy.
c. According to neoclassical economics, the total of individual utilities, and the sum of satisfaction of individual preferences or needs.

Philosophy: eudaimonia in classic Greek philosophy, commonly translated as happiness, welfare, or human flourishing and prosperity.

Humanism: the idea that, contrary to the dogma of essentially selfish human behavior found in neoclassical economics and the belief that rational economic agents act motivated by purely short-term chrematistic behavior, trying to maximize individual satisfaction or monetary profits, humans, by recognizing the essential interdependency of social life, may try to meet multiple objectives and the common good, including income, education, and health.

Andri W. Stahel

See also: Economic welfare, Human needs assessment, Ecosystem services, Eudaimonia, Happiness, Prosperity, Pareto optimality.

Reference

Stahel, A.W. 2020. Oikonomy—The Art of Living and Living Well. Campins-Barcelona: Montseny Spiral Edition.

Total income

Economics:

a. The maximum possible total product consumption by individuals, generated in the accounting period without reducing the total capital at the closing of the period in the ecosystem accounts (Campos et al. 2020). Measured as the net value added plus capital gain at observed and simulated market prices. Following an order of priority that conditions the remuneration of the production factors of labor, manufactured capital, and environmental assets, in the case of the latter a residual return (a balancing item).
b. "[T]he maximum amount which the beneficiary can consume over a given period without reducing the volume of her/his assets. It can also be … the total of the consumption and change in value of assets held over a given period, all other things being equal, as income represents what could have been consumed" (European Communities 2000, p. 87).
c. In the most general expression, sustainable (total) income is NDP (net domestic product) plus the residual value provided by omitted consumption and capital formation plus the residual due to autonomous dynamic factors, plus the revaluations factors (NRC 1999). Since the standard System of National Accounts (SNA) omits important components of consumption and of net capital accumulation, it may provide misleading measures of sustainable total income. This can be measured as NDP plus a residual, which is equal to the omitted consumption and investment. This residual (capital gain) may be negative or positive, depending on whether the sum of non-market consumption and net investment is negative or positive.

Pablo Campos Palacín

Further reading

McElroy 1976; Eisner 1988.

See also: Net value added, Environmental income, Non-market value, Manufactured capital, System of National Accounts (SNA), Gross domestic product (GDP).

References

Campos, P., Álvarez, A., Mesa, B. et al. 2020. Total income and ecosystem service sustainability index: accounting applications to holm

oak *dehesa* case study in Andalusia-Spain. Land Use Policy 97: 104692.
Eisner, R. 1988. Extended accounts for national income and product. Journal of Economic Literature 26(4): 1611–84.
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McElroy, M.B. 1976. Capital gains and social income. Economic Inquiry 14: 221–40.
National Research Council. 1999. Nature's Numbers: Expanding the National Economic Accounts to Include the Environment. Washington, DC: National Academies Press.

Total product

Economics: the intermediate product, final product consumption, plus investment in own account gross capital formation at the closing of the accounting period. Its measurement requires complete records of the production and capital accounts. Its transaction value can be broken down into intermediate consumption, manufactured and environmental work in progress used, labor compensation into employees and self-employed, normal consumption of fixed capital into manufactured and natural capital, and net operating margin into manufactured and environmental margins. These production factors are known by direct observation or simulated market measurements, except for the ordinary environmental net operating margin. This requires a residual estimation of the balance equation between the total product and its production factors as intermediate consumption, consumption of fixed capital, manufactured net operating margin, and investment environmental net operating margin (Campos et al. 2020, 2021).

Intermediate product incorporates commercial raw materials and services produced by manufactured activities valued at market prices or production cost, and also non-commercial activities valued in accordance with government compensation for corporation willingness to accept ordinary monetary losses from economic activities (as opportunity cost) in an ecosystem type and/or spatial unit during the current period and re-employed in the same period to produce another good or service in the same ecosystem type and/or spatial unit.

The Agroforestry Accounting System (AAS) and System of Environmental–Economic Account—Ecosystem Accounting (SEEA-EA) methods apply the simulated exchange value revealed or stated by consumers' marginal willingness to pay to value the final product consumption without market prices.

Pablo Campos Palacín

Further reading

Campos et al. 2017, 2019.

See also: Supply, Systems-oriented simulation models, Agroforestry Accounting System (AAS), Economic ecosystem accounting, Manufactured capital, Natural capital.

References

Campos, P., Álvarez, A., Mesa, B. et al. 2021. Linking standard Economic Account for Forestry and ecosystem accounting: total forest incomes and environmental assets in publicly-owned conifer farms in Andalusia-Spain. Forest Policy and Economics 128: 102482.
Campos, P., Álvarez, A., Mesa, B. et al. 2020. Total income and ecosystem service sustainability index: accounting applications to holm oak *dehesa* case study in Andalusia-Spain. Land Use Policy 97: 104692.
Campos, P., Caparrós, A., Oviedo, J.L. et al. 2019. Bridging the gap between national and ecosystem accounting application in Andalusian forests, Spain. Ecological Economics 157: 218–36.
Campos, P., Mesa, B., Álvarez, A. et al. 2017. Testing extended accounts in scheduled conservation of open woodlands with permanent livestock grazing: Dehesa de la Luz Estate case study, Arroyo de la Luz, Spain. Environments 4(4): 82.

Tradable permits

The currency of exchange in emissions trading systems and markets. Have been called allowances, emission credits, emission reduction credits, offsets, certified emissions reduction, or voluntary emissions reduction, depending on the program and whether it is

mandatory or voluntary. Tradable permits have been used to cost-effectively meet air pollution or greenhouse gas emission targets, especially in cap-and-trade systems, and are an alternative to pollution taxes (Solomon & Lee 2000). The first use of emissions trading was sanctioned by the United States Environmental Protection Agency in 1974, which was initially controversial and had weak monitoring and enforcement (Gorman & Solomon 2002). Early emissions trading systems also had high transaction costs. More recent programs have been more successful as advanced computerized monitoring and tracking systems were implemented.

Each tradable permit represents a specific quantity of emissions of a category of air pollution or greenhouse gas, which may be traded to another party, though sometimes subject to restrictions in time or locational usage. The owners of the permits are allowed to emit the indicated emissions quantity during the specified time period, as well as trade them, and often bank them for future use. However, normally the permits are not considered a property right. In most cases permits are initially allocated to air pollution or greenhouse gas sources, though their total quantity is usually restricted or reduced over time. Alternatively, the permits can be auctioned.

BARRY D. SOLOMON

See also: Emissions trading, Cap and trade, Carbon trading, Clean Development Mechanism (CDM), Climate change mitigation, Pollution taxes, Transaction costs, Property right.

References

Gorman, H.S. & Solomon, B.D. 2002. The origin, practice, and limits of emissions trading. Journal of Policy History 14(3): 293–320.

Solomon, B.D & Lee, R. 2000. Emissions trading systems and environmental justice. Environment 42(8): 32–45.

Trade liberalization

Increasing trade openness (decreasing trade protectionism) resulting from reductions in trade barriers. Trade barriers include explicit barriers to trade such as bans, quotas, and tariffs, which are applied to either imports or exports. Trade liberalization may also occur through the reduction or removal of non-tariff barriers, which ostensibly serve other purposes. Non-tariff measures that can act as trade barriers include technical, health, safety, and environmental standards and measures (for example, biosecurity protocols). Trade liberalization may be undertaken unilaterally, or occur through bi-, pluri-, or multilateral agreements. One of the purposes of the World Trade Organization (WTO) agreements is to provide for gradual trade liberalization so that countries have an adequate amount of time to adjust to the changes.

EMMA K. AISBETT

Further reading

Staiger 1995; OECD 2005.

See also: Commodity trade, Tariff, World Trade Organization (WTO), Green protectionism, Biosecurity.

References

OECD (Organisation for Economic Co-operation and Development). 2005. Looking Beyond Tariffs: The Role of Non-Tariff Barriers in World Trade. Paris: OECD Publishing.

Staiger, R.W. 1995. "International rules and institutions for trade policy," pp. 1495–1551 in Handbook of International Economics, Vol. III. G. Grosman & K. Rogoff, eds. Amsterdam: Elsevier Science.

Trade-related climate policy

Policy nominally addressing a climate objective, which has trade (and trade policy) implications. This includes border carbon adjustments, "green" and "low-carbon" certification schemes, preferential green goods and services liberalization, and linked emissions trading schemes (see Droege et al. 2017 for more examples).

Trade-related climate policy is complementary to, and overlapping with, climate-related trade policy, which is policy nominally addressing a trade objective, which has climate (and climate policy) implications. The intersection of these two areas is green trade policy, which is a subset of both. Examples of

climate-related trade policies that are not also trade-related climate policy include rare earth metal export restrictions, steel tariffs, and agricultural subsidies. Trade-related climate policy can be motivated by carbon leakage and/or competitiveness concerns, in which case it may be trade-reducing (for example, border carbon adjustments). Alternatively, it may be motivated by a desire to facilitate trade in climate-friendly goods and services (for example, international green certification schemes).

EMMA K. AISBETT

Further reading

Reeve & Aisbett 2021; Baccianti & Schenker 2015.

See also: Green trade policy, Climate change mitigation.

References

Baccianti, C. & Schenker, O. 2015. Report on the dynamic efficiency of trade-related climate policy instruments. Mannheim: ZEW-Gutachten und Forschungsberichte, Zentrum für Europäische Wirtschaftsforschung (ZEW). http://hdl.handle.net/10419/148927.

Droege, S., van Asselt, H., Das, K. & Mehling, M. 2017. The trade system and climate action: ways forward under the Paris Agreement. South Carolina Journal of International Law and Business 13(2): 195–276.

Reeve, A. & Aisbett, E. 2021. Making the numbers count: can national carbon accounting systems support effective trade-related climate policies? ZCEAP Working Paper ZCWP04-21, August 2021. Australian National University Grand Challenge Zero-Carbon Energy for the Asia-Pacific. www.anu.edu.au/zerocarbon.

Traditional energy sources

Primarily finite—that is, non-renewable—energy resources, formed from the remains of animal or vegetable organisms, subjected to intense heat and pressure between 350 and 100 million years ago. Includes the three fossil fuels: coal, petroleum, and natural gas. Nuclear energy is sometimes included among the traditional sources, to distinguish it from renewable sources (the key sources of the energy transition under way). Since these sources are non-renewable and impact heavily on the environment, towards the end of the 20th century they began to be replaced by renewable or alternative energy sources.

History: several primary energy sources were used since the birth of humankind and until the start of a first energy transition, based on the exploitation of the fossil fuels, from the 19th century onwards. These primary sources of energy were and are: (1) food for humans; (2) wood; (3) fodder for working animals (seen as biological converters, whose source of energy is fodder); and (4) water and wind (for mills and ships). Except for food, the other sources have been replaced partially or totally by fossil fuels since the 19th century. The economic, ecological, and historical definitions are not at odds. In both cases traditional energies preceded an energy transition: the transition to fossil fuels in the case of the historical definition, and the transition to renewables in the case of the economic and ecological definition.

PAOLO MALANIMA

Further reading

Kander et al. 2013; Smil 1994, 2010; Li et al. 2019.

See also: Energy transition, Fossil fuels, Primary energy, Secondary energy, Renewable energy.

References

Kander, A., Malanima, P. & Warde, P. 2013. Power to the People: Energy in Europe over the last Five Centuries. Princeton, NJ: Princeton University Press.

Li, Y., Chiu, Y.H. & Lin, T.Y. 2019. Research on new and traditional energy sources in OECD countries. International Journal of Environmental Research and Public Health 16(7): 1122.

Smil, V. 1994. Energy in World History. Routledge: London & New York.

Smil, V. 2010. Energy Transitions. History, Requirements, Prospects: Santa Barbara, CA: Praeger.

Traditional knowledge

A network of knowledge, beliefs, and traditions that is intended to communicate, preserve, and contextualize indigenous relationships with culture and landscape over time (Bruchac 2014). Many authors consider "traditional knowledge" to be synonymous with "indigenous knowledge" and "Aboriginal knowledge," while others note that not all traditional knowledge is part of indigenous knowledge, but all indigenous knowledge is a subset within traditional knowledge (Kudngaongarm 2009). This is because traditional knowledge may have been created by any group or individual of humankind, whether indigenous or not. Similarly, indigenous knowledge is therefore part of the traditional knowledge category. Thus, indigenous knowledge is traditional knowledge, but not all traditional knowledge is indigenous knowledge.

BARRY D. SOLOMON

See also: Indigenous knowledge, Indigenous communities, Indigenous rights.

References

Bruchac, M.M. 2014. "Indigenous knowledge and traditional knowledge," pp. 3814–24 in Encyclopedia of Global Archaeology. C. Smith, ed. New York: Springer Science and Business Media.

Kudngaongarm, P. 2009. Human rights standards for the protection of intellectual property: traditional knowledge and indigenous resources. Thailand Journal of Law and Policy 12(1). http://www.thailawforum.com/articles/IP-Traditional-Knowledge-Part1-3.html.

Tragedy of the commons

The commons were historically considered in European intellectual history as shared agricultural fields, grazing lands, and forests that over hundreds of years were eventually enclosed and claimed as private property for private use. However, when a resource is used jointly by multiple people, it is inevitably used beyond its carrying capacity, leading to tragic consequences for all users. This notion became widely known when biologist Garrett Hardin (1968) published his classic paper. Privatizing and publicizing the commons had already been advocated in economics based on similar ideas (Gordon 1954; Demsetz 1967), and the groundwork had been laid for the acceptance of the concept of the tragedy of the commons, which has had a strong influence on economics and resource management theory.

Several strong counterarguments were made by scholars who were conducting field research on the commons, because the tragedy of the commons model did not match many real-world situations. Political scientist Elinor Ostrom (Ostrom 1990) used the results of these multidisciplinary field studies to demonstrate that there were numerous cases where local people sustainably managed common pool resources, and to identify the institutional features common to such cases. Ostrom was subsequently awarded the Sveriges Riksbank Prize in Economics for this research in 2009. Currently, the commons is a subject of study as an institution that facilitates the sustainable use of resources.

DAISAKU SHIMADA

See also: Commons, the, Common property regimes, Common pool resources, Common property resources.

References

Demsetz, H. 1967. Toward a theory of property rights. American Economic Review 57(2): 347–59.

Gordon, J.S. 1954. The economic theory of a common-property resource: the fishery. Journal of Political Economy 62: 124–42.

Hardin, G. 1968. The tragedy of the commons. Science 162(3859): 1243–8.

Ostrom, E. 1990. Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge: Cambridge University Press.

Transaction costs

a. The cost of running an economic system of companies (Williamson 1979, 2013).
b. Any cost or fee required to make a trade, perform an economic exchange to transfer a property right, or arrange for a market service to be performed between persons or firms, besides the cost

of the goods or services being exchanged. Such costs are common in market economies and emissions trading systems, and can arise from planning, search and information-gathering, bargaining and decision-making, changing plans, monitoring (or measurement) and enforcement, and resolving disputes. In some cases, agents, consultants, brokerage services, contracts and other legal documents may be required to complete a transaction.

Barry D. Solomon

Further reading

Stavins 1995.

See also: Property right, Tradable permits, Emissions trading, Transaction prices.

References

Stavins, R.N. 1995. Transaction costs and tradeable permits. Journal of Environmental Economics and Management 29: 133–48.

Williamson, O.E. 1979. Transaction-cost economics: the governance of contractual relations. Journal of Law and Economics 22(2): 233–61.

Williamson, O.E. 2013. The Transaction Cost Economics Project: The Theory and Practice of the Governance of Contractual Relations. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Transaction prices

Prices observed in the market of a product, imputed by observing transactions of the product in other local markets, and simulated from the marginal willingness to pay or be compensated of consumers in the case of consumption of products without market prices (Stigler 1961). The corollary of this concept of exchange value is that the price of a consumed product can only be revealed in visible (market product) and implicit (non-market product) exchanges of things previously appropriated by physical persons or collective persons (firms or other organizations), which implies the exclusion of property rights of third parties. It is assumed that the exchange is voluntary and the equivalence of the values of the exchanged products takes place. If a product is unique, it has no other product to compare with, and consequently its price cannot be revealed, so equivalent exchange will not take place (Kant 1785 [1997]).

Pablo Campos Palacín

Further reading

Atkinson & Obst 2017; Bjorndahl et al. 2017.

See also: Exchange value, Willingness to pay (WTP), Willingness to accept (WTA), Systems-oriented simulation models.

References

Atkinson, G. & Obst, C. 2017. Prices for ecosystem accounting. World Bank-led Wealth Accounting and Valuation of Ecosystem Services global partnership (WAVES), pp. 1–38. https://www.wavespartnership.org/sites/waves/files/kc/Prices%20for%20ecosystem%20accounting.pdf.

Bjorndahl, A., London, A.J. & Zollman, K.J.S. 2017. Kantian decision making under uncertainty: dignity, price, and consistency. Philosophers' Imprint 17(7): 1–22.

Kant, I. 1785 [1997]. Groundwork of the Metaphysics of Morals. M. Gregor, translator; C.M. Korsgaard, ed. Cambridge: Cambridge University Press.

Stigler, G.J. 1961. The economics of information. Journal of Political Economy 69(3): 213–25.

Transdisciplinarity

Strategy to generate socially robust knowledge through the reflexive and systematic integration of different academic disciplines as well as non-academic stakeholders into processes of problem identification, co-creation of solutions-oriented knowledge, and its integrated dissemination and reintegration into real-world and academic contexts. It seeks to bring together systems knowledge, target knowledge, as well as transformative knowledge.

Sustainability science and ecological economics: based on the integration of various bodies of knowledge, transdisciplinary research addresses complex real-world problems and seeks to provide and advance

societally relevant solutions to sustainability problems.

Bernd Siebenhüner

Further reading

Bernstein 2015; Hirsch Hadorn et al. 2008; Jahn et al. 2012; Lang et al. 2012.

See also: Sustainability science, Ecological economics, Post-normal science, Stakeholder, Stakeholder participation, Bottom-up approaches.

References

Bernstein, J.H. 2015. Transdisciplinarity: a review of its origins, development, and current issues. Journal of Research Practice 11(1): 1–20.

Hirsch Hadorn, G., Hoffmann-Riem, H., Biber-Klemm, S. et al., eds. 2008. Handbook of Transdisciplinary Research. Heidelberg: Springer.

Jahn, T., Bergmann, M. & Keil, F. 2012. Transdisciplinarity: between mainstreaming and marginalization. Ecological Economics 79: 1–10.

Lang, D.J., Wiek, A., Bergmann, M. et al. 2012. Transdisciplinary research in sustainability science: practice, principles, and challenges. Sustainability Science 7: 25–43.

Transdisciplinary

See: Transdisciplinarity.

See also: Interdisciplinary, Multidisciplinary.

Transdisciplinary research

See: Transdisciplinarity.

See also: Interdisciplinary, Multidisciplinary.

Transfers

General:

a. To make something the legal property of another person or organization; for example, technology transfer.
b. To move something from one place to another.

Economics:

a. "Transfer payments" is the most common use of this term. These are payments made by a government to a person or firm, or income received, for which no good or service is being paid for. Examples include Social Security and Medicare in the United States, civil service pensions, student financial aid, unemployment compensation, and food stamps.
b. Benefit transfer refers to the practice of taking economic valuation of benefits found in one research setting and applying them to a different site or situation, often with adjustments made for spatial heterogeneity between sites or situations.

Ecological economics:

a. Individual transferable quotas (ITQs) are another form of transfer, which allow fishermen or women or vessel owners to sell their catch share to other parties.
b. Ecological fiscal transfers are a transfer of public revenues within a country between governments based on ecological indicators.

Barry D. Solomon

Further reading

Romer & Romer 2016; Johnston et al. 2015; Arnason 1993; Busch et al. 2021.

See also: Benefit transfer, Spatial heterogeneity, Individual transferable quotas (ITQs), Ecological fiscal transfers (EFT), Ecological indicators.

References

Arnason, R. 1993. The Icelandic individual transferable quota system: a descriptive account. Marine Resource Economics 8(3): 201–18.
Busch, J., Ring, I., Akullo, M. et al. 2021. A global review of ecological fiscal transfers. Nature Sustainability 4: 756–65.
Johnston, R.J., Rolfe, J., Rosenberger, R.S. & Brouwer, R., eds. 2015. Benefit Transfers of Environmental and Resource Values. Dordrecht: Springer.
Romer, C.D. & Romer, D.H. 2016. Transfer payments and the macroeconomy: the effect of social security benefit increases, 1952–1991. American Economic Journal: Macroeconomics 8(4): 1–42.

Transgenic

Biology:

a. A biological organism's possession of genetic material that would not arise (or would be extremely unlikely to arise) through natural selection or selective breeding on human-relevant timescales.
b. Transgenesis: the transfer of genetic material between two unrelated species (for example, via viral or bacterial vectors).

Biotechnology regulation: possessing genetic material from another, unrelated species, inserted artificially through recombinant DNA (rDNA) techniques.

Transgenic crops, or genetically modified organisms (GMOs), are increasingly grown by farmers. The four most common examples are maize, soybeans, cotton, and canola. Transgenic is distinct from "gene editing," which does not necessarily involve the transgenesis: for example, gene editing can involve the removal of existing genetic material without the use of rDNA techniques.

Zachary S. Brown

Further reading

Bourguet et al. 2005; Kuzma 2018; Brown 2017; Doudna & Sternberg 2017; NASEM 2016; NRC 2010; Kyndt et al. 2015.

See also: Genetic resources, Agribusiness.

References

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NRC (National Research Council). 2010. The Impact of Genetically Engineered Crops on Farm Sustainability in the United States. Washington, DC: National Academies Press.

Transition economies

A generic term for economies that are changing from primarily government-controlled or centrally planned to a market economy, or a mixed economy with a blend of a market economy and central planning. Sometimes called "transitional economies" or "economies in transition." Transition economies develop economic institutions similar to what exists in most developed countries; a process that can take from one to several decades, depending on government reforms and policies on the pace of transition. Such transitions are also often influenced by policies, financial support, and technical assistance from the World Bank and International Monetary Fund as well as other multilateral and bilateral aid organizations.

Transition economies in the late 20th century and early 21st century were concentrated in Europe and Asia and have included: Albania, Armenia, Azerbaijan, Belarus, Bulgaria, Cambodia, China, Croatia, Czech Republic, Estonia, Georgia, Hungary,

Kazakhstan, Kyrgyzstan, Laos, Latvia, Lithuania, Moldova, North Macedonia, Poland, Romania, Russia, Slovakia, Slovenia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan, and Vietnam.

BARRY D. SOLOMON

Further reading

Svejnar 2002; McMillan & Woodruff 2002.

See also: Economic institutions, Developed country, Developing country, Political economy, World Bank.

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Transparency

The quality or act of being done in an open way, with no secrets. In governance, a narrow definition of transparency restricts the concept to information disclosure on policies and actions (Bellver & Kaufmann 2005). Broader definitions go beyond information disclosure to consider the ability of the receiver to comprehend and utilize the information made available (Florini 2007), and the accountability of the targeted individual, government, or organization (Epremian et al. 2016).

Examples of theories of transparency in governance include: (from Fenster 2015; Heald 2006) a causal chain where increased transparency leads to a series of necessary stages, ending in improved governance; (from Fung et al. 2007; Kosack & Fung 2014) a transparency action cycle where state institutions provide information to citizens about their practices and policies, citizens act on the information and seek to influence the state, the state institutions find the citizen action and feedback salient, the state institutions respond constructively through changing practices and policies, and the state provides updated information to the public about the changes it has made to practices and policies for further evaluation, restarting the cycle; and (from Tienhaara 2020; Le Billon et al. 2021) leveraging transparency as an informational tool and bureaucratic process to enhance governance through improved procedures, greater efficiency, and reforms.

CHRISTA BRUNNSCHWEILER & PÄIVI LUJALA

See also: Accountability, Adaptive governance.

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Kosack, S. & Fung, A. 2014. Does transparency improve governance? Annual Review of Political Science 17(1): 65–87.

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Tienhaara, K. 2020. Beyond accountability: alternative rationales for transparency in global trade politics. Journal of Environmental Policy and Planning 22(1): 112–24.

Travel cost method

An economic valuation technique, based on revealed preferences, principally used to assess the demand for nature recreation and the recreational value of natural areas. It is based on people's actual behavior, generally collected through surveys, regarding the number and distribution of trips that they make to outdoor recreation sites as a function of the trip cost. The intuition behind it is that the demand for recreation, like a classical demand function, is reduced in quantity demanded (the number of visits) as the price of the good (the cost of transport and travel-related costs) increases. Thus, the closer a natural area is to one's home, the higher the probability that the resident will visit that area, and the travel cost is a complementary marketed good (a weak complement) of the outdoor recreational value. Other factors such as socio-economic characteristics of individuals, site characteristics, or time and available substitutes, also influence recreational demand.

There are two main approaches: single-site models (zonal or individual methods), and multi-site models. One of the main criticisms of this method is that it considers outdoor recreation as an economic good like any other, whose consumption results from a trade-off with, for example, other leisure activities representing competing uses of free time. Without denying the existence of such behavior, we can also consider that recreational practices call for other logics and "alternative" preferences such as prophylactic aims, social norms, or even attachment to places.

Léa Tardieu

Further reading

Parsons 2017; McConnell 1985; Mäler 1974; Hotelling 1947.

See also: Revealed preference methods, Non-market value, Economic valuation techniques.

References

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Triple bottom line (TBL)

The basis of the triple helix model, proposed by Henry Etzkowitz & Loet Leydesdorff (2000) to represent the "dynamics" of a ternary relationship, university–industry–government, aimed to support the "third mission of university." John Elkington first coined the term in 1994 as a challenge to business leaders to rethink capitalism: a first bottom line is the usual financial statement of the profit and loss account, the traditional measure of a company's profits; the second is that of the return to the public, that is, a measure of how socially responsible the company's activities have been; and the third is the return to the planet, a measure of how much the company has been responsible towards the environment (Elkington 1997, 2004).

Only a company capable of producing a TBL balance sheet can consider the true overall cost it faces for its business. Due to the growing attention to environmental and social issues on the part of customers, many companies have begun to consider social and environmental costs "hidden" in production, and TBL criteria have entered the markets as evaluation elements.

Massimo Scalia

Further reading

Scalia et al. 2018.

See also: Sustainability, Sustainable business, Corporate social responsibility.

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Trophic theory of money

The concepts and logic leading to the conclusion that the means of exchange (that is, money) originate as a function of the agricultural and extractive sector surpluses that allows for the division of labor into the manufacturing and services sectors (Czech 2019). Follows from the concept of trophic levels in the economy of nature, whereby primary and secondary consumers—all of which are animals—cannot exist without the surplus production of plants, or "producers" in the economy of nature. Supported by anthropological evidence of the origins of money in regions with rapidly developing agricultural surplus (for example, Mesopotamia and China's Yellow River Basin).

Accompanied by the corollary that the money supply and gross domestic product (GDP)—the stock and flow of money, respectively—are reliable indicators of environmental impact, because the trophic base of the economy comprises agricultural and extractive activities (including logging, mining, livestock production, and commercial fishing) that liquidate natural capital stocks and erode ecosystem services as the trophically structured economy grows. Refutes notions of "green growth" and dematerializing GDP.

BRIAN CZECH

See also: Money, Accumulation, Post-Keynesian economics, Ecosystem, Net primary production (NPP), Human appropriation of net primary production (HANPP), Exchange value, Ecologically unequal exchange.

Reference

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Trust

Psychology and sociology: individuals' belief about the honesty, fairness, and/or the benevolence of another person or organization. These beliefs can also relate to people in the individuals' networks (network trust) or in general (social trust), as well as to institutions (institutional trust).
Economics:

a. Individuals' willingness to voluntarily and without legal commitment place resources at the disposal of another party with the expectation that the act will pay off.
b. A relationship in which one party gives another party the right to hold title to property or assets for the benefit of a third party.

KATE M. LAFFAN

Further reading

Evans & Krueger 2009; Algan 2018; Son & Feng 2019.

See also: Social capital, Private property, Institutions.

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U

Ultimate ends

a. That which is intrinsically good in and of itself.
b. That which does not derive its value from being instrumental in achieving some other end. Ultimate ends usually fall within the realm of ethics, moral philosophy, or religion. By recognizing ultimate ends, and including them in its analytical framework, ecological economics can establish moral limits to any human activity, including economic activity. Mainstream economics only includes intermediate ends (goods and services, education, income, and so on) in its analytical framework, which are plural, relative, and limitless. More recently within ecological economics, ultimate ends have been conceptualized around human needs and human well-being (Daly 1991).

LINA BRAND-CORREA

Further reading

Gough 2015; Lamb & Steinberger 2017.

See also: Ends–means spectrum, Ultimate means, Well-being economy, Human needs assessment, Matrix of human needs.

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Lamb, W.F. & Steinberger, J.K. 2017. Human well-being and climate change mitigation. WIREs: Climate Change 8(6): 1–16.

Ultimate means

a. Low-entropy matter-energy.
b. The useful things of the world.
c. That which human activity cannot create or replenish.
d. That which is not the end of any human activity. Ultimate means usually fall within the realm of physics. By recognizing ultimate means, and including them in its analytical framework, ecological economics can address physical and thermodynamic limits. Mainstream economics only includes intermediate means (physical stocks) in its analytical framework, which can be created by human activity, are plural and substitutable, and potentially limitless given technological advances. More recently, ultimate means within ecological economics have been defined as geological and biophysical planetary processes, including the notion of planetary boundaries (Daly 1991).

LINA BRAND-CORREA

Further reading

Rockström et al. 2009; Steffen et al. 2015.

See also: Ends–means spectrum, Ultimate ends, Energy, Entropy, Biophysical constraints on human economic activity.

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Steffen, W.L., Richardson, K., Rockström, J. et al. 2015. Planetary boundaries: guiding human development on a changing planet. Science 347(6223): 1259855.

Uncertainty

A situation where a decision-maker does not fully know how the decision will affect the outcome. Uncertainty in the strict sense, also referred to as Knightian uncertainty, describes a situation where the decision-maker knows the set of possible outcomes, but cannot attach probabilities. Uncertainty in the strict sense is distinguished from risk, where the decision-maker can attach probabilities to outcomes; and ignorance, where the decision-maker does not even know the set of possible outcomes.

Martin F. Quaas

Further reading

Faber et al. 1992; Keynes 1921; Knight 1921.

See also: Maximin, Surprise, Risk.

References

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Keynes, J.M. 1921. A Treatise on Probability. London: Macmillan & Co.

Knight, F. 1921. Risk, Uncertainty and Profit. Boston, MA: Houghton Mifflin.

Uneconomic growth

The expansion of an economy (at both the micro and the macro level) that costs us more than the benefits of that expansion. The concept of uneconomic growth was introduced in the 1990s by ecological economist Herman Daly, and was inspired by William Stanley Jevons's 1871 labor market analysis in terms of balancing the marginal utility of wages with the marginal disutility of labor (Daly 1999a, 1999b, pp. 8–24; Jevons 1871).

Ecological economics: growth of the physical economy into the finite and non-growing Earth ecosystem that entails an opportunity cost (resource depletion, pollution, loss of ecosystem services) higher than the extra benefits of the expanded economy. The concept suggests that the macroeconomy must have an optimal scale relative to the Earth ecosystem that supports it, and that the impacts of uneconomic growth can be addressed only through lower rates of growth and aiming to build a steady state economy.

Environmental economics: economic growth (gross domestic product expansion) that leads to more harm (negative externalities) than good (increase in wealth) and produces a decline in the quality of life (welfare). It happens when the decreasing marginal benefits of growing economic activity are outweighed by the increasing marginal costs of growth. For instance, overconsumption of health care can lead to joint harms to human health and the natural environment (Hensher et al. 2020).

Gabriela L. Sabau

Further reading

Daly 2014; Sabau & van Zyll de Jong 2015.

See also: Economic growth, Optimal scale of the macroeconomy, Steady state economy, Throughput.

References

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Sabau, G. & van Zyll de Jong, M. 2015. From unjust uneconomic growth to sustainable fisheries in NL: the true cost of closing the inshore fishery of groundfish. Marine Policy 61: 376–89.

Unintended consequences

The unforeseen or unexpected outcomes that fall outside the stated intentions of a purposive action. These actions are either: (1) unorganized, referring to actions of individuals; that is, Adam Smith's (1776 [1999]) "invisible hand" and Karl Marx's (1867 [1990]) "coercive law of competition"; or (2) formally organized, referring to actions of institutions or organizations (from Merton 1936). American sociologist Robert Merton is attributed with the first in-depth analysis of the concept of unintended consequences, although the history of the concept dates back centuries.

Economics: mainstream use of unintended consequences is heavily skewed towards critique of public institutions, most often of government action as regulation or intervention. Unintended consequences of institutions and firms in the private sector are referred to by economists as externalities, since the costs associated with these consequences are not accounted for in market prices (Pindyck & Rubinfeld 1998). Since formally organized actions "ordinarily involve an explicit statement of purpose and procedure" (from Merton 1936), their unintended consequences can be identified relative to their intended consequences. Therefore, organized actions allow for more rigorous empirical analysis regarding their unintended consequences (Merton 1936, p. 896). Common categories for unintended consequences include unanticipated benefits, unanticipated downsides, and perverse results that make targeted problems worse.

Ecology: many ecologists argue that due to the complexity of ecosystems, targeted environmental intervention is at high risk of producing negative or perverse surprises and unintended consequences (Chauvenet et al. 2011), such as from the introduction of new species for pest control (Follett & Duan 2000), and biochar amendments to soil (Kookana et al. 2011), among others.

TRACEY J. KATOF

See also: Externalities, Environmental externalities, Tragedy of the commons, Surprise, Social cost.

References

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Pindyck, R. & Rubinfeld, D. 1998. Microeconomics, 4th edn. Upper Saddle River, NJ: Prentice Hall.
Smith, A. 1776 [1999]. The Wealth of Nations, Books I–III. London: Penguin Books.

United Nations Development Programme (UNDP)

Founded as the international development organization of the United Nations in 1965, today the UNDP works in 177 countries and territories with a mission to eradicate poverty and hunger, reduce inequalities, improve public health, and build resilience while protecting the environment. The UNDP headquarters is in New York City. The UNDP works in cooperation with developing coun-

tries to meet the 17 Sustainable Development Goals that were adopted in 2015. It also promotes technical and investment cooperation and helps countries to develop strong policies, skills, partnerships, and local institutions. The UNDP is known for its annual Human Development Index (Morse 2003). In 1992 it partnered with the United Nations Environment Programme (UNEP) and the World Bank to create the Global Environment Facility to help address and fund solutions to high-priority global environmental problems.

BARRY D. SOLOMON

Further reading

Murphy 2006; Malhotra 2003.

See also: United Nations Environment Programme (UNEP), World Commission on Environment and Development (WCED), Sustainable development, Human development, Human Development Index (HDI), Millennium Development Goals (MDGs), Sustainable Development Goals (SDGs), Sustainable development indicators.

References

Malhotra, K. 2003. Making Global Trade Work for People: United Nations Development Programme. London: Earthscan.

Morse, S. 2003. For better or for worse, till the human development index do us part? Ecological Economics 45(2): 281–96.

Murphy, C.N. 2006. The United Nations Development Programme: A Better Way? New York: Cambridge University Press.

United Nations Environment Programme (UNEP)

Founded after the United Nations Conference on Environment and Development in Stockholm in 1972, UNEP coordinates global responses to environmental issues within the United Nations system and promotes international and regional environmental agreements and treaties. The UNEP headquarters is in Nairobi. Priority areas include climate change, chemicals and wastes, ecosystem management, and environmental governance. In 1992, UNEP partnered with the United Nations Development Programme (UNDP) and the World Bank to create the Global Environment Facility to help address and fund solutions to high priority global environmental problems.

BARRY D. SOLOMON

Further reading

Ivanova 2007; UNEP, International Resources Panel 2011.

See also: Global change, Global warming, United Nations Development Programme (UNDP), World Commission on Environment and Development (WCED), REDD (Reducing Emissions from Deforestation and forest Degradation), Circular economy, World Bank.

References

Ivanova, M. 2007. Designing the United Nations Environment Programme: a story of compromise and confrontation. International Environmental Agreements: Politics, Law and Economics 7(4): 337–61.

UNEP, International Resources Panel. 2011. Decoupling Natural Resource Use and Environmental Impacts from Economic Growth. Nairobi: UNEP.

Universal basic services (UBS)

The provision of free public services that enable citizens and residents to live a good life through access to an appropriate level of security, personal opportunity/growth, and civic participation. Universal basic services include shelter, sustenance, health and care, education, transport, access to information, and access to legal institutions and representation (Coote et al. 2019, p. 11). "Services" are defined as collectively generated activities that serve the public interest. "Universal" conveys the idea that all citizens and/or residents are entitled to services that are sufficient to meet their needs, regardless of their ability to pay. "Basic" distinguishes activities that are essential and sufficient to enable people to meet their needs, as distinct from mere desires. This does not imply the provision of the bare minimum for survival,

but instead that which is required by an individual to flourish (Coote 2021).

KAI WHITING

Further reading

Coote & Percy 2020; Gough 2019; Büchs 2021.

See also: Energy services, Material services, Human needs assessment.

References

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Coote, A., Kasliwal, P. & Percy, A. 2019. Universal basic services: theory and practice—a literature review. Institute for Global Prosperity, University College London.

Gough, I. 2019. Universal basic services: a theoretical and moral framework. Political Quarterly 90(3): 534–42.

Urban

A descriptor for built-up areas of human settlement with high population density. Usually also called a city. The definition of an urban area varies in different parts of the world. In the United States and Japan, an urban area is defined as having 50 000 or more residents, while the threshold in China is 100 000, though in India it is only 5000 (Dijkstra et al. 2019, 2020). Geographic areas of smaller population densities are called towns and villages. Most employment in urban areas is in non-agricultural sectors. Infrastructure is usually well developed, with a high density of houses, roads, commercial and industrial buildings, and sometimes bridges and railways.

Additional designations are in use for geographic areas surrounding an urban core area (sometimes itself called a metropolitan area), which usually share infrastructure, such as housing, roads, and industry. These include: suburban areas (less densely populated and containing primarily housing, and not agriculture); and peri-urban areas (transition zones on the urban fringe and periphery between urban and rural areas, with discontinuous human settlements of over 40 persons/hectare). A rural area is the countryside outside of urban areas, cities, towns, and villages, with very low density of human population, fewer or no governmental facilities, and a dominance of agriculture.

BARRY D. SOLOMON

See also: Urban density, Peri-urban interface, Urban ecology, Urban economics, Urban metabolism, Urban planning, Urban resilience, Urban unsustainability.

References

Dijkstra, L., Poelman, H. & Veneri, P. 2019. The EU–OECD definition of a functional urban area. OECD Regional Development Working Papers 2019/11, Paris.

Dijkstra, L., Hamilton, E., Lall, S. & Wahba, S. 2020, March 10. How do we define cities, towns, and rural areas? World Bank Blogs. https://blogs.worldbank.org/sustainablecities/how-do-we-define-cities-towns-and-rural-areas.

Urban density

The number and concentration of people living in an urban area. Usually measured by the total number of people per square kilometer or mile, and sometimes by the number of dwelling units, floor area of buildings, employment levels, and so on, in urban areas.

While denser urban areas usually use less energy and release less greenhouse gas emissions per capita, those same urban areas typically have more air pollution, traffic congestion, and higher housing prices. Alternatively, urban areas with lower density tend to be much more automobile-dependent and use more energy, and encroach on surrounding farmlands. Thus, the relationship between urban density and sustainability is complex and contested.

BARRY D. SOLOMON

Further reading

Newman & Kenworthy 1999; Jones 2014; Hansen 2013; Ahlfeldt & Pietrostefani 2019.

See also: Urban, Population density, Peri-urban

interface, Urban ecology, Urban economics, Urban metabolism, Urban planning, Urban resilience, Urban unsustainability.

References

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Jones, C. 2014. Spatial distribution of U.S. household carbon footprints reveals suburbanization undermines greenhouse gas benefits of urban population density. Environmental Science and Technology 48(2): 895–902.

Newman, P. & Kenworthy, J.R. 1999. Sustainability and Cities: Overcoming Automobile Dependence. Washington, DC: Island Press.

Urban ecology

The study of relationships between biotic and abiotic elements in the city. These encompass material and thermodynamic interactions between humans, non-humans, and built form. These interactions constitute recurring patterns that allow the characterization of urban ecology as comprised not just of individuals, but of interdependent ecosystems (Odum 1977).

Urban ecology, as a discipline, originated from efforts to apply ecological concepts to cities, such as by scholars from the Chicago School of urban sociology (McDonnell 2011). However, urban systems, in contrast to natural systems, are products of human design and engineering, which determine much of the material and thermodynamic interactions that occur within them. More so than natural ecologies, material and energy are predominantly imported into the city, such that most primary production (of food, products, and building material) occurs outside the city. This means that much activity within the city consists of consumption and secondary production (or processing) of primary goods.

Raul P. Lejano

Further reading

Niemelä et al. 2011.

See also: Ecology, Social ecology, Industrial ecology, Biotic resources, Abiotic resources.

References

McDonnell, M.J. 2011. "The history of urban ecology: an ecologist's perspective," pp. 5–13 in Urban Ecology: Patterns, Processes, and Applications. J. Niemelä, J.H. Breuste, G. Guntenspergen et al., eds. Oxford: Oxford University Press.

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Odum, E.P. 1977. The emergence of ecology as a new integrative discipline. Science 295(4284): 1289–93.

Urban economics

The study of the economics of cities and towns in relation to their country, regions, and nations within the wider world, urban economics provides a major entry point to ecological economics. The emphasis on cities is not just because they are the seats of industrial pollution and other problems such as transport congestion, housing, sprawl, inequalities, climate change, and biodiversity loss, but also because cities drive the fossil fuel industry, economic growth, innovation, and new collective norms that can stimulate new types of modernity, inclusivity, and socio-ecological transformation.

The dominant school of thought in urban economics is neoclassical, including its variants such as new institutional economics and behavioral economics. In old-fashioned urban economics, pollution was deemed necessary for growth, which would become green over time. However, modern urban economics is more proactive. Here, externalities, technological backwardness, the tragedy of the commons, and individual behavior are deemed to be key drivers of "environmental" problems. Solutions typically emphasize market strategies such as pricing, taxes, charges, and instituting private property rights to internalize the problem, address market failures, and innovate new

technologies. The vision is to have clean and green growth.

Neoclassical economics alone does not define the urban economics approach to ecological economics. Marxist urban economics, (original) institutional urban economics, and, notably, Georgist urban economics, are vibrant radical alternatives. These versions all differ, but they have one thing in common: they are critical of the orthodox urban economics approach to, among others, the environment. Also, these alternatives emphasize visions of justice, both economic and ecological, over and above the dominant concerns in neoclassical urban economics centered on growth, efficiency, and "clean" energy.

FRANKLIN OBENG-ODOOM

Further reading

Stilwell 1992; Kahn 2021; Obeng-Odoom 2016.

See also: Neoclassical economics, Regional economics, Economic growth, Green growth, Geonomics, Urban ecology, Land economics, Behavioral economics, New institutional economics, Justice.

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Urban forestry

The highly multidisciplinary art, science, and technology of managing trees and forest resources in and around urban community ecosystems for the physiological, sociological, economic, and aesthetic benefits that trees provide to urban societies (Miller 1997; Helms 1998, p. 193; Konijnendijk 2003). The "urban" aspect of the term has been defined broadly. The term "urban forestry" was first used in the United States in 1894 and has evolved over time as it has spread to other countries and cultures. For example, in Europe the emphasis was historically on "town forestry," while urban forestry has been applied there on a wider scale only since the 1990s (Konijnendijk et al. 2006).

BARRY D. SOLOMON

See also: Forestry, Forest conservation, Forest resources, Community forestry, Ecosystem.

References

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Miller, R.W. 1997. Urban Forestry: Planning and Managing Urban Green Spaces, 2nd edn. Englewood Cliffs, NJ: Prentice Hall.

Urbanization

The process through which cities grow by the migration of people from rural areas in search of better economic opportunities, along with population increase from city residents. This leads to larger concentrations of people living in cities over time, along with several socio-economic and environmental challenges.

BARRY D. SOLOMON

Further reading

Tisdale 1941; Harvey 1985.

See also: Urban, Urban economics, Urban planning, Urban density, Urban ecology, Urban unsustainability, Sustainable cities and communities.

References

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Urban metabolism

Industrial ecology: the material and energetic functioning of cities. This research aims to quantify the metabolic inputs (for example, biomass, minerals, food, and fuel) and outputs (for example, waste, atmospheric emissions), optimize flows, and improve their environmental performance (Wolman 1965).

Urban political ecology: the socio-technical transformation of matter generated by urban capitalism and uneven processes, through the metabolic rift (Marx 1894 [1993]). The aim is to explore both how nature is transformed and inscribed in the political and socio-economic practices that shape the urban form and its hinterland, and how flows are entangled in relations of domination and power.

Ecological economics: the long-term socio-ecological process by which material, energy, and water flows are consumed, transformed, and discharged in different forms by cities. This research aims to understand the urban implications of socio-metabolic regime transitions.

JEAN-BAPTISTE BAHERS

Further reading

Clift & Druckman 2016; Ernstson & Swyngedouw 2018; Haberl et al. 2016.

See also: Industrial ecology, Political ecology, Political-industrial ecology, Material flow analysis, Multi-scale integrated analysis of societal and ecosystem metabolism (MuSIASEM), Metabolic rift.

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Marx, K. 1894 [1993]. Capital: A Critique of Political Economy, Vol. 3, Reissue edition. New York: Penguin Classics.

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Urban planning

The process of designing, regulating, and managing the use of space and the distribution of activities, infrastructures, and land covers in an urban area, with the overall purpose of matching the needs of the human communities with the characteristics of the biophysical environment. Urban planning is about preparing cities for the future, by helping to achieve social equity, economic growth, and environmental conservation and restoration. Hence, urban planning theory and practice draw from several disciplines, including the social sciences, architecture, ecology, and engineering.

The planning process includes both a political and technical dimension, involves public participation, and is typically regulated by legislation. The result of the process may be a formal plan (for example, city or neighborhood plan), which generally contains the following elements: analysis of the context; statement of vision and objectives; description of the strategies, policies, and actions to achieve the objectives; and a series of maps representing the information collected and the decisions taken during the planning process.

DAVIDE GENELETTI

Further reading

Steiner 2008; Wheeler 2013; Levy 2017.

See also: Urban economics, Urban ecology, Land use change.

References

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Steiner, F.R. 2008. The Living Landscape: An Ecological Approach to Landscape Planning, 2nd edn. Washington, DC: Island Press

Wheeler, S. 2013. Planning for Sustainability: Creating Livable, Equitable and Ecological Communities. London: Routledge.

Urban resilience

Cities' ability to withstand different shocks such as ecological, social, or economic, without losing an initial capacity of operations. Research on urban resilience mostly concentrates on intra-urban processes of cities' adaptation on the local level (communities), such as cities' resilience to natural disasters. However, there is an emerging trend in the literature towards a multi-level approach to urban resilience: along with bottom-up shocks originating from local scale (micro level) such as floods, earthquakes, and so on, on the other hand there are global changes that have a top-down nature, such as climate change, global economic recessions, or pandemics that influence all the cities differently (macro level). In this framework, a city constitutes a meso-level being, a complex adaptive system influenced both by intra-urban (local) and inter-urban processes (global), and thus urban resilience depends on and is shaped by the coevolution of processes unfolding at different urban levels.

A socio-ecological perspective to urban resilience remains dominant in both research and policymaking: for example, the United Nations Human Settlement Programme considers urban resilience in the context of natural disasters, climate change, demographic shifts, or insufficient and/or aging infrastructure (Spaliviero et al. 2018). Non-governmental initiatives working on urban resilience such as Local Governments for Sustainability, Cities Alliance, and 100 Resilience Cities, also focus on social-ecological dimensions, incorporating the notion of resilient communities. Most of the economic research on urban resilience focuses on the estimation of economic losses from natural disasters, whereas resilience of urban economies to economic shocks is considered within regional resilience perspectives.

MIKHAIL I. ROGOV

Further reading

Folke et al. 2010; Holling 2001; Meerow & Newell 2019; Rogov & Rozenblat 2018; Shutters et al. 2015.

See also: Resilience, Ecosystem resilience, Economic resilience, Rural resilience, Adaptive governance, Adaptive capacity, Top-down approaches, Bottom-up approaches.

References

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Spaliviero, M., Lopes, L.F., Tomaselli, C. et al. 2018. City Resilience: Action Planning Tool. Nairobi: UN-Habitat.

Urban unsustainability

Ecological economics recognizes that biophysically unsustainable human activities are concentrated in and demanded by urban areas that vary widely in density and population size from a few thousand people to meta-cities with more than 20 million residents. Urban environments are prone to a host of unsustainability challenges caused by clearing, construction, and engineering, such as pollution of air, water, and land; loss of vegetation and species' habitats; damaging changes to surface water flows and basins, and groundwater exploitation. Increasing frequency and intensity of natural disasters in coastal regions, where many cities are located, and "urban heat island" effects

attending climate change, exemplify urban unsustainability and associated policies for urban resilience and adaptation.

Cities frequently rely on extensive hinterlands and global trade for materials, energy, and water, upsetting and degrading various biomes' ecosystem services. Ecologically damaging systems for meeting citizens' needs for water, food, energy, housing, transport, and waste treatment systems result in unsustainability. Evaluations, measures, and indicators of urban metabolic relations and flows are key to ecological economics. Urban (un)sustainability is assessed using ecological footprints and carrying capacity indicators.

ANITRA R. NELSON

Further reading

Pearson 2013; Girardet 2017; Rees & Moore 2013.

See also: Biophysical constraints on human economic activity, Adaptation, Carrying capacity, Degrowth, Ecological footprint, Overshoot, Urban, Urban metabolism, Urban resilience, Sustainability.

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Use value

A measure of the economic value of an environmental asset (good), attribute (natural capital), or ecosystem service based on the actual use of the environmental good or service in question, planned use, or possible use.

Use value can be divided into direct use value, indirect use value, and option value. Direct use value may be derived from a harvestable good such as fish, water, timber, energy resources, and so on; as well as non-consumptive use such as the enjoyment of scenery, biodiversity, and so on. Indirect use value can be placed on regulating ecosystem services, such as climate regulation, flood control, air and water purification, and so on. Option value is related to possible use, which is the willingness to pay (WTP) value someone places on preserving the possible future use; for example, a future visit to observe an endangered species in its natural habitat.

BARRY D. SOLOMON

Further reading

Bergstrom et al. 1990; Chen et al. 2009.

See also: Non-consumptive use value, Non-use value, Total economic value (TEV), Willingness to pay (WTP), Economic valuation techniques.

References

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Chen, N., Li, H. & Wang, L. 2009. A GIS-based approach for mapping direct use value of ecosystem services at a county scale: management implications. Ecological Economics 68(11): 2768–76.

Utilitarianism

A philosophy asserting that the objective of human action should be the greatest good for the greatest number of people. Individual actions are judged on whether they increase overall happiness or well-being. Unlike other ethical principles, utilitarianism does not judge actions on motives or beliefs, but on consequences and outcomes. In economics, it shares some aspects with individual utility theory, but utilitarianism would not endorse self-directed individual actions without regard to their collective consequences.

Techniques such as benefit–cost analysis can be consistent with utilitarianism, although there are sometimes formidable technical problems in assigning monetary costs to actions (Kelman 2000). For example, in environmental and ecological economics, there are different plausible long-term discount rates for carbon reduction or dollar

values assigned to human life or biodiversity. Specific numerical choices will heavily influence a cost–benefit calculation and can result in a wide possible range of outcomes.

RICHARD M. MCGAHEY

See also: Utility, Utility function, Expected utility theory (EUT), Objective well-being, Subjective well-being, Happiness, Benefit–cost analysis (BCA), Rawlsian ethics.

Reference

Kelman, S. 2000. "Cost–benefit analysis: an ethical critique (with replies)," pp. 355–70 in Economics of the Environment: Selected Readings, 4th edn. R.N. Stavins, ed. New York: W.W. Norton.

Utility

Economics:

a. The intangible value, satisfaction, happiness, or welfare that a person receives from purchasing or consuming a good or service. Economists have traditionally assumed and argued that consumers are utility-maximizing agents. However, research in behavioral economics has shown that this is not always the case (Kahneman & Thaler 2006).
b. In welfare economics, the utility possibilities curve shows the maximum amount of one person's utility given the level of utility achieved by all other people in society. All points on this curve are, by definition, Pareto-efficient and maximize social welfare (Bator 1957).
c. A company that provides essential public services to consumers, such as electricity, natural gas, water and wastewater, solid waste disposal, and telecommunications (Crew & Kleindorfer 1986).

BARRY D. SOLOMON

Further reading

Kaldor 1939.

See also: Utility function, Expected utility theory (EUT), Law of diminishing marginal utility, Pareto optimality, Bounded rationality, Behavioral economics, Welfare economics.

References

Bator, F.M. 1957. The simple analytics of welfare maximization. American Economic Review 47(1): 22–59.
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Kahneman, D. & Thaler, R.H. 2006. Anomalies: utility maximization and experienced utility. Journal of Economic Perspectives 20(1): 221–34.
Kaldor, N. 1939. Welfare propositions of economics and interpersonal comparisons of utility. Economic Journal 49(195): 549–52.

Utility function

An economic concept that associates a degree of satisfaction to each potential level of consumption of goods and services. The maximization of the utility function means that an agent makes their economic choices in a way to receive the greatest possible satisfaction, given the constraints they face (notably, income). This supposes that people have an implicit ranking of all consumption alternatives, and economic choices are the expression of this ranking (Debreu 1954).

Utility is supposed to increase with the level of consumption at a decreasing rate, which implies that consumption of a variety of goods and services is preferred to the consumption of one good or service in a larger quantity. The arguments of a standard utility function are the quantities of goods and services (choice variables). In the duality framework, the arguments of indirect utility functions are the prices of goods and services (parameters) (Varian 1992). Expected utility functions (von Neumann & Morgenstern 1953) and prospect theory (Kahneman & Tversky 1979) help to understand choices that depend on uncertain events. Intertemporal utility functions help to understand choices that impact the future (Friedman 1957; Modigliani 1988). They are particularly useful in ecological economics.

The aggregation of individual utility functions into a social welfare function helps the decision-maker to choose between different states of the world, from a Pareto-improving perspective (increasing all individual utility levels) or from a distributive perspective

(increasing some utility levels at the expense of some others; see, e.g., Arrow 1963).

Tristan Le Cotty

Further reading

Bentham 1789; Mill 1863.

See also: Utility, Law of diminishing marginal utility, Social welfare function, Preference formation, Preference endogeneity, Preference heterogeneity, Pareto optimality, Uncertainty, Prospect theory, Utilitarianism.

References

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V

Value added

The monetary value increase provided by labor and capital to account for improvements made to a given economic good or service over its input costs at each stage of the production process. Value added per unit of output is the difference between the unit's profit and the unit labor cost, plus the depreciation cost of the capital stock. More than 80 percent of the countries in the world use a value-added tax (VAT) in lieu of a sales tax, which is assessed incrementally at each stage of production, distribution, and sale of goods and services (the tax is called a goods and services tax in some countries) to end-use consumers, though exports are often exempt from VAT (Tait 1988; Keen & Lockwood 2010).

BARRY D. SOLOMON

See also: Net value added, System of National Accounts (SNA), Value chain analysis.

References

Keen, M. & Lockwood, B. 2010. The value added tax: its causes and consequences. Journal of Development Economics 92(2): 138–51.

Tait, A.A. 1988. Value Added Tax: International Practices and Problems. Washington, DC: International Monetary Fund.

Value chain analysis

A framework used to map and categorize processes of an individual firm or overall system (that is, industry sector, supply chain, distribution network, or national economy). A value chain analysis takes on a product or spatial orientation, as well as an economic, socio-economic, or environmental focus (from Fasse et al. 2011) to help institutions and enterprises understand their value chain positioning and identify opportunities for improvement (Rawlins et al. 2018; Sterman

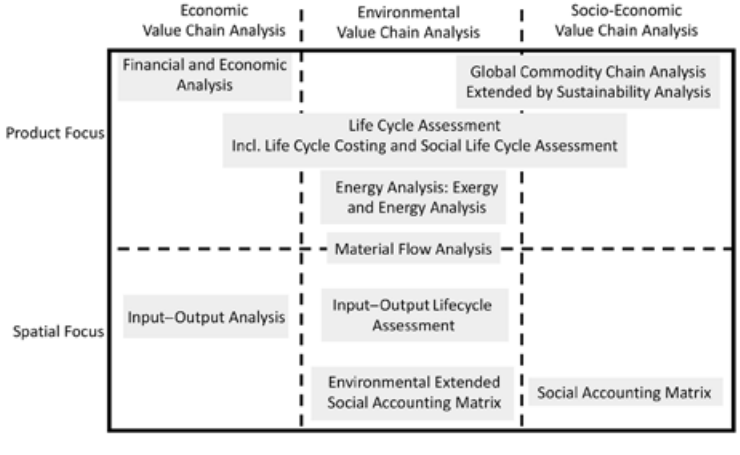

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Figure 21 Value chain analysis

2000). Methods of value chain analyses are shown in Figure 21 (Fasse et al. 2011).

Traditionally, value chain analysis focused on value-added of all interdependent activities or agents within the life cycle of a good or service, from conception through production, consumption, or utilization, and finally waste disposal (Kaplinsky & Morris 2001). The origins of value chain analysis can be traced to the *filière* approach to agriculture in the 1960s (Webber & Labaste 2010, p. 10), Immanuel Wallerstein's (1974) "commodity chain" concept, Michael Porter's (1990) "value-chain" concept, and Gary Gereffi's (1994) "global commodity chain" concept.

TRACEY J. KATOF

See also: Commodity supply chain, Supply chain management, Value added, Net value added, Life-cycle assessment (LCA), Input-output (I–O) analysis, Energy analysis, Exergy.

References

Fasse, A., Grote, U. & Winter, E. 2011. Recent developments in applying environmental value chain analysis. Environmental Economics 2(3): 74–86.

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Value judgments

Pronouncements of the worth of objects in relation to individuals; that is, the value which the individuals attached to the objects. It is a socially held objective evaluation of things. For example, "Energy conservation is a morally adorable act," is a judgment of value. The object of social experience in energy conservation reflects a social ideal, which is given with a value. Individuals experience it as obligations, duties, and restraints on their behavior. When an individual expresses the worth of a thing or an object of interest in relation to them, they are not only affirming its existence, but also psychologically demonstrating its "validity" by supporting it with impersonal arguments of value. The value of a thing may simply be the realization or non-realization of the effects (favorable or unfavorable) that it produces. When the effects of the act performed are favorable and appreciated, a positive value is ascribed, and vice versa.

CHOY YEE KEONG

Further reading

Durkheim 1953, 1958; Perry 1954; Choy 2020.

See also: Incommensurable values, Existence value, Intrinsic value, Amenity value, Cultural values, Duty, Obligation.

References

Choy, Y.K. 2020. Global Environmental Sustainability: Case Studies and Analysis of the United Nations' Journey Toward Sustainable Development. Amsterdam: Elsevier.

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Perry, R.B. 1954. Realms of Value: A Critique of Human Civilization. Cambridge, MA: Harvard University Press.

Vertical integration

A business strategy that involves a firm acquiring or controlling two or more stages of a supply chain of a product or service. For example, a fully vertically integrated petroleum corporation would have businesses involved in crude oil exploration, drilling, production, storage, transportation, refining, and marketing. Vertical integration can

occur through acquisition, merger, or internal expansion. The purpose of vertical integration is to increase economic efficiency and economies of scale, reduce costs, and reduce uncertainty. However, vertical integration can indirectly lead to decreased competition in an industry if an integrated firm gains the ability to foreclose rival companies from suppliers or customers. If this practice substantially lessens competition, it can violate antitrust laws.

Historically the steel, petroleum, automobile, and livestock industries, among others, have practiced vertical integration. Vertical mergers of firms have been scrutinized less aggressively than horizontal mergers by antitrust agencies, since horizontal integration has historically been assumed to be more likely to result in anti-competitive behavior.

BARRY D. SOLOMON

Further reading

Yergin 2008; Hilimire 2011.

See also: Fossil fuels, Agribusiness, Horizontal integration, Market power, Market failure, Market imperfections.

References

Hilimire, K. 2011. Integrated crop/livestock agriculture in the United States: a review. Journal of Sustainable Agriculture 35(4): 376–93.

Yergin, D. 2008. The Prize: The Epic Quest for Oil, Money and Power. New York: Free Press.

Viability analysis

An investigation of the states, controls, and thresholds that ensure the safety and good health of a dynamic natural system; that is, its ability to meet different constraints over time. Over the past several decades, the viability approach has been shown to be adaptable and applicable across a wide range of environmental and ecological contexts, including fishery management, exhaustible resource management, water management, land use, and conservation biology.

Eco-viability analysis (EVA) builds on the viability approach, specifically focusing on social-ecological system (SES) management, along with ecological-economic constraints. Population viability analysis (PVA) focuses on ecological constraints. The strong links between EVA and the other modeling approaches for sustainability, including the "safe operating space" (SOS), the "tolerable window approach" (TWA), and safe minimum standard (SMS), have been identified. Viability also extends the "maximin" approach to cope with intergenerational equity.

Another major interest of this approach for sustainability modeling stems from its multi-criteria viewpoint, which relates to strong sustainability. Links between viability and resilience or risk management have also been pointed out in numerous recent works using stochastic viability. The "viability kernel" plays a crucial mathematical role in viability analysis as the set of initial states from which exist controls, states, dynamics, and thresholds satisfying the viability constraints over time.

LUC DOYEN

Further reading

Aubin 1990; Béné et al. 2001; Baumgärtner & Quaas 2009; Doyen & Martinet 2012; Schuhbauer & Sumaila 2016; Oubraham & Zaccour 2018; Doyen et al. 2019.

See also: Sustainability, Resilience, Ecosystem resilience, Safe minimum standard (SMS), Social-ecological systems, Strong sustainability, Conservation biology, Fisheries management, Exhaustible resource theory.

References

Aubin, J.P. 1990. A survey of viability theory. SIAM Journal on Control and Optimization 28(4): 749–88.

Baumgärtner, S. & Quaas, M.F. 2009. Ecological-economic viability as a criterion of strong sustainability under uncertainty. Ecological Economics 68(7): 2008–20.

Béné, C., Doyen, L. & Gabay, D. 2001. A viability analysis for a bio-economic model. Ecological Economics 36(3): 385–96.

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Oubraham, A. & Zaccour, G. 2018. A survey of applications of viability theory to the sus-

tainable exploitation of renewable resources. Ecological Economics 145: 346–67.
Schuhbauer, A. & Sumaila, U.R. 2016. Economic viability and small-scale fisheries—a review. Ecological Economics 124: 69–75.

Violence in environmental conflict

The study of violence from a broad environmental perspective. For this, Navas et al. (2018, p. 650) have proposed a multidimensional approach, namely, a focus "in which violence is defined as an action or a process that appears in visible and unseen forms against humans, nature, and the sustainability of their relations." Based on different authors, multidimensional violence includes direct, cultural, and structural violence (Galtung 1969), slow violence (Nixon 2011), and ecological violence (Peluso & Watts 2001). As Navas and colleagues showed, these forms of violence can appear and overlap in environmental conflicts, since one form of violence can lead to another. Other forms might also be added depending on the context in which environmental conflicts are embedded.

Grettel V. Navas

Further reading

Martínez-Alier & Roy 2019.

See also: Ecological distribution conflicts, Political ecology.

References

Galtung, J. 1969. Violence, peace, and peace research. Journal of Peace Research 6(3): 167–91.
Martínez-Alier, J. & Roy, B. 2019. Editorial: some insights on the role of violence. Ecology, Economy and Society—the INSEE Journal 2(1): 27–30.
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Nixon, R. 2011. Slow Violence and the Environmentalism of the Poor. Cambridge, MA: Harvard University Press.
Peluso, N.L. & Watts, M., eds. 2001. Violent Environments. Ithaca, NY: Cornell University Press.

Virtual water

The volume of water used to produce commodities (Allan 1998, 2003). More recently understood as the volume of water consumed and/or polluted to produce products or services, aggregated across all stages of the supply chain (Hoekstra et al. 2011). Typically used in the context of international (or interregional) trade, particularly in agricultural commodities, to highlight: (1) the spatial disconnect between where water inputs occur in production and the location of final consumption; and (2) the "flows" of water associated with imports/exports.

Benjamin H. Lowe

See also: Water footprint, Water economics, Commodity supply chain, Embeddedness.

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Hoekstra, A.Y., Chapagain, A.K., Aldaya, M.M. & Mekonnen, M.M. 2011. The Water Footprint Assessment Manual: Setting the Global Standard. London: Earthscan.

Virtual wealth

A concept introduced by Frederick Soddy, the total value of real assets that the community voluntarily abstains from holding to hold money instead (Soddy 1926; Daly 1980). Since individuals can easily convert their money into real assets, they count their money holdings as wealth. Yet the community cannot convert money into wealth because someone must end up holding the money. Money wealth is therefore "virtual." Much of the wealth in stock, land, and other assets with inelastic supply is also virtual. When supply is highly inelastic, price is determined primarily by demand. Rising prices can increase demand in a positive feedback loop, creating a market bubble. The United States stock market, for example, increased in notional value by over 100 percent from

March 2020 through August 2021, and the owners of those stocks treated their market value as wealth. However, if a significant number of stockholders attempt to sell their stocks, the price will plunge. Wealth created by market bubbles is therefore "virtual" as well.

JOSHUA C. FARLEY

Further reading

Daly & Farley 2011.

See also: Money, Wealth, Exchange value.

References

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Soddy, F. 1926. Wealth, Virtual Wealth and Debt. New York: E.P. Dutton & Company.

Vulnerability

Ecology: an ecosystem's propensity to suffer harm from exposure to external social or environmental stressors. If a system is exposed, sensitive, and unable to adapt effectively to changes in the biogeochemical cycles and energy/matter fluxes, then it will not be able to maintain its essential functions, identities, and structures or its ability to adapt to future changes, and it will become vulnerable, which may lead to a regime shift.

Economics: the condition of an economic system that, given its exposure to suffering undesirable changes from exogenous shocks and stresses, is susceptible to the loss of the structures and conditions on which individuals and communities directly rely.

GABRIEL LOPEZ PORRAS

Further reading

Miller et al. 2010; Gunderson et al. 2010; Reed & Stringer 2016; Noy & Yonson 2018.

See also: Resilience, Ecosystem resilience, Stressors, Disturbance, Perturbation, Ecological perturbation.

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W

Walrasian and post-Walrasian economics literature

a. Of or relating to the mathematical formalization of general equilibrium, heralded as marking the transition to neoclassical economics. The general equilibrium describes the notion that surpluses or shortages in one market must imply shortages or surpluses in another market, thus creating a general, economy-wide equilibrium. Concerns analysis of supply and demand and their interaction in the determination of market prices. Determines, through the "invisible hand," the efficient allocation capital in an economy.
b. Implies that consumers and producers are perfectly rational and aim to maximize utility through consumption and profit maximization, respectively (Gowdy 2009).
c. Implies that prices are perfect proxies for utility and reflect all relevant information regarding goods and services (Farley et al. 2015; Gowdy & Erickson 2005).
d. Keynesian analysis argues, alternatively, that surplus or shortage in one market does not necessarily imply a shortage or surplus in another market and implies that an economy-wide general equilibrium does not universally exist.
e. Ecological economics generally argues that the marginal analysis of general equilibrium does not apply to thresholds (Farley et al. 2015), and that utility alone does not capture the complexity, interrelatedness, and feedback loops inherent in social and ecological systems.

Joseph A. Ament

See also: General equilibrium model, Utility, Neoclassical economics, Post-Keynesian economics.

References

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Warm glow effect

A term coined by the economist James Andreoni (1989, 1990) to describe the positive emotional reaction (pleasure or joy) people can feel when they help others or otherwise engage in charitable and pro-social behavior, including pro-environmental behavior. It is debatable whether warm glow is an indicator of people's pure and innate altruism, or whether the effect renders pro-social actions ultimately selfish (or "impurely" altruistic) since the helper gains individual "utility" from this internal emotional reward (e.g., Elster 2011, pp. 67–83).

Julian Rode

See also: Pro-social behavior, Pro-environmental behavior (PEB), Altruism, Utility.

References

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alence. Journal of Political Economy 97(6): 1447–58.
Andreoni, J. 1990. Impure altruism and donations to public goods: a theory of warm-glow giving. Economic Journal 100(401): 464–77.
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Waste absorption capacity

An ecosystem service, defined as the capacity of an ecosystem to absorb waste: (a) the total amount of land, air, and water available to absorb waste; or (b) the total amount of land available to absorb waste, expressed in hectares (Jiao et al. 2013). If human demand for waste absorption capacity exceeds available supply, there is a deficit and a condition of unsustainability. Waste absorption capacity is impacted by the removal/degradation of ecosystem structures. As absorption capacity is rival, the rate of discharge of waste into the ecosystem further decreases available capacity for future discharges (Farley 2012). Systems dynamics and thresholds impact the ability of an ecosystem to provide waste absorption services. Generally, ecosystems are more equipped to process biological waste compared to waste from mineral/abiotic resources (Daly & Farley 2004, pp. 107–10).

Waste absorption capacity can be calculated by multiplying the available area of land of a given land use type by the absorptive factor of the land use type. To assess the sustainability of waste generation, the waste absorption capacity can be compared to the waste absorption footprint of a given region (global, national, subnational).

Allison R. Elgie

See also: Assimilative capacity, Waste absorption footprint, Biotic resources, Abiotic resources, Waste management, Sustainable waste disposal, Ecological footprint, Carbon footprint.

References

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Jiao, W., Min, Q., Cheng, S. & Li, W. 2013. The waste absorption footprint (WAF): a methodological note on footprint calculations. Ecological Indicators 34: 356–60.

Waste absorption footprint

A given activity or human population's requirement for land and water area to absorb the waste that it generates, measured in hectares (Jiao et al. 2013). To assess the sustainability of waste generation, the waste absorption footprint can be compared to the waste absorption capacity of a given region (global, national, subnational).

Allison R. Elgie

Further reading

Jiao et al. 2015.

See also: Waste absorption capacity, Waste management, Sustainable waste disposal, Ecological footprint, Carbon footprint.

References

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Waste management

All the activities and actions required to manage waste from its point of generation to final disposal. Waste reduction, recycling, material/energy recovery, intermediate treatment, and final disposal should be systematically integrated and optimized using policy measures, engineering approaches, and integrated assessments in order to achieve the goal of zero waste disposal in society. An

appropriate hierarchy might be set up according to the contemporary lifestyle, social customs, government budgets, and available technology options. In addition to any technological limitation, public consensus and political power should also play important roles in waste management. The "stakeholders" of waste management should include the biosphere, as well as inter- and intragenerational human populations. The goal would be the formation of a zero-waste society.

YU-CHI WENG

Further reading

Cossu 2009; Pires et al. 2011; Weng & Fujiwara 2011.

See also: Sustainable waste disposal, Wastewater, Benefit–cost analysis (BCA), Life-cycle assessment (LCA).

References

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Pires, A., Martinho, G. & Chang, N.B. 2011. Solid waste management in European countries: a review of systems analysis techniques. Journal of Environmental Management 9(4): 1033–50.

Weng, Y.C. & Fujiwara, T. 2011. Examining the effectiveness of municipal solid waste management systems: an integrated cost–benefit analysis perspective with a financial cost modeling in Taiwan. Waste Management 31(6): 1393–1406.

Wastewater

Used water. Sources include toilets, sinks, showers, bathtubs, dishwashers, washing machines, faucets, and industrial and commercial processes including sewage treatment plants. Wastewater is a major point source of water pollution.

BARRY D. SOLOMON

Further reading

Tchobanoglous et al. 2014.

See also: Effluent, Pollutant, Pollution, Polluted, Pollution abatement, Waste management.

Reference

Tchobanoglous, G., Stensel, H.D., Tsuchihashi, R. & Burton, F. 2014. Introduction to wastewater treatment and process analysis, pp. 1–56 in Wastewater Engineering: Treatment and Resource Recovery, 5th edn. New York: McGraw-Hill Education.

Water economics

An interdisciplinary subdiscipline of applied economics and/or natural resource economics that brings together economics, hydrology, sociology, law, meteorology, engineering, and other disciplines as required, to understand and to analyze water-related challenges. Examples of water economics research and analysis include: the socio-economic analysis of alternative levels of water extractions for irrigation; and the pricing of household water that maximizes expected net benefits to water users while ensuring all water supply costs are recovered.

R. QUENTIN GRAFTON

Further reading

Griffin 2016; Young & Haverman 1985.

See also: Water resources, Available water capacity, Water governance, Integrated water resources management (IWRM), Groundwater governance, Applied economics, Natural resource economics.

References

Griffin, R.C. 2016. Water Resource Economics: The Analysis of Scarcity, Policies, and Projects, 2nd edn. Cambridge, MA: MIT Press.

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Water–energy–food nexus

The interdisciplinary study of the strong interdependencies and feedback effects among the water, energy, and food sectors, the trilemma of resource scarcity, and asso-

ciated policy initiatives. These three sectors are critically important for poverty reduction, human well-being, and sustainable development (FAO 2014).

The nexus is probably most clearly demonstrated by the biofuel industry in the United States, where the main feedstock is maize, a water-intensive and environmentally destructive food crop (Solomon 2010). The water–energy–food (WEF) nexus has invariably been discussed through a security lens; for example, by considering the biofuel policy impacts on food and water security, or in river basins where the competing demands for water can heighten the trade-offs and opportunity costs of water use for farming, electricity generation, and urban and environmental needs (Leck et al. 2017).

The WEF nexus first rose to prominence in development and policy discourses in 2011 (Hoff 2011; Waughray 2011; Bazilian et al. 2011) and sometimes also includes climate as a fourth realm. The demand for water, energy, and food all continue to grow in the 21st century, as the climate problem worsens.

BARRY D. SOLOMON

See also: River basin management, Integrated water resources management (IWRM), Watershed management, Water governance, Energy access, Sustainable energy assessment models, Food security, Sustainable Development Goals (SDGs).

References

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Leck, H., Fitzpatrick, D. & Burchell, K. 2017. "Energy, water and food: towards a critical nexus approach," pp. 411–24 in Handbook on the Geographies of Energy. B.D. Solomon & K.E. Calvert, eds. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Solomon, B.D. 2010. Biofuels and sustainability. Annals of the New York Academy of Sciences 1185: 119–34.

Waughray, D., ed. 2011. Water Security. The Water–Food–Energy–Climate Initiative. Washington, DC: Island Press.

Water footprint

Modeled after and inspired by the ecological footprint, a metric that accounts for the total volume of freshwater used in the production or supply of goods and services used by a person, a group of people, community, city, state, province, country, or produced by a business. Thus, the calculation tracks all "embodied water," which is sometimes also called "virtual water." First introduced in 2002 by Arjen Hoekstra in the Netherlands, the water footprint was developed to be a consumption-based indicator of water use (Chapagain & Hoekstra 2004).

a. A "blue water footprint" is the volume of water from surface and groundwater sources that has either been incorporated into a product, evaporated, taken from one water source and returned to another, or returned at a different time.
b. A "gray water footprint" is the water volume required to dilute pollutants to meet applicable water quality standards.
c. A "green water footprint" is the water volume from precipitation that after being stored in the soil's root zone is either incorporated by plant growth or lost to evapotranspiration.

BARRY D. SOLOMON

Further reading

Hoekstra & Chapagain 2006; Hoekstra et al. 2012.

See also: Ecological footprint, Virtual water, Available water capacity, Water–energy–food nexus, Carbon footprint, Material footprint.

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Water governance

a. An analytical concept to describe the relationships between the state, stakeholders, and society, in respect of water. Water governance encompasses the related concepts of water policy, or the instruments and mechanisms used to achieve a certain outcome; water politics, or the power relations between different actors; and water polity, or the institutions in which decision-making regarding water takes place (Schulz et al. 2017).
b. A normative concept to describe more flexible, constructive, and participatory approaches for governing water, which challenge traditional hierarchical relationships between the state and society, often captured under the headline "from government to governance" (Yazdanpanah et al. 2013).

CHRISTOPHER SCHULZ

Further reading

Antunes et al. 2009; Benson et al. 2015; Castro 2007; Cleaver & Hamada 2010; Lautze et al. 2011; Pahl-Wostl 2017.

See also: Groundwater governance, Governance, Environmental governance, Integrated water resources management (IWRM).

References

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Benson, D., Gain, A.K. & Rouillard, J.J. 2015. Water governance in a comparative perspective: from IWRM to a "nexus" approach? Water Alternatives 8(1): 756–73.
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Pahl-Wostl, C. 2017. An evolutionary perspective on water governance: from understanding to transformation. Water Resources Management 31(10): 2917–32.
Schulz, C., Martin-Ortega, J., Glenk, K. & Ioris, A.A.R. 2017. The value base of water governance: a multi-disciplinary perspective. Ecological Economics 131: 241–9.
Yazdanpanah, M., Thompson, M., Hayati, D. & Zamani, G.H. 2013. A new enemy at the gate: tackling Iran's water super-crisis by way of a transition from government to governance. Progress in Development Studies 13(3): 177–94.

Water resources

Natural resources of water that are essential for the existence and survival of humans and other natural organisms, including plants and the ecosystem they live in. It provides economic benefits to society both directly as an existential commodity used for drinking, washing, and bathing, and indirectly as a raw material used for producing other essential goods (for example, food, fuel, fiber, and so on) and services (for example, wildlife habitat) for human consumption.

The economic value of water depends on its natural scarcity, quality, and the competing uses it has at a given time and location. Although the total available water is abundant in nature, the quantity, timing, and distribution of usable freshwater are limited. Given the fixed or declining supply and the growing demand, water scarcity has risen worldwide.

Water sources are often viewed as renewable resources. However, should the rate of consumption exceed the rate at which a given water body is replenished each year, the same may become a non-renewable resource in the long run. Most of the usable freshwater comes from natural sources such as groundwater, surface water, snowmelt, and frozen water. A small portion of it is derived from desalinization of salt water.

MAHADEV G. BHAT

Further reading

Anisfeld 2010.

See also: Virtual water, Water governance, Water footprint, Renewable resource.

Reference

Anisfeld, S.C. 2010. Water Resources. Washington, DC: Island Press.

Watershed

a. The entirety of a region that drains through a common terminus, typically an outflowing river, reservoir, mouth of a bay, or any point along a stream channel. It is demarcated by ridges of highest elevation that divide where rainfall flows and snow melts. Watersheds can be as small as a footprint or large enough to encompass all the land that drains water into rivers (USGS n.d.).
b. The boundary that separates water flowing to multiple rivers (Creed & van Noordwijk 2018, p. 181).

The shared hydrology means that other biophysical systems are linked with upper-stream regions influencing low-stream ones (Haddad 2017). These interactions make a watershed more than a simple hydrological unit, but also a socio-ecological and political entity that plays a crucial role in providing life support services to rural people (Wani & Garg 2009).

PAOLA OVANDO

See also: Catchment area, River basin management, Integrated water resources management (IWRM), Water governance.

References

Creed, I.F. & van Noordwijk, M. 2018. Forest and Water on a Changing Planet: Vulnerability, Adaptation and Governance Opportunities. Vienna: International Union of Forest Research Organizations.

Haddad, B.M. 2017. The economics of watershed management. Encyclopedia Entry: Oxford Research Encyclopedia of Environmental Science. https://doi.org/10.1093/acrefore/9780199389414.013.526.

USGS (US Geological Survey). n.d. Watersheds and drainage basins. https://water.usgs.gov/edu/watershed.html.

Wani, S.P. & Garg, K.K. 2009. "Watershed management concept and principles," in Best-bet Options for Integrated Watershed Management: Proceedings of the Comprehensive Assessment of Watershed Programs in India, July 25–27, 2007, ICRISAT Patancheru, Andhra Pradesh, India.

Watershed management

Begins with multidisciplinary (economic, environmental, hydrological) studies of a drainage region followed by setting management goals and policies, implementing them, and evaluating outcomes. The process is ideally repeated following multi-year intervals. Due to the hydrological link of drainage and outflow, activities occurring high in a watershed, such as logging and road-building, can impact lower-elevation regions through flooding and landslides. Conversely, a dam built downstream can cause permanent flooding upstream beneath the reservoir. These impacts have spurred the call for comprehensive management of watersheds, not just management of, for example, a river and its riparian zone (Haddad 2017).

Watershed management is easier when the entire watershed falls within a single jurisdiction, but this is frequently not the case with international watersheds shared by two or more nations.

BRENT M. HADDAD

See also: Watershed, Catchment area, Multidisciplinary.

Reference

Haddad, B.M. 2017. The economics of watershed management. Encyclopedia Entry: Oxford

Research Encyclopedia of Environmental Science. https://doi.org/10.1093/acrefore/9780199389414.013.526.

Weak sustainability

Based on the work of neoclassical economists Robert Solow (1974) and John Hartwick (1977), the requirement that the sum of various categories of capital be maintained over time as a condition for non-declining well-being. Weak sustainability is most frequently considered in relation to human-made (manufactured) capital (infrastructure, buildings, and equipment) and natural capital (the materials, energy, and ecosystem services provided by nature). Under weak sustainability, manufactured capital and natural capital are assumed to be very close substitutes. Consequently, an economy is weakly sustainable if the sum of human-made and natural capital is non-declining over time. The ascertainment of whether this condition is being met, or is expected to be met, requires the use of a common unit of measurement. Market prices are used where available. In their absence, "shadow" prices are estimated despite concerns about their meaning and validity, especially when applied to natural capital.

Weak sustainability underlies indicators of sustainable economic development such as genuine saving (Hamilton 2000), now more commonly termed adjusted net saving (ANS), and comprehensive wealth (IISD 2018). Weak sustainability is contrasted with strong sustainability, where human-made capital and natural capital are considered complements rather than substitutes. Strong sustainability requires the maintenance of both manufactured and natural capital over time, rather than just their total, avoiding the use of a common unit of measurement.

PETER A. VICTOR

Further reading

Neumayer 2013; Victor 1991, 2020; Hanley et al. 2015.

See also: Solow sustainability, Hartwick rule, Strong sustainability, Capital, Manufactured capital, Natural capital, Human capital, Genuine saving, Adjusted net saving (ANS), Shadow price.

References

Hamilton, K. 2000. Genuine saving as a sustainability indicator. Washington, DC: World Bank, Environment Department papers no. 77, Environmental Economics Series.

Hanley, N., Dupuy, L. & McLaughlin, E. 2015. Genuine savings and sustainability. Journal of Economic Surveys 29(4): 779–806.

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Solow, R.M. 1974. Intergenerational equity and exhaustible resources. Review of Economic Studies 41: 29–45.

Victor, P.A. 1991. Indicators of sustainability: some lessons from capital theory. Ecological Economics 4(3): 191–213.

Victor, P.A. 2020. Cents and nonsense: a critical appraisal of the monetary valuation of nature. Ecosystem Services 42: 101076.

Wealth

Classical and neoclassical economics: a value anthropocentrically measured by the monetary value of both tangible (physical) and intangible (financial) assets, minus debts. Wealth is a stock while income is a flow. Historically, wealth has been defined differently according to the lives and times of proponents of various economic philosophies. Adam Smith (1776 [1977]), who was influenced by the physiocrats, defined the source of "real wealth" as "the annual produce of the land and labor of the society" (p. 12). Subsequently, the source of wealth continued to be redefined with labor taking emphasis during industrialization, culminating with a break from its biophysical basis and turning the focus to capital with the marginal revolution of the late 19th century. Ever since, economists have focused more on

human-made wealth than on natural wealth, and treat the liquidation of nature as income.

Ecological economics: low-entropy energy-matter is considered the ultimate source of wealth, a perspective that can overcome the dualism between humans and nature that money creates. Frederick Soddy (1926, 1933) and Herman Daly (1986) understood that the virtual nature of money/debt, subject to the laws of mathematics, was incompatible with the entropic nature of real wealth because it would be impossible to convert all money into tangible assets, since someone must be left holding the money, and debt can grow at an exponential rate while real wealth is biophysically limited. Moreover, Kenneth Boulding (1949) argued that capital stocks (real wealth) were a better measure of economic welfare than income/consumption (gross domestic product), and called for the latter to be minimized. Therefore, what truly matters is not an aimless obsession with maximizing consumption and virtual wealth, but how we sustainably manage our real wealth, defined as essential biophysical requirements for life. The Hawaiian word for wealth for example, is *waiwai*, which means having an abundance of freshwater.

RIGO E.M. MELGAR

See also: Physiocrats, Virtual wealth, Stocks, Flows, Capital, Welfare, Economic welfare.

References

Boulding, K.E. 1949. Income or welfare. Review of Economic Studies 17(2): 77–86.

Daly, H.E. 1986. "The economic thought of Frederick Soddy," pp. 199–218 in Frederick Soddy (1877–1956): Early Pioneer in Radiochemistry. G.B. Kauffman, ed. Dordrecht: D. Reidel Publishing Company.

Smith, A. 1776 [1977]. An Inquiry into the Nature and Causes of the Wealth of Nations. Chicago, IL: University of Chicago Press.

Soddy, F. 1926. Wealth, Virtual Wealth, and Debt. New York: E.P. Dutton.

Soddy, F. 1933. Wealth, Virtual Wealth and Debt: The Solution of the Economic Paradox, 2nd edn. London: George Allen & Unwin.

Wealth distribution

Neoclassical economics: describes the relative shares in the wealth of society, nation, or some other grouping of individuals. The narrow interpretation defines wealth quantitatively as an accumulation of valuable assets, including but not limited to productive capital. Because it ignores the capacity to produce income from human labor, a population's wealth distribution is invariably more unequal than its income distribution.

Ecological economics: can also include assets with qualitative or intangible values as part of wealth. Such assets, difficult or impossible to render in monetary equivalents, include ecosystems, human intellectual capacity, and possibly even social capital. Conceptually they are not unlike what traditional economists refer to as factors of production. In addition to traditional monetary wealth, richer countries tend to be far more abundant than developing countries in these qualitative types of assets. But because such wealth values can generally not be measured with any precision, it is impossible to quantitatively ascertain the extent of inequality in the global wealth distribution.

MARIANO TORRAS

Further reading

Davies et al. 2009; Wolff 2016; Soddy 1933.

See also: Wealth, Economic inequality, Stocks, Flows, Stock-flow consistent models, Natural capital, Human capital, Social capital.

References

Davies, J.B., Sandstrom, S., Shorrocks, A. & Wolff, E.N. 2009. "The world distribution of wealth," pp. 149–62 in The Global Social Policy Reader. C. Holden & N. Yeates, eds. Bristol: Policy Press.

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Wolff, E.N. 2016. Household wealth trends in the United States, 1962 to 2013: what happened over the Great Recession? RSF: The Russell Sage Foundation Journal of the Social Sciences 2(6): 24–43.

Wealth inequality

See: Economic inequality.

See also: Inequality, Inequity.

Welfare

See: Total human welfare.

See also: Economic welfare, Welfare economics, Measures of economic welfare, Social welfare function, Index of sustainable economic welfare (ISEW), Well-being economy.

Welfare economics

The branch of economics that measures the effects of economic policies on social welfare, which is described by a social utility function that represents the aggregation of single individual utilities. As economist Amartya Sen pointed out, defining social preferences by aggregating individual rankings (welfarism) is intrinsically problematic (Sen 1979).

There are two theorems of welfare economics: any allocation associated with a competitive market equilibrium is Pareto-optimal; and any Pareto-optimal allocation can be achieved as a competitive market equilibrium. Given that any Pareto-optimal allocation corresponds to a different income distribution in the economy, a social utility function might be defined regardless of the actual conditions of the individuals. The Kaldor–Hicks compensation principle, introduced in 1939, tried to mitigate the Pareto principle applied to social welfare by proposing that gainers could potentially compensate losers and still remain better off (Kaldor 1939; Hicks 1939). Later, the Rawlsian utility function was introduced as a form of measurement of social welfare by considering the utility of the worst-off member of society (the maximin criterion) (Rawls 1971). Neoclassical welfare economics also provided a foundation for environmental economics.

GIANDOMENICA BECCHIO

Further reading

Backhouse et al. 2021.

See also: Utility, Pareto efficiency, Kaldor–Hicks efficiency criterion, Social welfare function, Environmental economics, Utilitarianism.

References

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Rawls, J. 1971. A Theory of Justice. Cambridge, MA: Harvard University Press.

Sen, A. 1979. Utilitarianism and welfarism. Journal of Philosophy 76(9): 463–89.

Welfare maximization

See: Welfare economics.

See also: Pareto optimality, Utility, Utility function.

Well-being economy

A framework that emerged in the late 2010s within the limits-to-growth debate. According to well-being economy (WE) advocates, continuous material growth is unsustainable not only insofar as it takes a heavy toll on natural resources and ecosystems, but also because it has a detrimental impact on social cohesion along with psychological and physical wellness. The WE framework shifts attention away from material production and consumption as the main purpose of economic development, to embrace a wide variety of social and environmental dynamics, which are viewed as fundamental contributors to human and ecological well-being.

In going beyond the concept of economic growth, the WE framework recognizes the contributions of natural, social, and human capital to collective well-being. In the WE

perspective, development can no longer be measured by composite indicators such as gross domestic product (GDP), which simply add the market value of material production and consumption, but requires a multidimensional approach measuring the state of natural ecosystems, collective health outcomes and life expectancy, as well as public trust and the quality of social relations. Since 2018, several national governments have adopted the WE framework as a guiding principle to design development policies and assess progress.

Lorenzo Fioramonti & Riccardo Mastini

Further reading

Fioramonti 2017; Fioramonti et al. 2019; Costanza et al. 2018, 2020; Coscieme et al. 2019.

See also: Objective well-being, Subjective well-being, Post-growth, Degrowth, Natural capital, Social capital, Human capital, Steady state economy.

References

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Wetland

Economics:

a. An area of land saturated with water.
b. A natural resource that provides a variety of environmental ecosystem services to the surrounding population. The monetary value of these services is generally assessed using either revealed preference (RP) or stated preference (SP) methods. Examples for RP applications include protected values of real estate and public infrastructure due to reduced flood risk, cost savings in downstream water treatment, and revenues from extractive activities (for example, fishing in large saltwater estuaries). Some recreation benefits may also be estimated via RP by examining visitors' travel behavior and expenses. In contrast, SP methods based on surveys and contingent valuation or choice experiments are often the only feasible approach to value habitat or biodiversity services. Open questions in wetland valuation include the extent of the "market": whose benefits should be counted, the conversion of ecosystem services to economic welfare measures (for example, increased water clarity, improved water quality, number of nesting birds, and so on), and the connection between nearby agricultural practices and other non-point sources of water pollution to wetland health and services.

Ecology: an ecosystem where the ground surface is either saturated or flooded with water permanently or seasonally. These include swamps, bogs, fens, peatlands, and can be either saltwater or freshwater wetlands.

Klaus Moeltner

Further reading

Turner et al. 2000; Mitsch & Gosselink 2000; Woodward & Wui 2001.

See also: Wetland ecosystem services, Revealed preference methods, Stated preference methods, Contingent valuation method (CVM), Choice experiments, Travel cost method, Participatory modeling.

References

Mitsch, W.J. & Gosselink, J.G. 2000. The value of wetlands: the importance of scale and landscape setting. Ecological Economics 35(1): 25–33.
Turner, R.K., van den Bergh, J.C.J.M., Söderqvist, T. et al. 2000. Ecological-economic analysis of wetlands: scientific integration for management and policy. Ecological Economics 35(1): 7–23.
Woodward, R.T. & Wui, Y.S. 2001. The economic value of wetland services: a meta-analysis. Ecological Economics 37(2): 257–70.

Wetland ecosystem services

The benefits that people obtain from wetlands, including food, fresh water, climate regulation, pollution control and detoxification, coastal protection, biodiversity, reduced flood risk, nature-based tourism, and spiritual and inspirational services, among many others.

Marcello Hernández-Blanco

Further reading

Millennium Ecosystem Assessment 2005; Hernández-Blanco & Costanza 2019; Hernández-Blanco et al. 2021.

See also: Wetland, Ecosystem services, Natural capital.

References

Hernández-Blanco, M. & Costanza, R. 2019. "Natural capital and ecosystem services," pp. 254–68 in The Routledge Handbook of Agricultural Economics. G.L. Cramer, K.P. Paudel & A. Schmitz, eds. London: Routledge.
Hernández-Blanco, M., Costanza, R. & Cifuentes-Jara, M. 2021. Economic valuation of the ecosystem services provided by the mangroves of the Gulf of Nicoya using a hybrid methodology. Ecosystem Services 49: 101258.
Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Wetlands and Water Synthesis. Washington, DC: World Resources Institute.

Wicked problems

Difficult, seemingly intractable or impossible problems to solve because of complex and/or contradictory requirements of the solutions. These problems have no consistent formulation or stopping rule and solutions are neither right nor wrong, but rather better or worse outcomes compared to the initial problem. The term was initially developed in the context of social planning (Churchman 1967; Rittel 1972; Rittel & Webber 1973) and is now used more broadly across disciplines to recognize unique issues beyond the regular rules of problem-solving.

Katie M. Kish

Further reading

Ackoff 1974; Schumacher 1977.

See also: Complexity, Post-normal science.

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Churchman, C.W. 1967. Wicked problems. Management Science 14(4): 141–6.
Rittel, H. 1972. On the planning crisis: systems analysis of the "first and second generations." Bedriftskonomen 8: 390–96.
Rittel, H.W.J. & Webber, M.M. 1973. Dilemmas in a general theory of planning. Policy Sciences 4(2): 155–69.
Schumacher, E.F. 1977. A Guide for the Perplexed. London: Jonathan Cape.

Wildlife conservation

Any human activity, action, program, or practice designed to protect wild animal and plant species and their habitats. The goal of wildlife conservation is to protect healthy and viable population levels and their habitats from a variety of threats, and to thereby sustain or increase biodiversity. Threats include habitat fragmentation, degradation, and destruction, overexploitation, poaching, invasive species, disease, pollution, and climate change. Wildlife species that are endangered or threatened are often, though not always, given additional protections by government agencies and private groups and

individuals, due to national conservation laws and international agreements and treaties.

BARRY D. SOLOMON

Further reading

Usher 1986; Margules & Usher 1981.

See also: Habitat, Habitat fragmentation, Habitat banking, Invasive species, Endangered species, Threatened species value, Viability analysis, Species richness, Biodiversity.

References

Margules, C. & Usher, M.B. 1981. Criteria used in assessing wildlife conservation potential: a review. Biological Conservation 21(2): 79–109.

Usher, B.B. 1986. "Wildlife conservation evaluation: attributes, criteria and values," pp. 3–44 in Wildlife Conservation Evaluation. M.B. Usher, ed. Wildlife Conservation Evaluation. Dordrecht: Springer.

Wildlife reserves

See: Conservation areas.

See also: Reserves, Wildlife conservation.

Willingness to accept (WTA)

The minimum price that a consumer is willing to accept to sell a good or service, or to accept as compensation to suffer a negative externality such as air or water pollution. Individuals' well-being can be affected by changes in the price of a certain good or service, and in the quantity of an externality. WTA, as price decreases or an improvement in quantity increases, measured as equivalent variation or surplus, would be the minimum payment, at current price and quantity levels, that one is willing to accept to voluntarily forgo the equivalent utility gain from the price and quantity improvement. As price increases and quantity decreases, the compensating welfare measures will be the minimum payment that the individual will be WTA as compensation to prevent a loss in utility at new prices and quantities, and remain at the initial utility level (Freeman 2003). WTA at current price and quantity, that is, as equivalent variations, makes it easier to judge the value of money and compare policy changes leading to different price changes (Varian 1992).

RONALDO SEROA DA MOTTA

Further reading

Kahneman et al. 1990; Hanemann 1991.

See also: Willingness to pay (WTP), WTP vs. WTA disparity, Income effects, Substitution effects, Endowment, Utility, Externalities, Environmental externalities.

References

Freeman, A.M. 2003. The Measurement of Environmental and Resource Values, 2nd edn. Washington, DC: Resources for the Future.

Hanemann, W.M. 1991. Willingness to pay and willingness to accept: how much can they differ? American Economic Review 81(3): 635–47.

Kahneman, D., Knetsch, J.L. & Thaler, R.H. 1990. Experimental tests of the endowment effect and the Coase Theorem. Journal of Political Economy 98(6): 1325–48.

Varian, H.R. 1992. Microeconomic Analysis, 3rd edn. New York: W. Norton & Company.

Willingness to pay (WTP)

The maximum price that a consumer is willing to pay for a good, service, or benefit. When the price decreases, an individual's well-being increases. The same gain of well-being applies to an increased quantity of a positive externality; for example, an improvement in the environment. So there will be a maximum WTP for a payment that an individual will be willing to make to enjoy the same utility level before the price and quantity improvement at the new price or quantity levels, the so-called compensating variation for price changes and compensating surplus for quantity changes. If a price of a certain good increases or a supplying quantity of a positive externality decreases, the WTP will be the maximum willingness to pay for a payment at the current price and quantity levels to avoid the equivalent loss

of utility resulting from price and quantity changes, the so-called equivalent variation for price changes and equivalent surplus for quantity changes (Freeman 2003). WTP at current prices and quantities—that is, from equivalent variation welfare measures—makes it easier to judge the value of money and compare policy changes leading to different price changes (Varian 1992).

RONALDO SEROA DA MOTTA

Further reading

Kahneman et al. 1990; Hanemann 1991.

See also: Willingness to accept (WTA), WTP vs. WTA disparity, Income effects, Substitution effects, Endowment, Utility, Externalities, Environmental externalities.

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World Bank

The International Bank for Reconstruction and Development, established in 1945 by the Bretton Woods (New Hampshire) conference of Allied Nations from World War II, as part of a broader effort to promote economic growth in developing countries. Its headquarters is in Washington, DC. The Bretton Woods conference was held before the war's conclusion, in July 1944, and established the International Monetary Fund to help stabilize the global financial system and promote trade. The World Bank is made up of member nations, and initially focused on long-term lending to developing countries for capital projects, although its first loan was made to France. The International Development Association (IDA) was established in 1960 as part of the World Bank Group to offer concessional loans and grants to the poorest developing countries.

Initial World Bank project support focused on infrastructure; for example, highways, seaports, dams, powerplants, and commercial logging. This led to harsh criticism in the 1980s from environmental groups and others that its lending was causing significant environmental and social damage in developing countries. Reforms have altered the lending policies of the World Bank. While it still focuses on economic growth and development, and most recently poverty alleviation, the World Bank adopted policies and procedures in the late 1980s and early 1990s to assess and mitigate the adverse environmental effects of its projects, and to increase the transparency and accountability of its lending operations. Other structural changes occurred to help the World Bank promote environmentally sustainable development (Dubash & Seymour 1999). Herman Daly was even hired by the Environment Department, and he led many reform efforts there from 1988 to 1994 (Daly 1994).

BARRY D. SOLOMON

Further reading

Kapur et al. 1997.

See also: Economic growth, Development, Economic development, Developing country, Sustainable development, Non-state actors.

References

Daly, H.E. 1994. Fostering environmentally sustainable development: four parting suggestions for the World Bank. Ecological Economics 10(3): 183–7.

Dubash, N.K. & Seymour, F. 1999. World Bank's Environmental Reform Agenda. Washington, DC: Institute for Policy Studies.

Kapur, D., Lewis, J.P. & Webb, R. 1997. The World Bank: Its First Half Century, Vol. 1: History. Washington, DC: Brookings Institution Press.

World Commission on Environment and Development (WCED)

A special commission established by the General Assembly of the United Nations in 1983, by Resolution 38/161. More popularly known as the Brundtland Commission, after its Chair, Gro Harlem Brundtland, the former Prime Minister of Norway. The WCED was tasked with examining the global environment and development to the year 2000 and beyond. It is best known for its final report, *Our Common Future* (WCED 1987), which has been very influential in promoting sustainable development and related environmental policies, though not without vigorous debate and controversy.

BARRY D. SOLOMON

See also: Sustainable development, Sustainability.

Reference

WCED (World Commission on Environment and Development). 1987. Our Common Future. Oxford, UK and New York, USA: Oxford University Press.

World Trade Organization (WTO)

The WTO was established in Geneva in 1995 as the international organization to succeed the General Agreement on Tariffs and Trade (GATT). The creation of the WTO was one of several major outcomes of the Uruguay Round of GATT, which lasted from 1986 to 1994. The WTO has several functions: it administers trade agreements between its 164 member countries; it serves as a forum for trade negotiations; it resolves trade disputes between countries; it monitors national trade policies; it provides technical assistance for developing countries; and it cooperates with other international organizations, including those in the United Nations system.

The WTO has developed into a powerful organization in its promotion of free and fair international trade. It has been criticized for overruling national labor and environmental standards and concerns in its decisions, undermining local development, penalizing poor countries, increasing economic inequality, and only serving the interests of multinational corporations, among other concerns (Damian & Graz 2001).

BARRY D. SOLOMON

Further reading

Jinnah 2010.

See also: Commodity trade, Tariff, Trade liberalization, Free market.

References

Damian, M. & Graz, J.C. 2001. The World Trade Organization, the environment, and the ecological critique. International Social Science Journal 53(170): 597–610.

Jinnah, S. 2010. Overlap management in the World Trade Organization: secretariat influence on trade–environment politics. Global Environmental Politics 10(2): 54–79.

WTP vs. WTA disparity

Values measured based on consumption substitutability express the willingness to pay (WTP) and the willingness to accept (WTA) for prices and quantity changes. When price changes, individuals' well-being also changes. The same applies to quantity changes of an externality. In theory, WTP and WTA values applied to the same good or service or externality should be equal, but in practice they are often quite different, with WTA values often substantially higher (Horowitz & McConnell 2002; Brown & Gregory 1999).

Differences between WTP and WTA can exist because payment is constrained by income, while demand of compensation is not. Transaction costs can also be a problem. Lack of close substitutes can also lead to extreme WTA values (Hanemann 1991). Research from behavioral economics and psychology has found that the disutility of giving up an object being greater than the utility associated with acquiring it also affects the difference between WTP and WTA in the form of an endowment effect (Kahneman et al. 1990). These differences, underscoring

the importance of using WTA measures as opposed to WTP when an environmental loss is involved, may unduly encourage economic activities with negative environmental impacts if the real values of the losses are underestimated (Brown & Gregory 1999).

RONALDO SEROA DA MOTTA

Further reading

Freeman 2003; Varian 1992.

See also: Willingness to accept (WTA), Willingness to pay (WTA), Behavioral economics, Behavioral ecological economics, Endowment, Transaction costs.

References

Brown, T.C. & Gregory, R. 1999. Why the WTA–WTP disparity matters. Ecological Economics 28: 323–35.

Freeman, A.M. 2003. The Measurement of Environmental and Resource Values, 2nd edn. Washington, DC: Resources for the Future.

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