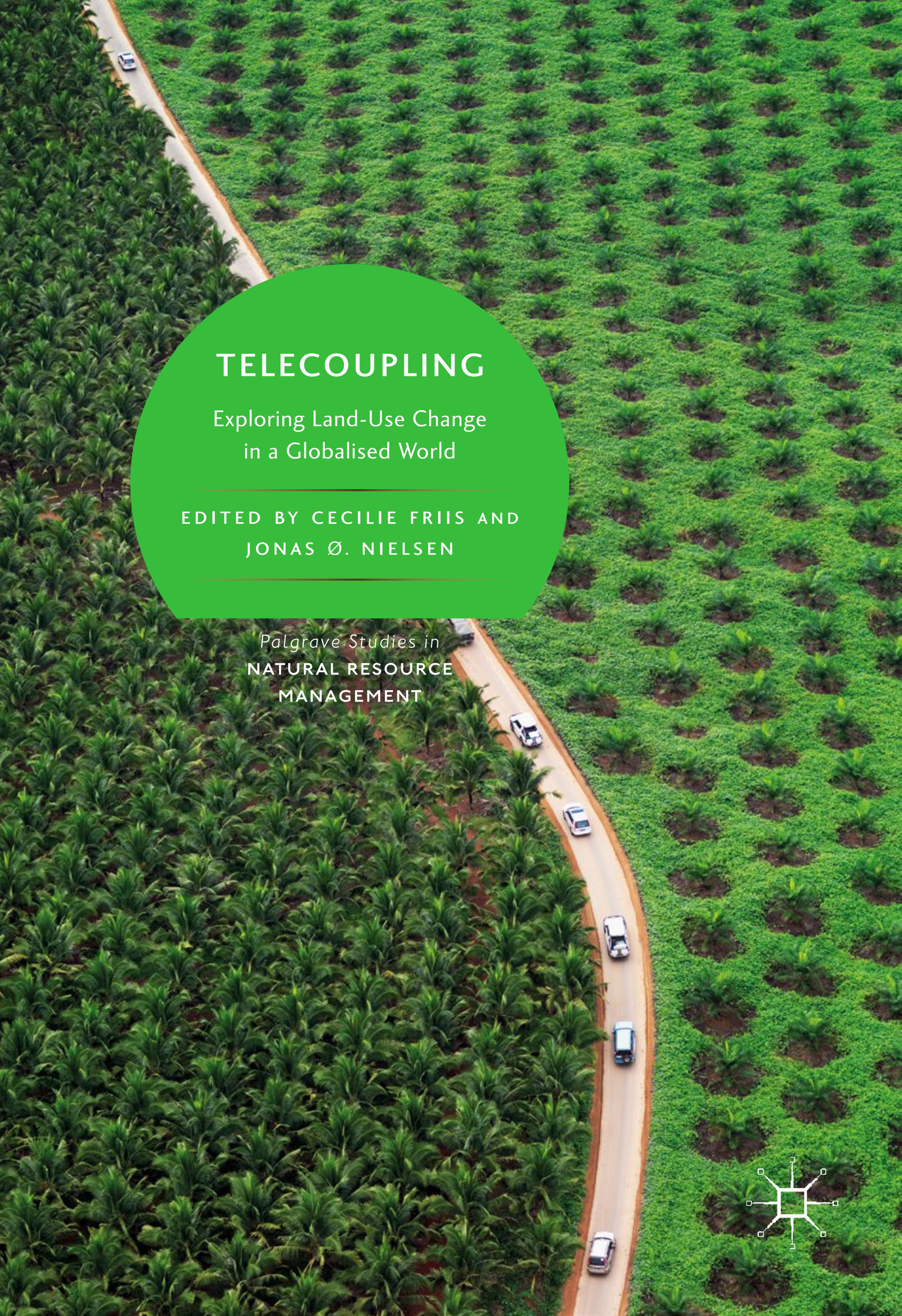


TELECOUPLING

Exploring Land-Use Change in a Globalised World

EDITED BY CECILIE FRIIS AND JONAS Ø. NIELSEN

Palgrave Studies in
NATURAL RESOURCE MANAGEMENT

Palgrave Studies in Natural Resource Management

Series Editor
Justin Taberham
London, UK

This series is dedicated to the rapidly growing field of Natural Resource Management (NRM). It aims to bring together academics and professionals from across the sector to debate the future of NRM on a global scale. Contributions from applied, interdisciplinary and cross-sectoral approaches are welcome, including aquatic ecology, natural resources planning and climate change impacts to endangered species, forestry or policy and regulation. The series focuses on the management aspects of NRM, including global approaches and principles, good and less good practice, case study material and cutting edge work in the area.

More information about this series at
http://www.palgrave.com/gp/series/15182

Cecilie Friis • Jonas Ø. Nielsen
Editors

Telecoupling

Exploring Land-Use Change in a Globalised World

palgrave
macmillan

Editors
Cecilie Friis
IRI THESys & Geography Department
Humboldt-Universität zu Berlin
Berlin, Germany

Jonas Ø. Nielsen
IRI THESys & Geography Department
Humboldt-Universität zu Berlin
Berlin, Germany

Palgrave Studies in Natural Resource Management
ISBN 978-3-030-11104-5 ISBN 978-3-030-11105-2 (eBook)
https://doi.org/10.1007/978-3-030-11105-2

Library of Congress Control Number: 2019933890

Cover illustration: xPACIFICA / Alamy Stock Photo

This Palgrave Macmillan imprint is published by the registered company Springer Nature Switzerland AG.
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Series Editor Foreword

The World Bank's definition of Natural Resource Management (NRM) is:

> The sustainable utilization of major natural resources, such as land, water, air, minerals, forests, fisheries, and wild flora and fauna. Together, these resources provide the ecosystem services that underpin human life.

NRM covers a very wide range of interwoven resource areas, management processes, threats and constraints, including aquatic ecosystems, natural resources planning and climate change impacts. Similarly, NRM professionals are very diverse in their qualifications and disciplines.

There is a significant and growing sector for NRM services and the worldwide market for this sector was almost $30 billion in 2015, according to *Environment Analyst*.

This book series will have a focus on applied, interdisciplinary and cross-sectoral approaches, bringing together professionals to publish titles across the global sector.

The series will focus on the management aspects of NRM and titles will cover:

- Global approaches and principles
- Threats and constraints
- Good (and less good) practices

- Diverse and informative case study material from practitioners and applied managers
- Cutting-edge work in the discipline

The issues covered in this series are of critical interest to advanced-level undergraduates and masters students, as well as industry professionals, investors and practitioners.

Series Editor
London, UK
www.justintaberham.com

Justin Taberham, CEnv

Preface

This book is the result of five years of working together on the topic of telecoupling. During this period we have experienced how telecoupling research has moved from being something that had to be explained and often defended to now being an established part of land system science. This has been a challenging, fun, and insightful journey.

In this book, we bring leading experts on telecoupling and land use together to systematically reflect upon the relevance of telecoupling research for understanding global land-use change. We are grateful that all authors approached agreed to partake. Discussing, reviewing, and editing their chapters has been a real pleasure and a very insightful experience. The result is a very strong book with state-of-the-art research relevant to students from many different disciplines as well as to early-career and experienced scientists. We believe this book provides a benchmark from which we can move forward with telecoupling research.

Written in a clear, concise, and approachable language, the volume is divided into three sections: *Overview*, *Topics*, and *Agenda*, framed by a general introduction that presents the individual chapters. The *Overview* section provides a coherent presentation of the field of telecoupling research and describes the emergence of the concept in land systems science, how it is currently understood, and how causal explanation can be derived with a telecoupling approach. In *Topics*, the telecoupling concept is used in nine chapters to analyse some of the most pressing concerns of contemporary global land-use change. In the *Agenda* section, the book widens the scope, illustrating how telecoupling research connects to contemporary scientific pursuits for inter- and transdisciplinary research. Interspersed within the *Topics* section of the book are four so-called *Toolboxes*. Covering flow, network, spatial, and qualitative methodological approaches, the *Toolboxes* provide the reader with a sense of how to do telecoupling research. All the chapters stand alone and can be read individually, but build and expand upon each other. Reading the book in its entirety will therefore be rewarding.

This book would not have been possible without the support of Rachael Ballard and Joanna O'Neill at Palgrave Macmillan. Kathrin Trommler provided very valuable work editing and assembling the book at the end. The reviewers provided excellent and fast reviews that improved all chapters. We are grateful to the people working at and around the IRI THESys at Humboldt-Universität zu Berlin, for engaging us in many great and challenging discussions on telecoupling. Indeed, Berlin is a wonderful and dynamic hub for land-use and land-cover research, as highlighted by the large number of contributors to this book from Humboldt-Universität zu Berlin's Geography Department—a department we are very fortunate to belong to. The Global Land Programme (GLP) provided us with the network needed to do an edited volume on land-use change and we are looking forward to continuing working together with the GLP on the issue of telecoupling. Last but not least, we extend a big *thank you* to all the contributing authors. We feel very privileged to be the editors of a book with such high-quality contributions from all of you. For economic support, we would like to acknowledge the generous funding from the European Union's Horizon 2020 research and innovation programme under Marie Skłodowska-Curie grant agreement no. 765408.

Berlin, Germany
November 2018

Cecilie Friis
Jonas Ø. Nielsen

Contents

Notes on Contributors

Louise Marie Busck-Lumholt is a PhD candidate at Universitat Autònoma de Barcelona in Spain. Her research aims at assessing potential conservation outcome of sustainable forest management projects in Argentina, as well as exploring the influence of international stakeholders. The research will contribute to develop the conceptualisation of political and financial telecouplings. She has a master's degree in Agricultural Development from the University of Copenhagen and fieldwork experience from Kenya and Malaysia.

Andrew K. Carlson is a distinguished fellow, PhD candidate, and Certified Associate Fisheries Professional® at the Center for Systems Integration and Sustainability at Michigan State University. After completing degrees at the University of Minnesota (BS, *summa cum laude in cursu honorum* with high distinction) and South Dakota State University (MS), he moved to Michigan to study fisheries as coupled human and natural systems with Drs. William W. Taylor and Jianguo 'Jack' Liu. In his current research, Andrew uses the telecoupling framework to investigate social-ecological interactions in fisheries.

Edward Challies is a human geographer and senior lecturer with the Waterways Centre for Freshwater Management at the University of Canterbury, Christchurch, New Zealand, and an adjunct senior research associate with the Research Group Governance and Sustainability at Leuphana University of Lüneburg, Germany. His main expertise is in geographies of globalisation, global commodity chains, environmental policy, and sustainability governance.

Thomas Connor is a PhD candidate at the Center for Systems Integration and Sustainability in the Fisheries and Wildlife department of Michigan State University. His main research focus is studying the effects of natural and anthropogenic landscape-level variables on wildlife distributions, population dynamics, and gene flow. In his current research, he is using a telecoupling perspective to investigate the effects of land-cover and land-use change, as well as landscape connectivity, on gene flows among wildlife population in southcentral China.

Esteve Corbera is a research professor at the Institute of Environmental Science and Technology, Universitat Autònoma de Barcelona (ICTA-UAB), Spain, where he co-directs the Laboratory for the Analysis of Social Ecological Systems. Esteve is an international development specialist interested in the study of biodiversity conservation and climate change policy programs, specifically their effects on local environments, institutions, livelihoods, and human behaviour in the Global South. Esteve has been a lead author of the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report (2014) and now serves as an editor of the journal *Geoforum*.

Cecilie Friis is a post-doctoral researcher at the IRI THESys at the Humboldt-Universität zu Berlin in Berlin, Germany. She finished her degree, Dr. Phil. in Human Geography, in 2017 at the Geography Department of the Humboldt-Universität zu Berlin. Her main expertise is in the conceptual and analytical development of the telecoupling framework, and on land-use change, crop booms, and land grabbing in frontier regions of Southeast Asia. She is currently co-organising a GLP Working Group on Telecoupling Research towards Sustainable Transformation of Land Systems.

Toby Gardner is a senior research fellow at the Stockholm Environment Institute (SEI) in Stockholm, Sweden, where he is the director of the Transparency for Sustainable Economies Initiative, Trase, and co-leads SEI's Initiative on Producer to Consumer Sustainability. His work is focused on transitions towards more sustainable land-use systems and the conservation of biodiversity and ecosystem services in human-modified landscapes, with a particular focus on the role of global trade in driving environmental change and opportunities to improve the sustainability governance of forest-risk commodity supply chains.

Rachael Garrett is an assistant professor in the Department of Earth and Environment at Boston University in Boston, USA. As of July 1 she will be joining the faculty at ETH Zurich in Switzerland. She is an expert in the interactions between agriculture, environmental governance, and economic development, particularly in Latin America. Her work aims to improve the sustainability of food production via improved policies and management technologies.

Javier Godar is a senior research fellow at the Stockholm Environment Institute, and co-founder of the Trase platform and initiative. His primary expertise is in understanding transitions towards more sustainable land-use systems in the forested tropics. His work focuses on the high-resolution mapping and assessment of global trade flows and the risks associated with the production and trade of forest-risk commodities. His research has contributed to improved footprinting assessments, as well as informing deforestation reduction, rural development policies, and the governance of international commodity supply chains, with a particular focus on the South American tropics.

Dagmar Haase is Professor of Landscape Ecology and Urban Ecology at the Geography Department, Humboldt-Universität zu Berlin in Berlin, and a guest scientist at the Helmholtz Centre for Environmental Research—UFZ, Leipzig, Germany. Her core expertise is in, first, modelling urban land-use change and urban system dynamics and, second, the quantification and assessment of ecosystem services and landscape functions using statistics and earth observation data.

Janine Hauer is Doctoral Researcher in Human Geography at the IRI THESys, Humboldt-Universität zu Berlin, Germany. She holds a master's degree from the Institute of European Ethnology at Humboldt-Universität zu Berlin, where she also worked as a junior lecturer and course coordinator. Her research is based in Burkina Faso, where she has previously worked on urban expansion in the capital Ouagadougou and is currently doing research on land conversion to rice production and the emerging rice market in conjunction with global development initiatives.

Andreas Heinimann is an associate director at the Centre for Development and Environment and a senior lecturer at Geography Institute, both at the University of Bern in Bern, Switzerland. He is an expert in land system science, with a focus on the spatial analysis, development studies, and land governance, as well as transdisciplinary research processes.

Anna Herzberger is a PhD candidate at the Center for Systems Integration and Sustainability (CSIS) at Michigan State University in East Lansing, Michigan. She has a background in environmental biology and integrated human-environment studies. In her current research, she combines systemic telecoupling analysis, network analysis, and agent-based modelling with microbial ecology to study the land-use change impacts of international soybean trade in China, the United States, and Brazil.

Emma Li Johansson is a researcher at the Department of Physical Geography and Ecosystem Science, Lund University, Sweden. She finished her doctoral degree at the same department in 2018, with strong ties to Lund University Centre for Sustainability Science. Her research focuses on land system change in the context of large-scale land acquisitions, investigating drivers, and impacts and feedbacks of socio-environmental change at different scales of analysis, with a mix of quantitative and qualitative research approaches.

Kelly Kapsar is a PhD candidate at the Center for Systems Integration and Sustainability at Michigan State University and a research associate at the Saint Louis Zoo. Her research focuses on interdisciplinary approaches to telecoupled systems modelling, with a particular focus on spatiotemporal data analysis, data mining, and evaluating the impacts of policy interventions on human-nature interactions.

Thomas Kastner is a senior scientist at the Senckenberg Biodiversity and Climate Research Centre (BiK-F) in Frankfurt am Main, Germany. His research focuses on methodological developments for studying and analysing telecouplings created via international trade of agricultural and forestry products.

Tobias Kuemmerle is Professor of Conservation Biogeography at the Geography Department at the Humboldt-Universität zu Berlin in Berlin, Germany. He is an expert in conservation science, land-use effects on biodiversity, and land-use mapping.

Yann le Polain de Waroux is an assistant professor at the Institute for the Study of International Development and at the Department of Geography at McGill University in Montreal, Canada. He is an expert on nature-society interactions, the influence of globalisation on land-use and land-cover change, as well as on livelihood changes and rural development.

Andrea Lenschow is Professor of European Integration at the Faculty of Social Science, the Jean Monnet Chair for European Politics, and the director of the Jean Monnet Center of Excellence in European Studies at the Osnabrück University in Osnabrück, Germany. She is an expert in environmental governance and European environmental policy, with a special focus on environmental policy integration and diffusion, which are concepts relevant to telecoupling research.

Christian Levers is a post-doctoral researcher at the Conservation Biogeography Lab at the Geography Department at Humboldt-Universität zu Berlin, Germany. His research expertise is in large-scale analyses of land system patterns and changes therein, with an emphasis on land-use intensity, crop production, and socio-environmental trade-offs associated with land management. Regionally, his work focuses mainly on Europe and South America, particularly the Gran Chaco ecoregion.

Jinguo Liu holds the Rachel Carson Chair in Sustainability and is a University Distinguished Professor and the director of the Centre for Systems Integration and Sustainability at Michigan State University in East Lansing, Michigan. He is a leading scholar in the field of coupled human and natural systems, introduced the concept of telecoupling, and has been leading the development and applications of the telecoupling framework.

Finn Mempel is a PhD candidate at the Institute of Environmental Science and Technology, Universitat Autònoma de Barcelona in Barcelona, Spain. His research aims to explore the dimensions and perceptions of environmental justice in telecoupled land-use systems. His work is centred on global agricultural value chains and has a regional focus on Latin America.

Ole Mertz is Professor of Human Geography and Head of the Section for Geography at the Department for Geosciences and Natural Resource Management at the University of Copenhagen in Copenhagen, Denmark. He is an expert on smallholder agricultural systems and land-use transitions in the tropics, as well as on global environmental policies such as the REDD+.

Peter Messerli is Professor of Sustainable Development at the Institute of Geography and the director of the Centre for Development and Environment at the University of Bern in Bern, Switzerland. He is also the co-chair of the Global Land Programme. His research expertise is in sustainable land use, development studies, and human geography.

Patrick Meyfroidt is a research associate at F.R.S.-FNRS and an associate professor at the Earth and Life Institute and Georges Lemaître Centre for Earth and Climate Research at the Université Catholique de Louvain in Louvain-la-Neuve, Belgium. His research focuses on non-linear land-use dynamics, causal effects and causal mechanisms in land systems, land-use displacement, and public-private land-use governance.

Daniel Müller is Deputy Head of the Department Structural Change at the Leibniz Institute of Agricultural Development in Transition Economies (IAMO) in Halle (Saale), Germany, and Lecturer in Geography at Humboldt-Universität zu Berlin. His main expertise is in integrative research that combines resource economics, regional science, and geomatics for the study of causes of land system change and the consequences of these changes for human welfare, food production, and environmental outcomes. The current geographic focus of his research is Central and Eastern Europe, the former Soviet Union, Southeast Asia, and Western China.

Jens Newig is professor and head of the Research Group Governance and Sustainability at Leuphana University of Lüneburg, Germany. An environmental scientist by training, he holds a PhD in Law and a habilitation in political science and applied systems science. He has published widely on different forms of state-based, participatory, and collaborative governance, their spatial and scalar implications, and their impact on environmental sustainability, from in-depth case studies to large-N meta-analyses. He is co-leading an ongoing project funded by the German Research Foundation on the governance of global telecoupling towards environmental sustainability.

Jonas Ø. Nielsen is Professor of Integrative Geography at the Geography Department and research group leader at the Integrative Research Institute for Transformation of Human-Environment Systems (IRI THESys) at the Humboldt-Universität zu Berlin, Germany. He has conducted extensive research on telecoupling, land-use change, and climate change adaptation. He is on the Scientific Steering Committee of the Global Land Programme and the coordinator of a Horizon 2020--funded Innovative Training Network on telecoupling.

Jörg Niewöhner is Professor of Social Anthropology and Human-Environment Relations at the Institute for European Ethnology at the Humboldt-Universität zu Berlin in Berlin, Germany. He is an expert in the anthropology of science and technology, urban anthropology, and human-environment relations.

Joel Persson is a PhD fellow at the Department for Geosciences and Natural Resource Management at the University of Copenhagen, Denmark. With a strong interest in environmental governance programmes, Joel's research focuses on how global conservation discourses manifest in land use and livelihood outcomes in local social-ecological systems through a telecoupling approach.

Siyu Qin is a doctoral researcher at the Conservation Biogeography Lab at the Geography Department at Humboldt-Universität zu Berlin, Germany. Her research looks at land system telecoupling enabled through international conservation. Prior to Humboldt-Universität, she worked at Conservation International to study the adoption and abandonment of area-based conservation interventions in the Amazonia and globally.

Beatriz Rodríguez-Labajos is an ecological economist and a senior researcher at the Institute of Environmental Science and Technology, Universitat Autònoma de Barcelona (ICTA-UAB). She is currently a Marie Curie Fellow based at the Energy and Resources Group of the UC Berkeley. Her research interests are environmental justice and the socioeconomic dimensions of biodiversity, particularly in agroecosystems and throughout the hydrosocial cycle. Her field experience includes regions of Europe, Latin America, and Southeast Asia.

Ximena Rueda is an associate professor and the Head of the Sustainability Area at the School of Management at Universidad de los Andes in Bogota, Colombia. She holds a master's degree in City Planning from MIT and a PhD in Geography from Clark University, and was a visiting scholar at the Center for Food Security and the Environment at Stanford University, as well as at the Department of Geography at Rutgers University. Dr. Rueda studies the impacts of globalisation on land use, with particular attention to corporate sustainability investments in the rural South.

Anke Schaffartzik is a María de Maeztu post-doctoral fellow at the Institute of Environmental Science and Technology, Universitat Autònoma de Barcelona (ICTA-UAB), and a senior researcher at the Institute of Social Ecology (SEC), University of Natural Resources and Life Sciences, Vienna. Anke's research focuses on the interplay between societal organisation and resource use across levels of scale. To collaborative analyses of global resource use, she contributes her primary expertise in social metabolism, with a focus on international trade and the methods of material flow accounting and environmentally extended input-output analysis.

Flurina Schneider is an integrative geographer and head of the land resource cluster of the Centre for Development and Environment, University of Bern. She has conducted extensive research on governance of natural resources, environmental justice, and sustainability transformations in the Global North and South. She is specialised in inter- and transdisciplinary co-production of knowledge, dialogue methods, and the facilitation of participatory processes.

Jonathan W. Seaquist is an associate professor at the Department of Physical Geography and Ecosystem Science at Lund University in Lund, Sweden. His research draws from the sciences of geographic information, Earth observation, and complex networks for mapping vegetation dynamics and land use/land cover and its change at regional-to-global scales.

Peter H. Verburg is Professor of Environmental Spatial Analysis and Chair of the Environmental Geography Group at the Institute for Environmental Studies at the VU University Amsterdam in Amsterdam, The Netherlands. He is also a visiting professor at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Switzerland. He is an expert in land system analysis and modelling, working at spatial scales from local to global, and interested in cross-scale interactions in socio-ecological systems and the exploration of visions and pathways towards sustainable use of land.

Julie G. Zaehringer is a postdoctoral researcher at the Centre for Development and Environment at the University of Bern in Switzerland. As a land system scientist with a background in environmental sciences, geography, and sustainable development, her research focuses on land-use changes, ecosystem services, and human well-being in the context of telecoupled land investments and conservation interventions in East Africa and Southeast Asia.

List of Figures

List of Tables

1

Global Land-Use Change through a Telecoupling Lens: An Introduction

Cecilie Friis and Jonas Ø. Nielsen

1 Introduction

Land use provides societies with indispensable resources such as food, feed, fibre and energy. Food security, climate change mitigation and adaptation, access to clean water and air, biodiversity conservation and a more just global society, all depend upon how we use land. In March 2018, the Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (IPBES) published the first global assessment report that takes stock of the state of the world's land resources (IPBES 2018). The report paints a gloomy picture of extensive and continuing land degradation throughout the world, estimating that land degradation is currently 'negatively impacting the well-being of at least 3.2 billion people' (IPBES 2018, 10). With projections putting the global population around 9.8 billion people by 2050 (UN 2017), finding solutions to secure our common 'life on land' as specified in the 15th Sustainable

C. Friis (✉) • J. Ø. Nielsen
IRI THESys & Geography Department, Humboldt-Universität zu Berlin, Berlin, Germany
e-mail: cecilie.friis@hu-berlin.de; jonas.ostergaard.nielsen@hu-berlin.de

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_1

Development Goal (UN 2015) is high on the global political and research agenda.

Yet, identifying and fostering more sustainable modes of land use—that can simultaneously deliver on food production and food access goals while conserving essential ecosystem services and securing life for the non-human part of the world in a just and equitable manner—constitute a substantial, almost overwhelming challenge. A major reason for this is that land-use change is increasingly characterised by a spatial disconnect between the main environmental, socioeconomic and political drivers of land change and the main impacts and outcomes of those changes. The surging levels of global trade in biomass (see Chap. 8), for example, illustrate how the production and consumption of land-based resources are increasingly separated in space, making the full environmental and social impacts of consumption patterns largely invisible to consumers, policymakers and researchers due to the distance separating them from producers and suppliers (see also Chaps. 5 and 6). The increasing number of transnational land acquisitions by private companies and investment firms (Messerli et al. 2014), as well as the push for biodiversity conservation led by international organisations (Adger et al. 2005; Fairhead et al. 2012), similarly demonstrates how land-use decisions are increasingly made in places other than where land-use changes occur.

To address the challenges posed by these spatial disconnections, the concept and framework of telecoupling have been proposed in the human-environment systems literature (Liu et al. 2013; Eakin et al. 2014; Friis et al. 2016; see also Chaps. 2 and 3). Telecoupling is conceptualised as combined socioeconomic and environmental interactions or flows between two or more human-environment systems that are separated in space (Liu et al. 2013). The telecoupling framework draws specifically on systemic thinking when dealing with human-environment interactions such as land-use change, while also emphasising the need to understand the networked relations of actors that mediate cross-scalar flows and feedbacks between systems. This requires attention to the place-based, as well as the flow-based human-environment processes shaping land use in specific places. For instance, understanding the shift in land use from rice to banana in northern Laos, local, regional and global processes, as well as their connectedness via various material and immaterial flows, needs to be grasped and integrated in the same analysis (Friis and Nielsen 2017). The telecoupling framework proposes a set of analytical components, including 'sending', 'receiving' and 'spillover systems', 'flows', 'feedbacks' and 'agents' to do this (Liu et al. 2013, 3). These components are used to determine and trace the origin and recipient of a particular flow, as well as the places and people that are affecting or affected by them directly or indirectly. In other words, telecoupling presents land system scientists with a systematic approach for studying the globalisation of land use, an approach that allows for breaking up the complexity of global interconnectivity into identifiable and manageable units of analysis, thereby addressing the problem of spatial disconnection of drivers and outcomes of land-use change (see Chaps. 2, 3 and 4).

The diversity of the processes that the telecoupling framework seeks to address leads to a need to engage many different methodological approaches and analytical perspectives. As such, the emergence of the telecoupling framework resonates with the increasing push for inter- and transdisciplinary research and exchange in the wider field of sustainability science (e.g. Jerneck et al. 2011; Fischer et al. 2015; Moran and Lopez 2016; Pulver et al. 2018). The pressing need to build a deeper understanding of unsustainable land systems, as emphasised by the IPBES report and the UN 2030 Sustainable Development Agenda, necessitates engagement across the natural and social sciences. In addition, the increasing recognition that science needs to make a stronger contribution to the identification of leverage points for transformation towards more sustainable land-use practices and to the design of better interventions into unsustainable and unjust ones (GLP 2016; Abson et al. 2017; van der Hel 2018), has led to calls for engagement of non-academic partners in the (co-) production of knowledge. Telecoupling research has the potential to make a substantial contribution to both these agendas. First, it offers a systemic, yet open approach to human-environment interactions that invites and enables interdisciplinary exchange; indeed, answering many questions related to telecoupling can only be done by engaging multiple disciplinary perspectives. Second, by explicitly focusing on understanding cross-scalar interactions, their potential implications on land use in specific places and the role of actors with or without power to influence these, telecoupling research opens up an opportunity for identifying relevant processes and stakeholders that are essential to include in solution-oriented sustainability research. Accordingly, the topic of this book is the scientific diversity and insights as well as the interdisciplinary and transdisciplinary breadth, scope and potential of telecoupling research.

2 Aims and Scopes of the Book

This book brings together leading scholars on land-use change, sustainability and telecoupling to take stock of the emerging field of telecoupling research. Assembled here is the first coherent and comprehensive consideration of how telecoupling challenges the study of global land-use change and sustainability, and in turn, how adopting a telecoupling lens can lead to new insights on and collaborations around those challenges. The chapter authors have highly diverse disciplinary backgrounds spanning from conservation biology, ecology and geography, via agricultural economics and political science to development studies and anthropology. Each chapter deals with a particular topic prominent in land-use change research, and considers how distal interactions and global connectivity contributes to this topic, as well as how a telecoupling perspective might facilitate a better understanding of the topic. What emerges is a thorough exploration of the state-of-the-art in telecoupling research related to global land-use change.

The book consists of 19 chapters divided into an *Overview*, a *Topics* and an *Agenda* section. Included in the *Topics* section are four short methodological *Toolbox* chapters that illustrate how to do telecoupling research. Flow analysis (Chap. 7), network analysis (Chap. 10), spatial analysis and modelling (Chap. 13), and qualitative ethnographic research (Chap. 16) are presented as examples of such methodological approaches illustrating the breadth of telecoupling research.

The *Overview* section provides a detailed introduction to the development of the telecoupling concept and framework and its application in the field of land-use change research. In **Chap. 2**, Jianguo 'Jack' Liu, Anna Herzberger, Kelly Kapsar, Andrew K. Carlson & Thomas Connor ask: '*What is telecoupling?*' Their answer presents the current understanding of the telecoupling concept and framework in a way that thoroughly introduces its analytical components and applicability to new readers. In addition, Liu et al. provide a further clarification of the structure of the framework, its analytical implementation in current literature, its implication for governance and its limitations. In conclusion, they discuss the ongoing efforts to operationalise the telecoupling framework with various methodological approaches.

In **Chap. 3**, Cecilie Friis considers the *emergence* and *development* of telecoupling research within the field of land system science and traces how the concept helps land systems researchers address global connectivity and distant interactions while simultaneously keeping a focus on place-based land-use change. Friis discusses how the potential for telecoupling research lies in exploring three fundamental and embedded tensions in the concept, namely, the wish to integrate systemic versus relational perspectives on human-environment change; the tension between post-positivist versus constructivist modes of knowledge production; and the need to empirically capture both place-based and flow-based aspects of change.

The *Overview* is concluded by **Chap. 4**. Here, Patrick Meyfroidt reflects upon how *causal explanations* of land-use change can be derived from a telecoupling approach. Meyfroidt sketches out the dominant approaches to building explanations in human-environment systems research and discusses how telecoupling research can build on these by paying particular attention to analytical methodologies for building complex causal chains of explanation. The chapter provides a very useful clarification of terminology around explanations. In the concluding discussion, Meyfroidt outlines some of the specific challenges facing researchers concerned with causal explanations when studying complex telecoupled systems and considers the possible ways of dealing with them.

In the *Topics* section, the potential of the telecoupling perspective for capturing and understanding some of the most pressing concerns for sustainability of contemporary land-use change are considered.

In **Chap. 5**, Christian Levers and Daniel Müller review the influence of telecoupling in relation to export-oriented agricultural *production*. Using FAO data and the Spatial Production Allocation Model (MapSPAM), Levers and Müller develop a spatial allocation algorithm to identify regional hotspots for the 13 most important export crops globally. Their original analytical approach and results show the effects that international trade of agricultural commodities have on steering land-use in producing regions. The chapter presents a novel approach for identifying regions as 'sending systems'. The authors argue that these warrant primary attention for telecoupling research concerned with the social-ecological costs of land-use change from agricultural production, as well as for raising awareness in importing countries regarding the impacts of their consumption.

Rachael Garrett and Ximena Rueda take up the issue of *consumption* and consumption-related telecoupling in **Chap. 6**. Starting from recent trends in global food consumption, Garrett and Rueda analyse the ways in which increasingly homogeneous global consumption practices create new telecouplings between apparently separated places of consumption and production. The authors discuss how two main food consumption trends—the mass consumption of homogenous goods 'from nowhere' and the emergence of niche markets for exotic place-based and sustainable products—are both driven by and give rise to new physical and informational telecouplings with very different outcomes for sustainability. This chapter highlights the varied challenges posed by telecoupled agri-food systems to policy-makers, private sector actors and civil society, and outlines the need for an increasing attention to governance responses that focus not only on production and sourcing processes, but also on consumption in itself.

Chapter 7 presents the first methodological toolbox in which Anke Schaffartzik and Thomas Kastner present *material flow accounting* as a tool for tracing the linkages from consumption to extraction of natural resources across scales in human-environment systems. Schaffartzik and Kastner situate material flow accounting within the field of social metabolism studies and illustrate how this perspective typically operationalises flows between telecoupled systems by following two 'trails'—a material or a monetary trail. The authors then discuss the different understandings of telecoupling that underpin each trail, and which sometimes lead different or even opposing assessments of the roles of the coupled systems in a particular interaction. The authors insist that these are informative differences requiring further analysis and in-depth interpretation in order to further our conceptual understanding of telecoupling.

Chapter 8 focuses on *trade* as a driver of global land-use change. Trade links production and consumption of agricultural products over distance and Javier Godar and Toby Gardner review the current methodological challenges, as well as emerging methodological approaches and opportunities for tapping into new data sources for mapping and analysing global trade flows. Using the recent work of the Trase initiative (www.trase.earth) to illustrate this, Godar and Gardner argue that a focus on spatially explicit and actor-specific data is essential for providing actionable information to support decision-making in specific landscapes and sectors. This chapter demonstrates how the continued focus on methodological advancements and operationalisation of the telecoupling approach is essential for the development of effective governance interventions in unsustainable land systems.

The challenges and implications of global interconnectivity and telecoupling for *governance* with the goal of sustainability are reviewed in detail by Edward Challies, Jens Newig and Andrea Lenschow in **Chap. 9**. Challies et al. outline the concept of sustainability governance and examine how key dimensions of governance change in relation to telecoupling and specific interregional connections. The authors particularly argue that there is a need to consider the multiplicity of governance actors, the dynamics of spatial and temporal scales, and the multiple modes of governance required to tackle the challenges posed by telecoupling. Doing so is vital, if we are to secure legitimate and effective sustainability governance in telecoupled systems.

Chapter 10 presents the second methodological toolbox. Jonathan W. Seaquist and Emma Li Johansson review and discuss how *network analysis* can contribute to a fruitful operationalisation of the telecoupling framework by means of local, global and community metrics. Starting with a brief account of the basic concepts of network analysis, including nodes and linkages, Seaquist and Johansson provide an accessible introduction to the fundamental principle of network analysis such as 'degree centrality', 'betweenness centrality' and 'clustering coefficient', and discuss how these can be usefully applied in telecoupling analysis.

In **Chap. 11**, Esteve Corbera, Louise Marie Busck-Lumholt, Finn Mempel and Beatriz Rodríguez-Labajos discuss why a focus on *environmental justice* matters for telecoupling research. Corbera et al. emphasise the importance of taking three interlinked, yet distinct aspects of justice into account—namely, distribution, participation and recognition—and discuss how each of these aspects are linked to particular telecoupling challenges. The chapter is based on an extensive literature review illustrating that only very few telecoupling studies have so far dealt with environmental justice. These, the authors argue, has to change if we are to push global land use towards greater sustainability.

In **Chap. 12**, Yann le Polain de Waroux demonstrates the importance of a telecoupling lens when an understanding of local and land-based *livelihoods* and the changes in them is desired. Examining four types of linkages that affect local people's livelihoods in rural regions around the world (migration and remittances, trade in niche agricultural products, large-scale land acquisitions and resource control, and ecosystem externalities), le Polain de Waroux convincingly shows how telecoupling provides a tool to describe and understand how livelihoods are embedded in global, social, economic and political networks. In conclusion, le Polain de Waroux discusses how the telecoupling lens allows for research that disentangles the complex fabric of the 'global' and transcends the 'localism' prevailing in many livelihood studies.

Chapter 13 presents the third methodological toolbox. Here, Peter H. Verburg considers the central role of *spatial analysis* and *land-use modelling* in land system science and the challenges that telecoupling presents for these tools. Verburg reviews the development of spatial analysis from a predominant focus on mapping spatial patterns of land-cover change to more integrated efforts aimed at linking *people and pixels* in order to establish connections between such patterns and the underlying processes creating them. In addition, Verburg discusses how different land-use models can facilitate a better understanding of telecoupled land systems, but also how capturing both local impacts and global processes is challenging with current modelling tools and will require new approaches to coupled models. Finally, Verburg reviews continuing efforts to represent and visualise connected places through spatial analysis and land-use modelling.

In **Chap. 14**, Dagmar Haase discusses the way in which urban areas and *urbanisation* create telecouplings with sustainability implications for land-use change elsewhere. She introduces the concept of 'urban telecoupling' as a specific form of distal interactions to and from cities, and examines the importance of urban telecouplings for global connectivity and sustainability. Urban telecouplings are recognised in relation to their largely negative impacts on land-use change elsewhere. However, Haase presents novel ideas on how particular urban telecouplings can contribute to more sustainable land use and land transformation, especially in relation to flows of ideas and discourses around 'green' consumption and transportation.

In **Chap. 15**, Tobias Kuemmerle, Thomas Kastner, Patrick Meyfroidt and Siyu Qin consider the topic of *conservation*. They start by showing how local threats to biodiversity and responses to such threats are increasingly shaped by distal actors and processes. Introducing the concept of 'conservation telecouplings' as the coupling of distal social-ecological systems through conservation-related responses, they demonstrate how this concept can help distinguish between targeted and diffuse threats to biodiversity, as well as local and distal causes of such threats. Kuemmerle et al. then use their concept to examine ways of detecting entry points for conservation, increasing conservation effectiveness and new ways of conservation planning, and discuss how conservation telecoupling might both lead to new types of conservation responses and new opportunities for conservation.

Chapter 16 presents the final methodological toolbox. Here Jonas Ø. Nielsen, Janine Hauer and Cecilie Friis examine how *qualitative* ethnographic fieldwork and analysis can contribute unique perspectives to telecoupling research. The authors consider how place-based fieldwork and zooming techniques, as well as multi-sited ethnography and collaboration represent key approaches through which to conduct qualitative research on telecoupling. Nielsen et al. discuss how these approaches allow telecoupling researchers using qualitative methods to capture both local-contextual and global-processual aspects of land-use change.

In the final topical chapter, **Chap. 17**, Joel Persson and Ole Mertz engage with conceptual insights from *discourse* analysis to develop an analytical lens that captures the heterogeneous outcomes of global discourses on socioenvironmental change in local land systems. Their concept of 'discursive telecoupling' encompasses the notion that the discourses accompanying material flows between land systems play an important role in influencing local land-use change processes by legitimising certain land-use decisions, policy models or intervention designs, while rendering others less viable or undesirable. Considering how these processes play out in the dissemination of global win-win discourses in the environmental conservation and development sectors, Persson and Mertz convincingly demonstrate the importance of taking into account the role of immaterial and discursive flows between land systems, when seeking an understanding of the complex sustainability challenges and trade-offs created by telecoupling.

In the final part of the book, *Agenda*, we widen the scope of discussions by illustrating how telecoupling research can advance the agenda within land system science in relation to knowledge production through both interdisciplinary research (Chap. 18) and transdisciplinary engagement (Chap. 19).

In **Chap. 18**, Jonas Ø. Nielsen, Cecilie Friis and Jörg Niewöhner explore how telecoupling research can and needs to foster *interdisciplinary* collaboration beyond the integration of methods and data. While acknowledging that the telecoupling framework is a clear response to the need for integrative interdisciplinary research to address and solve the sustainability challenges of the twenty-first century, Nielsen et al. argue that telecoupling research needs to be aware of different modes and logics of interdisciplinarity that can foster collaboration even when integration of data and methods is not possible. Specifically, the authors draw on perspectives from the sociology of science to discuss how telecoupling research should foster a reflexive, flexible and open process of exchange that depends on scientific differences with the goal of exploring productive tensions between perspectives, rather than of levelling them. To encourage and facilitate this interdisciplinary process, Nielsen et al. argue that telecoupling research needs to not only focus on the *how to* of interdisciplinarity, but also must actively discuss *what* political, economic or research *logics* drive the need for interdisciplinarity.

One example of these logics is the drive to foster *sustainable development* and *co-production of knowledge*. These themes are taken up by Julie

G. Zaehringer, Flurina Schneider, Andreas Heinimann and Peter Messerli in **Chap. 19**, the final chapter of the book. Zaehringer et al. start from the intimate relationship between land system change and sustainable development, and consider how telecoupling represents substantial challenges to this relationship. Throughout the chapter, the authors reflect on an ongoing inter- and transdisciplinary research project on the telecoupled land-use changes in Madagascar. The authors discuss how the sustainability perspective brings with it a particular normative underpinning to land system science that requires research on both the systemic aspects of land change and the power-related ones. In conclusion, Zaehringer et al. consider what types of knowledge and knowledge production approaches are needed to tackle the challenges that telecoupling pose for sustainable development and argue for a stronger commitment to transdisciplinary and co-productive modes of knowledge production in land system science.

3 Concluding Remarks

The globalisation of land use presents researchers and policy-makers with the challenging task of understanding what drives particular land-use changes. A multiplicity of human and non-human actors, who are often located far apart, interact via complex networks characterised by material and immaterial flows. These varied and multiple cross-scalar interactions create feedbacks, spillover effects and nonlinear responses, where uncertainty regarding benefits, risks and unintended consequences are rife. In this book, we show that telecoupling research is well positioned to engage with the academic, as well as governance challenges related to understanding and addressing complex causal relationships concerning global land-use change. Telecoupling research, as illustrated by this volume, helps us identify key actors, specific networks and flows through which these actors are connected and land-use change outcomes—actual as well as potential—of such connections. By contributing to a better understanding of this complexity, the telecoupling perspective also provides important contributions to the ongoing discussions on how to foster transformative solutions to the social and environmental sustainability challenges posed by global land-use change. Telecoupling research achieves this by separating global interconnectivity into sending, receiving and spillover systems, as well as considering how these are connected via flows that can be captured qualitatively and quantitatively, or, as is often the case, by a combination of these approaches. Thus, a major point of this framework and book is that telecoupling research has the potential to directly address the fundamental academic and political challenges of understanding and explaining land-use changes in a world characterised by distal interactions and spatial disconnections between the supply and demand of land-based services.

Beyond these perspectives, we see two important aspects of telecoupling research emerge across and between the chapters in the book. First, while telecoupling has received increasing attention in the literature, it is still very much a concept 'in the making', and no established consensus on the best way to approach telecoupling has been reached. This is illustrated by the different ways in which the chapter authors engage with and approach telecoupling. The attentive reader will note epistemological tensions embedded in these differences, which reflect very real differences in scientific perspectives and disciplinary approaches between the individual authors. Rather than aiming to streamline perspectives or settle on any 'right' definition and analytical approach, we have explicitly invited these differences because we believe they demonstrate the strength and flexibility of the telecoupling lens in accommodating diverse types of research questions, methods and analyses. Telecoupling research, as illustrated by this book, does not belong to either the social or the natural sciences but becomes most productive when such fields are brought into dialogue.

Second, and very much related, this volume illustrates how telecoupling research sets the stage for—indeed requires—different types of interdisciplinary exchange and collaboration. In particular, we argue, that understanding the highly diverse types of cross-scalar flows and processes that tie specific land-use changes together over distance requires a mode of interdisciplinarity that goes beyond mere integration, taking advantage of and prospering from disciplinary differences. The particular strength of the telecoupling framework, we are convinced, is that it brings researchers concerned with such diverse topics as discourses, conservation, trade and justice, and relying on methods ranging from modelling to qualitative fieldwork, together in discussions of which flows drive what, as well as how and why they matter for particular land-use changes. To foster such a discussion, the framework needs to remain open to epistemological diversity rather than strive for integration. Ultimately, if successful, we believe that such an approach will result in a better understanding of global land-use change and its sustainability challenges—one that is not reducible to the preceding natural or social science understandings, but rather belongs to this emerging field of telecoupling research. Consequently, this book is not an attempt to settle the ongoing discussion of the telecoupling concept and framework. Instead, it is an open invitation for different types of scholars concerned with global land-use change and its sustainability challenges to get involved in, explore, challenge and advance telecoupling research.

References

Abson, David J., Joern Fischer, Julia Leventon, Jens Newig, Thomas Schomerus, Ulli Vilsmaier, Henrik von Wehrden, Paivi Abernethy, Christopher D. Ives, Nicolas W. Jager, and Daniel J. Lang. 2017. Leverage Points for Sustainability Transformation. *Ambio* 46 (1): 30–39. https://doi.org/10.1007/s13280-016-0800-y.

Adger, W. Neil, Katrina Myrvang Brown, and Emma L. Tompkins. 2005. The Political Economy of Cross-scale Networks in Resource Co-management. *Ecology and Society* 10 (2): 9. https://doi.org/10.5751/ES-01465-100209.

Eakin, Hallie, Ruth DeFries, Suzi Kerr, Eric F. Lambin, Jianguo Liu, Peter J. Marcotullio, Peter Messerli, Anette Reenberg, Ximena Rueda, Simon R. Swaffled, Birka Wicke, and Karl Zimmerer. 2014. Significance of Telecoupling for Exploration of Land-Use Change. In *Rethinking Global Land Use in an Urban Era*, ed. Karen C. Seto and Anette Reenberg, 141–161. Cambridge, MA: The MIT Press.

Fairhead, James, Melissa Leach, and Ian Scoones. 2012. Green Grabbing: A New Appropriation of Nature? *The Journal of Peasant Studies* 39 (2): 237–261. https://doi.org/10.1080/03066150.2012.671770.

Fischer, Joern, Toby A. Gardner, Elena M. Bennett, Patricia Balvanera, Reinette Biggs, Stephen Carpenter, Tim Daw, Carl Folke, Rosemary Hill, Terry

P. Hughes, Tobias Luthe, Manuel Maass, Megan Meacham, Albert V. Norström, Garry Peterson, Cibele Queiroz, Ralf Seppelt, Marja Spierenburg, and John Tenhunen. 2015. Advancing Sustainability through Mainstreaming a Social-Ecological Systems Perspective. *Current Opinion in Environmental Sustainability* 14: 144–149.

Friis, Cecilie, and Jonas Ø. Nielsen. 2017. Land-Use Change in a Telecoupled World: The Relevance and Applicability of the Telecoupling Framework in the Case of Banana Plantation Expansion in Laos. *Ecology and Society* 22 (4): 30.

Friis, Cecilie, Jonas Ø. Nielsen, Iago Otero, Helmut Haberl, Jörg Niewöhner, and Patrick Hostert. 2016. From Teleconnection to Telecoupling: Taking Stock of an Emerging Framework in Land System Science. *Journal of Land Use Science* 11 (2): 131–153. https://doi.org/10.1080/1747423X.2015.1096423.

GLP. 2016. Global Land Programme. Science Plan and Implementation Strategy 2016–2021. *Global Land Programme*. Accessed June 6, 2017. https://glp.earth/sites/default/files/uploads/glpscienceplan_25_10_16.pdf.

IPBES. 2018. *Summary for Policymakers of the Assessment Report on Land Degradation and Restoration of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Edited by Robert Scholes, Luca Montanarella, Anastasia Brainich, et al. Bonn: Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (IPBES).

Jerneck, Anne, Lennart Olsson, Barry Ness, Stefan Anderberg, Matthias Baier, Eric Clark, Thomas Hickler, Alf Hornborg, Annica Kronsell, Eva Lövbrand, and Johannes Persson. 2011. Structuring Sustainability Science. *Sustainability Science* 6 (1): 69–82. https://doi.org/10.1007/s11625-010-0117-x.

Liu, Jianguo, Vanessa Hull, Mateus Batistella, Ruth DeFries, Thomas Dietz, Fu Feng, Thomas W. Hertel, R. Cesar Izaurralde, Eric F. Lambin, Shuxin Li, Luiz A. Martinelli, William J. McConnell, Emilio F. Moran, Rosamond Naylor, Zhiyun Ouyang, Karen R. Polenske, Anette Reenberg, Gilberto de Miranda Rocha, Cynthia S. Simmons, Peter H. Verburg, Peter M. Vitousek, Fusuo Zhang, and Chunquan Zhu. 2013. Framing Sustainability in a Telecoupled World. *Ecology and Society* 18 (2): 26. https://doi.org/10.5751/ES-05873-180226.

Messerli, Peter, Markus Giger, Michael B. Dwyer, Thomas Breu, and Sandra Eckert. 2014. The Geography of Large-Scale Land Acquisitions: Analysing Socio-ecological Patterns of Target Contexts in the Global South. *Applied Geography* 53 (0): 449–459. https://doi.org/10.1016/j.apgeog.2014.07.005.

Moran, Emilio F., and Maria Claudia Lopez. 2016. Future Directions in Human-Environment Research. *Environmental Research* 144 (Part B): 1–7. https://doi.org/10.1016/j.envres.2015.09.019.

Pulver, Simone, Nicola Ulibarri, Kathryn L. Sobocinski, Steven M. Alexander, Michelle L. Johnson, Paul F. McCord, and Jampel Dell'Angelo. 2018. Frontiers in Socio-environmental Research: Components, Connections, Scale, and Context. *Ecology and Society* 23 (3): 23. https://doi.org/10.5751/ES-10280-230323.

UN. 2015. *Transforming our World. The 2030 Agenda for Sustainable Development*. New York: United Nations.

———. 2017. World Population Prospects: The 2017 Revision, Key Findings and Advance Tables. *Working Paper No. ESA/P/WP/248*. United Nations, Department of Economic and Social Affairs, Population Division, New York.

van der Hel, Sandra. 2018. Science for Change: A Survey on the Normative and Political Dimensions of Global Sustainability Research. *Global Environmental Change* 52: 248–258. https://doi.org/10.1016/j.gloenvcha.2018.07.005.

Part I

Overview

2

What Is Telecoupling?

Jinguo Liu, Anna Herzberger, Kelly Kapsar, Andrew K. Carlson, and Thomas Connor

1 Introduction

Human and natural systems around the world are becoming increasingly connected through distant processes, such as international trade, migration, foreign investment, flows of ecosystem services, and species invasion. The speed, scale, complexity, and consequences of these interactions have profound implications for global challenges such as biodiversity conservation, food security, energy security, water security, environmental protection, and human well-being. For instance, biofuel policies in the USA and Europe catalyse land-use change that has socioeconomic and environmental impacts in distant areas worldwide (Liu et al. 2013). The complex impacts of these distant human-nature interactions demonstrate the need for an umbrella concept that can describe various distant interactions, and an integrated framework for systematic analysis to

J. Liu (✉) • A. Herzberger • K. Kapsar • A. K. Carlson • T. Connor
Department of Fisheries and Wildlife, Center for Systems Integration and Sustainability, Michigan State University, East Lansing, MI, USA
e-mail: liuji@msu.edu; herzber5@msu.edu; carls422@msu.edu; connort2@msu.edu

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_2

address the United Nations' Sustainable Development Goals and other global challenges.

The telecoupling concept and framework (Liu et al. 2013) are well-suited to understand the interconnected world and help map possible pathways towards desired goals. The concept of telecoupling refers to socioeconomic and environmental interactions over distances. The telecoupling framework was developed to provide a systematic, integrative method to evaluate telecouplings (Liu et al. 2013).

The goal of this chapter is to describe telecoupling—both the concept and the framework—with particular emphasis on telecoupled land-use change. We explain what the telecoupling framework is and address some frequently asked questions with example applications that illustrate the framework's utility for systematically understanding, managing, and sustaining telecoupled land use. We conclude the chapter by describing ongoing efforts to operationalise the telecoupling framework, apply it to telecoupled governance, and supplement it with an extended framework (i.e. metacoupling; Liu 2017) that is applicable across local to global scales.

2 Telecoupling Concept

The telecoupling concept was developed by integrating relevant disciplinary concepts such as teleconnections (interactions between distant climatic systems; Wallace and Gutzler 1981) and globalisation (interactions between distant human systems; Sassen 1999). Teleconnections and globalisation have been applied by land system scientists (Young et al. 2006; Haberl et al. 2009; Seto et al. 2012), but the telecoupling concept is more appropriate for land system research for several reasons. First, it avoids the confusion with the original meaning of those disciplinary concepts. Second, telecoupling emphasises feedbacks between distant systems, which are common among land systems. Third, it is a natural extension of concepts in land systems science that incorporates coupled systems, such as coupled human and natural systems, coupled social-ecological systems, and coupled human-environmental systems. Fourth, it connects various distant socioeconomic and environmental interactions, as well as their impacts. For example, studies on human migration and animal migration often focus on socioeconomic and ecological dimensions, respectively. However, in reality, human migration has ecological implications and animal migration has socioeconomic implications. Human migrants consume resources in destinations and emit pollutants, thus affecting the environment. Animal migrants, such as locusts, have enormous economic impacts because they predate crops along migration routes and in destinations. By including ecological dimensions in human migration research and socioeconomic dimensions in animal migration research, both human and animal migration can be treated as telecoupling processes. Similarly, other distant interactions can also be treated as telecouplings, such as international trade, foreign investment, water transfer, transnational land tenure transfer, species invasion, knowledge transfer, technology transfer, tourism, payments for ecosystem services, species dispersal, and atmospheric circulation (Liu et al. 2013). In other words, telecoupling is an umbrella concept that encompasses various distant interactions. It enables researchers to explore interrelationships among various distant interactions and feedbacks across multiple scales. It also captures the complexity of increasingly prevalent distant environmental and socioeconomic interactions, as well as their diverse drivers and effects.

The telecoupling concept was first proposed by the lead author in 2008, and the first symposium to discuss telecoupling was held at the 2011 annual meeting of the American Association for the Advancement of Science (AAAS; Table 2.1). Telecoupling was later chosen as a preferred concept by a group of land system scientists from around the world after long discussion at the Strüngmann Forum on "Rethinking Global Land Use in an Urban Era" held in Germany in 2012 (Eakin et al. 2014; Seto and Reenberg 2014). It was specifically recognised for its extension of teleconnections by explicitly considering socioeconomic and environmental interactions as well as feedbacks between systems. It was also noted for its comprehensiveness through its inclusion of distant interactions within a country or region rather than solely at the global scale implied in globalisation.

Table 2.1 Telecoupling events (examples)

Event name	Date	Location	Organisers
Telecoupling for Sustainable Development and Conservation Across Local to Global Scales (symposium)	April 9, 2018	United States Chapter of the International Association of Landscape Ecology, Annual Meeting, Chicago, IL, USA	Jianguo Liu, Yue Dou, Kelly Kapsar, Hongbo Yang
Telecoupling Framework: Concepts, Applications and Hands-On Exercises with the New Cloud-Based Telecoupling Toolbox (workshop)	April 10, 2018	United States Chapter of the International Association of Landscape Ecology, Annual Meeting, Chicago, IL, USA	Jianguo Liu, Francesco Tonini, Paul McCord, Min Gon Chung
Telecoupled Human and Natural Systems: Theory and Application to the International Food Trade (oral session)	June 8, 2017	Center for Global Trade Analysis, Purdue University's (GTAP) "20th Annual Conference on Global Economic Analysis", West Lafayette, IN, USA	Farzad Taheripour, Jianguo Liu
Telecoupling People and Landscapes among Distant Places around the World (symposium)	April 10, 2017	United States Chapter of the International Association of Landscape Ecology Annual Meeting, Baltimore, MD, USA	Jianguo Liu, Anna Herzberger, Jing Sun

(*continued*)

Table 2.1 (continued)

Event name	Date	Location	Organisers
Applications of the Telecoupling Framework and Hands-on Exercises with the Telecoupling Toolbox (workshop)	April 9, 2017	United States Chapter of the International Association of Landscape Ecology Annual Meeting, Baltimore, MD, USA	Jianguo Liu, Francesco Tonini, Yue Dou, Hongbo Yang
Telecoupling Framework as an Integrated Platform to Capture, Study, and Manage Complexity in a Changing World (poster session)	December 15, 2016	American Geophysical Union Fall Meeting, San Francisco, CA, USA	Falk Huettmann, Jianguo Liu
Exploring Mismatches and Power Asymmetries in Telecoupled Land Systems (oral session)	October 27, 2016	Global Land Project, 3rd Open Science Meeting, Beijing, China	Cecilie Friis
Untangling the Complexity of Telecouplings and Global Land System Change: Challenges and Opportunities for Bridging Geographic and Disciplinary Boundaries (forum)	October 27, 2016	Global Land Project, 3rd Open Science Meeting, Beijing, China	Jianguo Liu, Thomas Hertel
Land Systems in an Urbanising and Telecoupled World (poster session)	October 26, 2016	Global Land Project, 3rd Open Science Meeting, Beijing, China	Meeting organisers
Northern Eurasia in a Telecoupled World: Agricultural Potentials and Ecosystem Trade-offs (oral session)	October 26, 2016	Global Land Project, 3rd Open Science Meeting, Beijing, China	Alexander V. Prishchepov, Christian Levers, Florian Schierhorn

(*continued*)

Table 2.1 (continued)

Event name	Date	Location	Organisers
Urbanisation and Agricultural Land Use: Empirical Evidence, Models, and Policy Implications of Telecoupling (oral session)	October 26, 2016	Global Land Project, 3rd Open Science Meeting, Beijing, China	Daniel G. Brown, Qing Tian
Telecoupling Framework for the Global Land System Science Community (oral session)	October 25, 2016	Global Land Project, 3rd Open Science Meeting, Beijing, China	Jianguo Liu, Anna Herzberger, Emilio Moran, Peter Verburg
Interactions Between Food Security and Land Use in the Context of Global Change: the Belmont Forum Perspective (oral session)	October 25, 2016	Global Land Project, 3rd Open Science Meeting, Beijing, China	Reynaldo Luiz Victoria, William McConnell
Landscape networks as telecoupled human and natural systems (symposium)	April 4, 2016	United States Chapter of the International Association of Landscape Ecology Annual Meeting, Asheville, NC, USA	Jianguo Liu, Vanessa Hull
Telecoupling Framework for the Landscape Ecology Community (workshop)	April 3, 2016	United States Chapter of the International Association of Landscape Ecology, Annual Meeting, Asheville, NC, USA	Jianguo Liu, Vanessa Hull
Telecoupling Systems (satellite session)	October 1, 2015	European Conference on Complex Systems, Temple, AZ, USA	Beth Tellman, Jesse Sayles, Ashwina Mahanti, Karina Benessiah

(*continued*)

Table 2.1 (continued)

Event name	Date	Location	Organisers
Telecoupling framework for Studying Cross-border and Cross-scale Interactions (workshop)	July 5, 2015	International Association for Landscape Ecology, World Congress, Portland, OR, USA	Jianguo Liu, Vanessa Hull
Towards operationalisation of telecoupling concepts for land system science (workshop)	December 1–3, 2014	Global Land Project, Aeschi, Switzerland	Andreas Heinimann, Ricardo Grau, Ole Mertz, Ignacio Gasparri, Peter Verburg
Land Systems in a Telecoupled World	March 19–21, 2014	2014 Global Land Project, Open Science Meeting, Berlin, Germany	Patrick Hostert, Peter Verburg
Ecological Sustainability in a Telecoupled World (symposium)	August 8, 2013	Ecological Society of America, Annual Meeting, Minneapolis, MN, USA	Jianguo Liu, Harold Mooney
Ernst Strüngmann Forum on Rethinking Global Land Use in an Urban Era	September 23–28, 2012	Frankfurt, Germany	Karen C. Seto and Anette Reenberg,
Telecoupling and Land Change in Emerging Economies: Trade and the Rise of Eco-consumerism (oral session)	March 26, 2012	Planet Under Pressure, London, UK	Eric Lambin, Anette Reenberg, Juliette Caulkins, Tobias Langanke
Telecoupling of Human and Natural Systems (symposium)	February 18, 2011	American Association for the Advancement of Science, Annual Meeting, Washington, DC, USA	Jianguo Liu, William McConnell, Thomas J. Baerwald

3 Overview of the Telecoupling Framework and Applications

The telecoupling framework was first proposed by Liu et al. (2013) and is deeply rooted in coupled human-natural, human-environment or social-ecological systems analysis. Since its inception, it has been applied to develop more specialised frameworks to address specific issues. For example, Eakin et al. (2014) applied the framework to develop an actor-centred approach to telecoupling, and Lenschow et al. (2016) modified the framework from a governance perspective. This chapter provides an overview of the telecoupling framework as developed by Liu et al. (2013) and its applications.

3.1 Overview

The telecoupling framework is an explicit structuring of the telecoupling concept applicable to diverse research questions. The framework uses multiple coupled systems and the connections between them as its main structure (Fig. 2.1). These connections are captured in the framework with the term "flow", which is the movement of materials, people, energy, organisms, capital, and/or information between two or more coupled systems. The coupled system in which the flow originates is termed the "sending system", and the coupled system to which the flow is sent is called the "receiving system". Flows between sending and receiving systems can result in effects on other systems, which are named "spillover systems". The flows among sending, receiving, and spillover systems are a result of "causes", the reasons or drivers behind the flows. There are various causes, such as socioeconomic, environmental, cultural, and other factors. Flows may also induce feedbacks from receiving to sending systems that strengthen, weaken, or alter the flows themselves. The flows are facilitated by "agents", decision-making entities such as people and animals. The flows also generate various socioeconomic and environmental "effects" in the respective systems involved.

An example of a telecoupling is the flow of soybean exports from Brazil, the sending system, to China, the receiving system (Sun et al. 2017;

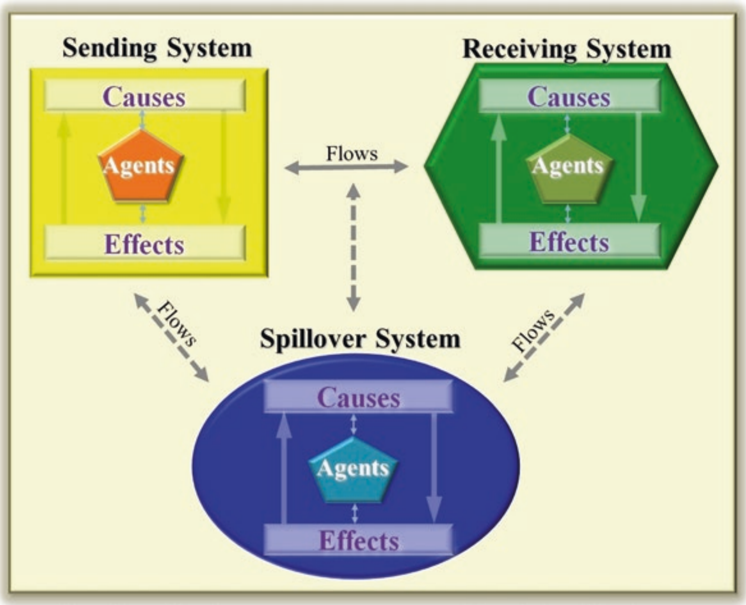


Fig. 2.1 A diagram illustrating the five major and interrelated components of the telecoupling framework (Liu et al. 2013)

Table 2.2). The main agents involved are representatives from Chinese companies that purchase soybeans, Brazilian farmers who plant and sell soybeans, and Chinese consumers driving the demand for soybeans. Causes are the historical use of soybeans as a staple in the Chinese diet, as well as increasing consumption of meat products in China, which require soybean-based feed. Effects of this telecoupling include the conversion of Amazonian rainforest and Cerrado into agricultural lands, with cascading environmental effects (e.g. cropland displacement, greenhouse gas emissions, and loss of carbon storage capacity; Bicudo da Silva et al. 2017; Sun et al. 2017; Liu 2017; Dou et al. 2018). In telecouplings that contribute to climate change, such as this one, the rest of the world can be considered a spillover system. This example is just one in a myriad of applications—the telecoupling framework can be applied to diverse research questions and used with interdisciplinary methodologies to measure and analyse its different components.

Table 2.2 Example systems, flows, agents, causes, and effects in the application of the telecoupling framework to land use

Paper title and authors	Systems	Flows	Agents	Causes	Effects
Telecoupling, urbanisation, and the unintended consequences of water development aid in Ethiopia (Chignell and Laituri 2016)	USA/United Nations (UN) international aid and development sector, Rural communities, Hydropower production systems	Water, Crops, People, Energy, Technology, Capital, Political/ Cultural influence	Foreign aid agencies, Ethiopian ministries, Development banks, Companies, Nongovernmental organisations (NGOs), Faith-based organisations, Farmers/ Pastoralists, Urban poor, Economists, Politicians, Geoscientists	Push and pull of global markets, Demand for water/food security, technological development	Lower infant mortality, Access to improved water, Competition for land/resources, Loss of traditional livelihoods
Spillover effect offsets the conservation effort in the Amazon (Dou et al. 2018)	Brazilian Cerrado, Brazilian Amazon	Soybeans, Beef, Information (policy, agreements, markets), Money	Farmers, Grain buyers, Ranchers, Livestock processing facility, Government, NGOs	China's demand, Brazilian national policy	Deforestation

(*continued*)

Table 2.2 (continued)

Paper title and authors	Systems	Flows	Agents	Causes	Effects
The Emerging Soybean Production Frontier in Southern Africa: Conservation Challenges and the Role of South-South Telecouplings (Gasparri et al. 2016)	South America, Southern African countries	Technology, Investment, Information	Extension agents, Governments, Universities, Development agencies, Companies	Favourable institutional conditions, Demand for soybean products	Increased soy production in South Africa
Telecoupled land-use changes in distant countries (Sun et al. 2017)	Western corn belt (USA), State of Mato Grosso (Brazil), Heilongjiang Province (China)	Soybeans, Money, Information	Governments, NGOs, Companies, Farmers	International food trade	Land-use change
Transatlantic wood pellet trade demonstrates telecoupled benefits (Parish et al. 2018)	Southeastern USA forests, European biopower facilities	Wood pellets, Money, Greenhouse gas emissions	Forest owners, Logging companies, Lumber mills, Coal companies, Miners, Governments, Power companies, Power consumers	EU Renewable Energy Directive	Fire-preventing practices in south-eastern USA, afforestation in Europe

(continued)

Table 2.2 (continued)

Paper title and authors	Systems	Flows	Agents	Causes	Effects
Forest sustainability in China and implications for a telecoupled world (Liu 2014)	China, Timber-producing countries (e.g. USA)	Forest products	Companies, Governments, International organisations, NGOs	Limited domestic supply and growing demand in China, Transition from socialism to capitalism	Varying deforestation rates in China and other Asia-Pacific countries
Telecoupling framework for research on migratory species in the Anthropocene (Hulina et al. 2017)	Breeding habitat, Overwintering habitat, Migratory stopover sites	Kirtland's Warblers, Tourism, Timber, Information, Money	Kirtland's Warblers, Brown-headed Cowbirds, Government agencies, NGOs, Timber and tourism companies, Landowners, Farmers	Socioeconomic incentives and social norms to support conservation	Synergism between socioeconomic and environmental efforts

(*continued*)

Table 2.2 (continued)

Paper title and authors	Systems	Flows	Agents	Causes	Effects
Operationalising the telecoupling framework for migratory species using the spatial subsidies approach to examine ecosystem services provided by Mexican free-tailed bats (Lopez-Hoffman et al. 2017)	Texas, New Mexico, and Colorado (USA); Chiapas, Hidalgo, Michoacán & Jalisco, Querétaro (Mexico)	Migratory species, Tourism	Mexican Free-tailed Bats, Tourists, Cotton producers	Bat migration patterns	Spatial subsidy in ecosystem services

3.2 Applications of the Telecoupling Framework

Since publication of the paper outlining the telecoupling framework (Liu et al. 2013), there has been a broad interest in the framework and its applications. Many telecoupling-related events, such as workshops and symposia, have been organised in many parts of the world (Table 2.1). The Global Land Programme has chosen telecoupling as a research priority,[1] and it is being applied in the global assessment of biodiversity and ecosystem services report, organised by the United Nations' Intergovernmental Platform on Biodiversity and Ecosystem Services. A number of projects on telecoupling have been supported by different funding sources, such as the U.S. National Science Foundation,[2] European Union,[3] and Belmont Forum.[4]

The telecoupling framework has been applied in a wide range of studies covering topics from species invasion and migration (Liu et al. 2014; Hulina et al. 2017), urbanisation and economic development (Fang and Ren 2017) to trade, tourism and foreign direct investment (Liu et al. 2015; Yang et al. 2016; Torres et al. 2017). The framework is also gaining traction in studies of land change driven by food trade, knowledge transfers, payment for ecosystem services and conservation (Liu 2014, 2017; Chignell and Laituri 2016; Friis and Nielsen 2017b; Hulina et al. 2017; Lopez-Hoffman et al. 2017; Sun et al. 2017). Given the theme of this book, in this section we illustrate some applications of the framework to land use. Due to space constraints, we focus on example publications that both cite telecoupling in the title and use framework components in relation to land use. The papers included address various agents-individual (e.g. farmers, ranchers, tourists), organisational (e.g. governments, NGOs, companies) and even non-human agents (e.g. migratory birds and bats). The flows include movements of agricultural and timber products, investments, information, technology, people, water, and energy (Table 2.2).

Regardless of the specific topics to which the telecoupling framework is applied, feedbacks between different systems are an important feature of all telecouplings. However, they are often difficult to detect empirically because they take time to form. Spatial separation poses additional challenges for detection. However, Chignell and Laituri (2016) applied the telecoupling framework to urban land expansion driven by clean water initiatives in rural areas of Ethiopia that caused a feedback of rural migrants. They found that the initiatives successfully reduced mortality rates and eventually led to population growth with increased resource competition between young adults. This drove rural migrants to urban areas in search of employment opportunities; the expanding population increased urban resource requirements, which prompted the construction of additional hydropower dams. The constructed dams generated electricity for distant cities, but displaced water resources for downstream communities. This then led to further rural-to-urban migration. The authors acknowledge the usefulness of applying the telecoupling framework in their analysis to "identify potential linkages and feedbacks among distant communities and systems" (Chignell and Laituri 2016, 133).

Spillover systems have been identified at both regional and national scales. At the regional scale, for example, Dou et al. (2018) focused on agents facilitating grain production in Brazil, which generated spillover production areas within the focal country. They modelled the response of farmer-agents to the Soy Moratorium in the Brazilian Amazon and identified the Cerrado as a spillover area of soybean expansion. At the national scale, Liu et al. (2014) used the telecoupling framework to identify spillover systems associated with transnational land deals. For instance, South Africa is a spillover system because it facilitates flows of financial capital to land-title-sending countries from receiving countries.

Going beyond elusive feedbacks and spillovers, the telecoupling framework has been used to bring a more complete understanding of the causes and effects of telecouplings. By enabling evaluation of the socioeconomic and environmental reasons (i.e. causes) for telecoupled flows, the telecoupling framework allows researchers to develop robust explanations of telecouplings. The systematic nature of the telecoupling framework provides a foundation for distinguishing effects (i.e. changes in outcomes brought about by changes in explanatory variables) and mechanisms (i.e. processes whereby explanatory variables produce their effects) (Meyfroidt 2016). In turn, discerning between these causal components can yield unexpected insights that are important for land-use policy and management. For example, Parish et al. (2018) used the telecoupling framework to examine the sale of wood pellets from the USA (i.e. sending system) to European biopower facilities (i.e. receiving system). They concluded that transatlantic wood pellet trade not only reduces European carbon emissions, but also protects European afforestation efforts and encourages management practices that can prevent the spread of wildfires and disease outbreaks throughout the south-eastern USA. Due to negative environmental perceptions of wood pellet trade, understanding the nuances of the telecoupled relationships, including less evident beneficial effects, is essential to maintain jobs and ecosystem services on both sides of the Atlantic Ocean. Further support for untangling complex drivers can be seen in Liu (2014), where China is defined as both a receiving system of forest materials and a sending system of forest products. Liu found that while China is offsetting its domestic wood demand by importing raw materials (e.g. from the USA, Russia, Indonesia, and Canada) and benefiting environmentally, China is also responding to export demand for forest products in other countries (e.g. Japan, South Korea, the USA, and the U.K.). In this light, China is seen not simply as a dominant wood importer, but also as a member of the supply chain, which provides insight for ways to appropriately address forest harvest. For example, policies and initiatives focused on reduced consumption and reuse of finished timber products in the countries importing them from China will likely have greater overall success in reducing forest loss than policies just focused on timber use within China itself.

Use of the telecoupling framework in studies that explicitly analyse the flows between distant places has demonstrated the need for telecoupled land management. For example, Hulina et al. (2017) showed that collaborative management in the sending (breeding) and receiving (wintering) systems for the migration of Kirtland's Warbler (*Setophaga kirtlandii*; a songbird of conservation concern) has resulted in increases in population size and suitable habitats through targeted timber harvest, heterogeneous agriculture landscapes, and tourism. While this is a success story of telecoupled land management, the authors note the lack of collaborative management in spillover systems (migratory stopover sites) that are crucial to sustain the Kirtland's Warbler as well as many other migratory species. Similarly, Lopez-Hoffman et al. (2017) estimate that the cotton producers in south-eastern USA receive pest control benefits (US $12.4

million a year) from flows of the migratory Mexican free-tailed bat (*Tadarida brasiliensis mexicana*), but they provide little support for bat conservation. In other words, the receiving systems of the migratory bats are being spatially subsidised by conservation efforts in the sending systems. Thus, telecoupled land management may be critical to realise the benefits of distant ecosystem services and identify hidden environmental costs.

4 Further Clarifications of the Telecoupling Framework

Since the publication of the telecoupling framework (Liu et al. 2013), there have been some divergent interpretations of its scope and utilisation. While the intentions of those interpretations are good as they aim to bring the field forward, they have unintentionally led to the propagation of further divergence from what the framework was intended to encompass. The different interpretations may be partially due to the lack of explicit statements in the telecoupling framework. Thus, in this section, we clarify these issues to avoid future misunderstanding and misinterpretations.

4.1 Structure of the Telecoupling Framework

The telecoupling framework is both structured and processual. The framework is structured in that it has identifiable components that are used to describe telecouplings. It is also processual as the flows themselves and their feedbacks are processes. Depending on the research questions being asked, an approach that focuses on the structural aspects of a telecoupling (e.g. quantifying system dynamics) will provide a different set of answers than a processual approach (e.g. quantifying the flows between sending and receiving systems). These differing analytical approaches to telecouplings are similar to the way in which ecosystems are defined, understood, and analysed. An ecosystem is defined as an entity encompassing the biotic community and abiotic environment (from a structural perspective), as well as a series of flows between particular components (from a processual perspective); some researchers have studied ecosystem structure, whereas others have studied the process by which interactions within an ecosystem occur (e.g. through nutrient cycling). Extending this example into human systems, an economy consists of producers, consumers, and distributors (structural), as well as relevant processes such as production, consumption, and distribution, that is, the transfers of goods and services between producers and consumers through distributors (processual).

The telecoupling framework can be employed to track changes in system dynamics over time. Telecouplings are usually dynamic and the telecoupling framework can be applied to analyse them retrospectively, contemporarily, and prospectively. Temporal dynamics are inherent to the framework, as telecouplings arise over time to result in current conditions. Likewise, temporal analyses can be used to track the strength of a telecoupling over time and to analyse potential changes to systems in the future. For example, the effects of one telecoupling process could serve as the cause of the emergence of a new telecoupling. Several telecoupling projects aim to understand contemporary land system change and/or project patterns of land change into the future (Millington et al. 2017; Dou et al. 2018). For example, Dou et al. (2018) modeled the response of farmer-agents in the Brazilian Amazon to the Soy Moratorium, which prevented farmers from clearing forest for soybean expansion. This policy displaced soybean expansion to the nearby Cerrado, generating an emergent soybean frontier. Through statistical projections, they estimated the deforestation that would have occurred between 2006 and 2015 in both the sending and spillover systems in the absence of the Soy Moratorium. Agent-based and simulation models are useful tools for understanding and simulating future long-term dynamics (e.g. of land-use change) resulting from telecoupling processes (Millington et al. 2017; Dou et al. 2018).

Receiving and sending systems can be active or passive. In any given telecoupling, it is not predetermined that sending systems are active and receiving systems are passive (e.g. Friis et al. 2016). Rather, the power dynamics or factors that trigger the telecoupling or dominate the telecoupling processes depend on specific circumstances. In other words, a sending system can be passive and a receiving system can be active, or vice versa. Many transnational land deals or land grabs are good examples, with countries buying land (i.e. the receiving systems) pursuing actively while countries from which the land is bought (i.e. the sending systems) acting passively (Liu et al. 2014). In the framework by Liu et al. (2013), causes and agents can occur in sending, receiving, and spillover systems. Together, they make a telecoupling possible. Moreover, many telecouplings work in two directions (e.g. flows of capital and biofuel researchers to Sierra Leone, flows of biofuels and knowledge to Europe; Oberlack et al. 2018), implying that power is distributed and sending and receiving systems can be considered "active" or "passive" depending on the flow considered.

4.2 Implementation of the Telecoupling Framework

The telecoupling framework is both comprehensive and flexible. Because the framework consists of five interrelated major components, it may be perceived as a "check list" (Friis et al. 2016). While checking the box for each telecoupling component does not represent the utility of the framework as a whole (as further analytical approaches are necessary to result in an adequate understanding of a telecoupling), the advantages of a systematic approach include the ability to holistically identify research gaps by comprehensively identifying all aspects of a telecoupling as well as their relationships (see Liu and Yang 2013). For instance, identifying the systems, flows, agents, causes, and effects of a telecoupling, as well as the relationships among them, often reveals complex dynamics (e.g. feedbacks, legacy effects, regime shifts). The framework is also flexible, depending on research goals and questions. For instance, the definition of sending and receiving system is dependent on the flow direction. In other words, the same system may be the sender of one flow, but the receiver of another. Take Liu et al. (2014) as an example—the main flow of interest was the transfer of land titles. Countries that provide land titles to foreign investors were classified as sending systems, whereas those obtaining land titles were classified as receiving systems. Counter-flows of capital (which can also be viewed as feedbacks) went from the receiving to the original sending systems. Nearly all telecouplings will have feedback-flow relationships, which can be accounted for in the framework and associated analyses. If the aim of the above example was to analyse the flow of the monetary investments instead of land titles, the analysis could readily be reversed, demonstrating the efficacy of the telecoupling framework for assessing diverse kinds of telecoupled flows. Rather than restrictive descriptors for unidirectional movements, sending system and receiving system are intuitive conceptual labels for evaluating flows in any direction in which they occur, regardless of research topic. Indeed, this inherent flexibility is an important reason behind the telecoupling framework's wide applicability and utility for addressing global challenges.

Uncovering unexpected or unforeseen effects. Telecouplings may or may not lead to unexpected effects. The types of effects vary greatly. While many effects may be planned or anticipated by researchers (e.g. based on theoretical understanding), some may be surprising or unexpected. For example, it is intuitive that soybean production in Brazil and the USA for exportation consumes domestic water and land. It is a conventional wisdom that exporting countries suffer environmentally while importing countries gain environmental benefits (Sun et al. 2018). However, applying the telecoupling framework changed this conventional wisdom by demonstrating that soybean importing countries also suffer environmental damage, such as higher nitrogen pollution and water consumption, from the soybean trade (Sun et al. 2018). These environmental problems occur because soybean imports cause the conversion of soybean lands to other croplands, such as corn fields and rice paddies, that use more fertilisers and water (Sun et al. 2018). Many of the studies described above also uncovered surprising results, such as more rural-to-urban migration driven by the clean water initiatives (Chignell and Laituri 2016), positive socioeconomic and environmental benefits from transatlantic wood pellet trade (Parish et al. 2018), and increased soybean expansion in the Cerrado in response to the reduction in soybean expansion rates in the Brazilian Amazon (Dou et al. 2018).

The framework is feasible to implement and has numerous analytical entry points. For feasible implementation of the framework, one does not have to work on every component for every project. Like almost any research, if one wants to have extensive, in-depth analysis of a subject, the research would be very time-consuming and resource-intensive. The framework by Liu et al. (2013) provides a comprehensive scope and flexibility. Because a paper is usually limited in space, it is possible to focus on one component for detailed analysis in the context of the framework. For example, five papers can each address one component in detail, and the sixth paper can integrate the previous five. In fact, some applications only focus on receiving systems (Yang et al. 2018) or sending systems (Bicudo da Silva et al. 2017; Dou et al. 2018), while other applications focus on flows (Lopez-Hoffman et al. 2017) or agents, causes, and effects (Friis and Nielsen 2017a). Working on different components under the framework separately maintains feasibility while providing a mechanism for collaborative, team-based research and an avenue for integration in the future. Although it is generally infeasible to "know everything" about a topic, particularly complex coupled human-natural systems, forming cooperative research teams is a practical way to implement the telecoupling framework and maximise its utility for addressing sustainability challenges. Further, due to its flexible nature, any component of the telecoupling framework can be an analytical entry point. A telecoupling analysis can therefore start by identifying flows between, agents involved in, and causes and/or effects of connected systems. For example, Leisz et al. (2016) used qualitative methods along with remote-sensing analysis to quantify land-use change along the East-West Economic Corridor in Southeast Asia from both a system-based and agent-based entry point.

System boundaries are context-dependent and need not be defined a priori. Defining system boundaries is important because different boundaries may lead to different outcomes. However, the framework does not finalise the definition of a system *a priori* and is flexible regarding the method for determining system boundaries. Depending on problems and questions of interest, systems may be defined by spatial units; cultural networks; or geographical, political, administrative, or management boundaries (see also Eakin et al. 2014; Friis and Nielsen 2017a). The time at which the system definition is finalised is also important. Friis and Nielsen (2017a) have expressed concern that defining systems *a priori* risks hiding the complexity of telecoupling. Many telecoupling studies take multiple steps and do not finalise system boundaries until after the first steps (Liu 2017). To save space, however, the detailed processes during the early steps leading to the system definition are often omitted from publications (Liu et al. 2015). The lack of reporting the early steps may cause the reader to perceive that the system is defined *a priori*. In fact, the systems under the telecoupling framework do not need to be and often cannot be finalised *a priori*. For example, the sending systems of tourists to Wolong Nature Reserve of China were not known until the interviews with tourists were completed and the interview data were analysed (Liu et al. 2015). More explicit descriptions of the definition of system boundaries, the reasons for defining these boundaries, and the potential effects of these boundary definitions should be undergone in future studies in order to improve transparency and research practice.

Application of the telecoupling framework at multiple scales is possible and may reveal unexpected scale dependencies. The dependency of a conclusion on the scale of analysis is a common issue in a variety of sciences and can affect applications of the telecoupling framework. The advantage of the framework is that its components can change according to the scale chosen for analysis. Friis and Nielsen (2014) present an example of rubber plantation development in Laos (receiving system) that is driven by Chinese investment from the Xishuangbanna region (sending system). By increasing the spatial and temporal scale, they reframed the problem so that rubber production in Xishuangbanna (receiving system) was driven by investments from Beijing (sending system), and Laos became a spillover system for excess rubber demand unable to be met by Xishuangbanna alone.

4.3 Implications for Telecoupled Governance

Facilitating the shift from place-based governance to flow-based governance. Recently, attention has been paid to the increasing shift in land governance from traditional place-based governance (i.e. focusing on governance or management of individual places) to flow-based governance arrangements, which emphasise that governance of one system should consider its relationships with other systems, including flows between them (Sikor et al. 2013). For example, Hulina et al. (2017) propose to expand the Kirtland's Warbler management paradigm from site-based to flow-based across sending systems (breeding sites), receiving systems (wintering sites), and spillover systems (e.g. stopover sites of the warbler migration, hometowns of tourists who travel to see the warbler). Because the warbler populations in wintering and breeding sites have reciprocal effects, land use in all sites affects the total population. Flows of money and tourists from other places to wintering and breeding sites are important for generating conservation funds. Eliminating or minimising the flow of Brown-headed Cowbirds (*Molothrus ater*) to breeding sites can reduce warbler mortality. This case is a clear example of the need for cooperation among agents in sending, receiving, and spillover systems to achieve flow-based governance. Flow-based governance of telecoupled interactions has also recently been suggested in food systems (Eakin et al. 2017) and biofuel production (Oberlack et al. 2018). Eakin and colleagues argue that social, institutional, and physical distances between systems can drive the capacity for changes in governance, and Oberlack and colleagues suggest a more integrated approach in linking polycentric governance with the telecoupling framework through the analysis of action/outcome networks. Such innovative analyses and approaches are needed for applied governance in a world increasingly connected via complex pathways.

Addressing global challenges. The telecoupling framework has important implications for addressing global challenges such as biodiversity conservation, food security, water security, and human well-being (Liu 2017). As an example, biofuel policies exert socioeconomic and environmental effects (e.g. land-use change; physical and economic displacement; decreased access to natural, economic, and cultural resources) in distant areas of the world (Oberlack et al. 2018). Because these impacts complicate efforts to address food and water security, there is a pressing need for governance that recognises telecouplings (i.e. telecoupled governance) associated with global biofuel production. The telecoupling framework can help address these and other global challenges (e.g. Sustainable Development Goals, biodiversity conservation) because it provides a systematic method for identifying the systems, flows, agents, causes, and effects associated with land-use changes. By operationalising the assessment of distant human-nature interactions, the telecoupling framework can help reveal the complexity of land use, aid managers in characterising global interconnectedness related to land use, and generate novel insights about land-use dynamics. Ultimately, this knowledge can catalyse the development of adaptive land-use policy and management strategies that promote telecoupled, polycentric governance (Oberlack et al. 2018) to solve global challenges.

4.4 Current Limitations of the Telecoupling Framework

As with all new frameworks, operationalising the telecoupling framework in all contexts will take time and effort. For a variety of reasons, such as researchers' interests and data limitations, some applications of the framework only focus on one or two of its particular aspects. Research gaps are thus inherent to this process of separately analysing individual telecoupling components. Specific areas that have been understudied include how telecouplings emerge and dissolve, their impact on sustainability and best practices for encouraging positive rather than negative impacts, and more explicit accounting for local and regional interactions in a broader context (see metacoupling framework below; Liu 2017). Further operationalisation of the telecoupling framework for quantitative and qualitative analyses of environmental and socioeconomic issues will help to address current limitations and future challenges.

5 Perspectives and Conclusions

In a world that is increasingly interconnected, the telecoupling framework offers a foundational tool to analyse linkages between systems over multiple scales, across distance, and through time. This chapter provided an overview of the telecoupling framework and highlighted several of its applications, drawing attention to the complex nature of telecoupling processes and the importance of feedback and spillover effects. The ability of the telecoupling framework to reveal connected, yet temporally or spatially separate effects underscores the importance of telecoupled, flow-based governance to harmonise human well-being with environmental sustainability.

Looking forward, there are many opportunities for telecoupling research in the future. In particular, the novelty of the telecoupling framework creates many opportunities for operationalising the framework to integrate previously isolated disciplinary research into a more holistic understanding of the socioeconomic and ecological aspects of distant interactions. Operationalisation of the telecoupling framework using geospatial analytical tools like those developed by Tonini and Liu (2017) as part of a new "Telecoupling Toolbox" can aid in the creation of telecoupled governance systems and help to address global challenges, such as those identified by the Sustainable Development Goals. Likewise, applying the telecoupling framework to identify previously unknown spillover systems and feedbacks is a critical component of future telecoupling research. As demonstrated in this chapter, policies intended to curb undesirable impacts in one system may displace these impacts to other systems not subject to the policy. Similarly, without the use of the framework, feedbacks from telecoupled flows are poorly understood due to temporal and spatial lags and may result in unintended consequences. Applications of the telecoupling framework to different systems can help detect hidden linkages and improve the management of telecoupled systems. Also, telecoupled systems are part of metacoupled systems, which encompass intracoupling (human-nature interactions within a system) and pericoupling (human-nature interactions between adjacent systems), in addition to telecoupling (Liu 2017). Understanding interactions among different types of couplings such as the interrelationships between telecouplings and pericouplings/intracouplings can help more holistically unveil the complexity of the real world to better address the Sustainable Development Goals and other global challenges.

Acknowledgments We thank Jonas Ø. Nielsen and Cecilie Friis for their invitation to write this chapter, and Cecilie Friis, Jonas Ø. Nielsen and Christoph Oberlack for reviewing the early draft. Funding was provided by the U.S. National Science Foundation and Michigan AgBioResearch.

Notes

1. https://glp.earth/our-science/themes/telecoupling-land-use-systems
2. https://www.nsf.gov/awardsearch/showAward?AWD_ID=1518518
3. http://coupled-itn.eu
4. http://www.belmontforum.org/projects/food-security-and-land-use-the-telecoupling-challenge/

References

Bicudo da Silva, Ramon F., Mateus Batistella, Yue Dou, Emilio F. Moran, Sara M. Torres, and Jianguo Liu. 2017. The Sino-Brazilian Telecoupled Soybean System and Cascading Effects for the Exporting Country. *Land* 6 (53): 1–19.

Chignell, Stephen M., and Melinda J. Laituri. 2016. Telecoupling, Urbanisation, and the Unintended Consequences of Water Development Aid in Ethiopia. In *Geoscience for the Public Good and Global Development: Toward a Sustainable Future*, ed. Gregory R. Wessel and Jeffrey K. Greenberg. Boulder, CO: Geological Society of America.

Dou, Yue, Ramon F. Bicudo da Silva, H. Yang, and Jianguo Liu. 2018. Spillover Effect Offsets the Conservation Effort in the Amazon. *Journal of Geographical Sciences* 28 (11): 1715–1732.

Eakin, Hallie, Ruth DeFries, Suzi Kerr, Eric F. Lambin, Jianguo Liu, Peter J. Marcotullio, Peter Messerli, Anette Reenberg, Ximena Rueda, Simon R. Swaffled, Birka Wicke, and Karl Zimmerer. 2014. Significance of Telecoupling for Exploration of Land-Use Change. In *Rethinking Global Land Use in an Urban Era*, ed. Karen Seto and Anette Reenberg, 141–161. Cambridge, MA: The MIT Press.

Eakin, Hallie, Ximena Rueda, and Ashwina Mahanti. 2017. Transforming Governance in Telecoupled Food Systems. *Ecology and Society* 22 (4): 32. https://doi.org/10.5751/ES-09831-220432.

Fang, Chuang Lin, and Yu Fei Ren. 2017. Analysis of Energy-based Metabolic Efficiency and Environmental Pressure on the Local Coupling and Telecoupling between Urbanisation and the Eco-environment in the Beijing-Tianjin-Hebei Urban Agglomeration. *Science China Earth Sciences* 60 (6): 1083. https://doi.org/10.1007/s11430-016-9038-6.

Friis, Cecilie, and Jonas Ø. Nielsen. 2014. Exploring the Potential of the Telecoupling Framework for Understanding Land Change. *THESys Discussion Papers 1*. Berlin: IRI THESys, Humboldt-Universität zu Berlin.

———. 2017a. On the System Boundary Choices, Implications and Solutions in Telecoupling Land-Use Change Research. *Sustainability* 9: 974.

———. 2017b. Land-Use Change in a Telecoupled World: The Relevance and Applicability of the Telecoupling Framework in the Case of Banana Plantation Expansion in Laos. *Ecology and Society* 22 (4): 30. https://doi.org/10.5751/ES-09480-220430.

Friis, C., J.Ø. Nielsen, I. Otero, H. Haberl, J. Niewöhner, and P. Hostert. 2016. From Teleconnection to Telecoupling: Taking Stock of an Emerging Framework in Land System Science. *Journal of Land Use Science* 11 (2): 131–153. http://www.tandfonline.com/doi/full/10.1080/1747423X.2015.1096423.

Gasparri, N.I., T. Kuemmerle, P. Meyfroidt, Y. le Polain de Waroux, and H. Kreft. 2016. The Emerging Soybean Production Frontier in Southern Africa: Conservation Challenges and the Role of South-South Telecouplings. *Conservation Letters* 9 (1): 21–31. https://doi.org/10.1111/conl.12173.

Haberl, Helmut, Karl-Heinz Erb, Fridolin Krausmann, Stefan Berecz, Nikolaus Ludwiczek, Joan Martínez-Alier, Annabella Musel, and Anke Schaffartzik. 2009. Using Embodied HANPP to Analyze Teleconnections in the Global Land System: Conceptual Considerations. *Geografisk Tidsskrift-Danish Journal of Geography* 109 (2): 119–130. https://doi.org/10.1080/00167223.2009.10649602.

Hulina, Jacqueline, Carol Bocetti, Henry Iii, Vanessa Hull, Wu Yang, and Jianguo Liu. 2017. Telecoupling Framework for Research on Migratory Species in the Anthropocene. *Elementa—Science of the Anthropocene* 5: 5. https://doi.org/10.1525/elementa.184.

Leisz, J. Stephen, Eric Rounds, Ngo The An, Nguyen Thi Bich Yen, Tran Nguyen Bang, Souvanthone Douangphachanh, and Bounheuang Ninchaleune. 2016. Telecouplings in the East-West Economic Corridor within Borders and Across. *Remote Sensing* 8 (12): 1012. https://doi.org/10.3390/rs8121012.

Lenschow, Andrea, Jens Newig, and Edward Challies. 2016. Globalisation's Limits to the Environmental State? Integrating Telecoupling into Global Environmental Governance. *Environmental Politics* 25 (1): 136–159. https://doi.org/10.1080/09644016.2015.1074384.

Liu, Jianguo. 2014. Forest Sustainability in China and Implications for a Telecoupled World. *Asia and the Pacific Policy Studies* 1: 230–250. https://doi.org/10.1002/app5.17.

———. 2017. Integration Across a Metacoupled World. *Ecology and Society* 22 (4): 29. https://doi.org/10.5751/ES-09830-220429.

Liu, Jianguo, Vanessa Hull, Mateus Batistella, Ruth DeFries, Tom Dietz, Fu Feng, Thomas W. Hertel, R. Cesar Izaurralde, Eric F. Lambin, Shuxin Li, Luiz A. Martinelli, William J. McConnell, Emilio F. Moran, Rosamond Naylor, Zhiyun Ouyang, Karen R. Polenske, Anette Reenberg, Gilberto de Miranda Rocha, Cynthia S. Simmons, Peter H. Verburg, Peter M. Vitousek, Fusuo Zhang, and Chunquan Zhu. 2013. Framing Sustainability in a Telecoupled World. *Ecology and Society* 18 (2): 26. https://doi.org/10.5751/ES-05873-180226.

Liu, Jianguo, Vanessa Hull, Junyan Luo, Yang Wu, Wei Liu, Andrés Viña, Christine Vogt, Zhenci Xu, Hongbo Yang, Jindong Zhang, Li An, Xiaodong Chen, Shuxin Li, Zhiyun Ouyang, Weihua Xu, Hemin Zhang, and Hemin Zhang. 2015. Multiple Telecouplings and their Complex Interrelationships. *Ecology and Society* 20 (3): 44. https://doi.org/10.5751/ES-07868-200344.

Liu, Jianguo, Vanessa Hull, Emilio Moran, Harini Nagendra, Simon R. Swaffled, and Benjamin L. Turner II. 2014. Applications of the Telecoupling Framework to Land-Change Science. In *Rethinking Global Land Use in an Urban Era*, ed. Karen C. Seto and Anette Reenberg, 119–139. Cambridge, MA: The MIT Press.

Liu, Jianguo, and Wu Yang. 2013. Integrated Assessments of Payments for Ecosystem Services Programs. *Proceedings of the National Academy of Sciences* 110 (41): 16297–16298. https://doi.org/10.1073/pnas.1316036110.

Lopez-Hoffman, Laura, Jay Diffendorfer, Ruscena Wiederholt, Kenneth J. Bagstad, Wayne E. Thogmartin, Gary McCracken, Rodrigo L. Medellin, Amy Russell, and Darius J. Semmens. 2017. Operationalizing the Telecoupling Framework for Migratory Species Using the Spatial Subsidies Approach to Examine Ecosystem Services Provided by Mexican Free-Tailed Bats. *Ecology and Society* 22 (4): 23. https://doi.org/10.5751/ES-09589-220423.

Meyfroidt, Patrick. 2016. Approaches and Terminology for Causal Analysis in Land Systems Science. *Journal of Land Use Science* 11 (5): 501–522.

Millington, James David Anthony, Hang Xiong, S. Peterson, and J. Woods. 2017. Integrating Modelling Approaches for Understanding Telecoupling: Global Food Trade and Local Land Use. *Land* 6 (3): 56. https://doi.org/10.3390/land6030056.

Oberlack, Christoph, Sebastien Boillat, Stefan Brönnimann, Jean-David Gerber, Andreas Heinimann, Chinwe Ifejika Speranza, Peter Messerli, Stephan Rist, and Urs Wiesmann. 2018. Polycentric Governance in Telecoupled Resource Systems. *Ecology and Society* 23 (1): 16. https://doi.org/10.5751/ES-09902-230116.

Parish, Esther S., Herzberger Anna, C. Phifer, and Virginia H. Dale. 2018. Telecoupled Transatlantic Wood Pellet Trade Provides Benefits in Both the Sending and Receiving Systems. *Ecology and Society* 23 (1): 28. https://doi.org/10.5751/ES-09878-230128.

Sassen, S. 1999. *Globalisation and Its Discontents: Essays on the New Mobility of People and Money*. New York: The New Press.

Seto, Karen C., and Anette Reenberg, eds. 2014. *Rethinking Global Land Use in an Urban Era*. Cambridge, MA: The MIT Press.

Seto, Karen C., Anette Reenberg, Christopher G. Boone, Michail Fragkias, Dagmar Haase, Tobias Langanke, Peter Marcotullio, Darla K. Munroe, Branislav Olah, and David Simon. 2012. Urban Land Teleconnections and Sustainability. *Proceedings of the National Academy of Sciences* 109 (20): 7687–7692. https://doi.org/10.1073/pnas.1117622109.

Sikor, Thomas, Graeme Auld, Anthony J. Bebbington, Tor A. Benjaminsen, Bradford S. Gentry, Carol Hunsberger, Anne-Marie Izac, Matias E. Margulis, Tobias Plieninger, Heike Schroeder, and Caroline Upton. 2013. Global Land Governance: From Territory to Flow? *Current Opinion in Environmental Sustainability* 5 (5): 522–527. https://doi.org/10.1016/j.cosust.2013.06.006.

Sun, Jing, Harold Mooney, Wenbin Wu, Huajun Tang, Yuxin Tong, Zhenci Xu, Baorong Huang, Yeqing Cheng, Xinjun Yang, Dan Wei, Fusuo Zhang, and Jianguo Liu. 2018. Importing Food Damages Domestic Environment: Evidence from Global Soybean Trade. *Proceedings of the National Academy of Sciences* 115 (21): 5415–5419.

Sun, Jing, Yuxin Tong, and Jianguo Liu. 2017. Telecoupled Land-Use Changes in Distant Countries. *Journal of Integrative Agriculture* 16 (2): 368–376. https://doi.org/10.1016/S2095-3119(16)61528-9.

Tonini, Francesco, and Jianguo Liu. 2017. Telecoupling Toolbox: Spatially Explicit Tools for Studying Telecoupled Human and Natural Systems. *Ecology and Society* 22 (4): 11. https://doi.org/10.5751/ES-09696-220411.

Torres, Aurora, Jodi Brandt, Kristen Lear, and Jianguo Liu. 2017. A Looming Tragedy of the Sand Commons. *Science* 357 (6355): 970.

Wallace, John M., and David S. Gutzler. 1981. Teleconnections in the Geopotential Height Field during the Northern Hemisphere Winter. *American Meteorological Society* 109: 784–812.

Yang, Dewei, Jingjing Cai, Vanessa Hull, Kaiyong Wang, Yin-Phan Tsang, and Jianguo Liu. 2016. New Road for Telecoupling Global Prosperity and Ecological Sustainability. *Ecosystem Health and Sustainability* 2 (10): e01242.

Yang, Hongbo, Frank Lupi, Jindong Zhang, Xiaodong Chen, and Jianguo Liu. 2018. Feedback of Telecoupling: The Case of a Payment for Ecosystem Services Program. *Ecology and Society* 23 (2): 45. https://doi.org/10.5751/ES-10140-230245.

Young, Oran R., Frans Berkhout, Gilberto C. Gallopin, Marco A. Janssen, Elinor Ostrom, and Sander van der Leeuw. 2006. The Globalisation of Socio-ecological Systems: An agenda for Scientific Research. *Global Environmental Change* 16 (3): 304–316. https://doi.org/10.1016/j.gloenvcha.2006.03.004.

3

Telecoupling: A New Framework for Researching Land-Use Change in a Globalised World

Cecilie Friis

1 Introduction

To study land-use change is to study the changing relationship between humans and their natural environment. We use land to produce food, energy and shelter, and many other life-supporting ecosystem functions are dependent on it. As a natural resource, land has biophysical properties such as soil composition, water retention capabilities and vegetation cover. Because a piece of land always has a geographical extent and location, these properties invariably change with the climatic, nutritional and geological conditions and properties of that location. How and in what manner humans use land thus depends on the natural environment. Any given land use, however, is also determined by the particular practices, relations and meanings that are available to and attributed by people to a particular piece of land. Such practices and relations change over time and across geographical space, and often land has overlapping, contrasting

C. Friis (✉)
IRI THESys & Geography Department, Humboldt-Universität zu Berlin, Berlin, Germany
e-mail: cecilie.friis@hu-berlin.de

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_3

or even conflicting meanings to different people at the same time. Researching land-use change thus inherently requires an understanding of the anthropogenic and the 'natural', the human and the environmental, the social and the ecological processes that shape decisions for and the outcomes of changing uses of land. As such, land-use change research requires multiple disciplinary perspectives.

This embedded need for interdisciplinarity in the study of land-use change underpins the land systems approach (Verburg et al. 2015). Land systems are conceptualised as coupled human-environment systems and thus incorporate both social and natural processes. Here, the coupling refers to the functional connection between the human and the environmental (sub)systems in the sense that "two systems are coupled if all or part of the outputs or fluxes of one system constitute (all or part) of the inputs of the other system" (Veldkamp 2009, 8). For land systems, the functional coupling entails the human practices that lead to land-use and land-cover changes,[1] as well as the feedbacks from the land and ecosystems that influence such practices. The concept of the 'land system' is used to describe the terrestrial component of the Earth System and, since land as a resource can always be spatially referenced, land systems are generally defined as place-based systems spanning from local landscapes to global regions in a nested scalar hierarchy. Land systems are furthermore understood as complex systems characterised by temporal and spatial dynamics, nonlinearity, feedbacks and emergent interactions between the human and environmental subsystems (Lambin and Geist 2006).

Over the past two decades, the land system, and the coupled human-environment system approach more broadly, has been adopted and promoted by land system science (LSS), an interdisciplinary research community that has consolidated around questions related to the role of land and land use in global environmental and social change (Lambin and Geist 2006; Turner et al. 2007). Aiming to bridge the natural, spatial and social sciences, LSS scholars have been at the forefront of building a better understanding of the patterns, drivers and outcomes of land-use and land-cover change (LUCC). With an initial focus on land-cover change detection and spatially explicit modelling of LUCC, LSS has increasingly sought to detect and assess the complex drivers and causal mechanisms behind such changes (Meyfroidt 2016). A widely used distinction between "proximate causes" and "underlying driving forces" (Geist and Lambin 2002) has allowed LSS researchers to separate and model immediate, proximate causal effects—for example, of agricultural expansion, intensification or logging—from the underlying processes that drive these effects, such as increasing demands, demographic factors and technological development.

However, the accelerating processes of *globalisation*—understood as the increasing pace and multifaceted dimensions of global connectivity in the economic, technological, political and cultural spheres—has led to new forms of land demand, new land-use agents and a general redistribution of land use locally and globally that complicates causal analysis in land-use change research, especially the distinction between proximate causes and underlying drivers (Seto and Reenberg 2014). This is because, while land is always used in a particular location, the primary land-use decision makers and main beneficiaries of land use are increasingly *not* found in the same location (all chapters, Niewöhner et al. 2016). Moreover, land use is embedded in long-distance flows and processes with wide spatial extents and increasing rates of exchange. These processes present a challenge for the conventional place-based analysis of land systems and require new conceptual and methodological approaches that can facilitate integration with more flow- and network-oriented analyses (Verburg et al. 2013; Munroe et al. 2014; Friis et al. 2016).

As a response, the concept of telecoupling and the telecoupling framework have been proposed (see Chap. 2). Building on, yet challenging the theoretical foundation of LSS, telecoupling adds an explicit focus on distal causal relations to coupled human-environment system thinking (Seto et al. 2012; Liu et al. 2013; Eakin et al. 2014; Friis et al. 2016). As such, telecoupling represent a heuritic device that can be used to think about how various flows and feedbacks, both socioeconomic and environmental, tie changes in land systems together over distance and produce particular land-use change outcomes. With a focus on the flows and networks that create such connections, telecoupling presents a potential starting point for understanding how specific processes of globalisation create particular land-use changes at particular moments in time.

To provide a framework for the topical chapters presented in Part II of this book, the rest of this chapter is dedicated to expanding on the contextual and conceptual background for the emergence of telecoupling research in LSS. In the next section, I consider some of the processes through which globalisation shapes contemporary land-use change by creating increased global connectivity between distant places and people, and by facilitating a spatial decoupling of the causes and outcomes of land-use change. Subsequently, I consider how the recognition of these issues leads to the conceptual development of the telecoupling framework in LSS as a way of bringing place-based and flow-based analysis together. I conclude by discussing a number of conceptual and analytical tensions embedded in the telecoupling framework and argue that a productive engagement with these has the potential to push LSS towards a new interdisciplinary agenda (see also Chap. 18).

2 Global Connectivity and Distant Interactions

Globalisation, in its multiple dimensions and manifestations, has had immense implications for land-use change. Specifically, the supply and demand of land-based resources and services are increasingly woven into networks of long-distance flows of materials, energy, products, technology, people, information and capital. While such flows and networks in many cases have long histories, their scope, scale and rate of connectivity is arguably reaching unprecedented new levels and influence in relation to land-use change (Eakin et al. 2014). The current magnitude and rate of global connectivity in land-use change is the outcome of diverse and intermingled social, political, economic, technical and environmental processes. While it is outside the scope of this chapter to provide a full historical account of these, a brief description of some of the key developments leading to increased global connectivity provides some context for the challenges facing land-use change research.

Within an ever-expanding world economy, the demand for and extraction of land-based resources translates into an increasing amount of energy and materials extracted from the environment, circulating around the globe and being released back into the environment as waste and emissions (Krausmann et al. 2009). The globally uneven distribution of land resources means that satisfying most societies' needs and demands for land-based material and products has only been possible through trade within and between countries. Over the course of the nineteenth and twentieth centuries, the increasing rate of global trade was facilitated by the availability of cheap fossil energy and technological developments allowing for, for example, energy-efficient transport and containerisation and refrigeration in shipping. Land- and labour-saving innovations in agriculture including, for example, increased mechanisation and the development and adoption of inorganic fertilisers made dramatic increases in production possible (Foley et al. 2011). The drastic decrease in transportation costs also incentivised a more widespread and often more intense production of export crops in many places, and allowed for the movement of large amounts of materials and products around the world (see also Chaps. 5, 6 and 8).

In the past decades, trade liberalisations and a neoliberal economic agenda pushed by powerful trade and financial institutions, such as the World Trade Organization and the International Monetary Fund, further enabled surging levels of global trade. Globally, one result has been that the control over land, resources and production, and consequently of economic wealth, has consolidated in the hands of fewer and fewer transnational private and corporate actors. These actors are often not located in the same places as the land resources, which increases the distance between land-use decision-making power and actual land-use changes. At the same time, the almost global adoption of telecommunication technologies and social media has increased the pace of knowledge and information exchange and expanded its spatial reach worldwide, making it possible for diverse stakeholders to share information about the detrimental ecological or social effects of specific land-use practices and, in turn, influence public discussions and policy debates on the responsibilities of land use. With more than half of the world's population now living in cities (UN 2014), urbanisation has become another key force in creating worldwide flows of material, energy and products (see Chap. 14). Cities are nodes of economic, political and social activity that attract migrants from rural areas drawn by the possibilities of better opportunities or pushed by lack of prospects in rural areas. This is, among other things, an outcome of the ongoing transition from small-scale manual to large-scale mechanised agricultural production. While cities have always relied on extensive hinterlands for their energy and food requirements, the spatial reach of such hinterlands has recently increased substantially and contemporary cities now can and need to source land-based resources from very distant locations around the world (Seto et al. 2012; Seto and Reenberg 2014). Finally, climate change and other environmental shifts are changing conditions for the use of land in many areas around the world. Droughts, floods, outbreaks of disease and biodiversity loss, for example, increasingly hinder agricultural production in some parts of the world, while increasing the incentive for production in others. Land-use changes, such as tropical deforestation, also create climatic teleconnections that change rainfall patterns and energy fluxes in very distant places (Lawrence and Vandecar 2014).

These entangled developments have created an increasing spatial disconnection between the sites of supply and production, and the sites of demand and consumption of land-based resources. As a result, land-use change in one location is more and more frequently the outcome of social and environmental processes taking place somewhere else (Lambin and Meyfroidt 2011). This challenges land-use research as well as governance because it makes it more difficult to trace and establish causal relations for land-use changes. On the one hand, the diverse processes tied to globalisation constitute a general, diffuse set of driving forces that, on an aggregate level, influence land-use change through, for example, economic growth and growing consumption that drives up the demand for agricultural production (see Chaps. 5 and 6). On the other hand, globalisation also creates specific interactions between places and people demanding and supplying land-based products, while enabling such interactions to take place over increasingly large distances. Growing demand among wealthy urban consumers in the Global North for so-called super-foods such as avocados has, for example, recently been shown to drive extensive illegal logging and deforestation in Mexico, which has led to a loss of important local ecosystem services including water retention and biodiversity (Siddique 2016). The demand for labour in Indonesian oil palm plantations has likewise been linked to land-use change in distant places, in which Filipino seasonal migrants transmit social remittances like knowledge of both the positive and negative impacts of oil palm cultivation to their home communities (Montefrio et al. 2014). Depending on how these social remittances are received and interpreted, the migrants' communities either embraced or contested the oil palm development. Environmental stresses, such as soil degradation and the spread of plant diseases, can also lead to land-use change in distant places, as exemplified in the case of the rapidly spreading *Fusarium Wilt Tropical Race 4*, a soil-pathogenic fungus that causes irreversible damage to banana roots. The spread of this disease, coupled with a general depletion of soil quality in Chinese banana-producing regions, has been linked to the extensive expansion of banana plantations in northern Laos (Friis and Nielsen 2017a).

These examples illustrate the need for capturing distant interactions that tie specific land-use changes to change processes in other locations, both near and far. However, they also illustrate that the inherently localised aspect of land-use requires continued attention to the place-based and contextual factors shaping such changes. This includes creating a better understanding of how various distal flows and causal relations, such as social remittances or soil-pathogens, are mediated in and by the local historical, political, social and environmental context to produce a given land-use change (Friis and Nielsen 2017a). In other words, we need to be able to capture and understand how globalisation manifests as land-use change on a particular piece of land at a particular moment in time.

3 The Emergence of Telecoupling Research

This outstanding challenge for land-use change research—that is finding ways of bringing together in-depth place-based analysis with flow-based and network-oriented approaches in land system analysis—underpins the emergence of telecoupling research in LSS.

As outlined in the introduction, LSS draws on the coupled human-environment system concept for the analysis of land-use change. This systemic perspective provides LSS with a holistic and integrative view on land-cover and land-use change that emphasises the co-constitution of natural and social dynamics, as well as the synergies, emergences and cross-scalar interactions that are inherent characteristics of complex systems (Lambin and Geist 2006; Turner et al. 2007; Verburg et al. 2015). The long-term aim of LSS to describe, explain and understand spatial patterns and dynamics, as well as determinants and causal mechanisms of land-cover and land-use changes, has made a place-based conception of land systems useful, since understanding places as systems has allowed researchers to treat administrative units or geographical regions as land systems, for example. Furthermore, land-use changes are understood to be embedded in spatially nested social- and biophysical enabling and constraining conditions that require analytical attention to a variety of processes happening at various scales. Disentangling the causal relations behind a given land-use change has therefore often been a matter of accounting for the proximate factors that lead to a specific land-use outcome and contextualising these to take broader mechanisms into account.

However, the complexity of global connectivity and the growing importance of distant interactions outlined in the previous section have started to challenge not only the conceptual distinction between proximate causes and underlying driving forces but also the central idea that such drivers can be analysed at various hierarchically nested scales, from the local to the global. One issue arises in the risk of introducing scale dependencies, meaning that processes 'observed' at the same scale as outcomes are attributed more plausibility in causal explanations than those cutting across scales (Turner 1999). Another issue relates to the risk of conflating scale with agency such that the actions of 'local' actors are given preference in explanations of 'local' processes and 'global' actors in relation to 'global' processes (Munroe et al. 2014). As discussed above, scale dependency is problematic since land-use changes are increasingly not the outcome of decisions made by 'local' actors and the primary beneficiaries of land use are likewise not necessarily found in proximity to the land use.

In recognition of these issues, LSS researchers have expanded their conceptual toolbox to account for what Reenberg et al. (2010) describe as the "spatial decoupling of the local land uses from the most important driving forces" (50). The idea that land-use changes are increasingly the indirect result of land-use changes happening elsewhere has gained traction (Lambin and Meyfroidt 2011), as have the notions of land-use displacement or leakage. For example, when primary pastureland in the South American Chaco region is converted into more intense agricultural uses such as soybean production, livestock ranching might be displaced to more marginal areas and in turn cause deforestation for new pastures (Fehlenberg et al. 2017). Whereas land-use displacement is used to characterise many different types of indirect land-use changes, leakage has specifically been used in cases where a policy change, such as the decision to protect primary forest in one place creates a leakage of deforestation to other areas. More broadly, LSS researchers have paid increasing attention to so-called distal drivers of change by adopting the concept of teleconnection from the atmospheric sciences to describe environmental and socioeconomic drivers operating "at a distance" between seemingly unconnected land systems (Chase et al. 2006, 1).

Yet at a more fundamental level, the conventional approach to space within LSS and the basic conceptualisation of land systems as place-based bounded entities has been problematised in recent years (Seto et al. 2012; Munroe et al. 2014; Friis and Nielsen 2017b). Within studies of urban land dynamics and sustainability, this critique has focused on how place-based conceptions of land systems promote an understanding of geographical places as discrete spatial units—or spatial 'containers'—characterised by internal conditions, actions and events into which distal drivers can exercise influence and cause change. This allows for, among other things, distinctions to be drawn between 'rural' and 'urban' places and land uses to be upheld, which in turn risks steering the analytical focus to particular 'rural' or 'urban' processes. In contrast, well-established ideas in human and economic geography theorise place and space as relationally constituted (e.g. Massey 1991; Henderson et al. 2002; Jessop et al. 2008). The relational perspective posits that the uniqueness of a place arises in the relations and processes that tie them to other places and that are contingent on the social, political and economic history of these interactions (Massey 1991). Urban land scientists drew on these ideas in the development of the Urban Land Teleconnections framework, which suggests that land systems are intertwined through the processes and multidirectional interactions that link specific places of both 'urban' and ‘rural’ land uses regardless of their proximity to or distance from each other in geographical space (Seto et al. 2012; Chap. 14).

The telecoupling concept picks up on this processual reconfiguration of distal drivers and teleconnection and widens the frame of analysis from rural-urban interactions to wider human-environment interactions (Liu et al. 2013; Eakin et al. 2014; see Chap. 2 for a detailed description). Eakin et al. (2014, 143) emphasises how telecoupling captures “not only the ‘action at a distance’ but also the feedback between social processes and land outcomes in multiple interacting systems” by providing explicit analytical attention to “the processes and causal chain[s] that links land parcels to land systems, to actors and actor networks, to institutions and governance, and ultimately to other land systems and places” (153). The basic proposition is that a telecoupling arises when a change in one coupled system leads to socioeconomic or environmental flows that give rise to indirect changes in another system and potentially produce feedbacks mediated through existing networks of actors and institutional arrangements. Depending on the analytical focus and the direction of the main flow in question, the interacting systems can be classified as either sending, receiving or spillover, where the latter entails systems that are indirectly or unintentionally affected or affecting the main interaction (Liu et al. 2013). The ‘tele-’ prefix is used to invoke a sense of the distance between the systems interacting, while the flow- and network-focus implies that the distance over which the interactions take place is not limited to geographical space, but can be social, political, economic or institutional as well (Eakin et al. 2014, 2017). By adding such distances to the coupled human-environment systems framework, telecoupling enables us to move beyond a distinction between the ‘local’ and the ‘global’ in a manner that transcends the need for nested spatial hierarchies and to give specificity to the diffuse set of underlying driving forces (Friis et al. 2016; Friis and Nielsen 2017a).

As a heuristic device, telecoupling offers an integrative perspective for analysing distal causal relations of a particular land-use change, while avoiding a ‘holistic trap’ where everything is linked to everything else. Instead, global interconnectivity and complexity is broken up into tractable units of analysis, mainly systems, flows, feedbacks and agents (Friis and Nielsen 2017a). Depending on the specific research objective and the land-use change in question, LSS can tackle various aspects of global interconnectivity that influence particular land-use changes.

4 Productive Tensions: The Potentials of Telecoupling Research

The telecoupling framework is gaining momentum in LSS because it presents an approach to land-use change analysis that attempts to maintain the usefulness of the coupled human-environment system perspective while explicitly opening this approach up to relational and networked understandings of human-environment change. As an integrative framework, it necessitates attention to multidirectional interactions, cross-scalar processes and feedbacks without abandoning place-based land-use change analysis and makes, in the words of Eakin et al. (2014, 153), telecoupling a potential "new heuristic from which to evaluate and think about land use change". Yet, for this potential to be reached, strong interdisciplinary collaboration is required. Although LSS has always reached across different disciplines in its efforts to link, for example, the spatial geographical sciences with behavioural economics, the telecoupling framework embeds a number of fundamental conceptual, or even epistemological, tensions that can only be engaged through inter- and transdisciplinary discussion (Chaps. 18 and 19).

Chief among these is a tension between the systemic and the relational perspective on human-environment interactions embedded in the effort to integrate coupled systems with (social) networks of interaction. Telecoupling aims at pushing the understanding of coupled human-environment systems forward by acknowledging that while ecological systems can be described in spatial hierarchical terms, people are part of networked organisations and communities that might span large geographical areas but that cannot necessarily be scaled hierarchically (Veldkamp 2009). In telecoupling analysis, the question of system boundaries and where and how to define separate systems in an interconnected world thus presents a point of analytical tension. On the one hand, a system analysis requires the definition of a set of interconnected elements that can be separated from their environment. In much LSS and coupled systems research, boundaries are often defined in the initial stages of research in order to establish the closure considered necessary for scientific inquiry. On the other hand, capturing the relations and networks of actors involved in bringing about telecouplings for a particular land-use change requires an open and exploratory mode of inquiry that avoids bounding of the field of research a priori. In an effort to accommodate this tension, Eakin et al. (2014) have suggested that telecoupling analysis defines the boundaries between systems in a manner that takes into account the localised factors of a given land-use change, as well as the "aspatial social networks, institutions, and governance structures that directly influence those [place-based human-environment] interactions" (142). However, the question of how to implement studies building on this definition in practice remains a challenge. One potential way to engage both perspectives is to approach land systems as epistemological constructs, where scale and boundary choices are based on what and who the object of study is (Friis and Nielsen 2017b). This allows for problem-oriented and empirically founded discussions of what is considered inside and outside the 'system of interest' (Friis and Nielsen 2017b, 4). What is required then is a reflexive mode of research, where the researcher(s) pay explicit attention to how and why certain scale and boundary choices are made, and with what trade-offs and limitations.

These discussions reveal a second fundamental tension within telecoupling research, namely, between the post-positivist approaches to knowledge production that dominate much LSS and coupled systems research (Turner and Robbins 2008), and the constructivist stance, adopted by the critical social sciences, that telecoupling research seeks to open up to (e.g. Niewöhner et al. 2016). LSS studies conventionally adhere to the scientific method and principle of objectivity, but account for critiques of logical positivism by adopting a critical realist ontology that argues that real-world phenomena exist, even while they are imperfectly understood (Turner and Robbins 2008, 301). This position comes to the fore, for example, in the approach to space discussed in Sect. 3, where a dominant position in LSS has persisted that spatial scale exists independent of the object or process being studied, as well as of the observer (Manson 2008). With telecoupling research and with the push towards a wider interdisciplinary engagement in LSS, more constructivist positions on knowledge and theory production are entering LSS. Specifically, there is growing awareness and reflexivity regarding how the use of concepts, such as 'competition', 'leakage' or 'system', influences the way a particular land-use change is analysed and hence understood (Niewöhner et al. 2016; Friis and Nielsen 2017b). While this is not a 'strict' social constructivist stance, in the sense that a land-use change such as 'deforestation leakage' only exists when described by researchers, it is a position that acknowledges how any research endeavour is contingent on the labels and categories used to make it meaningful (Mansvelt and Berg 2010, 342). In the example of space and scale, this more 'moderate' constructivist position insists that no scale exists 'naturally' or independent of a given research object, and critical reflection on how naturalised scale metaphors such as 'the local' are constructed for each analytical or political purpose is therefore crucial (Howitt 1993).

Furthermore, the post-positivist/constructivist tension finds expression in what could be described as an emerging difference between (a) studies aiming to describe and assess telecouplings and telecoupled systems as 'real-world' phenomena and (b) studies employing the framework and its analytical categories as heuristic devices with which to think about global interconnectivity in human-environment change. In the first type of studies, the underlying assumption is that telecouplings 'exist' as empirical phenomena that can be revealed and described by scientific methods and inquiry. In the second type, telecoupling is used as an analytical tool that can capture, discuss and reflect upon the creation of connections, networks and relations over distance between causes and outcomes of land-use change. The aim is thus not to get to a complete understanding of the telecoupled system but rather that the process of exploring how various connections come about can reveal something about the land-use change.

Finally, there is a key analytical tension in the need and ambition for empirical telecoupling research to capture both the place-based and flow-oriented aspects of land-use change. A challenge arises, both methodologically and empirically, when producing in-depth place-based and contextual knowledge of a given land-use change, while simultaneously capturing the multiple flows, networks of actors, and interactions that link it to other land systems. For one, creating an in-depth understanding of a particular land-use change and its social and environmental outcomes, as well as the decision-making processes and institutional setup, requires long-term engagement in the field. In turn, capturing flows and processes often necessitates either computational methods (see Chaps. 7 and 10) or a more mobile and multisited methodological approach, where actors and connections are followed in space and time (see Chap. 16). This is difficult within a single-study setup, where trade-offs between the scope and the depth of analysis often have to be made. In addition, the variety of flows considered in telecoupling research—be it money, people, material, energy, knowledge, information or technology—operate through very different modes and logics of exchange and cannot easily be captured using a single methodological framework. This points to the need for collaborative research projects or even programmes that draw on the heuristic of telecoupling while bringing in a variety of conceptual and analytical approaches to address the different aspects of interconnectivity in global land-use change (see Chaps. 18 and 19).

The three main tensions illustrated here represent core and inherent conceptual, methodological and empirical challenges for telecoupling research. However, the potential of telecoupling research to advance our understanding of land-use change in a globally interconnected world lies exactly in exploring these tensions. This necessitates an interdisciplinary engagement and discussion that draws on epistemological and analytical openness, flexibility and mobility. Indeed, my point here is not to suggest that, as researchers concerned with global interconnectivity and land-use change, we should seek to overcome, merge or integrate the diverging perspectives embedded in the concept of telecoupling nor that any of them are more valid or important than the others. Rather, we need to adopt a reflexive approach to our own research, assumptions and 'delivered truths', while actively challenging each other's assumptions and results. By remaining open to such discussions, telecoupling research can be a vehicle for a new mode and logic of interdisciplinary research that is needed to push LSS forward (see also Chap. 18).

5 Conclusion

In our globalised world, land-use change is shaped by increasing connectivity and a spatial decoupling between causes and outcomes of change. To tackle this issue, we need conceptual and analytical approaches that can capture the manifold ways in which globalisation manifests in land-use change in particular places. Telecoupling is emerging as one such new framework within which to think about and analyse global interconnectivity in land-use change. The telecoupling framework draws on the concept of human-environment systems while also paying explicit attention to the relations and networks of interactions that cause change over distance. As a heuristic device, the strength of the telecoupling concept lies in the flexible manner in which it directs attention to flows and feedbacks without favouring specific scales of analysis or types of interactions and maintaining attention to the actual place-based land-use change. Telecoupling analysis thus requires a broad interdisciplinary engagement that draws on both systemic and relational perspectives on human-environment change. While this interdisciplinary agenda brings with it a number of fundamental analytical and epistemic tensions, the true potential for telecoupling research lies in productively exploring these tensions in order to open up new understandings of land-use change in a globalised world.

Note

1. Land-cover change is mainly used in remote sensing analysis to describe the change from one category of land-cover to another within a given pixel or area, while land-use change is used to describe the change in use category and can thus denote qualitative changes such as intensification or extensification of agriculture.

References

Chase, Thomas N., Roger A. Pielke, and Roni Avissar. 2006. Teleconnections in the Earth System. In *Encyclopedia of Hydrological Sciences*. Hoboken, NJ: John Wiley & Sons, Ltd.

Eakin, Hallie, Ruth DeFries, Suzi Kerr, Eric F. Lambin, Jianguo Liu, Peter J. Marcotullio, Peter Messerli, Anette Reenberg, Ximena Rueda, Simon R. Swaffled, Birka Wicke, and Karl Zimmerer. 2014. Significance of Telecoupling for Exploration of Land-Use Change. In *Rethinking Global Land Use in an Urban Era*, ed. Karen C. Seto and Anette Reenberg, 141–161. Cambridge, MA: The MIT Press.

Eakin, Hallie, Ximena Rueda, and Ashwina Mahanti. 2017. Transforming Governance in Telecoupled Food Systems. *Ecology and Society* 22 (4). https://doi.org/10.5751/ES-09831-220432.

Fehlenberg, Verena, Matthias Baumann, Nestor Ignacio Gasparri, Maria Piquer-Rodriguez, Gregorio Gavier-Pizarro, and Tobias Kuemmerle. 2017. The Role of Soybean Production as an Underlying Driver of Deforestation in the South American Chaco. *Global Environmental Change* 45: 24–34. https://doi.org/10.1016/j.gloenvcha.2017.05.001.

Foley, Jonathan A., Navin Ramankutty, Kate A. Brauman, Emily S. Cassidy, James S. Gerber, Matt Johnston, Nathaniel D. Mueller, et al. 2011. Solutions for a Cultivated Planet. *Nature* 478 (7369): 337–342. https://doi.org/10.1038/nature10452.

Friis, Cecilie, and Jonas Ø. Nielsen. 2017a. Land-Use Change in a Telecoupled World: The Relevance and Applicability of the Telecoupling Framework in the Case of Banana Plantation Expansion in Laos. *Ecology and Society* 22 (4). https://doi.org/10.5751/ES-09480-220430.

———. 2017b. On the System. Boundary Choices, Implications, and Solutions in Telecoupling Land Use Change Research. *Sustainability* 9 (6): 974. https://doi.org/10.3390/su9060974.

Friis, Cecilie, Jonas Ø. Nielsen, Iago Otero, Helmut Haberl, Jörg Niewöhner, and Patrick Hostert. 2016. From Teleconnection to Telecoupling: Taking Stock of an Emerging Framework in Land System Science. *Journal of Land Use Science* 11 (2): 131–153. https://doi.org/10.1080/1747423X.2015.1096423.

Geist, Helmut, and Eric F. Lambin. 2002. Proximate Causes and Underlying Driving Forces of Tropical Deforestation. *BioScience* 52 (2): 143–150. https://doi.org/10.1641/0006-3568(2002)052[0143:PCAUDF]2.0.CO;2.

Henderson, Jeffrey, Peter Dicken, Martin Hess, Neil Coe, and Henry Wai-Chung Yeung. 2002. Global Production Networks and the Analysis of Economic Development. *Review of International Political Economy* 9 (3): 436–464. https://doi.org/10.1080/09692290210150842.

Howitt, Richard. 1993. 'A World in a Grain of Sand': Towards a Reconceptualisation of Geographical Scale. *The Australian Geographer* 24 (1): 33–44. https://doi.org/10.1080/00049189308703076.

Jessop, Bob, Neil Brenner, and Martin Jones. 2008. Theorizing Sociospatial Relations. *Environment and Planning D: Society and Space* 26 (3): 389–401. https://doi.org/10.1068/d9107.

Krausmann, Fridolin, Simone Gingrich, Nina Eisenmenger, Karl-Heinz Erb, Helmut Haberl, and Marina Fischer-Kowalski. 2009. Growth in Global Materials Use, GDP and Population during the 20th Century. *Ecological Economics* 68 (10): 2696–2705. https://doi.org/10.1016/j.ecolecon.2009.05.007.

Lambin, Eric F., and Helmut Geist. 2006. *Land-Use and Land-Cover Change. Local Processes and Global Impacts*. Berlin: Springer.

Lambin, Eric F., and Patrick Meyfroidt. 2011. Global Land Use Change, Economic Globalization, and the Looming Land Scarcity. *Proceedings of the National Academy of Sciences* 108 (9): 3465–3472. https://doi.org/10.1073/pnas.1100480108.

Lawrence, Deborah, and Karen Vandecar. 2014. Effects of Tropical Deforestation on Climate and Agriculture. *Nature Climate Change* 5: 27. https://doi.org/10.1038/nclimate2430.

Liu, Jianguo, Vanessa Hull, Mateus Batistella, Ruth DeFries, Thomas Dietz, Feng Fu, Thomas W. Hertel, R. Cesar Izaurralde, Eric F. Lambin, Shuxin Li, Luiz A. Martinelli, William J. McConnell, Emilio F. Moran, Rosamond Naylor, Zhiyun Ouyang, Karen R. Polenske, Anette Reenberg, Gilberto de Miranda Rocha, Cynthia S. Simmons, Peter H. Verburg, Peter M. Vitousek, Fusuo Zhang, and Chunquan Zhu. 2013. Framing Sustainability in a Telecoupled World. *Ecology and Society* 18 (2). https://doi.org/10.5751/ES-05873-180226.

Manson, Steven M. 2008. Does Scale Exist? An Epistemological Scale Continuum for Complex Human-Environment Systems. *Geoforum* 39 (2): 776–788. https://doi.org/10.1016/j.geoforum.2006.09.010.

Mansvelt, Juliana, and Lawrence D. Berg. 2010. Writing Qualitative Geographies, Constructing Geographical Knowledge. In *Qualitative Research Methods in Human Geography*, ed. Iain Hay, 333–355. Don Mills, Canada: Oxford University Press.

Massey, Doreen. 1991. A Global Sense of Place. *Marxism Today* 38: 24–29.

Meyfroidt, Patrick. 2016. Approaches and Terminology for Causal Analysis in Land Systems Science. *Journal of Land Use Science* 11 (5): 501–522. https://doi.org/10.1080/1747423X.2015.1117530.

Montefrio, Marvin Joseph F., Yasmin Y. Ortiga, and Ma Rose Cristy B. Josol. 2014. Inducing Development: Social Remittances and the Expansion of Oil Palm. *International Migration Review* 48 (1): 216–242. https://doi.org/10.1111/imre.12075.

Munroe, Darla K., Kendra McSweeney, Jeffrey L. Olson, and Becky Mansfield. 2014. Using Economic Geography to Reinvigorate Land-Change Science. *Geoforum* 52: 12–21. https://doi.org/10.1016/j.geoforum.2013.12.005.

Niewöhner, Jörg, Antje Bruns, Patrick Hostert, Tobias Krueger, Jonas Ø. Nielsen, Helmut Haberl, Christian Lauk, Juliana Lutz, and Daniel Müller. 2016. *Land Use Competition. Ecological, Economic and Social Perspectives*, Human-Environment Interactions 6. Cham: Springer International Publishing.

Reenberg, Anette, Tobias Langanke, Søren Bech Pilgaard Kristensen, and Tina Svan Colding. 2010. Globalisation of Agricultural Landscapes: A Land Systems Approach. In *Globalisation and Agricultural Landscapes. Change Patterns and Policy Trends in Developed Countries*, ed. Jørgen Primdahl and Simon Swaffield, 31–56. Cambridge: Cambridge University Press.

Seto, Karen C., and Anette Reenberg. 2014. *Rethinking Global Land Use in an Urban Era*. Cambridge, MA: The MIT Press.

Seto, Karen C., Anette Reenberg, Christopher G. Boone, Michail Fragkias, Dagmar Haase, Tobias Langanke, Peter Marcotullio, Darla K. Munroe, Branislav Olah, and David Simon. 2012. Urban Land Teleconnections and Sustainability. *Proceedings of the National Academy of Sciences* 109 (20): 7687–7692. https://doi.org/10.1073/pnas.1117622109.

Siddique, Haroon. 2016. Rising Avocado Prices Fuelling Illegal Deforestation in Mexico. *The Guardian*, August 10. https://www.theguardian.com/lifeandstyle/2016/aug/10/avocado-illegal-deforestation-mexico-pine-forests.

Turner, Billie L., Eric F. Lambin, and Anette Reenberg. 2007. The Emergence of Land Change Science for Global Environmental Change and Sustainability. *Proceedings of the National Academy of Sciences* 104 (52): 20666–20671. https://doi.org/10.1073/pnas.0704119104.

Turner, Billie L., and Paul Robbins. 2008. Land-Change Science and Political Ecology: Similarities, Differences, and Implications for Sustainability Science. *Annual Review of Environment and Resources* 33: 295–316. https://doi.org/10.1146/annurev.environ.33.022207.104943.

Turner, Matthew D. 1999. Merging Local and Regional Analyses of Land-Use Change: The Case of Livestock in the Sahel. *Annals of the Association of American Geographers* 89 (2): 192–219. https://doi.org/10.1111/1467-8306.00142.

UN. 2014. *World Urbanization Prospects: The 2014 Revision*. New York: United Nations, Department of Economics and Social Affairs, Population Division.

Veldkamp, A. 2009. Investigating Land Dynamics: Future Research Perspectives. *Journal of Land Use Science* 4 (1–2): 5–14. https://doi.org/10.1080/17474230802645592.

Verburg, Peter H., Neville Crossman, Erle C. Ellis, Andreas Heinimann, Patrick Hostert, Ole Mertz, Harini Nagendra, Thomas Sikor, Karl Heinz Erb, Nancy Golubiewski, Ricardo Grau, Morgan Grove, Souleymane Konaté, Patrick Meyfroidt, Dawn C. Parker, Rinku Roy Chowdhury, Hideaki Shibata, Allison Thomson, and Lin Zhen. 2015. Land System Science and Sustainable Development of the Earth System: A Global Land Project Perspective. *Anthropocene* 12: 29–41. https://doi.org/10.1016/j.ancene.2015.09.004.

Verburg, Peter H., Karl-Heinz Erb, Ole Mertz, and Giovana Espindola. 2013. Land System Science: Between Global Challenges and Local Realities. *Current Opinion in Environmental Sustainability* 5 (5): 433–437. https://doi.org/10.1016/j.cosust.2013.08.001.

4

Explanations in Telecoupling Research

Patrick Meyfroidt

1 Introduction

Not all research is about explaining, but explanation is an important component of many scholarly endeavours, and research on telecouplings is no exception. Indeed, telecoupling has been proposed precisely as a framework to help understanding and explaining phenomena that could be observed in a local context, but where the causes of these phenomena were at least partly invisible when only observing the local situation. The notion of telecouplings can be seen as an empirical phenomenon, that is, specific linkages between places through distal processes, flows and networks and the actual outcomes, such as land-use changes, through which

P. Meyfroidt (✉)
Fund for Scientific Research F.R.S.–FNRS, Brussels, Belgium

Georges Lemaître Centre for Earth and Climate Research (TECLIM), Earth and Life Institute, UCLouvain, Louvain-la-Neuve, Belgium
e-mail: Patrick.Meyfroidt@uclouvain.be

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_4

these linkages manifest themselves in distinct human-environment (H-E) systems. Alternatively, it can also be considered as an analytical framework or heuristic device to analyse these kinds of processes in coupled H-E systems (see Chaps. 2 and 3). By nature, research on telecouplings is challenging, since they typically involve complex combinations of local and distant causes with interactions, feedback and spatial and temporal lags, all features that complicate tracing the explanation of a given phenomenon. This chapter will discuss how a telecoupling approach can contribute to some types of explanations in H-E systems' research and for what purposes.

The first section will present a brief survey of the literature about explanations in H-E systems' research. The second section will discuss the circumstances under which the telecoupling approach can specifically be fruitful to build understanding and explanations of phenomena related to H-E systems and particularly land-use change. The third section will then discuss specific challenges related to explanations when studying systems that are complex and composed of distant components such as in globalisation and telecoupling research.

2 Explanations in Human-Environment Systems Research

Telecouplings are presented as either an analytical framework or heuristic device to analyse some processes in coupled H-E systems, or concretely as a specific type of such coupled H-E systems (Liu et al. 2013, Chap. 2). Therefore, it is worth starting with a short digest of the discussion about *explanations* in the broader literature on H-E interactions. A more elaborate treatment of the issue and methodologies for causal analysis in H-E systems research can be found in Meyfroidt (2016). Epistemologically, H-E (or social-ecological) research lie at the interface between social and natural sciences, implying a perpetual tension between the mainstream epistemology in natural sciences and a wider diversity of epistemologies in social sciences and humanities. On the one hand, post-positivism largely embraces the positivist notion that objective explanations can be captured by scientific endeavour combining empirical analyses and rational reasoning, though acknowledging the subjectivity of the researcher and possible biases. On the other hand, social constructivist and hermeneutic approaches focus mainly on explanations as discourses or mental representations and more broadly as social and cultural constructions that may be shared among certain social groups and conflicting or interacting with those of other groups. In this epistemology, especially relevant for telecouplings are the anthropological theories of scapes that articulate the different types of information and cultural flows that link distant places (Tsing 2005). Further work is needed to improve the dialogue between these different forms of explanation (see Chap. 18). Much of this chapter will focus on the first, post-positivist approach where explanation essentially amounts to understanding the causes and mechanisms through which some events or features arise. Explanation therefore goes beyond the mere description of phenomena (Meyfroidt 2016; Magliocca et al. 2018). Explanations may serve different purposes. A key goal is to design policies or other forms of interventions to steer an H-E system of interest in a desired direction. This builds on the premises that a proper explanation of how and why a given phenomenon arose serves as a basis for a credible theory of change of how the intervention is supposed to act on the system. Another common goal is that explanations support the design of scenarios or projections—be they quantitative modelling or through qualitative narratives—of different possible future evolutions of a system.

Explanations in post-positivism build on three modes, namely the deductive-nomological mode grounded in laws that are combined to provide a logical explanation to a given event or to an observed regularity; the inductive mode based on identifying empirical regularities between some phenomena and their possible causes; and the abductive mode that starts from the effect and search for the most plausible and simple cause, ruling out other candidate explanations (Walton 2005). Different disciplines are more strongly building on one or the other approach, for example, neoclassical economics and political ecology typically give a strong weight on deductive explanations building on a set of assumptions such as on rationality of actors and the influence of power struggles and inequalities, respectively. Other disciplines, such as geography, have traditionally built more on inductive generalisations, such as the forest transition theory that explained long-term shifts in forest cover trends based on generalising regularly observed processes in agriculture, forestry and, more broadly, socio-economic and political spheres (Meyfroidt et al. 2018). Abductive reasoning is widely used in case studies to explain specific phenomena (Walters 2017), but typically requires being combined with inductive and deductive approaches to produce explanations of more general phenomena.

Research on H-E systems typically falls under what is called “historical sciences”, that is, scientific investigation that focuses on explaining social and natural phenomena as they occurred in the real, historical world, such as in history, sociology but also geology or evolutionary biology, as opposed to phenomena described in the laboratory through experimental sciences (Meyfroidt 2016). The assumption is that phenomena observed are always specific occurrences of a more general class of phenomena that are sought to be explained, which are never exactly and entirely reproduced or reproducible, and where single factors cannot be perfectly isolated. The manifestation of new phenomena over time changes the universe studied. The telecoupling frameworks precisely emerged as an approach to keep up with increasingly complex and distant chains of interactions that produce H-E outcomes, as a result of new forms of globalisation and linkages between places. Emerging phenomena such as land grab, biofuels or private-sector led and hybrid forms of land-use regulations (Lambin et al. 2018), among other things, forced a rethink of theories and knowledge about H-E processes. As such, human agency leads to perpetual emergence of new situations, decisions and behaviours, which in turn require adaptation in problems conceptualisation.

Building explanations in H-E systems research often relies on a back and forth between the abductive goal of explaining the causes of a given observed effect (Walters 2017), and quasi-experimental approaches that focus on explaining the effects of a given cause (Ferraro and Hanauer 2014; Law et al. 2017). As a result, explanations in historical sciences rarely result in the formulation of general, universal covering laws, but rather rely on a dialogue between regularities and general mechanisms or laws on the one hand and contextual interpretation of contingencies on the other (Meyfroidt 2016). Explanations of specific cases can form a basis for more generalised forms of knowledge, which can range from mostly descriptive claims to those inferring causal effects, causal mechanisms and theories (Magliocca et al. 2018). One way through which explanations can be generalised is through middle-range theories, that is, contextual generalisations, which describe chains of causal mechanisms that explains a well-bounded range of phenomena, and the conditions which trigger, enable or prevent these causal chains (Meyfroidt et al. 2018).

3 Why and for What Do We Need a Telecoupling Approach?

Against this backdrop, what is new about the telecoupling concept compared to the multiple fields and frameworks that study H-E systems? In other words, what are the kinds of phenomena or the analytic perspectives for which the telecoupling framework may be useful or perhaps even required? Research on H-E systems have a long tradition of focusing on understanding the dynamics in a particular place. Early research tended to consider these as "cases" or self-contained entities that could be studied as closed systems, where understanding endogenous processes would suffice to explain the dynamics (Fig. 4.1A) (e.g. see the discussions in Turner et al. 1993). Over time, important progress was made in considering more directly the multiple and cross-scalar interactions and feedbacks between the focal system and the rest of the world.

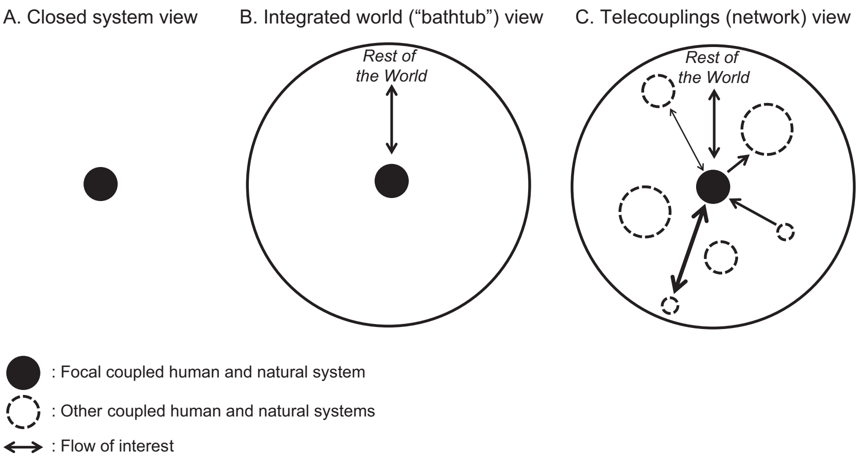


Fig. 4.1 Conceptual diagram of the *closed system*, *bathtub* and *telecoupling* conceptualisation of H-E changes related to distant drivers

Such advancements initially conceptualised these linkages within an open systems approach, where processes occurring in other places or at other scales were considered as exogenous or contextual factors affecting local dynamics (Fig. 4.1B) (Lambin and Geist 2006; Meyfroidt et al. 2013). The origins of the signals coming from the outside world, as well as the destinations of possible feedbacks from the studied system, were considered largely irrelevant. In this view, the outside world can be interpreted as a "bathtub", into which flows are well mixed and fungible—that is, products are fully substitutable notwithstanding their origin or other characteristics—, so that this outside world is essentially treated as one homogenous place. In geographical terms, this view would be slightly nuanced by considering that the influence of features from the outside world monotonously decreases with Cartesian distance to the focal system. In economic terms, it suggests that trade would function as if markets were fully integrated and any bilateral flow between two countries is susceptible to drastically change over time due to change in global markets conditions. In this approach, mobilising knowledge about several specific distant H-E systems takes the form of comparisons of disconnected case studies rather than investigations of the linkages between these systems.

But with increasing recognition of the complexity of linkages between H-E systems separated geographically or along other dimensions (institutionally, culturally, economically…), the limitations of the bathtub view for understanding H-E dynamics and for identifying efficient policies to steer such dynamics in desired ways has become apparent. Several authors have critiqued the misleading conclusions that can be drawn from looking at places as being disconnected case studies, instead of considering them as interacting (Meyfroidt et al. 2013; Munroe et al. 2014; van Vliet et al. 2016). This critique has, for example, targeted studies that link forest transition and recovery in temperate countries to domestic economic growth, in a relation akin to environmental Kuznets curve, but obliterate the role of North-South trade dynamics in promoting forest recovery in the North. Critical sociological theories related to world system theories, such as dependency theory, core-periphery relations and (ecological) unequal exchange (Hornborg 1998; Moran et al. 2013), highlight that with whom a country trades matters greatly to determine the outcomes of this trade.

Several studies showed the growing importance of distant causes and indirect consequences of land-use changes as they arise across international borders and in the context of differing national policy and socio-economic regimes (Meyfroidt et al. 2013, Chap. 2). With globalisation, land-use displacement and leakage have emerged as major research priorities in land system science and their effects have been shown to depend on the specific places where such displacement occurs (Jadin et al. 2016). Actors and drivers of land change thus increasingly operate across distant places, moving capital, knowledge, institutions and labour strategically to shape and respond to dynamic human and natural environments (Gasparri et al. 2016; le Polain de Waroux et al. 2016, 2018). Other studies investigated, for example, the distinct effects of a given type of actors depending on their geographic origin, such as studies of the distinct behaviours and impacts of domestic, Chinese and other traders and logging companies in the timber sector in Africa (Cerutti et al. 2011; Wertz-Kanounnikoff et al. 2013) or in agriculture in Southeast Asia (Friis and Nielsen 2017). With increased influence of external actors and processes in local land systems, tracing the complex supply chains of products exported from these localities, including the actors and locations involved, as well as potential spillovers and leakages, becomes crucial for governance (Godar et al. 2016, Chaps. 8 and 9). Hence, understanding these complex linkages requires moving beyond considering distant relations as exogenous factors in an open "bathtub" systems approach.

The telecoupling perspective (Eakin et al. 2014; Friis et al. 2016) represents one form of response to this need. It aims at describing and studying H-E systems with an explicit consideration of the multiple links that may exist between different systems, including via flows of people, money and products, but also of information, governance, norms and technology (Chaps. 2 and 3). This framework becomes particularly useful when the distinct effects of flows depend on their specific origin and destination, the actors involved, as well as on the structure of the network that connect actors and flows (Fig. 4.1C). In geographical terms, this would correspond to analysing linkages between places based on social, cultural or political networks such as linguistic, ethnic or post-colonial bonds, rather than on mere Cartesian distance. In economic terms, this would mean that we observe a significant degree of persistence in trade flows, that is, markets that exhibit forms of stickiness or rigidity which influence how shocks restructure the production and trade relations and thus also the allocation of environmental impacts (Villoria and Hertel 2011). The presence of such stickiness is called the "Armington assumption" for trade in agricultural products. These rigidities or preferred connections can arise, for example, from some hard to account for differences between products originating from different places making them imperfect substitutes (Agcaoili-Sombilla and Rosegrant 1994), specific linkages between trading partners due to ethnic networks (Coughlin and Wall 2011), colonial history (Head et al. 2010), consumer concerns about the perceived sanitary risks of some production places (Kawashima and Sari 2010; Garrett et al. 2013; Schierhorn et al. 2016), tensions that affect certain trade routes such as piracy (Burlando et al. 2015), specific institutional ties or transport infrastructures, or multiple other factors (Anderson and van Wincoop 2004).

When designing a study based on the telecoupling approach, the price to pay compared to the bathtub view is increased complexity in analytical terms, including for defining manageable and meaningful units of analysis and for tracing the causal connections between places, actors and variables. The telecoupling approach is thus relevant when the researcher assumes that the links and flows between the focal system and different networked nodes (H-E systems) are not all equally important or relevant or do not all function in the same way, and that disregarding this heterogeneity would hinder the understanding of the processes and outcomes of interest in the focal system and in others. In that sense, using the telecoupling or network perspective is a strategic decision that should reflect and match the assumptions of the researcher about the behaviour of the system of interest and the balance of costs and benefits of engaging with increased complexity. Two examples illustrate this: Analysing the specific trade networks of soy between Brazil, other South American countries, Europe and other soy consuming countries help understanding how the competitive advantage that Brazilian soy has built on the European markets has facilitated an upgrading of the soybean supply chain, which in turn helps to explain why Brazilian soybean farmers have adopted environmental certification programmes on a larger scale than their competitors (Garrett et al. 2013). In contrast, a counter-example is provided by

Müller et al. (2013), who analyse the main agents of deforestation in the Bolivian lowlands in order to design spatially effective policies for reducing deforestation. Although they acknowledge that international trade is an important underlying driver of these changes, the specific destination of exports is not considered as relevant for their purposes, which makes this study thus closer to the bathtub view.

4 Complex Causal Chains in Telecouplings

When a telecoupling perspective is adopted, how can we then concretely approach the task of building causal explanations in complex chains that link distant places and people?

Two key questions, which in practice are strongly interrelated, are:

1. Among the multiple flows and linkages between the focal system and the rest of the world, how can we identify which ones actually matter for explaining a given phenomenon? and
2. How can we actually establish causality in situations that are characterised by complex interactions and feedbacks across places and scales?

I first discuss here the question of where and how to set the boundaries of the analysis. A first approach, which is expressed in the original telecoupling framework and by some empirical studies, is to start by an H-E system that we can consider as bounded, that is, a system that largely functions or functioned as a well-identifiable system absent the specific telecoupling that is studied. This may be, for example, the Brazilian Amazonian land-use system (da Silva et al. 2017) considered as an integrated H-E system where land use is structured based on the interactions between local human (population, technologies, economic structures, policies and so on) and environmental components (e.g. the soils, climate and vegetation). Then, this approach identifies a specific flow of interest between this system and some outside place, which changes or dynamics are hypothesised to strongly influence the original H-E system (e.g. here, dramatic increase in soybean flows from the Brazilian Amazon to China).

Based on this flow the researchers will define a second H-E system (e.g. China), which is telecoupled to the initial system. This defines two systems that are distinct but coupled over distance. At this stage, in principle, any feature from each system (e.g. from the Brazilian Amazon and from China) can be considered as relevant for the explanation, and this will constitute the boundaries of the analysis. This perspective thus helps to draw boundaries in geographic terms but is not, in itself, sufficient to set up analytical boundaries of what features of the considered H-E systems matter. Any additional system can be coupled following the same logic, if additional spillovers that involve other H-E systems are identified, but phenomena outside of any of the coupled systems will not be considered in the analysis. This approach for setting boundaries is very widely used in studies that seek to describe telecoupled systems, that is, map the flows, actors and processes involved in the telecouplings.

Another, more fluid, approach for bounding the analysis is similar to the chain of explanations approach in political ecology (Blaikie and Brookfield 1987) or progressive contextualisation (Walters 2017). This approach will also start by a focal system, but instead of considering its coupling with another well-identified and bounded system, it will follow the different flows stemming in and out of the focal system to progressively redefine boundaries and scope of the system of interest. In effect, this approach ends up with a telecoupled system in the sense that the system of interest now becomes composed of people and features that can be spread across multiple places and only incorporates the features of each place that are considered as relevant. As such, the telecoupling framework is used to facilitate an analysis of which flows and connections that links to a given H-E change. One example starts by considering the initial system of interest as the land-use system of a given Laotian village, aiming specifically at explaining rapid expansion of banana plantations (Friis and Nielsen 2017). The analysis then identifies the specific importance of Chinese investors and traders that contract local farmers for banana planting, tracing these flows to Chinese consumers in China's large cities, the specific role of Chinese policies supporting fresh fruits consumption and geopolitical tensions between China and the Philippines, which triggered a need for Chinese retailers to find new sources of banana. The authors end up by redefining their system of interest as the "banana land system", "constructed and understood as the lowland fields, the villagers leasing out the land, the stakeholders in the cross-border banana production network, and the governance institutions aimed at regulating the land-use change" (Friis and Nielsen 2017, 14). This system incorporates aspects of what happened in Laos, China, the Philippines, for example, but does not require considering that "China" is one system telecoupled with this other "Laotian village" system. This perspective thus largely moves beyond the initial telecoupling framework, as the identification of several distinct systems that exist in themselves and are then coupled becomes irrelevant. The boundaries of the analysis are not based on the identification of these distinct systems that are then coupled, but rather on an explicit decision to stop the exploration of the chain of explanations at the point that matches the goal of the research as well as the practical capabilities and resources of the researchers. In the above example, the researcher may decide to put aside the explanation and investigation of the geopolitical tensions between China and the Philippines as a root cause of Chinese investors' presence, to instead focus on how to improve the local processes of land governance to empower local communities in relation with external actors. In practice, this second approach is thus intimately linked with the second question of assessing causality, as the limits of the focal system are, in fact, given by the identification of relevant causal linkages. This approach for setting boundaries is thus more relevant for studies that seek to actually explain the causal chains that give rise to telecouplings.

The second question is how to trace causality when the chains and flows are complex and interact across places and scales? Some specific techniques exist to explore causal influences in complex systems such as Convergent Cross Mapping (Sugihara et al. 2012) but these typically require very dense time series of robust quantitative data and can thus hardly be applicable in most studies. A well-known approach in social sciences related to the chains of explanation or progressive contextualisation discussed above is process tracing (Meyfroidt 2016), which takes a point of departure in any component of the system and analyses causal links by decomposing them into increasingly "shorter" links that can be supported by various evidence. As indicated above, different traditions would put the point of departure either in the cause—for example, what are the causes of a given land-use change in a specific place?—or on the effects—for example, what are the effects of a given policy shock?—and different methods are appropriate for these different questions (Meyfroidt 2016; Law et al. 2017). Conceptually, the theoretical toolbox of complex adaptive systems analysis can be mobilised, with notions of non-linearity, feedbacks, regime shifts or tipping points and others (Walker et al. 2004). Operationally, the appropriate methods are not as straightforward to identify. At least three types of approaches can be mobilised, that is, quantitative empirical methods, simulation modelling and qualitative approaches (see Chaps. 7, 10, 13 and 16). In statistical or econometrics works, spatial statistics are increasingly used to incorporate distant effects causing telecouplings such as through indirect land-use change (iLUC, Richards et al. 2014), agglomeration economies (Richards 2017) or other forms of spillovers (Meyfroidt et al. 2016, 2018). This has proved to generate interesting insights and opening new avenues for research, but these spatial approaches remain limited in that the distant effects are still mostly incorporated based on a measure of spatial (Cartesian) distance or neighbourhood. A way forward to properly acknowledge the nature of telecouplings is to measure distant influences based on various other forms of linkages such as social networks, market connections and others, but these are much more complicated to operationalise.

Simulation modelling of H-E systems and in particular of land use has an already well-established but still progressing tradition of couplings between models of multiple scales. One typical approach is to couple global models, which can be economic (Computable General Equilibrium, CGE) models or Integrated Assessment Models (IAMs) for example, to capture global demand for land-use and trade flows, with local models such as Agent-Based Models (ABMs) to explore how these flows are absorbed and distributed in the local system (Millington et al. 2017). The limitation of this approach is that if often correspond to the integrated market or bathtub vision (Fig. 4.1B) above, in the sense that specific places interact together only indirectly, through their relations with global-scale processes. This approach is limited in its ability to capture the horizontal interactions between specific H-E systems. Coupling models at similar scales for distinct places (e.g. coupling a Brazilian Amazon and a China land-use model) addresses this issue but assumes that the relation between these two systems is not influenced, mediated or moderated by anything that happens outside of these two places. Incorporating seriously the telecoupling idea in modelling would require coupling local models of the different systems of interest together and to global-scale models that capture these multiple feedbacks.

In qualitative studies, multi-sited ethnography has been proposed as a way to reconsider the place-based focus of anthropological studies (Marcus 1995, Toolbox: Qualitative methods). Although some consider this as mainly a form of comparative analysis where the researcher explores how a similar social phenomenon unfolds across different contexts, many highlight that multi-sited ethnography is perhaps more appropriately described as a form of "trans-site" ethnography, where the site of research (what others would call the system) is formed by discontinuous geographical places or social groups. Research budgets, time and other constraints such as knowledge of local contexts, lack of local contacts providing entry points to the field or language or administrative barriers often hinder the full use of multi-sited research. In-depth qualitative and place-based research thus often focuses on one side of the telecouplings. Overall, studies on telecoupling still mostly rely on ad hoc combinations of methods pulled out of the existing H-E research toolbox.

5 Conclusion

The general principles of explanation in telecouplings research are largely building on research in H-E dynamics, social-ecological systems and complex adaptive systems. Explanations in H-E systems build on the deductive, inductive and abductive approaches and have to balance the identification of regularities and general mechanisms with contextual interpretation of contingencies. A telecoupled or network perspective matters when the distinct effects of flows between H-E systems depend on their specific origin and destination, the actors involved and the structure of the network. Yet, the explicit recognition of the complex networks of relations between places and actors beyond the bathtub view comes with a cost in terms of increasing complexity, with a potentially infinite network of connections to explore. The decisions of adopting such a network perspective, identifying the relevant connections to explain and where to bound the analysis are thus crucial and should reflect strategic balancing of costs and benefits, requiring a back and forth between theoretical insights and empirical information.

Acknowledgements This chapter benefited from constructive discussions that took place during a workshop on "Towards operationalisation of telecouplings concepts for land system science" organised by the Global Land Programme in 2014. This work has received support from the European Research Council under the European Union's Horizon 2020 research and innovation programme (Grant agreement No 677140 MIDLAND) (https://erc-midland.earth). This work contributes to the Global Land Programme www.glp.earth.

References

Agcaoili-Sombilla, Mercedita C., and Mark W. Rosegrant. 1994. International Trade in a Differentiated Good: Trade Elasticities in the World Rice Market. *Agricultural Economics* 10 (3): 257–267.

Anderson, James E., and Eric van Wincoop. 2004. Trade Costs. *Journal of Economic Literature* 42 (3): 691–751.

Blaikie, Piers, and Harold Brookfield. 1987. *Land Degradation and Society*. London: Methuen.

Burlando, Alfredo, Anca D. Cristea, and Logan M. Lee. 2015. The Trade Consequences of Maritime Insecurity: Evidence from Somali Piracy. *Review of International Economics* 23 (3): 525–557.

Cerutti, Paolo O., Samuel Assembe-Mvondo, Laura German, and Louis Putzel. 2011. Is China Unique? Exploring the Behaviour of Chinese and European Firms in the Cameroonian Logging Sector. *International Forestry Review* 13 (1): 23–34.

Coughlin, Cletus C., and Howard J. Wall. 2011. Ethnic Networks and Trade: Intensive versus Extensive Margins. *Economics Letters* 113 (1): 73–75.

da Silva, Ramon Felipe Bicuda, Mateus Batistella, Yue Dou, Emilio Moran, Sara McMillan Torres, and Jianguo Liu. 2017. The Sino-Brazilian Telecoupled Soybean System and Cascading Effects for the Exporting Country. *Land* 6 (3): 53.

Eakin, Hallie, Ruth DeFries, Suzi Kerr, Eric F. Lambin, Jianguo Liu, Peter J. Marcotullio, Peter Messerli, Anette Reenberg, Ximena Rueda, Simon

R. Swaffled, Birka Wicke, and Karl Zimmerer. 2014. Significance of Telecoupling for Exploration of Land-Use Change. In *Rethinking Global Land Use in an Urban Era*, ed. Karen C. Seto and Anette Reenberg, 141–161. Cambridge, MA: The MIT Press.

Ferraro, Paul J., and Merlin M. Hanauer. 2014. Advances in Measuring the Environmental and Social Impacts of Environmental Programs. *Annual Review of Environment and Resources* 39: 495–517.

Friis, Cecilie, and Jonas Ø. Nielsen. 2017. On the System. Boundary Choices, Implications, and Solutions in Telecoupling Land Use Change Research. *Sustainability* 9 (6): 974.

Friis, Cecilie, Jonas Ø. Nielsen, Iago Otero, Helmut Haberl, Jörg Niewöhner, and Patrick Hostert. 2016. From Teleconnection to Telecoupling: Taking Stock of an Emerging Framework in Land System Science. *Journal of Land Use Science* 11 (2): 131–153.

Garrett, Rachael D., Ximena Rueda, and Eric F. Lambin. 2013. Globalization's Unexpected Impact on Soybean Production in South America: Linkages between Preferences for Non-Genetically Modified Crops, Eco-Certifications, and Land Use. *Environmental Research Letters* 8 (4): 044055.

Gasparri, Nestor Ignacio, Tobias Kuemmerle, Patrick Meyfroidt, Yann le Polain de Waroux, and Holger Kreft. 2016. The Emerging Soybean Production Frontier in Southern Africa: Conservation Challenges and the Role of South-South Telecouplings. *Conservation Letters* 9 (1): 21–31.

Godar, Javier, Clément Suavet, Toby A. Gardner, Elena Dawkins, and Patrick Meyfroidt. 2016. Balancing Detail and Scale in Assessing Transparency to Improve the Governance of Agricultural Commodity Supply Chains. *Environmental Research Letters* 11 (3): 035015.

Head, Keith, Thierry Mayer, and John Ries. 2010. The Erosion of Colonial Trade Linkages after Independence. *Journal of International Economics* 81 (1): 1–14.

Hornborg, Alf. 1998. Towards an Ecological Theory of Unequal Exchange: Articulating World System Theory and Ecological Economics. *Ecological Economics* 25 (1): 127–136.

Jadin, Isaline, Patrick Meyfroidt, and Eric F. Lambin. 2016. Forest Protection and Economic Development by Offshoring Wood Extraction: Bhutan's Clean Development Path. *Regional Environmental Change* 16 (2): 401–415.

Kawashima, Shigekazu, and Deffi Ayu Puspito Sari. 2010. Time-Varying Armington Elasticity and Country-of-Origin Bias: From the Dynamic Perspective of the Japanese Demand for Beef Imports. *Australian Journal of Agricultural and Resource Economics* 54 (1): 27–41.

Lambin, Eric F., and Helmut Geist, eds. 2006. *Land-Use and Land-Cover Change: Local Processes, Global Impacts*. Berlin and Heidelberg: Springer.

Lambin, Eric F., Holly K. Gibbs, Robert Heilmayr, Kimberly M. Carlson, Leonardo C. Fleck, Rachael D. Garrett, Yann le Polain de Waroux, Constance L. McDermott, David McLaughlin, Peter Newton, Christoph Nolte, Pablo Pacheco, Lisa L. Rausch, Charlotte Streck, Tannis Thorlakson, and Nathalie F. Walker. 2018. The Role of Supply-Chain Initiatives in Reducing Deforestation. *Nature Climate Change* 8: 109–116.

Law, Elizabeth A., Paul J. Ferraro, Peter Arcese, Brett A. Bryan, Katrina Davis, Ascelin Gordon, Matthew H. Holden, Gwenllian Iacona, Raymundo M. Martinez, Clive A. McAlpine, Jonathan R. Rhodes, Jocelyne S. Sze, and Kerrie A. Wilson. 2017. Projecting the Performance of Conservation Interventions. *Biological Conservation* 215: 142–151.

le Polain de Waroux, Yann, Matthias Baumann, Nestor Ignacio Gasparri, Gregorio Gavier-Pizarro, Javier Godar, Tobias Kuemmerle, Robert Müller, Fabricio Vázquez, José N. Volante, and Patrick Meyfroidt. 2018. Rents, Actors, and the Expansion of Commodity Frontiers in the Gran Chaco. *Annals of the American Association of Geographers* 108 (1): 204–225.

le Polain de Waroux, Yann, Rachael D. Garrett, Robert Heilmayr, and Eric F. Lambin. 2016. Land-Use Policies and Corporate Investments in Agriculture in the Gran Chaco and Chiquitano. *Proceedings of the National Academy of Sciences* 113 (15): 4021–4026.

Liu, Jianguo, Vanessa Hull, Mateus Batistella, Ruth DeFries, Thomas Dietz, Feng Fu, Thomas W. Hertel, et al. 2013. Framing Sustainability in a Telecoupled World. *Ecology and Society* 18 (2): 26.

Magliocca, Nicholas R., Erle C. Ellis, Ginger R.H. Allington, Ariane de Bremond, Jampel Dell'Angelo, Ole Mertz, Peter Messerli, Patrick Meyfroidt, Ralf Seppelt, and Peter H. Verburg. 2018. Closing Global Knowledge Gaps: Producing Generalized Knowledge from Case Studies of Social-Ecological Systems. *Global Environmental Change* 50: 1–14.

Marcus, George E. 1995. Ethnography in/of the World System: The Emergence of Multi-Sited Ethnography. *Annual Review of Anthropology* 24 (1): 95–117.

Meyfroidt, Patrick. 2016. Approaches and Terminology for Causal Analysis in Land Systems Science. *Journal of Land Use Science* 11 (5): 501–522.

Meyfroidt, Patrick, Rinku Roy Chowdhury, Ariane de Bremond, Erle C. Ellis, Karl-Heinz Erb, Tatiana Filatova, Rachael D. Garrett, Morgan Grove, Andreas Heinimann, Tobias Kuemmerle, Christian A. Kull, Eric F. Lambin, Y. Landon, Yann le Polain de Waroux, Peter Messerli, Daniel Müller, Jonas Ø. Nielsen, Garry D. Peterson, V. Rodriguez García, Maja Schlüter, Benjamin

L. Turner II, and Peter H. Verburg. 2018. Middle-Range Theories of Land System Change. *Global Environmental Change* 53: 52–67.

Meyfroidt, Patrick, Eric F. Lambin, Karl-Heinz Erb, and Thomas W. Hertel. 2013. Globalization of Land Use: Distant Drivers of Land Change and Geographic Displacement of Land Use. *Current Opinion in Environmental Sustainability* 5 (5): 438–444. https://doi.org/10.1016/j.cosust.2013.04.003.

Meyfroidt, Patrick, Florian Schierhorn, Alexander V. Prishchepov, Daniel Müller, and Tobias Kuemmerle. 2016. Drivers, Constraints and Trade-Offs Associated with Recultivating Abandoned Cropland in Russia, Ukraine and Kazakhstan. *Global Environmental Change* 37: 1–15.

Millington, James D.A., Hang Xiong, Steve Peterson, and Jeremy Woods. 2017. Integrating Modelling Approaches for Understanding Telecoupling: Global Food Trade and Local Land Use. *Land* 6 (3): 56.

Moran, Daniel D., Manfred Lenzen, Keiichiro Kanemoto, and Arne Geschke. 2013. Does Ecologically Unequal Exchange Occur? *Ecological Economics* 89: 177–186.

Müller, Robert, Till Pistorius, Sophia Rohde, Gerhard Gerold, and Pablo Pacheco. 2013. Policy Options to Reduce Deforestation Based on a Systematic Analysis of Drivers and Agents in Lowland Bolivia. *Land Use Policy* 30 (1): 895–907.

Munroe, Darla K., Kendra McSweeney, Jeffrey L. Olson, and Becky Mansfield. 2014. Using Economic Geography to Reinvigorate Land-Change Science. *Geoforum* 52: 12–21.

Richards, Peter. 2017. It's Not Just Where You Farm; It's Whether Your Neighbor Does Too. How Agglomeration Economies are Shaping New Agricultural Landscapes. *Journal of Economic Geography* 18 (1): 87–110.

Richards, Peter D., Robert T. Walker, and Eugenio Y. Arima. 2014. Spatially Complex Land Change: The Indirect Effect of Brazil's Agricultural Sector on Land Use in Amazonia. *Global Environmental Change* 29: 1–9.

Schierhorn, Florian, Patrick Meyfroidt, Thomas Kastner, Tobias Kuemmerle, Alexander V. Prishchepov, and Daniel Müller. 2016. The Dynamics of Beef Trade between Brazil and Russia and Their Environmental Implications. *Global Food Security* 11: 84–92.

Sugihara, George, Robert May, Hao Ye, Chih-Hao Hsieh, Ethan Deyle, Michael Fogarty, and Stephan Munch. 2012. Detecting Causality in Complex Ecosystems. *Science* 338 (6106): 496–500.

Tsing, Anna Lowenhaupt. 2005. *Friction: An Ethnography of Global Connection*. Princeton, NJ: Princeton University Press.

Turner, Billie L., Goran Hydén, and Robert W. Kates. 1993. *Population Growth and Agricultural Change in Africa*. Gainesville, FL: University Press of Florida.
van Vliet, Jasper, Nicholas R. Magliocca, Bianka Büchner, Elizabeth Cook, José M. Rey Benayas, Erle C. Ellis, Andreas Heinimann, Eric Keys, Tien Ming Lee, Jianguo Liu, Ole Mertz, Patrick Meyfroidt, Mark Moritz, Christopher Poeplau, Brian E. Robinson, Ralf Seppelt, Karen C. Seto, and Peter H. Verburg. 2016. Meta-Studies in Land Use Science: Current Coverage and Prospects. *Ambio* 45 (1): 15–28.
Villoria, Nelson B., and Thomas W. Hertel. 2011. Geography Matters: International Trade Patterns and the Indirect Land Use Effects of Biofuels. *American Journal of Agricultural Economics* 93 (4): 919–935.
Walker, Brian, C.S. Holling, Stephen R. Carpenter, and Ann Kinzig. 2004. Resilience, Adaptability and Transformability in Social-Ecological Systems. *Ecology and Society* 9 (2): 5.
Walters, Bradley B. 2017. Explaining Rural Land-Use Change and Reforestation: A Causal-Historical Approach. *Land Use Policy* 67: 608–624.
Walton, Douglas. 2005. *Abductive Reasoning*. Tuscaloosa, AL: University of Alabama Press.
Wertz-Kanounnikoff, Sheila, Patrícia Marinho Falcão, and Louis Putzel. 2013. Facing China's Demand for Timber: An Analysis of Mozambique's Forest Concession System with Insights from Cabo Delgado Province. *International Forestry Review* 15 (3): 387–397.

Part II

Topics

5

Mapping Export-Oriented Crop Production

Christian Levers and Daniel Müller

1 The Globalisation of Agricultural Production

Globalisation has shaped land use for centuries, first through trade along the major land routes, such as the Silk Road, and increasingly via sea transport following the discoveries of Christopher Columbus and Vasco da Gama. The exchange of capital, goods, and services across international borders, including trade in agricultural commodities, gained fur-

C. Levers (✉)
Geography Department, Humboldt-Universität zu Berlin,
Berlin, Germany
e-mail: christian.levers@geo.hu-berlin.de; christian.levers@ufz.de

D. Müller
Geography Department, Humboldt-Universität zu Berlin,
Berlin, Germany

Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale), Germany
e-mail: mueller@iamo.de

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_5

ther momentum in the mid-nineteenth century with the adoption of steam propulsion during the Industrial Revolution, which reduced freight costs (Harley 1988). However, the largest absolute increase in the volume of globally traded agricultural commodities occurred following the end of World War II and was mainly facilitated by trade liberalisation, urbanisation, and the drastic decline in international transport costs (Huwart and Verdier 2013). Particularly relevant for agricultural trade were the technological advances in international shipping, namely, the introduction of containerisation and specialised vessels for refrigerated transport that allowed for economies of scale and led to increased shipping volumes (Hummels 2007). The rapidly growing quantity and value of internationally traded agriculture and food products, often to distant places, provides evidence of the rise of globalisation in agriculture (Kastner et al. 2014). This rapid growth has resulted in an overhaul of the global food system and fundamental changes in global land use.

The globalisation of agricultural production is a prime example of how human and natural systems are coupled, often over large geographical distances (Liu et al. 2013; Friis et al. 2015). Consuming societies act as receiving systems by creating a demand for agricultural products that is not satisfied by domestic markets. This results in commodities being produced elsewhere, with farmers acting as the sending systems from where commodities are exported. International trade links the two systems and establishes the flow between telecoupled locations, which can lead to spillover effects between sending and receiving systems (see Chaps. 2 and 3). The telecoupling framework offers an analytical lens through which the globalisation of agricultural production can be analysed by assessing the related drivers, actors (and their interests), and physical resources.

The accelerating globalisation of agriculture, with its associated rise in the volumes and values of agricultural products that are internationally traded, results in increasingly telecoupled production systems, especially in regions where a large share of production is destined for export (MacDonald et al. 2015). The large spatial footprint of export-oriented agriculture is responsible for substantial environmental costs, including negative local (on-site) effects, such as soil degradation, regional impacts due to excessive freshwater use or nutrient and pesticide runoff, and global concerns, such as carbon emissions and biodiversity loss due to the conversion of land for export-oriented commercial agriculture (see Chaps. 2 and

3). Indeed, the globalisation of agriculture is a major driver for the tropical deforestation that has occurred over the last 50 years and its related greenhouse gas emissions and biodiversity losses. A large share of the tropical deforestation that has occurred to date has fuelled capital-intensive and export-oriented agriculture, such as the expansion of soybean production in Latin America or of tree crops in Southeast Asia (Malhi et al. 2014).

The environmental costs associated with the expansion of export-oriented agriculture are of increasing societal concern. International trade in agricultural commodities externalises the environmental costs by shifting the burden from the places of consumption towards the places of production of the exported commodities (Hoekstra and Wiedmann 2014). Consequently, policies that aim at globally sustainable land use need to account for the land-use footprints embodied in consumption that occur at the sites of production. One economically efficient strategy for doing so is to quantify the environmental costs of production and impose consumption taxes that account for the size of the negative externalities. However, quantifying the costs is difficult and tax implementation is obstructed by political hurdles. Another approach to linking production externalities with consumption is the use of labels that detail the land-use footprint of the products. The aim of such labelling is typically to achieve voluntary reductions in the consumption of products that cause environmental costs elsewhere. However, quantification of the production footprints necessitates tracking the value chain from consumption to production (see Chaps. 6, 7, and 8).

Increasing trade in agricultural commodities altered the spatial configuration of global land use, which underlines the important role of the globalisation of the agricultural sector in driving telecoupled land-use dynamics. In particular, the emergence of production regions that are dominated by export-oriented land uses substantially influenced land systems (Lambin and Meyfroidt 2011). These production hotspots of export-oriented agriculture are typically restricted to a small number of key agricultural commodities that are designated for international markets and generate most of the region's agricultural revenue (e.g., soybean meal in the Neotropics or palm oil in Indonesia). Delineating the emerging spatial configurations of export-oriented agricultural production, including their extent, location, and key commodities, can help in assessing the spatial clustering of export production and its associated environmental trade-offs.

To assess the land-use footprint of exported agricultural commodities, data on the extent of the domestic land use that is devoted to exports and estimates of where the domestic export production takes place are necessary. The share of a nation's total crop production that comes from export crops can be extracted from Food and Agriculture Organization Corporate Statistical Database (FAOSTAT) data for every year since 1961. However, the land-use footprint of export-oriented crop production has, to the best of our knowledge, never been assessed globally or at a subnational scale. This is unfortunate because estimations at fine spatial scales permit a better assessment of the spatial footprint of land use devoted to export crop production and allow for a more accurate assessment of the social and environmental effects of agricultural exports.

In this chapter, we spatially delineate the land footprint of export-oriented crop production for major global export crops using the telecoupling framework to combine flow- with place-based analysis (Friis and Nielsen 2017). By developing a spatial allocation algorithm that approximates a region's likelihood of being dominated by export production, we go beyond traditional approaches that assume the proportionality of patterns, rates, and volumes between export production and overall production. Our allocation algorithm generates global, crop-specific maps that depict the share of crops produced for export in 2005. The maps demonstrate the effect of telecoupling on agricultural production by showing the effect that the international trade of agricultural commodities has on land use in the producing regions. Knowing the type and original location of export crops at a subnational scale allows for a better approximation of their environmental and social costs, which can, in turn, help to raise the primary importing countries' awareness about the impacts of their consumption. Such analysis thus informs policy-making, influences consumer preferences, and stimulates design and supply-chain interventions that can assist in steering telecoupled systems towards sustainability (see Chap. 6). The algorithm also has the ability to identify export crop production hotspots that underlie the analysis of the positive and negative place-based consequences of the increasing focus on exports in commercial agriculture. By identifying the regions and commodities for which telecouplings typically manifest, the analysis can pinpoint the producing regions (by crop) and commodity flows that are strongly linked by telecoupling. In that way, our approach highlights source regions of telecoupled systems that warrant prime attention for telecoupling research.

2 The Major Global Export Crops

The global area harvested for all crops, as reported by FAOSTAT (FAO 2018), increased by 724 million hectares (Mha) between 1961 and 2016, an increase of 26%. Over the same period, the harvested areas of the 13 crops with the largest areas dedicated to export (according to data from 2005, our year of analysis) increased by 325 Mha (55%). The expansion of export crops was therefore responsible for 45% of the net increase in total area harvested since 1961.

We focus our subsequent analysis on the most important export crops, which we define as those crops with the largest harvested area devoted to export in the year 2005. To do so, we use updated data from Kastner et al. (2014), who exploited bilateral trade matrices from FAOSTAT to link consumption to the product's point of origin, following the approach of Kastner et al. (2011). Figure 5.1 depicts the changes in the harvested areas of the 13 selected crops. Maize showed the largest increase in harvested area between 1961 and 2016, with an increase of almost 82 Mha (77%): this expansion alone is equivalent to 25% of the total net increase in the harvested areas of the 13 major export crops. The increase in the global harvested area of wheat is much smaller, at 16 Mha (8%) over the 56-year period. The area harvested for barley actually declined by 8 Mha (14%) over the same period. Figure 5.1 also reveals a steady increase in the area devoted to the cultivation of non-staple crops, such as cacao, sugar crops, and rubber. Similarly, the most important oil crops (soybean, rapeseed, oil palm, and sunflower) gradually occupied a greater area during this period. Overall, the increase in harvested area is much larger for non-staple crops than for staple crops, and the same is true for the quantities the crops produced (Rueda and Lambin 2014).

Figure 5.2 summarises the total area harvested for export in 2005 for the 13 selected crops, using the data from Kastner et al. (2014). Soybean and wheat clearly dominate global export production in terms of area harvested, with approximately 50 Mha each, followed by the coarse-grains maize (17 Mha) and barley (12 Mha). The other export crops occupy between 5 and 8 Mha and include oil crops (rapeseed, sunflower, and oil palm), tree crops (cocoa, coffee, and rubber), as well as sugar, paddy rice, and cotton. Tree crops exhibit the highest share of the area

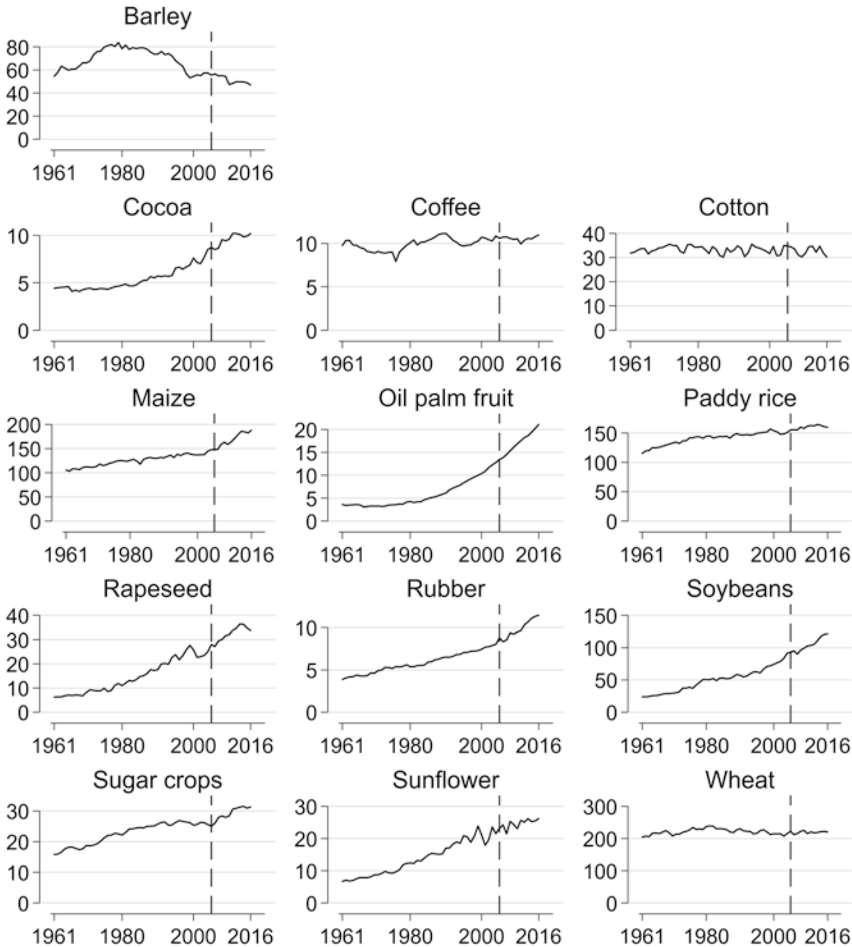


Fig. 5.1 Increase in area harvested in million hectares (Mha, y-axis) of the major export crops (in alphabetical order). Data are from FAO (2018) and the vertical line indicates the year 2005 for which we conducted the spatial allocation. Note the different scales on the y-axis

devoted to export production (right axis in Fig. 5.2) at 85% (cocoa), 75% (rubber), and 68% (coffee). Around 25% to 55% of the total area harvested for oil crops (soybean, oil palm, rapeseed, and sunflower) was devoted to exports in 2005. Conversely, less than a quarter of the area

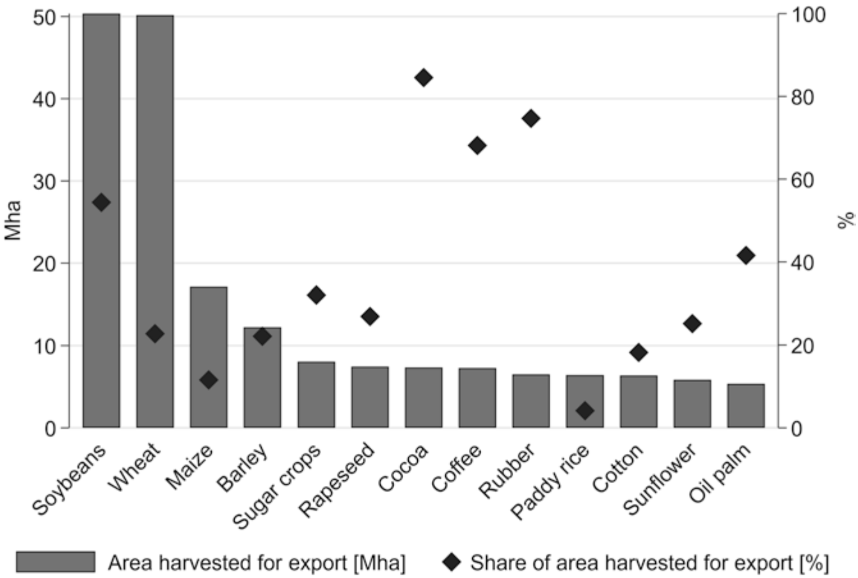


Fig. 5.2 Absolute area harvested for export (Mha) and share of area harvested for export (%) of the 13 most important export crops. Data are from Kastner et al. (2014), based on FAOSTAT

harvested for cereal crops was traded internationally, of which paddy rice was the lowest (4%).

Overall, the absolute and relative values of the area harvested for the 13 most important export crops present a mixed picture (Fig. 5.2). Large proportions of the key staple crops, wheat and maize, are traded internationally. Large areas of oil crops (mainly soybean) are also dedicated for export, mostly to feed monogastric livestock herds in distant places (Eitelberg et al. 2017). The major export crops in our analysis included crops that grow best in temperate conditions (wheat, barley, and rapeseed), as well as crops that originate from subtropical and tropical regions (cocoa, coffee, and oil palm). Similarly, the list includes both staples (wheat, maize, and rice), as well as crops that are non-essential for balanced nutrition, the so-called luxury crops (soybean, sugar, coffee, and rubber).

3 Spatial Allocation of Export Crops

3.1 The Allocation Approach

We used the most recent crop data available (2005) from the Spatial Production Allocation Model (MapSPAM) as our cropland layer (You et al. 2014b). MapSPAM downscales subnational agricultural statistics for harvested area and yields for 20 crops and 6 production technologies (irrigated, rainfed with high inputs, rainfed with low inputs, rainfed subsistence, all rainfed, and all technologies combined). The downscaling approach employed in MapSPAM uses entropy optimisation and accounts for crop-specific biophysical conditions, population density, and crop prices to distribute cropland in a spatially explicit way, with a grid cell size of approximately 10 × 10 km (You et al. 2014a, b). We excluded rubber from the crops that we mapped because no suitability data are available for rubber from the Global Agro-Ecological Zones (GAEZ) data that we used as the suitability layer for crop production in the allocation algorithm. This is unfortunate because 6.5 Mha (75%) of the total 8.7 Mha of area harvested for rubber were dedicated for export in 2005 (Fig. 5.2).

We allocated the crop-specific harvested areas from MapSPAM for the year 2005 based on an index representing their likelihood for export-oriented crop production. We created one likelihood index for each of the twelve selected export crops by combining data from three indicators: (1) crop-specific land suitability (IIASA and FAO 2012), (2) field size of cropland (Fritz et al. 2015), and (3) accessibility to cities with more than 50,000 inhabitants (Nelson 2008). The assumption in the selection of these indicators is that most export production is driven by profit-seeking behaviour and hence is concentrated in areas with high natural suitability, relatively large agricultural fields, and relatively large farms (unfortunately, spatially explicit data on farm size is lacking) (Neven et al. 2009). For the same reason, export-oriented agriculture tends to cluster close to populated places where access to trade hubs facilitate international trade (Iimi et al. 2015). We used the "high input/advanced management" version of the crop-specific suitability data, which assumes that the farming systems are mainly market-oriented with commercial production as the main management objective—a realistic assumption for the majority of the export-oriented crops. Under this assumption, crop production uses improved high-yield varieties, is capital intensive and mechanised, has low labour intensity, uses appropriate applications of nutrients, and applies pest, disease, and weed control (IIASA and FAO 2012).

We min-max-transformed all the indicators to a range between 0 and 1, thereby maintaining their original data distribution. We then calculated the sum of the three likelihood indicators per grid cell to derive the crop-specific likelihood index that quantifies the propensity of a grid cell to be allocated to the production of a specific export crop. The likelihood indices represent the likelihood of export crop production in additive fashion, without weights applied to any of the three likelihood input indicators. We tested the ability of the likelihood indices to capture the export crop production by calculating the correlation between the mean likelihood index and the actual export share per country for each crop (Fig. 5.3). Overall, the relationship between the likelihood and the export share was positive and high, with a correlation coefficient of $\rho = 0.42$. The correlation was especially high for cereals (barley $\rho = 0.65$, wheat $\rho = 0.56$) and oil crops (rapeseed $\rho = 0.69$, sunflower $\rho = 0.60$) but was moderate for the remainder of the crops. The exceptions were cocoa and coffee, for which negative correlations were calculated. The suitability surfaces for these tree crops are apparently not adept at capturing cropping patterns. In the case of coffee, this is likely because the two main coffee species, Arabica and Robusta, are subsumed in one suitability layer despite their different agro-ecological demands. The negative correlation between the likelihood index and the export share in the case of cocoa might reflect the relative tolerance of the cocoa plant, which grows in most hot and humid tropical areas.

We derived the total harvested area and the area harvested for export crop production for each crop and country from the data of Kastner et al. (2014). We then calculated the crop- and country-specific shares of the areas harvested for export. The area demand of export crop production was calculated for each crop and country individually by multiplying the share of exported crop production (see above) with the harvested crop area from MapSPAM (aggregated for each country). We verified the agreement between the harvested crop areas from MapSPAM and the

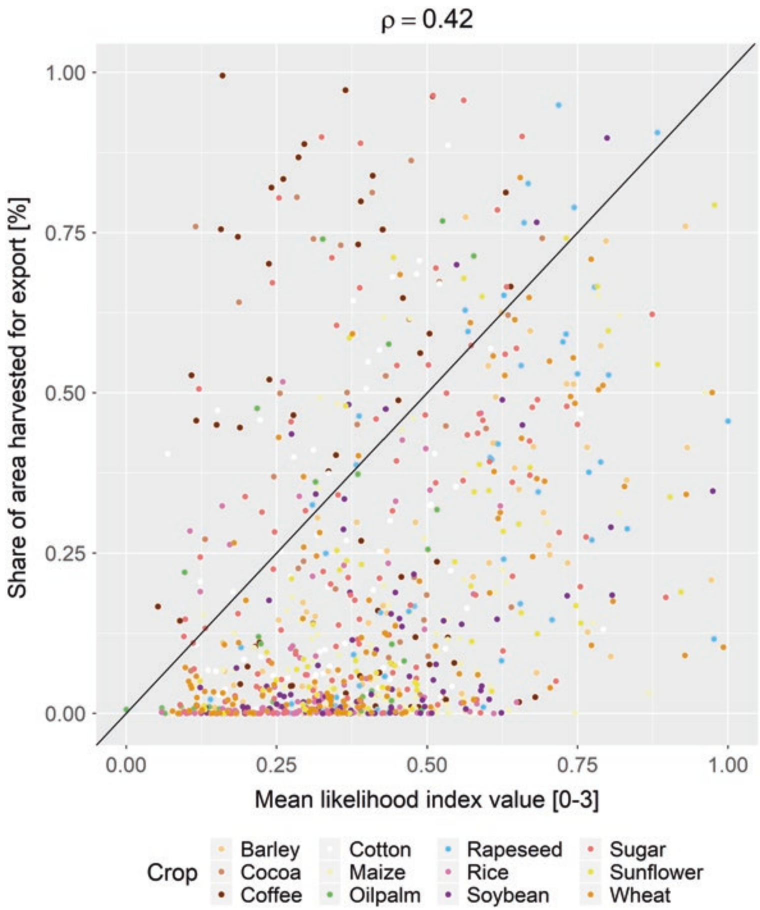


Fig. 5.3 Share of area harvested for export (%) in relation to the mean likelihood index [0–3] for all crops by country (N = 999). The Spearman correlation coefficient ρ is provided in the title. Note that export share values exceeding 100% (N = 36) were excluded

data from Kastner et al. (2014) based on FAOSTAT to ensure that the allocated harvested areas cover the actual export areas for each country and crop (correlations were larger than ρ = 99 for all crops).

We then spatially allocated each crop within each country by selecting the grid cell with the highest index value from our crop-specific likelihood index for export (see above) and defined this grid cell as destined for export. The allocation process stopped when the entire crop-specific export demand was allocated. We cross-checked whether all demand in the statistical data was allocated by comparing the sum of the harvested area for export production with the maps of the allocated demand (the differences were minor and ranged between 61 ha for rapeseed and 676 ha for rice).

Our allocation scheme resulted in binary classifications that contained grid cells, which were either categorised for export (i.e., the grid cell was selected by the allocation routine due to its high likelihood index) or not. As the area harvested for export has to be equal to or lower than the total area harvested for each crop, our approach always allocated the entire demand to the grid cells, starting with the highest likelihood index value and descending from there. We used these binary layers as masks to obtain the actual harvested area of each crop from the MapSPAM data. We calculated area shares for each crop by dividing the harvested area (in hectares) within each grid cell by 10,000 (the approximate size of a 10 × 10 km MapSPAM grid cell in hectares). Finally, we calculated the sum of the area shares for all 12 crops to obtain and to map the overall harvested area within a given grid cell that was destined for export. We further created a categorical map of the dominant crop type destined for export within each grid cell.

3.2 Caveats of the Allocation Algorithm

The resulting maps yield an interesting general spatial representation of the footprint of export-oriented agriculture, yet the spatial details must be interpreted with care. First, we used MapSPAM data from 2005, which were the most recent MapSPAM data available to us at the time of writing. However, both the harvested area dedicated to non-staple crops and the share of these crops being exported has continued to grow since 2005 (cf. Fig. 5.1). Our maps therefore represent a conservative illustration of the extent of the footprint of global export crops. Moreover, the available data only allowed for mapping a single point in time; we were therefore unfortunately unable to assess the temporal dynamics of the spatial footprint of global export crop production.

Second, we used ad hoc rules for the spatial allocation of export-oriented agriculture within countries. While this yields a useful qualitative and visual impression of the spatial footprint of crop exports, it does not allow for a cell-by-cell validation of the locations within countries where harvested areas likely to be used for export are concentrated. Uncertainties in the spatial allocation arise because the share of exports is only available from FAOSTAT at the country level and because the data we used to characterise the commercial orientation of export-oriented crop production are coarse and marred by uncertainty. We also cannot account for within-country crop trade or for the share of within-country commercial agricultural production that is destined for domestic consumption.

Third, our spatial allocation strongly depends on the quality of the input data, and especially on the MapSPAM data and the FAO trade statistics. MapSPAM data is extensively evaluated by several institutions for plausibility (see You et al. 2014b), yet these evaluations were mainly qualitative or semi-quantitative in nature. We are only aware of one independent and quantitative assessment of the MapSPAM data by Tan et al. (2014), who compared the accuracy of the crop maps with empirical case study results for China and found a satisfactory agreement. Regarding the FAO trade data, we rely on the data from Kastner et al. (2014) that circumvents the common problem of bilateral trade data by tracing the primary origin of imported agricultural produce, linking crops to their actual places of consumption. These data are a seminal and well-established product for trade flow data. However, FAO data may suffer from the misreporting of trade statistics from some countries and, by definition, only contain trade that was officially registered.

Fourth, our examination of global export-oriented crop production fails to account for the important role of the livestock sector in driving telecoupled land-use dynamics. Although our trade data includes a (rough) estimate of cropland used for feed, embodied in meat exports (e.g., maize used as feed for German pork exports), pasture areas are not included. However, enormous land resources are used for livestock grazing, particularly in South America, where a large increase in meat exports was correlated with a dramatic increase in pasture areas (Aide et al. 2013). Moreover, the assessment of the land-use footprint of meat production is challenging because data on pasture use and fodder production are often not available and, when available, are marred by uncertainties, which further complicates tracing the origins of livestock production.

Finally, telecouplings as empirical, global-scale phenomena complicate a holistic assessment of the place- and flow-based processes of global export agriculture. Our analysis does not disentangle the underlying causes that drive the export patterns and thus the land uses in distant places (see Chap. 6). Nor could we identify the spatial linkages between production locations and end-consumption or land-use spillovers and displacements. Such information would be a crucial addition to our crop export maps and would permit a better understanding of telecoupled food-production systems.

4 Spatial Patterns and Hotspots of Exported Crop Production

4.1 Spatial Patterns of Crop Production for Export

Crop production predominantly destined for export in 2005 was clearly concentrated in few regions: the Midwestern US and south-central Canada, the Chaco, Cerrado, and Southern Amazonia in South America, Central and Eastern Europe, and the southern part of West Africa, as well as Southeast Asia and southern Australia (Fig. 5.4, top panel). The highest export shares of the total harvested area can be found in the US, Argentina, Brazil, Ukraine, and Australia. With regard to crop type groups, such as cereals or oil crops, strong spatial clustering is apparent (Fig. 5.4, bottom panel). Cereals dominate the temperate climate regions of the Northern Hemisphere (except for wheat in Australia and rice in Pakistan) and tree crops dominate along the Equator. In contrast, oil crops show diverse spatial patterns, with soybean exports particularly clustered in South America (but also in North America and India), rapeseed in parts of India and Poland, and sunflower in Central and Eastern Europe.

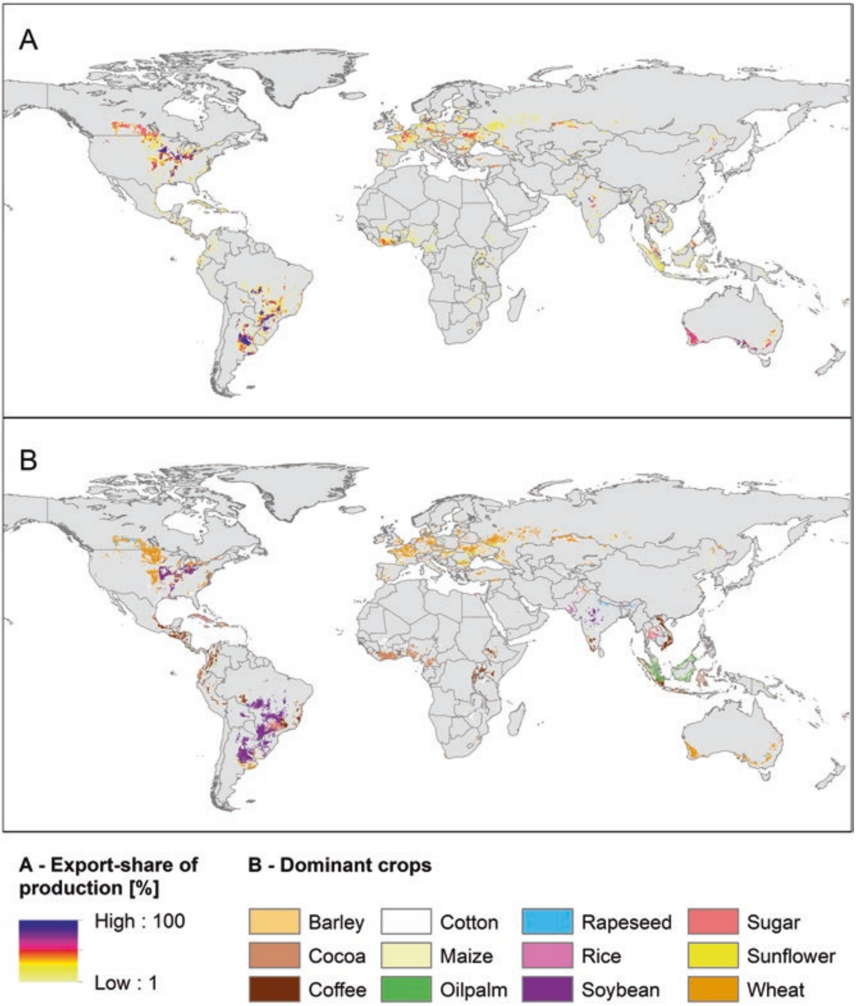


Fig. 5.4 Share of harvested area (**A**) and main crops (**B**) devoted to export crop production

4.2 Hotspots of Individual Export Crops

Investigating the shares of the harvested areas destined for export per grid cell provides distinct, crop-specific spatial patterns. The most visually striking pattern in the map of the dominant export crops (Fig. 5.4) are the large areas of soybean (the crop with the largest exported harvested area globally; cf. Fig. 5.2) in South America, and in particular, the western and central region of the Brazilian Cerrado, the northern part of the Pampas in Argentina, the south-western part of the Atlantic Forest in Brazil and Paraguay, as well as the Argentinian and Bolivian parts of the Chaco. The second largest global hotspot of soybean production destined for export is located in the northern Midwestern states of the US. Central India hosts another hotspot of export soybean production, but with a much smaller area than the hotspots of South and North America.

In terms of cereal production, wheat exports are concentrated in the large breadbaskets of the temperate zone, including the wheat belts in the US (Montana, North Dakota, South Dakota, and Minnesota), Canada (Saskatchewan, Alberta, and Manitoba), Australia (Western Australia, South Australia, New South Wales), France, Germany, and across the large black soil areas of the former Soviet Union (i.e., Russia, Ukraine, and Kazakhstan). Smaller hotspots can be found in parts of the Czech Republic, Hungary, and Turkey, and in the Pampas and Chaco regions of Argentina.

Maize exports mainly originate from the US (Great Lakes region, Minnesota, and Iowa) but also from the Pampas and Chaco regions in Argentina and the south-western region of the Atlantic Forest (Brazil, Paraguay), as well as parts of France, Ukraine, and smaller regions in Hungary, Bulgaria, and northern China (Jilin, Heilongjiang). Barley is mainly exported from European Union (EU) countries, in particular France, Germany, and Denmark, but also from parts of Ukraine and Canada (Saskatchewan, Alberta, and Manitoba), and from the wheat belt of Australia (Western Australia, South Australia, and New South Wales).

Harvested areas of sugar production used for export, including sugar cane and sugar beet, are predominantly located in the Brazilian Cerrado, the Central American countries, the Greater Antilles (Cuba, Dominican Republic), central and northern India, and several countries of the EU (e.g., northern France, central and north-western Germany, western Poland), as well as Ukraine and Belarus. Rapeseed cultivated for export shows distinct hotspots in Canada (Saskatchewan, Alberta, and Manitoba), Central and Eastern Europe (France, Germany, the UK, Czech Republic, Poland, Hungary, and the Baltic countries), northern India, and, to a lesser degree, in the wheat belt of Australia.

The areas cultivated for tree crop exports were mainly concentrated in the tropics and subtropics. The land-use footprint of exported coffee cultivation (almost 70% of total global area cultivated for coffee goes into export; cf. Fig. 5.2) shows clusters in parts of Brazil (mainly in Minas Gerais and Rondônia), Colombia, Central America, and eastern Africa, and in much of Vietnam, where the Robusta variant dominates. Exports of palm oil are seen in the large and well-known land-use footprints in Malaysia and Indonesia, with particularly drastic environmental consequences due to the high greenhouse gas emissions and the high levels of endemic species that are threatened by the expansion of export-oriented oil palm cultivation (Carrasco et al. 2017). Cocoa is the most important export crop in western Africa and has a substantial footprint in Ecuador (cf. Figs. 5.4 and 5.5). Large shares of the harvested areas of Indonesia, Malaysia, and Vietnam are tree crops destined for export (particularly palm oil and coffee), but this pattern is likely an artefact of the 2005 MapSPAM data. Despite known spatial clustering, such as the hotspot of Vietnamese coffee production in the Central Highlands (Meyfroidt et al. 2013), the harvested area of these crops are relatively homogeneously distributed across very large areas in the MapSPAM data.

We also stratified our allocated harvested areas of export-oriented crop production by global biomes (Olson and Dinerstein 2002). Figure 5.6 reveals that the largest area used for export is located in the "Temperate Grasslands, Savannahs and Shrublands" biome (ca. 52 Mha), followed by the "Temperate Broadleaf and Mixed Forests" biome (ca. 44 Mha), and the "Tropical and Subtropical Moist Broadleaf Forests" biome (ca. 33 Mha). The biomes with lower but still substantial export crop cultivation include the "Tropical and Subtropical Grasslands, Savannahs and Shrublands" (ca. 19 Mha), the "Mediterranean Forests, Woodlands and Scrub" (ca. 11 Mha), and the "Tropical and Subtropical Dry Broadleaf Forests" (ca. 10 Mha). The remaining biomes had less than 5 Mha of harvested areas destined for export.

Wheat, soybean, and maize production (and to a smaller degree barley) contributed the largest share of the area harvested for export in the "Temperate Broadleaf and Mixed Forests" biome and the "Temperate Grasslands, Savannahs and Shrublands" biome, which cover large parts of the US, Central and Eastern Europe, and Central and East Asia. The

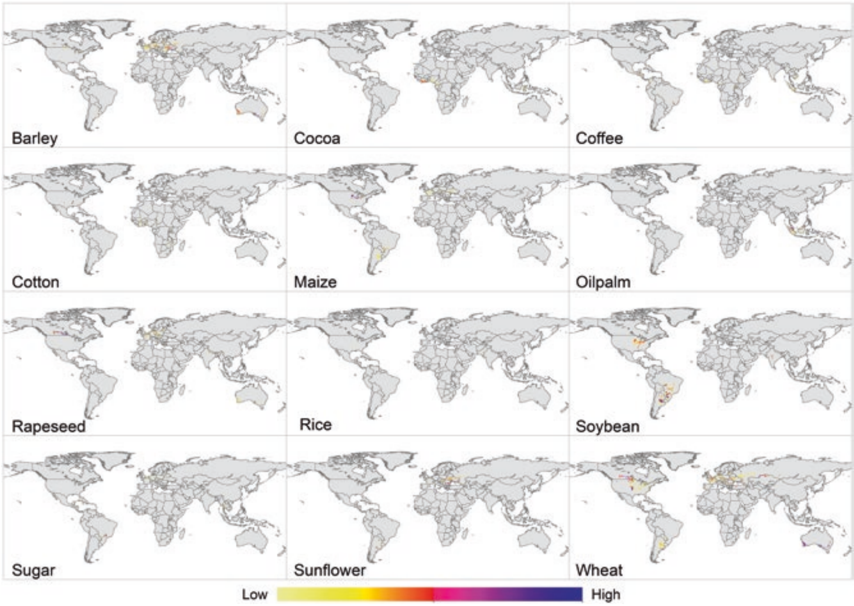


Fig. 5.5 Hotspots of crop area harvested for export. Value ranges have a common minimum of 1% for all crops but crop-specific maximum values. Maximum values are 34% (barley), 85% (cocoa), 85% (coffee), 67% (cotton), 78% (maize), 41% (oil palm), 38% (rapeseed), 100% (rice), 82% (soybean), 78% (sugar), 26% (sunflower), and 100% (wheat). Due to the fixed grid-cell size of 10 × 10 km, the relative values also represent absolute area estimates (e.g., cotton: 67% of a 10 × 10 km [i.e., 100 km^2] grid cell is equal to 67 km^2)

"Tropical and Subtropical Moist Broadleaf Forests" biome, which covers the northern part of South America, equatorial Africa, and Southeast Asia, was predominantly characterised by tree crops (cocoa, coffee, and oil palm) that accounted for more than half of the harvested area. The remaining areas were mainly dedicated to soybean, sugar, and rice production. The areas harvested for export within the "Tropical and Subtropical Dry Broadleaf Forests" and the "Tropical and Subtropical Grasslands, Savannahs and Shrublands" biomes were mostly dedicated to soybean production and were predominant in the Chaco (Argentina) and the Cerrado (Brazil) in South America, large parts of Sub-Saharan Africa, and northern Australia. The major export crops from the "Mediterranean Forests, Woodlands and Scrub" biome are cereals, mainly wheat but also

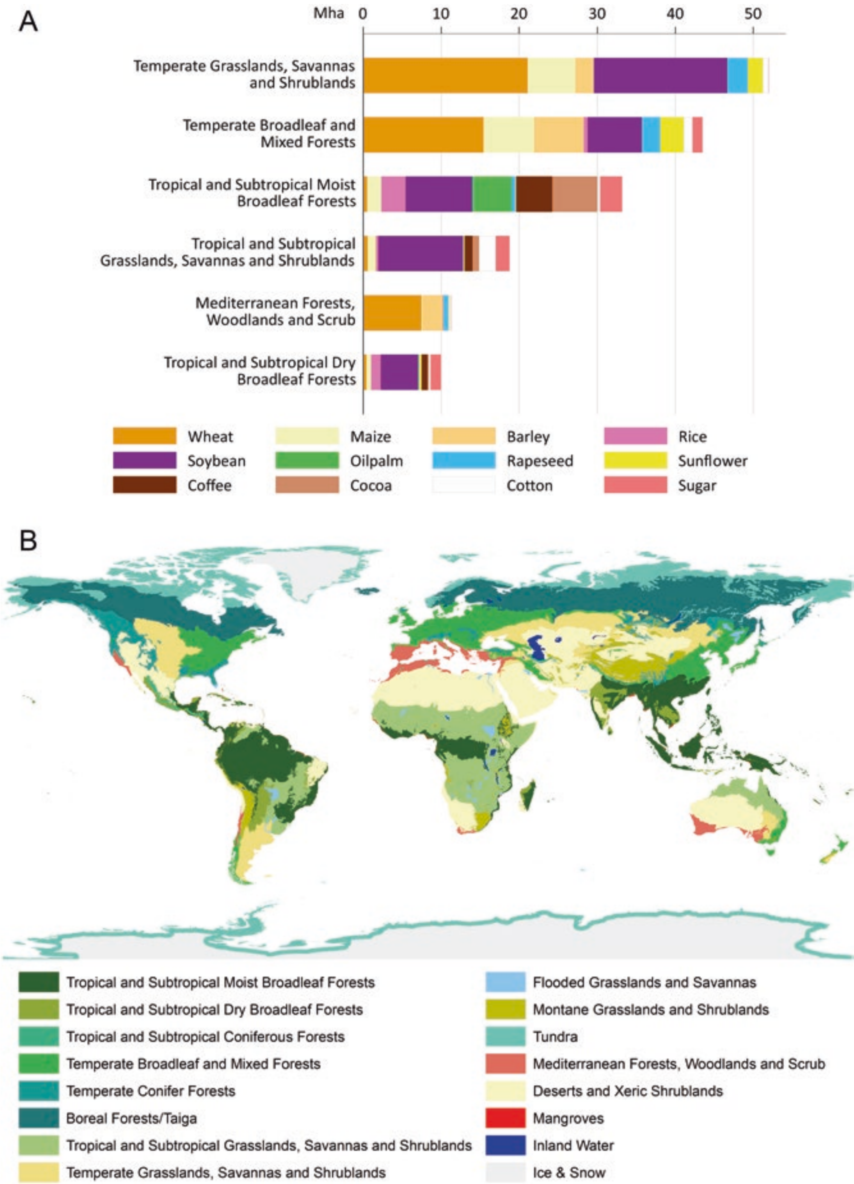


Fig. 5.6 Decomposition of crop area harvested for export by terrestrial ecoregion (biome) (panel A). Only biomes with more than 5 Mha of allocated export-oriented crop production are shown. Panel B shows the spatial distribution of the terrestrial ecoregions of the world (Olson and Dinerstein 2002)

barley. Cereal exports originate from many countries of the Mediterranean region, in particular, from Spain, Italy, Greece, West Turkey, Morocco, and Algeria.

5 Effects of Growing Export Crops on Food Systems and the Environment

The globalisation of agriculture has resulted in enormous increases in the amount and value of agricultural commodities that are traded internationally. In particular, the last 50 years have seen unprecedented acceleration in agricultural commodities produced exclusively for export. The rising volume of international trade has contributed to improved diets by providing better access to nutrition, in particular for food importing countries (Wood et al. 2018). At the same time, the growing globalisation of agricultural production facilitated the transition towards diets with a higher proportion of saturated fats, sugars, animal-sourced products, and processed foods (Popkin 1993). However, the impacts of agricultural globalisation not only affected consumption opportunities (see Chap. 6) but also overhauled production systems. With an increasing focus on export, food production became more commercialised and capital intensive, farm sizes increased, and farms concentrated on a smaller number of crops that generated the highest profits (Graesser et al. 2018; Reardon et al. 2009).

We examined land-use footprints associated with export-oriented agriculture at the point of product origin. We mapped the global centres of agricultural export production for 12 major export crops. To do so, we allocated the crop-specific harvested area destined for international trade by combining global cropland maps and spatial layers capturing the crop's suitability for export. The results demonstrate the high concentration of export crop production in Latin America, the US, and Southeast Asia and provide visual confirmation that much of the world's farmland is dedicated to a few, high-value crops. Our analysis also identifies specific crop-country combinations that are characterised by high degrees of telecoupling. We used data from 2005, which were the latest data available at the time of writing. Since then, the degree to which agriculture is globalised has continued to increase (cf. Fig. 5.1). For example, global meat production has increased by 238 million tons (Mt) to 1343 Mt and almost a quarter (58 Mt) of this additional production was exported (FAO 2018). The increase in the global meat trade has considerable land-use implications (see Chaps. 2 and 3), such as the stimulation of soybean trade, because soybean meal is the major protein source in the diets of monogastric livestock. Moreover, much of the increase in global livestock trade arguably comes from the expansion of pastures. This implies that including grazing lands when calculating the impact of livestock production would further elevate the spatial footprint of export agriculture.

The growing land-use footprint of consumption is of great societal concern because of the associated environmental impacts on regions where this demand has been met through expansion or intensification of production (Carrasco et al. 2017). In temperate regions, suitable land resources have long been used for agricultural production, therefore, most of the expansion of agricultural production in recent decades took place in tropical and subtropical regions, where large stocks of carbon are captured in the vegetation and where species richness is high. Another example of an environmental impact that has been well documented is the large amount of water that is required for the production of internationally traded agricultural products despite the fact that many of these traded products originate from water-scarce regions (Dalin et al. 2017; Konar et al. 2011). Awareness of the effects of agricultural production on foreign lands is becoming increasingly prominent among the consumers in importing countries, and recognition of the natural resources that are embedded in the traded agricultural commodities is rising.

The growing importance of food trade has implications for domestic food security in the countries that rely on imports, and particularly in countries that rely on imports of staple food commodities. The growing reliance on imports can result in undesirable social and ecological outcomes, as evidenced by the food cost crises of 2007 and 2011 that highlighted the geopolitical implications of import dependence (Bren d'Amour et al. 2016). Co-occurring adverse weather conditions reduced cereal yields in key exporting regions, resulting in export restrictions. These, in turn, contributed to spikes in wheat prices, which had detrimental consequences for the food supply and food security in the importing countries. High prices for food staples have, for example, adversely affected countries in the Middle East, which heavily rely on wheat imports, and may have been a potential trigger for the Arab Spring (Bren d'Amour et al. 2016; Lagi et al. 2011).

Telecoupled land systems can also be an impetus for conservation by improving the flow of global information and triggering new policies in food production systems, such as codes of conduct or certification schemes, that can improve food security and livelihoods (Eakin et al. 2017, see Chaps. 9, 12, and 15). For example, international markets and financial institutions increasingly pressured soybean producers in the Brazilian Amazon for higher environmental and social standards, and this consumer pressure eventually resulted in the implementation of the soybean moratorium, a voluntary zero-deforestation agreement (Gibbs et al. 2015). Anticipating the impacts of export-oriented agriculture is of increasing importance because it informs the growing numbers of consumers that are concerned about the environmental and social implications of their consumption patterns. Better place-based insights on the land-use footprints of consumption may support the implementation of voluntary schemes as well as compulsory regulations that aim at more sustainable land use.

Acknowledgements We are grateful to Thomas Kastner for providing the trade flow data. We thank Jonas Ø. Nielsen, Liangzhi You, and Thomas Kastner for useful comments that helped improve this chapter. Parts of this research were supported by the German Ministry of Education and Research (BMBF, project PASANOA, 031B0034A).

References

Aide, T. Mitchell, L. Clark Matthew, H. Ricardo Grau, David López-Carr, Marc A. Levy, Daniel Redo, Martha Bonilla-Moheno, George Riner, María J. Andrade-Núñez, and María Muñiz. 2013. Deforestation and Reforestation of Latin America and the Caribbean (2001–2010). *Biotropica* 45 (2): 262–271. https://doi.org/10.1111/j.1744-7429.2012.00908.x.

Bren d'Amour, Christopher, Leonie Wenz, Matthias Kalkuhl, Jan Christoph Steckel, and Felix Creutzig. 2016. Teleconnected Food Supply Shocks. *Environmental Research Letters* 11 (3): 035007. https://doi.org/10.1088/1748-9326/11/3/035007.

Carrasco, Luis Roman, Thi Phuong Le Nghiem, Zhirong Chen, and Edward B. Barbier. 2017. Unsustainable Development Pathways Caused by Tropical Deforestation. *Science Advances* 3 (7). https://doi.org/10.1126/sciadv.1602602.

Dalin, Carole, Yoshihide Wada, Thomas Kastner, and Michael J. Puma. 2017. Groundwater Depletion Embedded in International Food Trade. *Nature* 543 (7647): 700–704. https://doi.org/10.1038/nature21403.

Eakin, Hallie, Ximena Rueda, and Ashwina Mahanti. 2017. Transforming Governance in Telecoupled Food Systems. *Ecology and Society* 22 (4): 32. https://doi.org/10.5751/ES-09831-220432.

Eitelberg, David A., Jasper Van Vliet, and Peter H. Verburg. 2017. Accounting for Monogastric Livestock as a Driver in Global Land Use and Cover Change Assessments. *Journal of Land Use Science* 12 (1): 1–16. https://doi.org/10.1080/1747423X.2016.1270361.

FAO. 2018. *FAOSTAT Data*. Rome: Food and Agriculture Organization of the United Nations. Accessed February 10, 2018. http://faostat3.fao.org/.

Friis, Cecilie, and Jonas Ø. Nielsen. 2017. Land-Use Change in a Telecoupled World: The Relevance and Applicability of the Telecoupling Framework in the Case of Banana Plantation Expansion in Laos. *Ecology and Society* 22 (4): 30. https://doi.org/10.5751/ES-09480-220430.

Friis, Cecilie, Jonas Ø. Nielsen, Iago Otero, Helmut Haberl, Jörg Niewöhner, and Patrick Hostert. 2015. From Teleconnection to Telecoupling: Taking Stock of an Emerging Framework in Land System Science. *Journal of Land Use Science* 11 (2): 131–153. https://doi.org/10.1080/1747423X.2015.1096423.

Fritz, Steffen, Linda See, Ian McCallum, Liangzhi You, Andriy Bun, Elena Moltchanova, Martina Duerauer, Fransizka Albrecht, Christian Schill, Christoph Perger, Petr Havlik, Aline Mosnier, Philip Thornton, Ulrike Wood-Sichra, Mario Herrero, Inbal Becker-Reshef, Chris Justice, Matthew Hansen, Peng Gong, Sheta Abdel Aziz, Anna Cipriani, Renato Cumani, Giuliano Cecchi, Giulia Conchedda, Stefanus Ferreira, Adriana Gomez, Myriam Haffani, Francois Kayitakire, Jaiteh Malanding, Rick Mueller, Terence Newby, Andre Nonguierma, Adeaga Olusegun, Simone Ortner, D. Ram Rajak, Jansle Rocha, Dmitry Schepaschenko, Maria Schepaschenko, Alexey Terekhov, Alex Tiangwa, Christelle Vancutsem, Elodie Vintrou, Wu Wenbin, Marijn van der Velde, Antonia Dunwoody, Florian Kraxner, and Michael Obersteiner. 2015. Mapping Global Cropland and Field Size. *Global Change Biology* 21 (5): 1980–1992. https://doi.org/10.1111/gcb.12838.

Gibbs, H.K., L. Rausch, J. Munger, I. Schelly, D.C. Morton, P. Noojipady, B. Soares-Filho, P. Barreto, L. Micol, and N.F. Walker. 2015. Brazil's Soy Moratorium. *Science* 347 (6220): 377–378. https://doi.org/10.1126/science.aaa0181.

Graesser, Jordan, Navin Ramankutty, and Oliver T. Coomes. 2018. Increasing Expansion of Large-Scale Crop Production onto Deforested Land in Sub-Andean South America. *Environmental Research Letters* 13 (8): 084021. https://doi.org/10.1088/1748-9326/aad5bf.

Harley, C. Knick. 1988. Ocean Freight Rates and Productivity, 1740–1913: The Primacy of Mechanical Invention Reaffirmed. *The Journal of Economic History* 48 (4): 851–876. https://doi.org/10.1017/S0022050700006641.

Hoekstra, Arjen Y., and Thomas O. Wiedmann. 2014. Humanity's Unsustainable Environmental Footprint. *Science* 344 (6188): 1114–1117. https://doi.org/10.1126/science.1248365.

Hummels, David. 2007. Transportation Costs and International Trade in the Second Era of Globalization. *Journal of Economic Perspectives* 21 (3): 131–154. https://doi.org/10.1257/jep.21.3.131.

Huwart, Jean-Yves, and Loic Verdier. 2013. *Economic Globalisation: Origins and Consequences*. Edited by OECD Insights. Paris: OECD Publishing.

IIASA, and FAO. 2012. *Global Agro-Ecological Zones (GAEZ v3.0)*. Laxenburg: IIASA, and Rome: FAO.

Iimi, Atsushi, Liangzhi You, Ulrike Wood-Sichra, and Richard Martin Humphrey. 2015. *Agriculture Production and Transport Infrastructure in East Africa: An Application of Spatial Autoregression*. Washington, DC: World Bank.

Kastner, Thomas, Karl-Heinz Erb, and Helmut Haberl. 2014. Rapid Growth in Agricultural Trade: Effects on Global Area Efficiency and the Role of Management. *Environmental Research Letters* 9 (3): 034015. https://doi.org/10.1088/1748-9326/9/3/034015.

Kastner, Thomas, Michael Kastner, and Sanderine Nonhebel. 2011. Tracing Distant Environmental Impacts of Agricultural Products from a Consumer Perspective. *Ecological Economics* 70 (6): 1032–1040. https://doi.org/10.1016/j.ecolecon.2011.01.012.

Konar, M., C. Dalin, S. Suweis, N. Hanasaki, A. Rinaldo, and I. Rodriguez-Iturbe. 2011. Water for Food: The Global Virtual Water Trade Network. *Water Resources Network* 47 (5). https://doi.org/10.1029/2010WR010307.

Lagi, Marco, Karla Z. Bertrand, and Yaneer Bar-Yam. 2011. The Food Crises and Political Instability in North Africa and the Middle East. *arXiv*: 1108.2455.

Lambin, Eric F., and Patrick Meyfroidt. 2011. Global Land Use Change, Economic Globalization, and the Looming Land Scarcity. *Proceedings of the National Academy of Sciences* 108 (9): 3465–3472. https://doi.org/10.1073/pnas.1100480108.

Liu, Jianguo, Vanessa Hull, Mateus Batistella, Ruth DeFries, Thomas Dietz, Feng Fu, Thomas W. Hertel, R. Cesar Izaurralde, Eric F. Lambin, Shuxin Li, Luiz A. Martinelli, William J. McConnell, Emilio F. Moran, Rosamond Naylor, Zhiyun Ouyang, Karen R. Polenske, Anette Reenberg, Gilberto de Miranda Rocha, Cynthia S. Simmons, Peter H. Verburg, Peter M. Vitousek, Fusuo Zhang, and Chunquan Zhu. 2013. Framing Sustainability in a Telecoupled World. *Ecology and Society* 18 (2): 26. https://doi.org/10.5751/ES-05873-180226.

MacDonald, Graham K., Kate A. Brauman, Shipeng Sun, Kimberly M. Carlson, Emily S. Cassidy, James S. Gerber, and Paul C. West. 2015. Rethinking Agricultural Trade Relationships in an Era of Globalization. *Bioscience* 65 (3): 275–289. https://doi.org/10.1093/biosci/biu225.

Malhi, Yadvinder, Toby A. Gardner, Gregory R. Goldsmith, Miles R. Silman, and Przemyslaw Zelazowski. 2014. Tropical Forests in the Anthropocene. *Annual Review of Environment and Resources* 39 (1): 125–159. https://doi.org/10.1146/annurev-environ-030713-155141.

Meyfroidt, Patrick, Tan Phuong Vu, and Viet Anh Hoang. 2013. Trajectories of Deforestation, Coffee Expansion and Displacement of Shifting Cultivation in the Central Highlands of Vietnam. *Global Environmental Change* 23 (5): 1187–1198. https://doi.org/10.1016/j.gloenvcha.2013.04.005.

Nelson, Andy. 2008. *Estimated Travel Time to the Nearest City of 50,000 or More People in Year 2000*. Ispra: Global Environment Monitoring Unit, Joint Research Centre of the European Commission. http://bioval.jrc.ec.europa.eu/products/gam/.

Neven, David, Michael Makokha Odera, Thomas Reardon, and Honglin Wang. 2009. Kenyan Supermarkets, Emerging Middle-Class Horticultural Farmers, and Employment Impacts on the Rural Poor. *World Development* 37 (11): 1802–1811. https://doi.org/10.1016/j.worlddev.2008.08.026.

Olson, David M., and Eric Dinerstein. 2002. The Global 200: Priority Ecoregions for Global Conservation. *Annals of the Missouri Botanical Garden* 89 (2): 199–224. https://doi.org/10.2307/3298564.

Popkin, Barry M. 1993. Nutritional Patterns and Transitions. *Population and Development Review* 19 (1): 138–157. https://doi.org/10.2307/2938388.

Reardon, Thomas, Christopher B. Barrett, Julio A. Berdegué, and Johan F.M. Swinnen. 2009. Agrifood Industry Transformation and Small Farmers in Developing Countries. *World Development* 37 (11): 1717–1727. https://doi.org/10.1016/j.worlddev.2008.08.023.

Rueda, Ximena, and Eric F. Lambin. 2014. Global Agriculture and Land Use Changes in the Twenty-First Century. In *The Evolving Sphere of Food Security*, ed. Rosamond L. Naylor. Oxford Scholarship Online.

Tan, Jieyang, Zhengguo Li, Peng Yang, Qiangyi Yu, Li Zhang, Wenbin Wu, Pengqin Tang, Zhenhuan Liu, and Liangzhi You. 2014. Spatial Evaluation of Crop Maps by Spatial Production Allocation Model in China. *Journal of Applied Remote Sensing* 8 (1): 085197.

Wood, Stephen A., Matthew R. Smith, Jessica Fanzo, Roseline Remans, and Ruth S. DeFries. 2018. Trade and the Equitability of Global Food Nutrient Distribution. *Nature Sustainability* 1 (1): 34–37. https://doi.org/10.1038/s41893-017-0008-6.

You, Liangzhi, Stanley Wood, Ulrike Wood-Sichra, and Wenbin Wu. 2014a. Generating Global Crop Distribution Maps: From Census to Grid. *Agricultural Systems* 127: 53–60. https://doi.org/10.1016/j.agsy.2014.01.002.

You, Liangzhi, Ulrike Wood-Sichra, Steffen Fritz, Zhe Guo, Linda See, and Jawoo Koo. 2014b. *Spatial Production Allocation Model (SPAM) 2005 v2.0*. http://mapspam.info/global-data/#sort/harvested_area/total.

6

Telecoupling and Consumption in Agri-Food Systems

Rachael Garrett and Ximena Rueda

1 Introduction

The recent wave of globalisation that started in the 1970s and accelerated from the 1990s onward brought large transformations for food and other land-based systems. The process of liberalisation helped separate or decouple food production from the places of consumption, contributed to the growth of multinational food companies, and coincided with several other socio-economic phenomena that reconfigured global food

These authors contributed equally and are listed alphabetically.

R. Garrett (✉)
Department of Earth and Environment, Boston University, Boston, MA, USA

Department of Environmental System Science and Humanities, Social, and Political Science, ETH Zurich, Zurich, Switzerland
e-mail: rgarr@bu.edu

X. Rueda
School of Management, Universidad de los Andes, Bogota, Colombia
e-mail: x.rueda@uniandes.edu.co

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_6

systems: population growth, income growth, and urbanisation. Population increased by 2.1 billion between 1990 and 2015, reaching over 7.6 billion people by 2016 (The World Bank 2016). At least 33 countries have moved from the low- to the middle-income category between 1994 and 2014 (Anderson 2015). For the first time in human history, more people live in cities than in rural areas.

All of these changes have contributed to greater liberalisation of trade, making commodity prices more volatile for most agricultural products. Often this has resulted in negative consequences for rural households who make up a majority of the global poor and who, in many cases, have been increasingly marginalised from participating in global trade. The world's remaining native ecosystems are under severe threat from agricultural expansion, while foreign investment in land has increased. Supermarkets bring to the table 'food from nowhere', acquired from regions that can supply it in large quantities and low prices. Agri-food businesses have seen a process of consolidation and global expansion as large multinational corporations buy small local brands. However, these human-environment systems, spaces of food production and consumption, are only distal in a geographic sense. Complex social and ecological processes tie them together in ways that have been described as telecoupling (Eakin et al. 2014). A more profound discussion of telecoupling is provided elsewhere in this book (see Chaps. 2 and 3). For the purpose of this chapter, we refer to telecoupling as the causal interactions that emerge among multiple systems, in the absence of governance arrangements that effectively account for the multiple social, environmental, or economic outcomes produced by the interactions (Eakin et al. 2014). Those interactions can be flows of capital, labour, information that link socio-ecological systems that are geographically separated, but also cultural and symbolic elements such as norms, values, and attitudes.

The purpose of this chapter is to analyse the drivers of food systems globalisation and the ways in which increasingly global and homogeneous consumption practices are creating new couplings between apparently separated places of consumption and production. We start by presenting recent data on food consumption trends to characterise the 'receiving system' of these telecouplings and then describe the changes in demographics, economies, information flows, and policies that gave rise to global changes in consumption. Next, we describe how consumption changes are telecoupled with land use, the ‘sending system’, and in some cases give rise to feedbacks from new sending systems—multinational companies, through the introduction of novel governance linkages. We highlight two main trends: the mass consumption of homogeneous goods that ‘come from nowhere’ and the emergence of niche markets for ‘exotic’ place-based products and ‘sustainable’ products. We argue that those two trends not only are *driven by* new physical and informational telecouplings but also *give rise* to additional physical and informational telecouplings. While the former reconfigurations generally lead to greater sustainability challenges (i.e. mono-crops, land grabs, deforestation, degradation, biodiversity erosion), the latter may lead to greater opportunities for engagement of value chain actors in determining the social and ecological processes of food production and marketing. We conclude with a reflection on the sustainability challenges posed by telecoupled agri-food systems for policymakers, the private sector, and civil society.

2 The Geography and Composition of Food Availability

For all major food groups, country-level food availability (food production plus imports, minus exports) has increased substantially in most countries since 2000 (Table 6.1), with the exception of cereals.[1] Fruits and vegetables show the greatest increases (27% and 23%). Animal sources of food have all increased—seafood (19%), meat (16%), and milk (15%). Within meat, consumption of pork and poultry has grown particularly rapidly, nearly quadrupling between 1990 and 2010. Notably, vegetable oils have also increased (11%), while starchy roots and sugars have remained almost constant.

China is responsible for a large share of these changes. Between 2000 and 2013, milk and fruits availability has shown remarkable increases (251% and 115%, respectively); vegetables, seafood, and meat availability also grew (54%, 42%, and 37%), while cereals and starchy roots decreased (−7% and −11%). The European Union (EU) shows a similar pattern. Nevertheless, seafood consumption is 59% larger in China than

Table 6.1 Food availability per region 2000–2013 (kg/person/year)

Group	Item	2000	2013	Growth rate
World	Cereals	149.02	147.06	−1.32%
	Starchy roots	62.09	63.06	1.56%
	Sugar and sweeteners	24.07	24.71	2.66%
	Vegetable oils	10.26	11.37	10.82%
	Fruits	61.13	77.87	27.38%
	Vegetables	113.72	140.48	23.53%
	Meat	37.34	43.22	15.75%
	Milk	78.24	90	15.03%
	Fish, Seafood	15.9	18.98	1.37%
China	Cereals	160.75	149.92	−0.067371695
	Starchy roots	75.54	67.58	−10.54%
	Sugar and sweeteners	6.24	7.38	18.27%
	Vegetable oils	6.54	7.44	13.76%
	Fruits	43.74	94.19	115.34%
	Vegetables	152	234	53.95%
	Meat	45.06	61.82	37.19%
	Milk	9.45	33.18	251.11%
	Fish, Seafood	24.4	34.67	42.09%
Europe	Cereals	130.43	132	1.20%
	Starchy roots	92.18	82.7	−10.28%
	Sugar and sweeteners	38.89	41.75	7.35%
	Vegetable oils	15.63	17.65	12.92%
	Fruits	79.55	94.93	19.33%
	Vegetables	114.19	115.1	0.80%
	Meat	69.73	77.34	10.91%
	Milk	206.62	215.11	4.11%
	Fish, Seafood	19.08	21.85	14.52%
North America	Cereals	115.28	106.99	−7.19%
	Starchy roots	67	57.85	−13.66%
	Sugar and sweeteners	67.32	62.22	−7.58%
	Vegetable oils	27.36	29.68	8.48%
	Fruits	125.43	107.63	−14.19%
	Vegetables	131.19	113.42	−13.55%
	Meat	119.69	112.72	−5.82%
	Milk	252.63	248.03	−1.82%
	Fish, Seafood	22.18	21.61	−2.57%
Africa	Cereals	146.94	151.22	2.91%
	Starchy roots	123.17	135.34	9.88%
	Sugar and sweeteners	15.19	16.77	10.40%
	Vegetable oils	8.19	8.64	5.49%
	Fruits	58.02	66.18	14.06%
	Vegetables	59.32	67.57	13.91%

(*continued*)

Table 6.1 (continued)

Group	Item	2000	2013	Growth rate
	Meat	15.65	19.01	21.47%
	Milk	37.04	43.82	18.30%
	Fish, Seafood	7.87	10.77	36.85%
Latin America	Cereals	146.94	151.22	2.91%
	Starchy roots	123.17	135.34	9.88%
	Sugar and sweeteners	15.19	16.77	10.40%
	Vegetable oils	8.19	8.64	5.49%
	Fruits	58.02	66.18	14.06%
	Vegetables	59.32	67.57	13.91%
	Meat	15.65	19.01	21.47%
	Milk	37.04	43.82	18.30%
	Fish, Seafood	7.87	10.77	36.85%
South Asia	Cereals	163.82	154.47	−5.71%
	Starchy roots	24.13	32.22	33.53%
	Sugar and sweeteners	21.91	22.25	1.55%
	Vegetable oils	8.03	8.83	9.96%
	Fruits	38.4	53.45	39.19%
	Vegetables	59.29	82.86	39.75%
	Meat	5.89	6.67	13.24%
	Milk	65.64	85.99	31.00%
	Fish, Seafood	5.14	6.36	23.74%

Source: FAO (2017)

in the EU, but Europeans eat six times more sugar and milk than the average Chinese, twice more vegetable oils, and 25% more meat. North Americans, in contrast, have seen a decrease in the national availability of all major food groups since 2000. Still, they consume, on average, 65% more vegetable oils, 49% more sugar, and 46% more meat than Europeans do.

In the rest of the developing world, national food availability has also increased, although absolute figures are still smaller than for the developed countries and some important differences remain. For Africa, country-level availability of all food groups has increased, notably for fish and seafood (37%), meat (21%), and milk (18%). Nevertheless, a person in Africa consumes only 20% the amount of milk and 25% the amount of meat that a European does. Their diet is still heavily dependent on cereals and starchy roots. For Latin America, food availability for all major groups also increased, particularly animal protein, but also fruits and vegetables. Southern Asia has reduced its consumption of cereals (especially rice), while fruits, vegetables, starchy roots, and milk have increased more than 30%.

In general terms, diets today are richer in animal protein, fats, and sugars, but also a wider variety of nonlocal fruits and vegetables. Consumption of stimulants, such as tea, coffee, and chocolate, has also increased substantially, particularly in emerging economies. These shifts in consumption in emerging economies were driven by interactions between demographic changes, economic growth, information systems, and policies, described in greater detail next.

3 Drivers of Changes in Global Consumption Patterns

3.1 Shifts in Demographics

Between 1990 and 2017, the world population increased by 40%, with an average annual increase of 1.3% (FAO 2017). The region with the fastest population growth was Africa (2.6% per year, leading to a doubling of the population), but all regions besides Europe grew by 38% or more during the same period. Asia accounted for more than half of the 2.2 billion global increase, while Africa accounted for over a quarter of the growth. Leaving aside concurrent changes in income, urbanisation, and so on, this growth in population contributed to a substantial increase in global demand for food, necessitating some agricultural area expansion in regions where large-scale increases in yields were not possible.

Aggregate population growth has corresponded to greater growth of populations in urban areas, either through reproduction or through in-migration. Over the twentieth century, the proportion of people living in urban areas increased from 10% to 50%. By 2050, the proportion is likely to increase to 70% (United Nations 2014). Urbanisation tends to lead to a transition towards more western diets, characterised by foods with a higher salt, fat, and sugar content (Smil 2000). Access to foreign, processed foods (e.g. hamburgers, pizza) is facilitated by an increase in large multinational supermarkets and fast food chains (Kearney 2010).

3.2 Shifts in Economies

In developing countries, and in particular emerging economies, increasing income is leading to higher animal-based caloric and protein intake, and higher rates of obesity. For example, Tilman et al. (2011) estimate that a 250–400% increase in income in the middle-income counties will lead to a 60–100% increase in calories and 80–120% increase in animal products. However, after some level of affluence, dietary preferences may shift once again, towards healthier and less processed foods and fewer meat products (Marmot 2001). Income growth is also linked to greater fruit and vegetable consumption. A key uncertainty for the future of global food systems worldwide is how much incomes will grow in Africa over the coming decades, and whether income growth and urbanisation there will result in the same dramatic changes in consumption witnessed in Asia since the 1990s.

Economic growth in middle-income economies has coincided with large reductions in global trade barriers and the rise of a complex yet concentrated multinational trade logistics sector (e.g. major food traders, such as Cargill and Louis Dreyfus). Consequently, consumers in developing regions are increasingly able to source products from formerly remote regions, thousands of miles away, through only a handful of large companies. Generally, reduced barriers to trade have contributed to improving the availability of animal products and processed foods.

However, trade barriers have not been reduced equally across the global food system. Typically, more industrialised countries in the Global North have been able to preserve protections for domestic producers of grains, while countries in the Global South have been forced to eliminate protections (McMichael 2009). Ultimately this has enabled the North to maintain staple grain and livestock production domestically, while countries in the South have begun importing staple products. However, export linkages to more developed regions may decline in proportion over time as emerging economies, such as Russia, China, and India, assume greater importance in the global food system.

Urbanisation and trade liberalisation have enabled the growth and consolidation of multinational food sourcing and retailing corporations. Supermarkets, in particular, have transformed the way food is purchased by a majority of consumers in the Global South, particularly within urban regions (Reardon and Timmer 2012). Where once a majority of consumers purchased a limited number of brands and products from small local purveyors, they now have access to a much larger selection of global brands and products in large stores run by major international brands like Carrefour and Tesco. This trend is also driven in part by the increasing participation of women in the workforce. As women spend more time outside of the household, they have less time to purchase and prepare food. Nowhere has this phenomenon been more apparent than in Latin America, where the supermarket revolution occurred rapidly in the late 1990s and 2000s. However, East and South-East Asia and Eastern and Central Europe are now experiencing the same transformation.

3.3 Shifts in Information Systems

As a result of globalisation, food is increasingly produced at great distances from where it is consumed. This condition leads to a loss of information to consumers regarding the origin and production practices associated with the goods they are consuming, particularly when such goods are highly processed and undifferentiated. As supply chains lengthen, a majority of the global food trade consolidates under the control of just a handful of private multinational companies, whose competitive advantage is their ability to navigate the complex array of information on regional production and consumption to link agents across distant landscapes.

The obscurity of information about global food processes has given rise to increasing efforts to promote transparency about the impacts associated with food trade and sourcing practices (Gardner et al. 2018), and to 'name and shame' individual companies who are contributing to social and ecological harm within the food system (e.g. Greenpeace 2006). The rise of consumer and company awareness about the environmental and social harms associated with distal production systems is now leading to novel governance telecouplings (Eakin et al. 2017). Yet, for the most part, the consequences of distant production remain unknown to consumers, leading to time lags between changes in social and ecological outcomes in production regions and the rise of organised efforts to govern those production processes.

To consolidate their control over the food system, TV advertising by the powerful multinational brands owned by these big companies has driven increases in the types of foods that contribute most to their profit margins—highly processed, low nutrition products (Kearney 2010). Beyond marketing, supermarkets have influenced consumers' expectations about product quality by requiring suppliers to deliver products of a uniform and unblemished appearance. While the growth of supermarkets can provide producers with new outlets and offer privileged consumers greater access to fresh, safe, and niche foods, they can also contribute to greater food waste (discarding products that don't reach supermarket standards) and the marginalisation of smaller farmers, who often have greater difficulty in meeting quality standards and coordinating contracts (Konefal et al. 2005).

3.4 Shifts in Energy Policies

Biofuels policies are particularly relevant in altering consumption and production pathways in other sectors and regions in a globalised economy. Biofuels mandates and subsidies in the western world have increased the demand for agricultural products in countries such as Brazil and the United States. The Brazilian government has invested heavily in sugarcane ethanol and, to a lesser extent, biodiesel production since the 1970s, driving an uptick in domestic production of sugarcane at the expense of pasture lands (Lapola et al. 2013). The United States has mainly promoted ethanol through a long-standing (30-year) ethanol tax credit that expired in 2012, but also a Renewable Fuel Standard that required the use of 9 billion gallons of biofuels in 2008 and 36 billion gallons by 2022. Historically, most of this ethanol came from corn. However, considering the low efficiency of corn production and indirect land-use impacts of devoting a large share of the land area towards energy production, the United States recently amended its biofuels policies. The target set by the EU biofuels directive was 5.75% of fuels by 2010 and 10% by 2020 (Zhang et al. 2003). Because much of the soybean and oil palm consumed in Europe is produced outside of the region, these changes in energy policy have contributed to a broader global epidemic of forest conversion for agricultural expansion (Carlson and Garrett 2018).

4 Outcomes

The changes in consumption described above contributed to a new global wave of commodity cropland expansion in the sending systems, including oilseeds, fruits, and stimulants, as well as a new wave of global food governance telecouplings or feedbacks, to help mitigate both environmental and physical food quality concerns. In this sense, multinational actors have become a new sending system for information and rules about production processes (Fig. 6.1). These consumption drivers have had

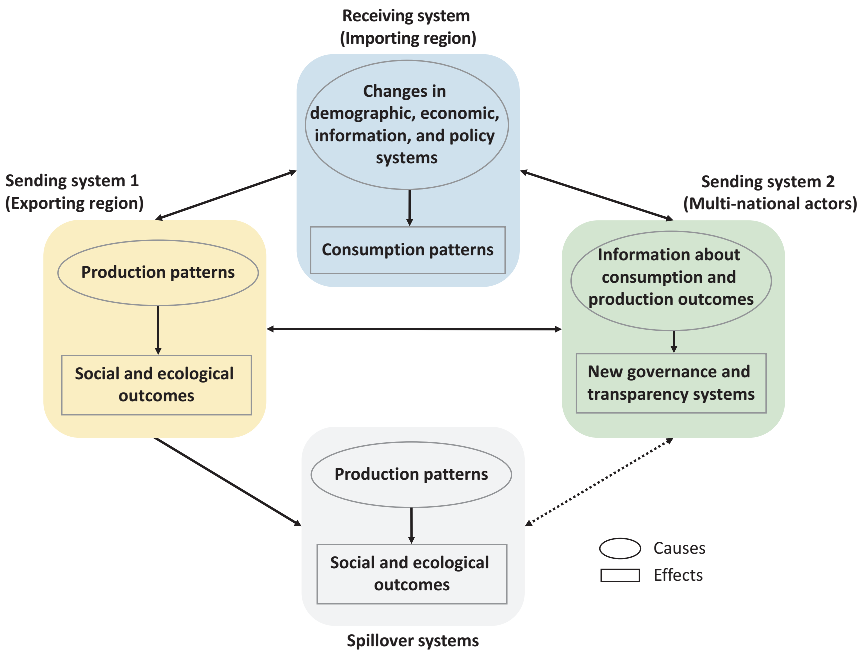


Fig. 6.1 Conceptual model of telecouplings between consumption, land use, and governance

different land-use outcomes, depending on existing trade couplings, arable land availability, intensification responses, and domestic land and environmental institutions, as well as other factors.

4.1 Land-Use and Land-Cover Change

Since 2000, the production of nonstaple foods has outpaced that of staple crops. Palm oil, soybeans, maize, and sugar production has skyrocketed in recent years, while rice and wheat have remained stagnant. These crops are very versatile: they can be used for food, fodder, industrial products, and biofuels. Their yields are high and technological improvements—such as better seeds and crop rotation—have allowed production to increase faster than land expansion. Nevertheless, most of these crops have had deleterious impacts on ecosystems, mainly via deforestation and land conversion of tropical and subtropical ecosystems (Rueda and Lambin 2014; Carlson and Garrett 2018).

Food production is today highly concentrated in land-rich countries with good supply-chain infrastructure and large domestic markets. The United States, China, India, Indonesia, Brazil, Argentina produce the majority of soybeans, sugar, maize, rice, and tea, as well as almost 50% of palm oil and coffee, and significant amounts of beef and cocoa. Those six countries together are also the largest producers of apples (with China representing close to half of the market) and oranges (dominated by the United States and Brazil) (FAO 2017). Even the global production of key vegetables such as onions, tomatoes, and garlic is dominated by some of those six countries (FAO 2017).

In decomposing the total effect of different consumption drivers on land use, Alexander et al. (2015) estimate that population growth is responsible for the largest share of increasing demand for agricultural land (60.3 million hectares [Mha] per year since 1960), while changes in diet (due to income growth, urbanisation, etc.) are responsible for the second largest share of expansion (39.8 Mha per year). An increase in the amount of land used to produce animals or animal feeds has contributed to over 65% of the land change since 1960, while increases in biofuels demand were responsible for just 3.2 Mha per year of the agricultural land expansion since 1994. Approximately 95% of these increases in agricultural land-demand were offset by increased yields, resulting in a net expansion of land use for animal products of 1.6 Mha/year. China accounted for 43% of the dietary-driven increase in agricultural land globally.

Thus, socio-ecological systems that are geographically distant start to influence each other: European regulators, looking to reduce dependence on fossil fuels, have increased their biofuels requirements, with dramatic deforestation impacts in places as distant as Borneo or Amazonia, where palm and soy-based biofuels are being produced. A trade signal coming from a 'sending system' (i.e. European demand for biofuels) produces environmental impacts in the 'receiving systems' (i.e. socio-ecological tropical systems of the South) that are not properly governed by either system.

The case of the Brazil-China soy supply chain provides a clear example of how these multiple physical and governance telecouplings occur (Fig. 6.2). Soy expansion in Brazil to meet increasing demand for livestock feed in China and other countries resulted in a rise in deforestation

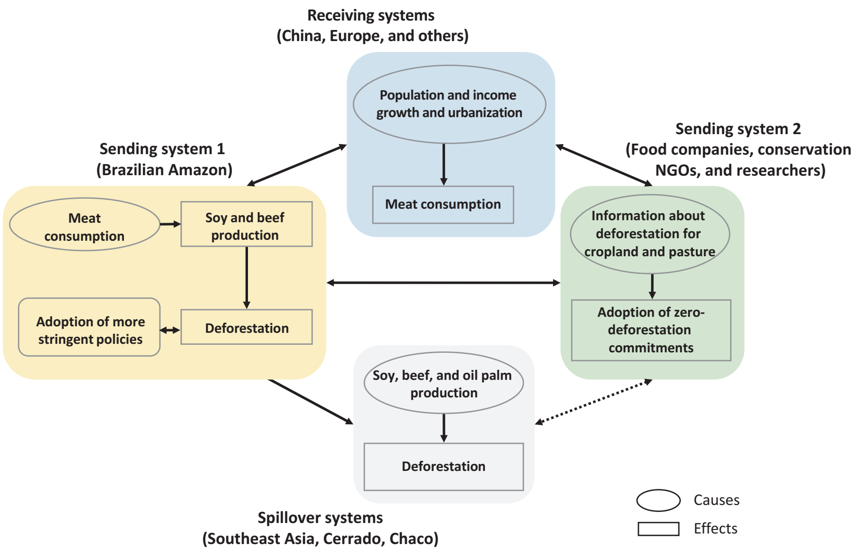


Fig. 6.2 Consumption changes in China drive land-use and land-cover change and governance responses in South America, leading to spillovers within South America and other regions

in the Amazon tropical forest. Increasing information about deforestation in the region attracted the attention of consumers and civil society and European countries that also source soy from Brazil. This led to an uptick in the adoption of commitments by European food companies to eliminate deforestation from their supply chains. Domestic land-use processes in Brazil are now influenced by domestic changes in demand for meat, changes in consumption in the receiving systems, as well as changes in conservation policy from the national government and multinational agri-food companies. Thus, land-use decisions in many agricultural frontiers that used to respond mainly to local opportunities and constraints are increasingly linked to corporate actors that mobilise technology, credit, contractual agreements, and infrastructure to produce the required commodities that satisfy the demands of consumers in emerging and mature markets.

Increasing food consumption has contributed to renewed interest by many consuming countries and multinational companies in acquiring land in the South for future production (Borras et al. 2011). Despite decades of food surplus and cheap food production, this effort at enclosing Southern land is justified by governments under the rationale of maintaining food and energy 'security' (McMichael 2012), though for companies it is undoubtedly influenced by hedging and speculative interests (Fairbairn 2014). Over the last decade, it is estimated that between 20 and 45 Mha of land have been purchased by foreign entities (Von Braun and Meinzen-Dick 2009; Deininger et al. 2011).

Investments in land have not been greatly dampened by domestic governments' attempts to prohibit foreign land ownership (Fairbairn 2015) and have been accompanied by investments in related supply chain infrastructure by multinational companies. In the case of oilseeds (soybean and oil palm), these investments have led to rapid expansion of supply in places once completely isolated from markets (Garrett et al. 2013). The social and ecological impacts of rapid oilseed expansion in sensitive environments—deforestation, biodiversity loss, increasing income inequality—have been well documented (Byerlee et al. 2016; Carlson and Garrett 2018), leading to adoption of new soybean and oil palm supply-chain governance initiatives focused on aimed at mitigating brand risks and maintaining legitimacy (Rueda et al. 2017).

Foreign land transactions, lengthening value chains, and accompanying quality standards have called into question the role of and outcomes for smallholders in the global food system. Some have argued that these processes are either actively dispossessing smallholders or rendering them unviable via processes of competition. Others suggest that smallholders can benefit from these processes when domestic labour (not just land) is needed for emerging commodity crop production and when domestic land tenure and agricultural policies support smallholders' ability to engage in new supply chains (Hall et al. 2015).

4.2 Novel Governance Telecouplings

The new food regime has created a delocalisation of food consumption from the places of production (Zhou 2016). Thus, thanks to corporate control of global food chains, consumers around the world have a more diverse, processed, and inexpensive food available today than two decades ago. This delocalisation and telecoupling of consumption and production systems has produced new forms of governance for both systems, mainly through two instruments: (1) global coordination in supply chains that include quality/safety assurance required to make those global flows possible and (2) development of explicit standards and codes of conduct for production and trade to reduce environmental impacts.

As described in Chap. 2, telecoupling can be understood as the linkages established between two (geographically or socially) distal socio-ecological systems. When systems become linked through trade, consumption patterns, or other mechanisms, there could be governance responses that try to match the new domain of the telecoupled systems. Otherwise, systems remain governed independently with negative consequences for the sustainability of at least one if not both systems, since externalities of one system over the other are not internalised in the cost of doing business (e.g. see the maize-energy coupling case discussed by Eakin et al. 2017). Typically, these systems will not remain governed independently forever. Rather, there is a greater time lag in establishing the governance systems between consumers and producers, potentially due to a need to prioritise some regions above others or a lack of information about outcomes in the nongoverned region. In the remaining of this section, we will explore the first scenario: instances in which consumption changes drive the establishment of governance mechanisms to manage telecoupled systems and its consequences for sustainability.

4.2.1 Coordination and Standard Setting

Since 2000, there have been an increasing number of food safety scares (e.g. BSE, *E. coli*, dioxin pollution, and avian influenza) that have helped increase consumer awareness of the issue (Bosona and Gebresenbet 2013). The presence of genetically modified organisms in supply chains can be lumped in with these concerns, given consumers' perceptions of potential health risks from these products. Food safety issues have contributed to an increasing demand for transparency about where products are coming from and how they were produced, but also how they are handled along the way. This, in turn, requires traceability mechanisms and new transparency databases and platforms that are able to handle large volumes of complex data (Gardner et al. 2018). For animal products, these concerns can be addressed through individual animal identification and tracking, including the use of ear tags and DNA samples. While adoption of these types of systems is currently very limited due to their costs, broader adoption could have important feedbacks on the effectiveness of conservation policies and land use by improving helping to prevent laundering of animals between properties. However, to date, there has been very little research on the impacts of food safety information systems and innovations on land-use processes.

4.2.2 Responsible Consumption

The second pathway through which consumption has fostered new governance mechanisms for tele-coupled systems has been through a push for responsible, ethical consumption. Increased awareness of the environmental impacts associated with agricultural production and new governance linkages have given rise to the growth of both consumer demand for more sustainable products as well as a proliferation of voluntary environmental policies and standards among food companies (Rueda et al. 2017). The adoption of voluntary sustainability mechanisms can help firms avoid mitigation risks and ensure consistent quality and a reliable supply.

Supply chain standards by individual companies are the most common sustainability mechanism (occurring in 90% of the top 250 businesses) (Thorlakson et al. 2018). Because of the impacts of increasing consumption on deforestation in particular, there has been a particularly rapid growth in voluntary sustainability mechanisms related to land-cover change. Third-party certifications, for environmental or social causes (or both), such as the Rainforest Alliance and Fairtrade, have become a common instrument used by corporations that trade or manufacture products grown in tropical regions. Adoption of these instruments has grown exponentially for some commodities, representing more than 40% of global coffee production, about 20% of cacao and oil palm, and smaller but growing portions of global soy, bananas, cotton, and sugar production (Potts et al. 2014). In terms of market uptake, however, only a fraction of what is certified annually is sold as such, showing that even though certified products have a very dynamic market, they represent a small portion of the mainstream purchases of consumers around the world, especially in emerging economies.

The case of the Latin America-Europe coffee supply chain provides a clear example of how new information about systems that are physically telecoupled can give rise to new governance telecouplings (Fig. 6.3). The end of the International Coffee Agreement as the main governance mechanism for coffee production and consumption around the world led to plummeting coffee prices and created a deep crisis in producing countries. Aid agencies and charities in industrialised nations channelled their concerns over unequal development and exchange terms by promoting ethical trade in coffee. Nongovernmental organisations (NGOs) formalised this intention via compliance with sustainable practices. Larger companies followed suit, adopting sustainability standards in their supply chains, generating a spillover effect across tropical regions for coffee and other commodities. Thus information about livelihoods and environmental degradation was incorporated into new standards for coffee production that shaped land use in the original sending system, with spillover effect throughout all coffee producing regions and even other commodities.

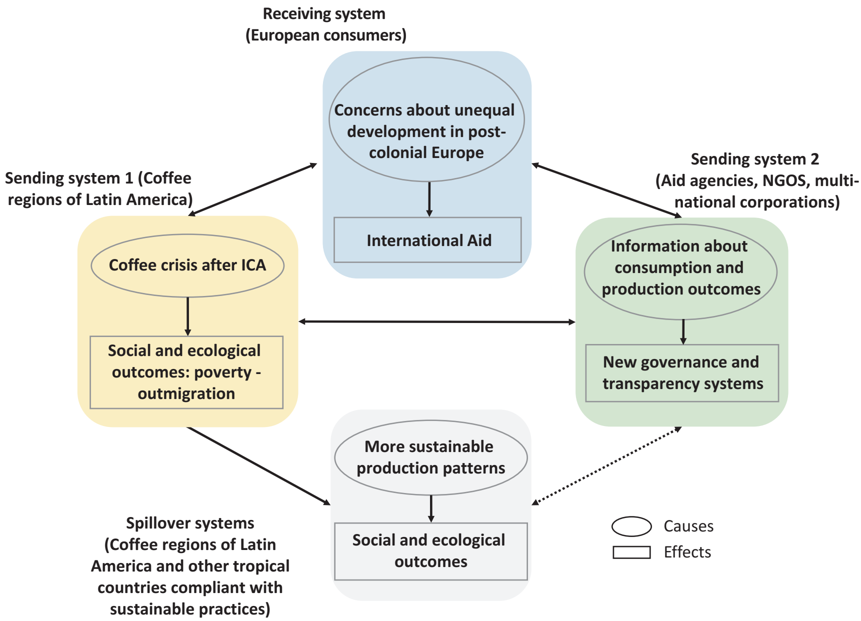


Fig. 6.3 Poverty concerns resulting from the collapse of international coffee agreement drive governance responses that influenced land use in Latin America and other coffee producing regions

4.2.3 Impacts of New Governance Initiatives

The emergence of ecoconsumerism and quality assurance requirements have led to a bifurcation of consumer markets and supply chains into (1) 'food from nowhere', comprised of highly processed, undifferentiated, standard edible commodities of unknown origin, and (2) 'food from somewhere', focused on place-based production of quality-audited food chains purporting to adhere to agro-ecological and sustainability standards (McMichael 2009). In the United States, this bifurcation is epitomised by distinct sets of retailers serving different consumer groups (e.g. Walmart, which specialises in the undifferentiated, low-cost products, and Whole Foods, which specialises in the higher priced, 'quality' products).

The impacts of these new forms of governance on land use and livelihoods are not thoroughly understood and have been deeply criticised by some as further facilitating agricultural expansion and other forms of extractivism by 'greening' it (Baletti 2014). Standards for quality and health issues have, in many cases, forced smallholders out of global value chains (Li 2009). In others, farmers have been able to upgrade and participate in higher-value chains with important welfare benefits (Rueda et al. 2018). A broader reaction against the globalisation of food systems has been the re-embeddedness of agri-food systems in local contexts that emphasise noncapitalist forms of production and exchange. These new circuits advocate for scaling deep, intensifying relationships between consumers, producers, and the land, rather than growing (i.e. scaling out) or increasing value capture (i.e. scaling up) (Moore et al. 2015). Consumption becomes a political act against the homogenising properties of corporate food dominance. The slow food movement and other local consumption initiatives are examples of such responses.

4.3 Recent Changes in Historical Context

The telecouplings we have described here between changes in consumption in the North and their impacts on land-use systems in the South are not entirely new. They mirror the historical dependencies embodied by the colonial food regime which outsourced the production of luxury goods to tropical colonies, leading to the conversion of land and subjugation of people for sugar, tea, coffee, banana, palm oil, and peanut production and export (McMichael 2009).

The new turn in these telecouplings is the level of control levied by corporate actors, leading to the bifurcation of these global markets into the high value, high quality products accompanied by standards and *terroir* branding and low cost, undifferentiated products. Yet, the current structuring continues to support accumulation and overconsumption by an increasingly wealthy minority, rather than the food security and well-being of the majority. Global imports of agricultural products from Southern countries still represent about 80% of their consumption of agricultural products, with the Southern ecosystem as the sacrifice zones. Despite liberalised trade, agriculture in Northern countries, especially in Europe and the United States, still enjoys a level of protection that has been stripped from Southern producers, while dumping of surplus grains on the world market drives small farmers out of business.

5 Conclusion

The lens of telecoupling is useful for exploring how changes in socio-ecological systems in one region drive land-use and land-cover processes in distant regions. Here, we described how changes in consumption and associated governance responses are influencing demand for land and production practices in telecoupled systems.

Despite the fact that increasing consumption is clearly the most dominant driver of land-use change globally, the governance responses to growing consumption have focused almost entirely on production and sourcing processes. There has been comparatively less focus by major international NGOs and international food companies on consumption itself (or a failure to consume, i.e. waste, what is produced). Educational campaigns about the harmful land-use effects of consuming and wasting animal products, or processed oils and biofuels, armed with better transparency about the origins of these products and their impacts, are drastically needed to nudge global food systems to a more sustainable trajectory. If consumers take the lead in curbing their own harmful behaviours, it could reinforce the signal being sent to governments and food companies that all actors in the global food system must be engaged in the process of reducing its harmful impacts on people and the planet.

Governments also have an important role to play. Agri-food companies serving markets in the North have been obliged to disclose the nutritional qualities of the products they sell, and many of them are developing better-quality foods. Those products, unfortunately, are still not available in the South, whose consumers are still bombarded with processed food high in salt, sugar, and saturated fats. Exercising higher transparency and the right-to-know, together with economic instruments, should push transnational corporations to strive for improvements in their global supply of nutritious food with high standards of quality and land use.

Note

1. To assess changes in food availability, we examine Food Balance Sheets (FBS) collected by the UN Food and Agriculture Organisation (FAO 2017). FBS data rely on official information on food production, exports,

and imports to produce a figure for country-level food availability. These data do not take into account re-exports of food (imported and processed in one country and then exported to others) nor changes in inventories.

References

Alexander, Peter, Mark D.A. Rounsevell, Claudia Dislich, Jennifer R. Dodson, Kerstin Engström, and Dominic Moran. 2015. Drivers for Global Agricultural Land Use Change: The Nexus of Diet, Population, Yield and Bioenergy. *Global Environmental Change* 35 (Suppl. C): 138–147. https://doi.org/10.1016/j.gloenvcha.2015.08.011.

Anderson, Marc. 2015. World Bank Data Shows Number of 'Low-Income' Countries Halves in 20 Years. *The Guardian*, July 10. http://www.theguardian.com/global-development/datablog/2015/jul/10/world-bank-data-number-low-income-countries-halved-since-1994.

Baletti, Brenda. 2014. Saving the Amazon? Sustainable Soy and the New Extractivism. *Environment and Planning A* 46 (1): 5–25. https://doi.org/10.1068/a45241.

Borras, Saturnino M., Jr., Ruth Hall, Ian Scoones, Ben White, and Wendy Wolford. 2011. Towards a Better Understanding of Global Land Grabbing: An Editorial Introduction. *The Journal of Peasant Studies* 38 (2): 209–216. https://doi.org/10.1080/03066150.2011.559005.

Bosona, Techane, and Girma Gebresenbet. 2013. Food Traceability as an Integral Part of Logistics Management in Food and Agricultural Supply Chain. *Food Control* 33 (1): 32–48. https://doi.org/10.1016/j.foodcont.2013.02.004.

Byerlee, Derek, Walter P. Falcon, and Rosamond L. Naylor. 2016. *The Tropical Oil Crop Revolution: Food, Feed, Fuel, and Forests*. Oxford: Oxford University Press.

Carlson, Kimberly M., and Rachael D. Garrett. 2018. Environmental Impacts of Tropical Soybean and Palm Oil Crops. In *Oxford Encyclopedia of Agriculture and the Environment*, ed. Hank Shugart. Oxford: Oxford Research Encyclopedia of Environmental Science.

Deininger, Klaus, Derek Byerlee, Jonathan Lindsay, Andrew Norton, Harris Selod, and Mercedes Stickler. 2011. *Rising Global Interest in Farmland: Can It Yield Sustainable and Equitable Benefits?* Washington, DC: The World Bank.

Eakin, Hallie, Ruth DeFries, Suzie Kerr, Eric F. Lambin, Jianguo Liu, Peter J. Marcotullio, Peter Messerli, Anette Reenberg, Ximena Rueda, Simon R. Swaffield, Birka Wicke, and Karl Zimmerer. 2014. Significance of Telecoupling for Exploration of Land-Use Change. In *Rethinking Global Land Use in an Urban Era*, ed. Karen C. Seto and Anette Reenberg, 141–161. Cambridge, MA: MIT Press.

Eakin, Hallie, Ximena Rueda, and Ashwina Mahanti. 2017. Transforming Governance in Telecoupled Food Systems. *Ecology and Society* 22 (4): 32. https://doi.org/10.5751/ES-09831-220432.

Fairbairn, Madeleine. 2014. Like Gold with Yield: Evolving Intersections between Farmland and Finance. *Journal of Peasant Studies* 41 (5): 777–795. https://doi.org/10.1080/03066150.2013.873977.

———. 2015. Foreignization, Financialization and Land Grab Regulation. *Journal of Agrarian Change* 15 (4): 581–591. https://doi.org/10.1111/joac.12112.

FAO. 2017. *FAOSTAT Data*. Food and Agriculture Organization of the United Nations. Accessed November 9, 2018. http://faostat3.fao.org/.

Gardner, Toby, Magnus Benzie, Jan Börner, Elena Dawkins, Stephen Fick, Rachael Garrett, Javier Godar, A. Grimard, S. Lake, Rasmus K. Larsen, N. Mardas, C. McDermott, Patrick Meyfroidt, Maria Osbeck, M. Persson, T. Sembres, Clément Suavet, B. Strassburg, A. Trevisan, Chris West, and P. Wolvekamp. 2018. Transparency and Sustainability in Global Commodity Supply Chains. *World Development*. https://doi.org/10.1016/j.worlddev.2018.05.025.

Garrett, Rachael D., Eric F. Lambin, and Rosamond L. Naylor. 2013. The New Economic Geography of Land Use Change: Supply Chain Configurations and Land Use in the Brazilian Amazon. *Land Use Policy* 34: 265–275. https://www.bu.edu/gdp/files/2018/02/dx.doi.org/10.1016/j.landusepol.2013.03.011.

Greenpeace. 2006. *Eating Up the Amazon*. Amsterdam: Greenpeace International.

Hall, Ruth, Marc Edelman, Saturnino M. Borras Jr., Ian Scoones, Ben White, and Wendy Wolford. 2015. Resistance, Acquiescence or Incorporation? An Introduction to Land Grabbing and Political Reactions 'From Below'. *Journal of Peasant Studies* 42 (3–4): 467–488. https://doi.org/10.1080/03066150.2015.1036746.

Kearney, John. 2010. Food Consumption Trends and Drivers. *Philosophical Transactions of the Royal Society B: Biological Sciences* 365 (1554): 2793–2807. https://doi.org/10.1098/rstb.2010.0149.

Konefal, Jason, Michael Mascarenhas, and Maki Hatanaka. 2005. Governance in the Global Agro-Food System: Backlighting the Role of Transnational Supermarket Chains. *Agriculture and Human Values* 22 (3): 291–302. https://doi.org/10.1007/s10460-005-6046-0.

Lapola, David M., Luiz A. Martinelli, Carlos A. Peres, Jean P.H.B. Ometto, Manuel E. Ferreira, Carlos A. Nobre, Ana P.D. Aguiar, Mercedes M.C. Bustamante, Manoel F. Cardoso, Marcos H. Costa, Carlos A. Joly, Christiane C. Leite, Paulo Moutinho, Gilvan Sampaio, Bernardo N. Strassburg, and Ima C.G. Vieira. 2013. Pervasive Transition of the Brazilian Land-Use System. *Nature Climate Change* 4 (1): 27–35. https://doi.org/10.1038/nclimate2056.

Li, Tania M. 2009. Exit from Agriculture: A Step Forward or a Step Backward for the Rural Poor? *The Journal of Peasant Studies* 36 (3): 629–636. https://doi.org/10.1080/03066150903142998.

Marmot, Michael. 2001. Income Inequality, Social Environment, and Inequalities in Health. *Journal of Policy Analysis and Management* 20 (1): 156–159. https://doi.org/10.1002/1520-6688(200124)20:1%3C156::AID-PAM2009%3E3.0.CO;2-9.

McMichael, Philip. 2009. A Food Regime Genealogy. *The Journal of Peasant Studies* 36 (1): 139–169. https://doi.org/10.1080/03066150902820354.

———. 2012. The Land Grab and Corporate Food Regime Restructuring. *The Journal of Peasant Studies* 39 (3–4): 681–701. https://doi.org/10.1080/03066150.2012.661369.

Moore, Michele-Lee, Darcy Riddell, and Dana Vocisano. 2015. Scaling Out, Scaling Up, Scaling Deep: Strategies of Non-profits in Advancing Systemic Social Innovation. *The Journal of Corporate Citizenship* 58: 67–84. https://doi.org/10.9774/gleaf.4700.2015.ju.00009.

Potts, Jason, Matthew Lynch, Ann Wilkings, Gabriel Huppé, Maxine Cunningham, and Vivek Voora. 2014. *The State of Sustainability Initiatives Review: Standards and the Green Economy*. International Institute for Sustainable Development (IISD) and the International Institute for Environment and Development (IIED).

Reardon, Thomas, and C. Peter Timmer. 2012. The Economics of the Food System Revolution. *Annual Review of Resource Economics* 4 (1): 225–264. https://doi.org/10.1146/annurev.resource.050708.144147.

Rueda, Ximena, Rachael D. Garrett, and Eric F. Lambin. 2017. Corporate Investments in Supply Chain Sustainability: Selecting Instruments in the Agri-Food Industry. *Journal of Cleaner Production* 142: 2480–2492. https://doi.org/10.1016/j.jclepro.2016.11.026.

Rueda, Ximena, and Eric F. Lambin. 2014. Global Agriculture and Land Use Changes in the Twenty-First Century. In *The Evolving Sphere of Food Security*, ed. Rosamond L. Naylor. Oxford Scholarship Online.

Rueda, Ximena, Andrea Paz, Theodora Gibbs-Plessl, Ronald Leon, Byron Moyano, and Eric F. Lambin. 2018. Smallholders at a Crossroad: Intensify or Fall behind? Exploring Alternative Livelihood Strategies in a Globalized World. *Business Strategy and the Environment* 27 (2): 215–229. https://doi.org/10.1002/bse.2011.

Smil, Vaclav. 2000. *Feeding the World: A Challenge for the Twenty-First Century*. Cambridge, MA: The MIT Press.

The World Bank. 2016. *World Population*. Washington, DC: World Bank. Accessed November 10, 2018. https://data.worldbank.org/indicator/SP.POP.TOTL.

Thorlakson, Tannis, Jens Hainmueller, and Eric F. Lambin. 2018. Improving Environmental Practices in Agricultural Supply Chains: The Role of Company-Led Standards. *Global Environmental Change* 48: 32–42. https://doi.org/10.1016/j.gloenvcha.2017.10.006.

Tilman, David, Christian Balzer, Jason Hill, and Belinda L. Befort. 2011. Global Food Demand and the Sustainable Intensification of Agriculture. *Proceedings of the National Academy of Sciences* 108 (50): 20260–20264. https://doi.org/10.1073/pnas.1116437108.

United Nations. 2014. *World Urbanization Prospects: The 2014 Revision, Highlights*. United Nations, Department of Economic and Social Affairs, Population Division. New York: United Nations.

Von Braun, Joachim, and Ruth S. Meinzen-Dick. 2009. *"Land Grabbing" by Foreign Investors in Developing Countries: Risks and Opportunities*. IFPRI Policy Brief. Washington, DC: International Food Policy Research Institute.

Zhang, Y., Marc A. Dubé, David D. McLean, and Morris Kates. 2003. Biodiesel Production from Waste Cooking Oil: 2. Economic Assessment and Sensitivity Analysis. *Bioresource Technology* 90 (3): 229–240. https://doi.org/10.1016/S0960-8524(03)00150-0.

Zhou, Y. 2016. Localization/Delocalization. In *International Encyclopedia of Geography: People, the Earth, Environment and Technology*. Hoboken, NJ: John Wiley & Sons.

7

Toolbox: Flow Analysis—Social Metabolism in the Analysis of Telecoupling

Anke Schaffartzik and Thomas Kastner

1 Uncovering Underlying Causes of Land-Use Change

Soap and lotion, bread and margarine, and biodiesel: For many of us, not a day goes by that we do not consume palm oil in some form or other. Palm oil is made from the fruit of palm trees grown on plantations in Southeast Asia, Latin America, and sub-Saharan Africa. These plantations exist at the expense of tropical rainforest, subsistence forestry and

A. Schaffartzik (✉)
Institute of Environmental Science and Technology,
Universitat Autònoma de Barcelona (ICTA-UAB), Barcelona, Spain

Institute of Social Ecology (SEC),
University of Natural Resources and Life Sciences Vienna, Wien, Austria
e-mail: anke.schaffartzik@boku.ac.at

T. Kastner
Senckenberg Biodiversity and Climate Research Centre (BiK-F),
Frankfurt am Main, Germany
e-mail: thomas.kastner@senckenberg.de

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_7

agriculture, and habitats of endangered species. Across hundreds or even thousands of kilometres, our consumption is linked to land-use change elsewhere. Material flows—palm oil exports from Indonesia to the Netherlands, for example—are an important indication of this connection between land systems. Power relations, political ties, and economic investments are simultaneously maintained by and shape material flows across levels of scale, making material flows an integral part of the systems' telecoupling (Chap. 2).

Wherever land-use change occurs—where oil palm plantations expand, for example—empirical trails can lead us to the underlying causes of that change. Studying a system's metabolism and accounting for the material flows it requires for its reproduction leads onto one such trail. The metabolism of a socio-economic system—from community to country—encompasses the material and energy inputs, transformation, stock integration, and outputs required not only for the biophysical but also for the socio-cultural reproduction of that system (Fischer-Kowalski and Erb 2016). Material flow accounting is one tool for the empirical study of social metabolism (Krausmann et al. 2017). Which material flows are considered as inputs or outputs depends on the definition of system boundaries, in particular, the boundary between a socio-economic system and its natural environment and the boundary between two socio-economic systems (Fig. 7.1). In the study of social metabolism, humans, their livestock, and artefacts—from buildings and infrastructures to durable household goods—biophysically constitute a society that is hybrid, a coupled human-environment system, clearly subject to the laws of nature and simultaneously (trans)formed through cultural meaning and purpose. Food and feed, fertilizer minerals, stones and sand, and oil and gas required to build and maintain these hybrids constitute inputs into the socio-economic system. These inputs always initially stem from the natural environment but may be supplied by other socio-economic systems via trade.

Identifying trade flows presents the challenge of defining the humans (as these tend to be most relevant in terms of agency, but possibly also the livestock and artefacts) that biophysically constitute a socio-economic system. For example, if a Dutch company harvests palm fruit in Indonesia, does the corresponding flow cross the nature-society boundary in

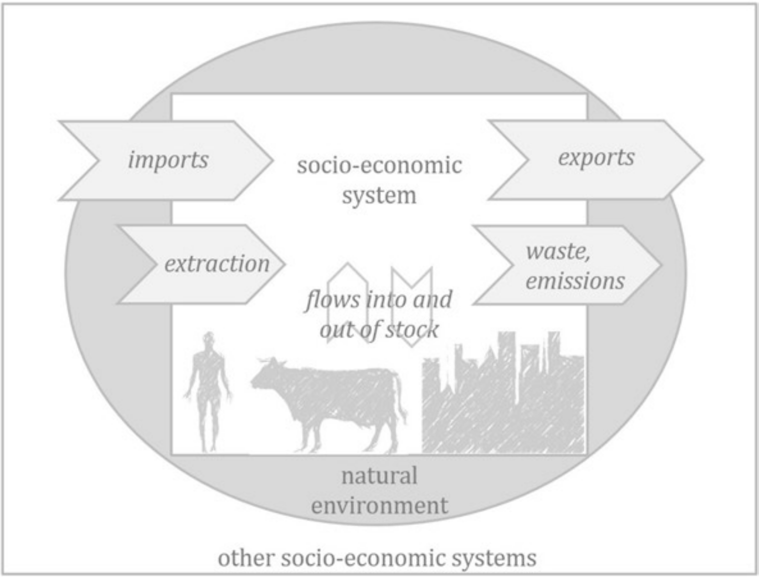


Fig. 7.1 Material flows cross the boundaries between a socio-economic system and its natural environment and between socio-economic systems

Indonesia or the Netherlands? If a Malaysian company ships Indonesian palm oil to Rotterdam, from where it is transported to a German factory that produces cookies eaten in France, then which socio-economic system has caused deforestation in Indonesia? The study of material flows does not provide one definite answer to such questions but, instead, allows for the empirical investigation of possible conceptualizations of what links land-use systems.

Material flow accounting is flanked by two groups of approaches concerned with following the trail from consumption in a socio-economic system to extraction from the natural environment across levels of scale. These approaches differ not only, but especially, in how they empirically operationalize the flows that indicate telecoupling, namely, (1) as material or (2) as monetary flows.

In interpreting the results of these approaches as indications of telecoupling, links between systems are predefined in a manner that may or may not be admissible in terms of how we conceptualize telecoupling and useful for our specific research question. The empirical study of telecoupling through the lens of social metabolism is closely tied to the advancement of our conceptual understanding of functional links across levels of spatial scale.

2 Following the Material Trail

Material flow accounting allows us to empirically investigate material trade as an expression of the links between telecoupled systems. In following this material trail, we may either be led to examine land use in agriculture, forestry, or mining in the exporting country or find that multiple systems are linked through a web of material flows. Malaysia, for example, exports palm oil made from palm fruit harvested on Malaysian plantations and also (re-)exports palm oil imported as crude oil from Indonesia. Countries may also export what they cannot extract domestically at all: We will not find oil palms in Dutch greenhouses, Emirati deserts, or German forests, but the Netherlands, the United Arab Emirates, and Germany are among the world's top ten exporters of palm oil. To link palm oil trade flows to land use and land-use changes through oil palm plantations, material flows are traced back to their origin (Kastner et al. 2011), revealing a web of telecoupled systems between which the steps of extraction, primary and secondary processing, transport, distribution, retail, and final use are divided.

2.1 Heavy Harvest, Traded Lightly

The material trail extends beyond trade flows with their mass as they cross an administrative boundary (Krausmann et al. 2017). From extraction through primary and secondary processing, material flows generally become "lighter". In order to produce one tonne of palm oil, four–five tonnes of oil palm fruit are required, harvested for oil production, but not included in the mass of the exported oil. From the use of land, energy, and auxiliary materials to the machines, infrastructures, and buildings required in the extraction and production processes, material exports additionally depend on manifold upstream inputs. To produce palm oil for export, land must be cleared, roads must be built, plantations fostered; palm fruit must be harvested and transported to constructed mills and possibly onwards to refineries. Construction materials and fossil fuels must be mined or imported. We may know that Indonesia exports almost six million tonnes of palm oil in a year, but this figure alone tells us little about the direct and indirect consequences for the local or the global land system.

2.2 The Land Requirements of Material Flows

Until almost any product reaches its final consumer, myriad materials at sundry sites have been used directly and indirectly requiring land. The land use associated with observed material flows is commonly estimated using coefficients. Material import and export flows are multiplied by a factor representing land required for the production of one unit of that traded good. If, for example, 4.5 tonnes of oil palm fruit yield 1 tonne of palm oil and one Indonesian palm plantation hectare yields an average of 17 tonnes of oil palm fruit, then each tonne of Indonesian palm oil—no matter where in the world it is consumed—requires slightly more than one quarter of a hectare of plantation land.

When one process yields more than one product—in co-production—the total resource use of the process can be assigned to the co-products either according to their relative biophysical (mass, energy content) or according to monetary (value) characteristics. In the production of palm oil, palm kernel cake is produced, sold, and used as animal feed. Oil and cake may be produced at a mass ratio of approximately 3:1, an energy ratio of 19:1, and a value ratio of 15:1. Accordingly, anywhere between 75% and 95% of the land use would be interpreted as required for palm oil production, while between 25% and 5% are required for palm kernel cake production. Consistently addressing co-production in empirical telecoupling analysis is the prerequisite to avoiding double counting. Which manner of representing co-production is most appropriate depends on the specific research question, for example, on the aspects of a telecoupling to be brought into particular focus.

In identifying the relevant material inputs, system boundaries must be defined in accordance with the research question. This decision covers the nodes of the production network taken into consideration as well as to the temporal scope of the analysis. Electricity used in palm oil production, for example, requires a power grid connected to a power plant. Both require their own material inputs, the extraction and processing of which in turn requires further material flows. In theory, each flow could be traced back to extraction as raw material, but this is an endless undertaking in which the relevant material flows become successively smaller and thus have less impact on the overall results. The researcher therefore decides on where to truncate the consideration of the production network, limiting the system boundaries for the telecoupling analysis accordingly (Friis and Nielsen 2017). This truncation may also be based on temporal criteria, that is, to consider, for example, only material flows incurred in the same year as the export flow occurred.

3 Following the Monetary Trail

Material trade flows are generally[1] associated with revenue from exports and spending on imports. Investments in land, either for purchase or for lease, may indicate connections between systems well before extraction and trade materialize. In close conjunction with—although asymmetrically to—material flows, monetary flows link coupled systems.

Environmentally extended input-output analysis has been implemented as a tool for the study of social metabolism, which follows the monetary rather than material trail from consumption to production. This modelling approach is based on input-output tables that may be organized by sectors (e.g. agriculture, production of food, restaurants) or by goods and services (e.g. cereals, flour, restaurant services). For each year, these tables provide information on the purchases made by each sector from all other sectors, the supply of each sector to final demand (e.g. households, government, exports), and the total output of each sector. Multiple input-output tables—commonly representing national economies—can be combined into multi-regional input-output (MRIO) models according to bilateral monetary trade flows.

3.1 Direct and Indirect Monetary Flows

Based on the input-output data, the technical coefficient matrix A indicates the inputs required by each sector per single unit of total monetary output.[2] From this matrix, we would be able to extract the information on the agricultural goods and services, the energy and water supplies, and the transport services that agriculture had to purchase *directly* in order to produce one unit of monetary exports. Of course, each and every of these monetary flows in turn induces other flows. For example, a unit of output from restaurants will require direct inputs from food production. In order to deliver to restaurants, food production will require input from agriculture; hence, restaurants *indirectly* require input from agriculture. In order to produce what it delivers to food production, agriculture requires inputs of fossil energy and fertilizer minerals. The energy and chemical processing sectors that provide these inputs require inputs of energy and water, the provisioning of which in turn requires a specific set of inputs. To calculate all the indirect inputs required by restaurants could be an endless, reiterative calculation, with each successive step adding information on smaller indirect flows. The Leontief inverse, calculated by inverting the difference between the aforementioned technical coefficient matrix A and the identity matrix I $(I-A)^{-1}$, makes it possible to condense this reiteration into one step (for a mathematical explanation of why this is possible, please see Schaffartzik et al. 2014; Miller and Blair 2009).

3.2 The Land Requirements of Monetary Flows

The monetary input-output tables can be extended by matrices or vectors of environmental factors, hence the name *environmentally extended* input-output analysis. The environmental factors can range from land use, material extraction, or energy use to the emission of pollutants or the discharge of waste and must be organized by sector or product group in accordance with the structure of the input-output tables. By extending the input-output tables of an MRIO model with land-use data, the direct land-use requirements per unit of total monetary output of each sector can be calculated as well as—using the Leontief inverse—the direct *and indirect* requirements. Via monetary flows between sectors and countries, final demand in any one country can be linked to land use at the sites of production.

In their study of the global land use related to national consumption, for example, Yu et al. (2013) found that significant levels of use of cropland and forestland in Southeast Asia occurred in sectors directly or indirectly producing for export. The researchers used an MRIO model with 12 agricultural sectors (including rice, vegetables and fruits, oilseeds, and milk) to which they allocated cropland and grazing land data. Forestland was allocated to the forestry sector. Built-up land had to be distributed to essentially all sectors. The economic classifications of flows necessarily subsume high variance in land uses. Indonesian yields of palm fruit, for example, are 44 times higher than yields of cocoa beans, but both types of production are part of the same agricultural sector.

4 Money Or Material: What Makes the World Go 'Round?

Both material and monetary flows can be traced through increasingly globalized production and consumption, revealing vast and changing webs of telecoupled systems. Which type of approach is used in empirical studies or to underpin conceptual advances depends on whether it is the monetary or the material link that is considered more functionally pertinent.

Land use, the colonization of land, the extraction from that land is, of course, a material process. This process can occur independently of monetary flows, as in subsistence agriculture. Monetary final demand for food, in contrast, presupposes some type of material flow. While it may be argued that under the political and economic system of capitalism, production requires investment, no amount of money can ever completely substitute material resources. Systems involved in international monetary production and consumption networks are distinct from those in the corresponding material networks.

Which system is a producer or a consumer may also change, depending on the perspective. In the flow relations within and between systems, money and materials not only flow in opposite directions but are also asymmetrical. The price paid for the same type of material varies over time and by country and also by subnational region and even sector. Depending on whether we follow the material or the monetary trail, we will obtain a different picture of the systems coupled and also by the nature of that coupling. Its monetary production and consumption patterns make China a net exporter of cropland; the country dedicates more land to the production for export than is used globally for Chinese imports. China's material use renders the country a net importer of cropland; more land is required globally to produce for China's imports than is used in China to produce for export (Schaffartzik et al. 2015).

The asymmetries between monetary and material flows that characterize the links between telecoupled systems point to other pivotal characteristics of the underlying relationships: wealth and power differentials, political agreements and disputes, system-specific incentives for production, and trade. Monetary and material trails lead us to these larger issues. In this way, the quantification of material and monetary flows between systems and across levels of scale and the identification of underlying causes of these flows are deeply intertwined. By further operationalizing the concept of social metabolism and its tools for telecoupling analysis, we enter into a highly productive back-and-forth between empirical observations and conceptual advances.

Acknowledgements Anke Schaffartzik acknowledges financial support from the Spanish Ministry of Economy and Competitiveness, through the "María de Maeztu" programme for Units of Excellence (MDM-2015-0552).

Notes

1. Food aid constitutes an important exception to the opposing monetary flows associated with material trade flows and can be extremely relevant to the telecoupling of land systems.

2. For an in-depth introduction to input-output analysis, see Miller and Blair (2009). For an overview of environmentally extended input-output analysis focusing on its role in material flow accounting, see Schaffartzik et al. (2014).

References

Fischer-Kowalski, Marina, and Karl-Heinz Erb. 2016. Core Concepts and Heuristics. In *Social Ecology. Society-Nature Relations Across Time and Space*, ed. Helmut Haberl, Marina Fischer-Kowalski, Fridolin Krausmann, and Verena Winiwarter, 29–61. Cham: Springer.

Friis, Cecilie, and Jonas Ø. Nielsen. 2017. On the System. Boundary Choices, Implications, and Solutions in Telecoupling Land Use Change Research. *Sustainability* 9 (6): 974. https://doi.org/10.3390/su9060974.

Kastner, Thomas, Michael Kastner, and Sanderine Nonhebel. 2011. Tracing Distant Environmental Impacts of Agricultural Products from a Consumer Perspective. *Ecological Economics* 70 (6): 1032–1040. https://doi.org/10.1016/j.ecolecon.2011.01.012.

Krausmann, Fridolin, Heinz Schandl, Nina Eisenmenger, Stefan Giljum, and Tim Jackson. 2017. Material Flow Accounting: Measuring Global Material Use for Sustainable Development. *Annual Review of Environment and Resources* 42 (1): 647–675. https://doi.org/10.1146/annurev-environ-102016-060726.

Miller, Ronald E., and Peter D. Blair. 2009. *Input-Output Analysis: Foundations and Extensions*. Cambridge: Cambridge University Press.

Schaffartzik, Anke, Helmut Haberl, Thomas Kastner, Dominik Wiedenhofer, Nina Eisenmenger, and Karl-Heinz Erb. 2015. Trading Land: A Review of Approaches to Accounting for Upstream Land Requirements of Traded Products. *Journal of Industrial Ecology* 19 (5): 703–714. https://doi.org/10.1111/jiec.12258.

Schaffartzik, Anke, Magdalena Sachs, Dominik Wiedenhofer, and Nina Eisenmenger. 2014. Environmentally Extended Input-Output Analysis. *Social Ecology Working Paper 154*. Vienna: Institute of Social Ecology, Alpen-Adria-Universität.

Yu, Yang, Kuishuang Feng, and Klaus Hubacek. 2013. Tele-Connecting Local Consumption to Global Land Use. *Global Environmental Change* 23 (5): 1178–1186. https://doi.org/10.1016/j.gloenvcha.2013.04.006.

8

Trade and Land-Use Telecouplings

Javier Godar and Toby Gardner

1 Introduction

Production of commodities fuelled by global demand for food, fibre and energy is arguably the most important driver of land-use change globally, contributing to widespread land degradation (IPBES 2018). Historically, land use has been tightly linked to local or regional resource demands, but globalisation has led to a sharp spatial decoupling in the production and consumption of land-based products, underscoring the key role of international trade in shaping land use globally.

About 1.5 trillion dollars' worth of agricultural commodities were traded internationally in 2016 (FAOSTAT 2018), about 10% of global trade in that year (WTO 2017). The share of exports in agricultural and other natural resource commodities, as a proportion of total exports, is considerably larger in many developing countries that have a relatively small domestic demand and/or a large agricultural surplus. Trade in land-based resources has boosted the economic growth of many developing

J. Godar (✉) • T. Gardner
Stockholm Environment Institute, Stockholm, Sweden
e-mail: javier.godar@sei.org; toby.gardner@sei.org

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_8

and emerging economies, whilst also improving global food security by buffering the effects of local shocks (such as drought) on food production, and facilitating the exchange of technology and information (FAO 2003; Clapp 2015). However, global market integration has also exacerbated land degradation and unsustainable levels of resource use at local, regional and global scales (Lambin and Meyfroidt 2010; IPBES 2018). Indeed, the environmental impacts that are embedded in globally traded commodities make it impossible to decouple the economic growth of a country from environmental degradation (Wiedmann et al. 2015). Typically, as countries become wealthier, pressure on the environment is not reduced but rather displaced to other countries—often low-income nations that take the role of cheap producers of raw materials for the global economy (Srinivasan et al. 2008).

Understanding how to identify the role of trade as a driver of land-use change, mitigate its negative impacts and amplify possible benefits is therefore of central importance to tackling the impacts of land-use changes globally. Liu et al. (2013, 2015) define telecouplings as the interaction between social and environmental factors over distance, and in this chapter, we focus specifically on interactions that are mediated by trade—a major channel of telecoupling flows—and have effects on land use.

A combination of the spatial decoupling of production and consumption processes, increasing globalisation and the myriad production, processing and consumption processes that are mediated by trade, has made analysis of the causal relationships between commodity trade and land-use change dynamics extremely challenging, hampering efforts to inform policy decisions. For instance, several alternative land uses are possible in the same unit of land, including from different sectors (e.g. agriculture, urban development, forestry, energy and mining) and within the same sector (e.g. alternative farming products such as soy, maize or cattle ranching). As such, factors affecting one aspect of a given system (such as crop prices, levels of demand or changes in crop productivity) will have cascading effects on the entire land-use system. By the same token, international trade involves a growing number and diversity of supply chain actors, including producers, traders, manufacturers, retailers, consumers and policy-makers, but also intermediary and service providing actors such as transporters and manufacturers of agricultural inputs. As such, changes in the behaviour of one actor, in one stage of a global supply chain for a specific commodity, can have cascading effects on the behaviour of other actors involved in the production, trade and consumption of the same and other commodities.

We argue that our understanding of the challenges posed by the telecoupling of trade and global land use remains weak due to the inadequacy of current data and approaches for mapping and analysing trade—land-use connections, which were developed at a time when appreciation of these complexities was poor, and key datasets were less accessible and understood. We further argue that while the telecoupling conceptual framework can help respond to this complexity by helping surface hidden causal linkages to underlying drivers of land-use change, it is still limited operationally and needs to be further developed to support practical applications in decision-making in land use and trade. We review new methodological approaches and poorly tapped data sources that can help overcome some of these limitations. Two key limitations of existing approaches are:

1. *Spatial explicitness of trade flow mapping*. Most analyses of international trade rely on national scale databases, whether based on bilateral trade flows from FAOSTAT and COMTRADE (e.g. Kastner et al. 2011) or monetary flow estimations from financial input-output tables between the economic sectors of countries (Bruckner et al. 2015). Therefore, the spatial heterogeneity in socio-environmental conditions within a given country is not considered, with analyses relying on crude national averages of resource use (e.g. land to produce a tonne of a given commodity) and embedded impacts (e.g. deforestation per tonne of traded commodity). This lack of spatial explicitness means that international demand is assumed to affect all areas of production within a country of interest uniformly, whilst embedded impacts are considered to be the same per unit of product for all consumers, regardless of differential sourcing patterns. Moreover, a reliance on national-level data also means that analyses are not commensurate with the scale at which key resource-use decisions are made, which is often within individual subnational regions (Godar et al. 2015).
2. *Nominality of actors*. Most quantitative analyses do not include information on the identity of the actors (e.g. traders, investors, retailers)

involved in the production and trade. This makes it challenging to engage relevant actors, whether they are specific companies or jurisdictional governments, in the design and implementation of interventions, and to strengthen accountability for environmental and social impacts linked to trade (Godar et al. 2016).

The chapter is structured into three more sections. In the second section, we examine the causes and effects of trade and land-use telecouplings, using examples to demonstrate how often unexpected, remote drivers can override the influence of local drivers on land-use and hence environmental change. We identify both the underlying properties, such as the increasing volume of trade and increased market integration that predispose many systems to be affected by trade and land-use telecouplings, as well as the more specific causes and effects of such telecouplings. In the third section, we illustrate the methodological challenges that have hampered attempts to understand trade and land-use telecouplings. We identify opportunities to advance this understanding by using hitherto untapped, granular data on both material and financial flows in international supply chains, providing with examples from recent work of the Trase initiative (www.trase.earth). We argue that a key step towards improved understanding of trade and land-use telecouplings is to use spatially explicit and nominal data to link international supply chains and demand to specific landscapes and land-use changes, as well as to specific actors. In the final section, we discuss ways in which research on trade and land-use telecouplings may change in the near-future in the face of a rapid shift towards greater transparency and open-data access in public, private and civil society sectors, and reflect on how a new level of understanding of existing institutional and policy contexts can provide with relevant and actionable information for policy-makers.

2 Globalisation and the Causes and Effects of Trade and Land-Use Telecouplings

In an ever-more globalised world, land and resource use in one place is increasingly shaped by drivers originated on the other side of the planet, and are mediated by trade. Globalisation can both amplify and attenuate drivers of land-use change by breaking down regional barriers and strengthening global connections and influences, such as trade tariffs and restrictions, global prices, legal conventions and access to information over local factors, such as regional markets, extension services and local governance regimes (Lambin et al. 2001; Liu et al. 2013).

2.1 Trade Telecouplings and Emerging Properties of a Globalised Economy

A number of key emergent properties of an increasingly globalised economy set the stage for trade-related telecouplings, and have an increasing influence on land use.

Increasing global demand for internationally traded commodities. Cross-border trade in agricultural and forestry commodities increased threefold between 2000 and 2016, rising from c. 500 billion to 1.5 trillion US dollars' worth (COMTRADE data, as of November 2018 https://resourcetrade.earth). Rapid growth of major emerging markets over the last 20 years has boosted global demand for commodities, with Brazil, China, India, Indonesia, Mexico, Russia and Turkey accounting for 39% of the increase in global food consumption (Baffes et al. 2018). For example, China has rapidly emerged as the biggest global importer of soy. Exports of soy from Brazil to China have risen by 300% over the last decade, with much of the trade being in raw beans that are processed into animal feed on arrival. As shipments to China have grown to comprise two-thirds of Brazil's soy exports (and nearly 80% of its raw beans exports), major traders have shifted their patterns of operation and investment accordingly, with implications for land use and deforestation (Fig. 8.1). It has also spurred the entry of new companies, often from Asia such as COFCO, into the market.

Increased market integration. Increasing market integration and cross-scale interdependencies in how land and natural resources are managed can have a significant, if not over-riding, effect in mediating local drivers of land-use change. The most evident example of this is in the shift of many smallholder farmers from the production of staple crops to cash crops, such as palm oil in Indonesia, cocoa in West Africa, maize across much of sub-Saharan Africa, or banana plantations in Central America, to name but a few (Bryceson 2002; McCarthy 2010).

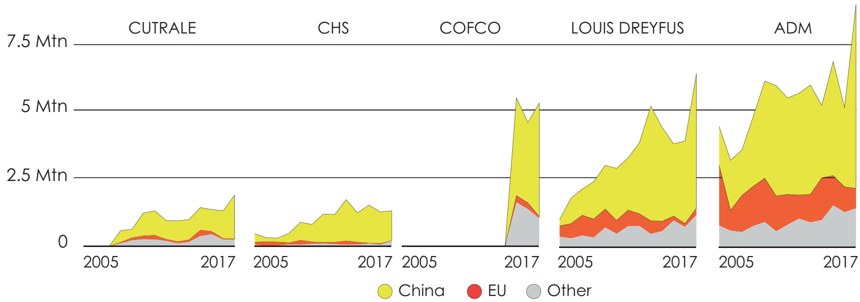


Fig. 8.1 Response of different traders to China's emergence as the world's largest soy importer, 2005–2017. Values in soybean equivalents, exports of soy cake and soy oil are included and converted to their raw commodity equivalents. Redrawn from Trase (2018a)

Changes in the number, diversity and specialisation of actors involved in global trade. Globalisation has given rise to increased competition that is altering the structure of international supply chains and entire sectors of the economy (Gereffi and Lee 2012). Supply chain operations have become more complex, with different actors specialising in different stages of production, trade, processing and retail, as well as on indirect roles such as inputs supply (e.g. seeds, fertilisers), transport, financial services and capital investment. In 2009, global export of intermediate goods exceeded the total export value of final and capital goods (IDE-JETRO and WTO 2011). Moreover, many of these actors operate in different places, responsible only for specific sections of the supply chain, and often with very limited engagement with all other supply chain actors. In parallel to this increased specialisation, increasing demand and a deepening of global interdependencies in the supply chains of many products has also driven a process of capital accumulation and consolidation of assets and market share into fewer, larger actors. For example, more than 1000 companies exported soy from Brazil between 2005 and 2016, but no more than 40 have held a significant share of the market—over 1% of total exports—in any given year (Trase 2018a). In 2016, the six largest traders—Bunge, Cargill, ADM, COFCO, Louis Dreyfus and Amaggi—accounted for 57% of all soy exports from Brazil (Trase 2018a).

Increased importance of the private sector. The rising importance of international trade in land-based commodities has dramatically raised the importance of private sector actors and market processes over state-orientated governance in shaping patterns of natural resource use (Rudel 2007). This is particularly visible in deforestation frontiers across the tropics where well-capitalised and market-integrated farmers and loggers have become more important than local population growth dynamics in driving deforestation (Rudel et al. 2009).

2.2 Drivers of Trade and Land-Use Telecouplings

The drivers of trade and land-use telecouplings are typically manifold and interacting, often involving a combination of social, economic and political changes in consumer economies that can mediate or override the influence of local drivers of land use in production regions. Land-use impacts are often exacerbated by changes in production systems associated to the influence of global markets and trade dynamics. For example, Liu et al. (2013) analysed the soybean trade between Brazil and China, showing that a superficial analysis identifies the strong demand for soybean products, including animal feed (mostly pigs) in China as being the dominant cause of land-use dynamics in the Brazilian soy sector. However, political considerations of the Chinese government in pursuing foreign investments and securing future supply, as well as the Brazilian government's interest in developing its export market also play a strong role. Strong cultural preferences for products that demand soybeans underpins the economic demand from China, whilst landmark developments in agricultural technology by Embrapa, Brazil's agricultural research institution, were important drivers enabling soy planting under difficult biophysical conditions of the Brazilian Cerrado.

Despite this complexity of interaction effects, it is instructive to separate the important role that a number of key factors can play in causing trade and land-use telecouplings.

Economic factors. Economic factors are often the dominant drivers of trade and land-use telecouplings, and can be both exogenous, such as related to overall economic growth or currency exchange volatility, and endogenous, such as changes in productivity or logistic efficiency. For example, Yao et al. (2018) assessed the importance of different drivers of telecouplings in the global soybean complex and found that China's macroeconomic growth played the most important role in shaping soybean production and exports in both Brazil and the US. In addition, they found that Brazil's rapid growth in soy productivity (endogenous factor) contributed towards reducing the dependence of the Chinese market on US exports and reducing overall growth of soybean output in the US—demonstrating the complexity of two-way interactions between supply and demand that can occur via international commodity trade.

Market regulatory factors. Regulatory factors in consumer countries, including different forms of trade barriers, tariffs and embargoes, can have a profound effect on land use in production countries. For example, the Amazon cattle industry was barred from many international markets due to the presence of foot-and-mouth disease (FMD), but the subsequent eradication of FMD from the main producing states in the early 2000s stimulated beef production and contributed towards a marked rise in prices (Kaimowitz et al. 2004), as well as access to new markets that accepted Brazilian beef at the time, and that continue to be strong trade partners today. Conversely, the lack of regulations on the environmental impacts of imported commodities in most consumer countries is often a key factor that facilitates unsustainable practices in producer countries.

Investment factors. Changes in financial markets can catalyse telecoupled effects on land use via changes in international commodity trade. For instance, through price volatilities that are often driven by trading in complex derivatives and ultra-rapid, algorithm-based trading technologies, including through speculation on futures trading (Galaz et al. 2015). In 2010, a British hedge fund, Armajaro, purchased instruments worth 7% of the world's cocoa supply, betting that prices would rise in face of poor weather conditions and pushing prices to a then all-time high (Futures Magazine 2010). The impacts of financial trading of farming commodities on global land use are amongst the most poorly understood drivers, yet if better quantified and analysed, it could deliver the most substantive sustainability gains (Scholtens 2017).

Buyer preference factors. The impact of increasing demand for Latin American soybeans by consumers in China and Europe on the clearance of native vegetation in the Amazon, Cerrado and Chaco biomes has been well documented. Less well understood is the role of consumer preferences for specific production systems. Garrett et al. (2013) demonstrate how Brazil's production of non-genetically modified soy has enabled it to better access European markets than its competitors in Argentina and Paraguay, who almost exclusively grow genetically modified soy. Once established, these segregated trade-linkages have further facilitated the upgrading of some Brazilian soy supply-chains to different sustainability certification schemes and access to price premiums (Garrett et al. 2013). On the flip side, there are concerns that sustainability standards can also exclude more marginal, smallholder producers (Brandi 2017), whose activities often lead to more sustainable and diverse landscapes than larger agro-industrial enterprises (Pokorny 2013). At the same time, a lack of government-imposed minimum standards can drive a "race to the bottom" in producer countries, depending on differences in their pool of export markets (Gamso 2017).

Demographic factors. Global demographic changes can shape land-use and trade telecouplings, such as when the agricultural capacity for a given crop is met within a country, leading to increased demand for imports. Demographic factors can interact closely with individual lifestyle choices and buyer preferences, either reinforcing or counteracting the influence of specific preferences.

Environmental shocks and changes in biophysical conditions. There is growing evidence that the ongoing degradation of ecosystem services, as well as increasing shocks related to climate change, urbanisation and pollution, to name a few, are major disruptions to farming systems, and in turn to trade of farming commodities. Examples include from the devastating effects of fires in Southeast Asia on transportation and regional economic development, affecting trade of key commodities such as palm oil from major producing countries (Varkkey 2017), to the melting of Arctic sea ice and the opening up of much shorter trade routes in the polar region (Patel and Fountain 2017).

2.3 Effects of Trade and Land-Use Telecouplings

We argue that trade-mediated telecouplings can have first-, second-, or multiple-order effects on land use. First-order effects have a direct influence on the level of expansion and type of production practices of the commodity in question—for example, changes in the production of soy and beef in Brazil, as shaped by changes in Chinese demand and European import restrictions.

Second-order effects are those that indirectly influence wider land-use changes beyond those linked to the production of a specific traded commodity, but typically occur within the land-use sector, such as leakage and indirect land-use change effects. For example, the effect of increased demand for biofuels to meet targets set by the EU's Biofuels Directive has likely had, under some analyses, a perverse effect through indirect land-use change that has pushed other commodities (such as cattle ranching) further into forest frontiers (e.g. Lapola et al. 2010; Khanna and Crago 2012). Second-order effects can also occur through other indirect pathways. For example, da Silva et al. (2017) demonstrate how the strong influence of Chinese demand for Brazilian soy had a cascading effect on Brazilian maize farming, consolidating much of the production of the latter as a second-rotation crop in soy farms. This shift in the production of maize increased the volume of maize exports, with a knock-on effect of increasing prices in the domestic market, inflating the internal prices of meat consumption, whilst also leaving maize production as a second-crop more exposed to drought impacts. Similarly, the collapse of the Soviet Union led to a marked strengthening of beef exports from Brazil to Russia, now one of the primary importers of Brazilian beef, following a collapse in domestic production in the early 1990s and a rebound of domestic consumption since the late 1990s (Schierhorn et al. 2016).

The realm of multiple-order effects is much more complex and out of the scope of this chapter, but includes effects that are intrinsically unrelated with, or at least not limited to, the land-use sector. For example, geopolitical decisions related to security and power influence can lead to major changes in land use. One example is the Chinese One Belt, One Road initiative (Tekdal 2018), or the recent trade wars initiated by the Trump administration (Reuters 2018), with multiple and uncertain cascading effects and multisectoral ramifications that will have profound impacts on land use in different regions worldwide. Other multiple-order effects can occur through displaced, biophysical impacts of production and trade. For example, the production and trade of farming commodities impacts water use and scarcity, which changes moisture recycling patterns, with cascading impacts on precipitation patterns in production areas elsewhere (Keys et al. 2017). In turn, this can lead to variations in the suitability of competing crops and land uses, but also on socio-environmental conditions that can have further rebound effects, including via other trade telecouplings, to the regions that were originally subjected to water scarcity and to other regions, which in turn may be telecoupled with each other in diverse ways. Second- and multiple-order effects of trade and land-use telecouplings are inherently more unpredictable and complex with increasing globalisation and socio-technological complexity.

3 Methods and Data for Linking International Trade to Specific Land-Use Changes and Associated Effects

To date, methods for linking international trade and land-use change include partial equilibrium models, agent-based and systems dynamics models and environmental-economic export-import accounting, physical accounting and hybrid approaches (Bruckner et al. 2015; Millington et al. 2017). Inputs for these methods are typically based on national-level data. For instance, environmental-economic accounting relies on input-output economics applied to depictions of global financial flows between different sectors of the economy and different countries. Environmentally extended multiregional input-output approaches have been used to track embodied environmental impacts from production to final consumption (Corong et al. 2017; Stadler et al. 2018). By contrast, physical accounting of trade flows does not rely on monetary data but on information on exports, imports, production and consumption, measured in physical units such as kilogrammes, cubic metres or cattle heads. The vast majority of physical accounting approaches have relied on bilateral national trade statistics (e.g. Kastner et al. 2011), as compiled, for example, by the UN (COMTRADE and FAOSTAT) or other supranational organisations (e.g. EUROSTAT). Hybrid approaches have sought to combine economic modelling and physical accounting approaches (e.g. Weinzettel et al. 2014). They recognise that while physical accounting is appropriate for trade of raw and simple commodities and/or for the initial stages of a given supply chain (e.g. production to countries of import), economic modelling and environmental-economic accounting is more appropriate for assessing impacts of complex, derived products.

These methods and datasets are used for calculating overall environmental footprints and for assessing certain aspects of trade-related telecoupling dynamics, including the importance of different market-mediating factors as drivers of both land-use and market change in international trade (e.g. Yao et al. 2018), and the assessment of economic and environmental spillover effects that impact third parties outside of bilateral trade relationships (e.g. Xiong et al. 2018).

However, methods based on national-level data are not well-suited to assess and inform subnational and landscape level interventions in production systems, or to assess specific causal linkages between individual trade flows, actors and associated direct and indirect impacts on the land-use system, the role of different supply chain actors in shaping differential sourcing patterns, or the effects of multilevel governance on the telecoupled system (Godar et al. 2015, 2016). There are several reasons for these limitations. First, the lack of spatial explicitness in subnational sourcing of trade flows in almost all economic models and accounting approaches means that spatial variability in productive, environmental, physiographic and socio-economic conditions within producer countries is not captured. This can lead to large oversimplications and errors, especially for large, heterogeneous producer countries (Fig. 8.2). For example, analyses that depend on national-level data require that all deforestation in Brazil is allocated to all the exports of a given commodity, regardless of whether some are produced in areas with no recent deforestation, or if they are produced under strict safeguards, for example, under the Amazonian Soy Moratorium. As a consequence, current country-to-country assessments of social and environmental impacts embedded in international trade assume an average impact per unit of primary product, thus attributing embedded impacts to consumer countries proportionally to the amount of product they source from each country, not affected by differences and preferences in sourcing strategies (Godar et al. 2015).

This lack of spatial explicitness in accurately describing production, trade flows and supply chain connections also means that most studies of

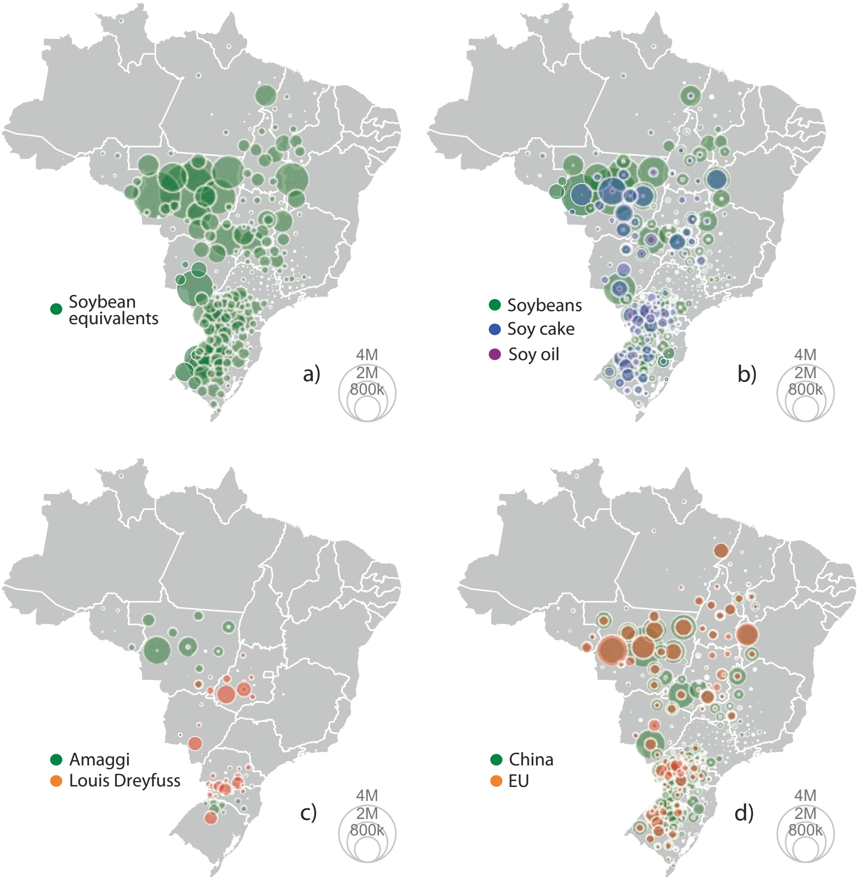


Fig. 8.2 Spatially explicit exports and sourcing of selected traders and countries, Brazilian soy supply chain 2016. Panel (**a**) represents the volume of Brazilian soy exports per municipality of sourcing; (**b**) volume of Brazilian soy exports per soy product type (beans, cake, oil) and municipality of sourcing; (**c**) volume of Brazilian soy exports for two of the main exporter companies, Amaggi and Louis Dreyfus; (**d**) volume of Brazilian soy imports for the two largest Brazilian soy importers, China and the EU. The size of the bubbles represents total volume exported, see scales. Data from www.trase.earth

trade and land-use telecouplings fail to make good use of the recent revolution in access to fine-scale remotely sensed data (Kwok 2018). For example, the aggregation of per-pixel information on levels of deforestation to inform a country level analysis both trivialises the value of having access to such fine-scale data, whilst also failing to provide the level of analysis that is needed to understand trade and land-use telecouplings in a way that can be operationalised for practical decision-making.

Another major shortcoming of current approaches is a lack of nominality—that is, the identity—of individual actors in trade and production datasets. Differences in the characteristics of key actors involved in the production, trade and consumption of a given commodity can be of fundamental importance in understanding drivers and impacts of trade and land-use telecouplings, as well as the effectiveness of sustainability interventions (see Fig. 8.2b, c, for examples of actor variability in sourcing patterns and therefore risks embedded in export flows). For example, it is important to identify if specific trade flows and associated impacts are dominated by a small group of actors, if the actor-place relationships are persistent—"sticky"—over time (alternatively if relationships are more ephemeral, making accountability for local dynamics more nebulous), or under voluntary measures to improve the sustainability and transparency of their supply chains. These shortcomings are of particular concern when set against a backdrop of increased reliance on private sector actors and supply chain approaches to improve the sustainability of global trade (Lambin et al. 2018), and a diminishing influence of multilateral processes and the role of the national state, paired with an increase in the importance of subnational levels of governance following rising decentralisation in recent decades (Wright et al. 2016).

Recent research demonstrates that new types of data, which remained largely untapped by the sustainability research community, can help overcome some of these limitations (Fig. 8.2). In particular, the use of detailed trade accounts from custom declarations and bills of lading (Godar et al. 2016) and shipping manifests (Schim van der Loeff et al. 2018), as inputs of a physical accounting approach (Trase 2017) provide per shipment information on the exporters and importers of specific products, as well as precise information on total volumes being shipped to specific locations. This information is available for a growing number of countries of export and import. Trade data can also be combined with spatially explicit information on supply chain nodes in the country of production, allowing for high accuracy in mapping subnational sourcing patterns per supply chain actor. These data include, but are not limited to, taxation records per asset of the companies involved in the production, processing and trade of commodities; sanitary inspections identifying a given commodity volume with a specific location at a given date (Klingler, Richards and Ossner 2018); logistics ownership of traders and producers (e.g. farms, silos, crushing facilities, slaughterhouses); sourcing of certified products; recorded movements of traded goods, for example, vessel trackers using the AIS system (Schim Van der Loeff et al. 2018). By combining these datasets, it is possible to map linkages between commodity buyers and specific production geographies with an unprecedented level of accuracy. This approach has been undertaken by the Trase initiative (www.trase.earth), co-founded by the authors, which by 2020 seeks to map subnational sourcing patterns for entire supply chains for more than 70% of the globally traded volume in tropical forest risk commodities. Figure 8.3 represents three selected illustrative pathways depicting the location of the cargo and its ownership alongside a supply chain, as well as some selected indicators for soy deforestation and shipping emissions. The figure shows the large variability in deforestation risk and international shipping emissions, respectively, per tonne of soy in these three illustrative trade routes. The totality of the exports and a number of other embedded impacts and risks of a given supply chain can be obtained at the Trase home page (https://trase.earth/flows), as of November 9, 2018.

These new data-driven approaches allow for a much finer-scale assessment of consumption footprints and actor-specific risk exposure. For example, Flach et al. (2016) and Godar et al. (2015) demonstrated that while China imports more sugar and soy from Brazil than the EU, the fact that the EU preferentially sources from the Amazon and Northern Cerrado in the case of soy, and the dry Brazilian Northeast in the case of sugar, means that compared to China, it has higher levels of embedded deforestation and impacts on local water scarcity per unit of commodity (and see Trase 2018b). A recent study (Schim van der Loeff et al. 2018) suggests that differential sourcing patterns are strongly related with operational and shipping logistics considerations, for example, due to the

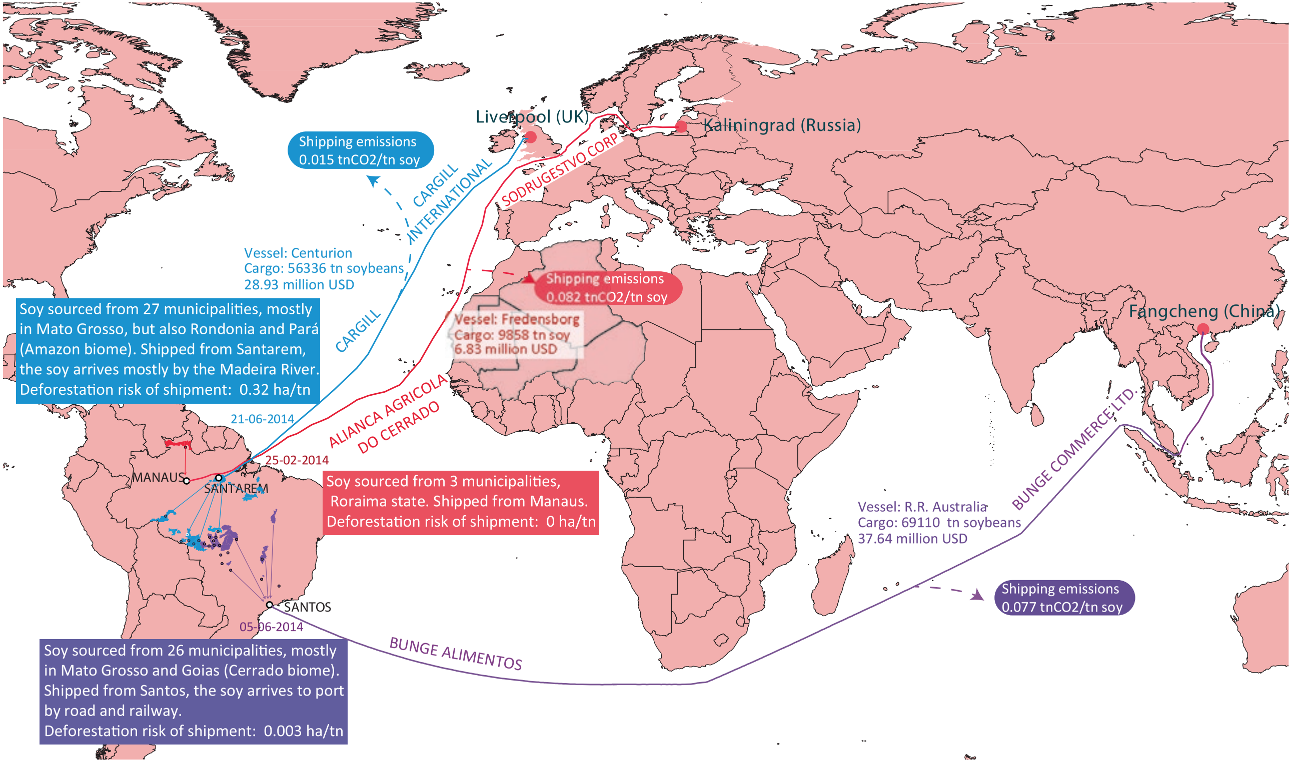


Fig. 8.3 Illustrative description of three trade flows of Brazilian soy exports, from municipalities of production to countries of import, as mapped by the SEI-PCS physical accounting approach used by the Trase initiative. Each of the stages include sourcing and ownership of the cargo (municipality of production, exporter, vessel name, importer company, country of import), as well as logistic relevant data (port of loading and discharge, mode of transport to export port, real shipping pathway as per the AIS system (Schim Van der Loeff et al. 2018))

simple fact that the EU is closer to the ports in the North and Northeast of Brazil, which in turn are closer to forested areas at risk—a basic observation that is lost in country-level analyses. Figure 8.4 represents the risk per imported tonne of soy of major consumer markets, and of major traders.

Data on the role of specific actors in different supply chain stages is key to understanding the nature of existing trade and land-use telecouplings and for designing actionable sustainability interventions, whether to improve corporate decision-making or strengthen accountability processes by governments and civil society. By discriminating sourcing patterns of individual companies or buying countries, it is possible to discriminate differences in embedded deforestation risk among actors. Given differences in total sourcing volumes and links to different deforestation hotspots, different buyers can be exposed to very different levels of risk. For example, Louis Dreyfus exported 6.5% of total Brazilian soy exports in 2006–2016. In this period, it mostly sourced from the south of Brazil, where there has been little recent deforestation for soy. Because of its high volumes and its sourcing from areas with little soy deforestation risk, the company's deforestation risk per exported tonne in the period was about 25 times smaller than that of the joint venture Amaggi & Louis Dreyfus Commodities, who sourced exclusively from the deforestation frontier of Matopiba (see Trase 2018a).

By discriminating sourcing patterns and associated levels of deforestation risk for individual companies and importing countries, it then becomes possible, for the first time, to monitor changes in total deforestation risk exposure over time—whether for individual companies or countries that have made zero-deforestation commitments, or for industry groups (such as the Consumer Goods Forum) or groups of committed countries (such as the EU countries signing the Amsterdam Declaration). In order to assess the net effects of such voluntary commitments overall (rather than the independent effect of a given actor), it is essential to be able to map changes in deforestation embedded in commodity trade for the entire exports of a given country and region, making it possible to discern whether a particular buyer has reduced their risk exposure either by moving their sourcing to regions with no recent deforestation, or by investing to reduce deforestation in hotspot areas.

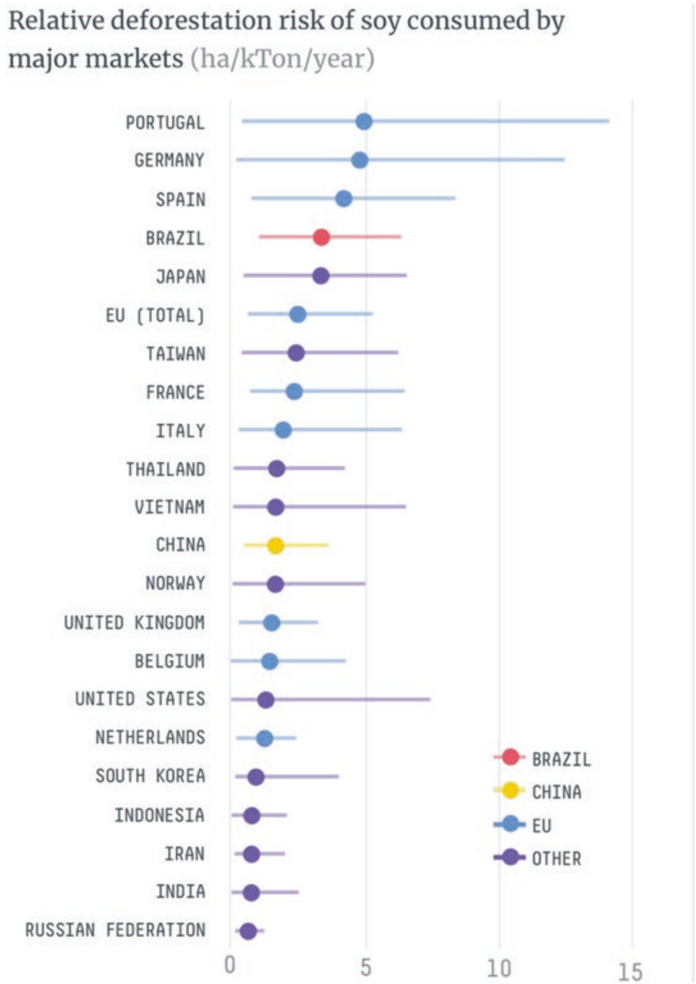


Fig. 8.4 Annual relative deforestation risk, in the Cerrado and Amazon biomes, of soy consumed by major markets, 2006–2016 (ha/Ktn/year). Points show the mean relative deforestation risk linked directly to soy expansion per country for the period 2006–2016. The error bars show the minimum and maximum between 2006 and 2016. Amounts of deforestation risk are allocated to different countries in proportion to volumes sourced from each Brazilian municipality. Data from www.trase.earth (retrieved June 2018)

While mapping the different roles of actors directly participating in a given supply chain is a major advance, there are other actors that shape trade and land-use telecouplings more indirectly, whether from the vicinity of a given supply chain (e.g. suppliers of farming inputs, investors, trading operators, regional governments) or from afar (e.g. traders in global commodity futures, trade negotiators). The role and responsibility of these indirect actors is still poorly recognised, and even more poorly assessed and understood. However, recent developments in both data access and processing methods offer options for potentially ground-breaking research in understanding more indirect drivers of land-use and trade telecouplings. These include data mining techniques, Open Access Linked Data (http://linkeddata.org/) enabling the linking of datasets that were not previously connected (e.g. via common name or ID matching techniques), Natural Language Programming (NLP) enabling the automated interpretation of complex documents—such as news reports, trading records and public listings of companies, to identify indirect linkages between actors, including financial relationships in the form of subsidiary-parent relationships, joint ventures, shareholdings and equity and debt holdings. Mapping these relationships can greatly facilitate the otherwise overwhelming task of understanding the complex web of dependencies and economic instruments and mechanisms that sustain the global trade architecture and the trade and land-use change telecouplings.

While we argue for the need to move from national-level datasets to spatially explicit and nominal trade flow data to help advance our understanding of trade—land-use telecouplings, assessing causality of specific land-use changes, and attributing impacts and thus responsibility to distant actors remains immensely challenging. Robust impact evaluation methodologies are very difficult to design and often require datasets that are not readily available, even for assessing relatively "simple" cause-effect relationships. Assessing the specific impact of more remote drivers includes the fundamental problem of determining how responsibility for impacts of a specific supply chain should best be allocated and shared across multiple actors involved and profiting from that supply chain—including more indirect beneficiaries such as input providers and investors. For example, it is possible to discern, at some level, the relative levels of benefit that accrue to different actors and sectors linked to a specific supply chain based on differences in income (Godar et al. 2016). However, moving from allocation of financial benefits to allocation of responsibilities for improving the sustainability of production is much harder, and is partly a political rather than a technical problem as it is possible to argue that each stage or sector involved in a supply chain bears responsibility for the entire amount of deforestation embedded in a given supply chain. However, it is also important not to get lost in the complexity and seek to apportion impacts and responsibilities to all participants, given that in an increasingly globalised economy the list of candidate participants can be extremely large. While technical solutions, such as those derived from blockchain technology applied to supply chains and machine learning and big data techniques applied to supply chain intelligence, are postulated as partial solutions to some of these problems, they are fundamentally limited when it comes to disentangling what are inherently co-dependent effects and multiple-order causal pathways. Multiple-method approaches, including both quantitative and qualitative methods, are needed to disentangle causal pathways. The more data-driven (over pure modelling) approaches to mapping commodity supply chains that are advocated for in this chapter, accounting for spatial explicitness and actor nominality, can go a long way towards grounding these analyses closer to the practical needs of decision-makers.

4 Transparency and a Data-Driven Opportunity to Provide Decision-Relevant Information on Trade–Land-Use Telecouplings

In this chapter, we have argued for the research community to adopt and invest in a more granular and data-driven approach to mapping and assessing global commodity trade as a basis for improving our understanding of trade and land-use telecouplings. Specifically, we argue that a focus on spatially explicit and actor-specific data, distinct from the dominant focus to date on national-level data and model-intensive methods, is essential for providing actionable information to support decisions in specific regions and for specific actors and sectors. Recent breakthroughs in the harnessing of hitherto poorly tapped data sources, including individual-shipment level trade data, as well as advances in methods for processing these and other linked data, open the door to exciting and important new research opportunities on trade-related telecouplings.

Underpinning these breakthroughs is an explosion of accessible, transparent information on how supply chains operate and the environmental and social risks and opportunities they pose (Gardner et al. 2018). Labelled by some as the "Information Age," the last few decades have given rise to an era where information transparency processes are increasingly capable of supporting entirely new modes of environmental governance (Mol 2015).

Changes in purchasing and investment practices of commodity buyers and financial institutions are driven by a multitude of interests and often contesting agendas that require compromises and trade-offs involving both private and public actors. Recent increases in supply chain transparency, the adoption of ambitious sustainability commitments by an increasing number of actors and the increased involvement of non-state actors have all contributed towards significant changes in the governance of commodity supply chains (Gardner et al. 2018; Lambin et al. 2018). Analyses to help unpick and reveal the roles played by specific downstream actors in shaping distant patterns of land use can help in facilitating both a shift towards more cooperative action, with hybrid governance arrangements and increased precompetitive collaboration among private companies, as well as a strengthening of top-down compliance (Egels-Zandén et al. 2015). Transparency as a means of cooperation can work by helping to equip actors with the information and tools they need to contribute effectively towards collective action problems, including by helping build coalitions of trusted actors who can reduce costs by working together (Boström et al. 2015). By contrast, transparency as a means of compliance works by way of threats. Threats—and associated repercussions—can come from downstream buyers who shift responsibility for improved practice standards to their upstream suppliers, from campaigning organisations seeking to expose unsustainable or illegal practices, or through surveillance operations by governments and voluntary accountability initiatives.

Acknowledgements We thank Ben Ayre, Trase data analyst at Global Canopy, for his support in producing some of the figures in this chapter.

References

Baffes, John, Alain N. Kabundi, Peter S. O. Nagle, and Franziska L. Ohnsorge. 2018. The Role of Major Emerging Markets in Global Commodity Demand. *Policy Research Working Paper 8495*. Development Prospects Group. Washington, DC: The World Bank.

Boström, Magnus, Anna M. Jönsson, Stewart Lockie, Arthur P.J. Mol, and Peter Oosterveer. 2015. Sustainable and Responsible Supply Chain Governance: Challenges and Opportunities. *Journal of Cleaner Production* 107: 1–7. https://doi.org/10.1016/j.jclepro.2014.11.050.

Brandi, Clara A. 2017. Sustainability Standards and Sustainable Development—Synergies and Trade-Offs of Transnational Governance. *Sustainable Development* 25 (1): 25–34. https://doi.org/10.1002/sd.1639.

Bruckner, Martin, Günther Fischer, Sylvia Tramberend, and Stefan Giljum. 2015. Measuring Telecouplings in the Global Land System: A Review and Comparative Evaluation of Land Footprint Accounting Methods. *Ecological Economics* 114: 11–21. https://doi.org/10.1016/j.ecolecon.2015.03.008.

Bryceson, Deborah F. 2002. The Scramble in Africa: Reorienting Rural Livelihoods. *World Development* 30 (5): 725–739. https://doi.org/10.1016/S0305-750X(02)00006-2.

Clapp, Jennifer. 2015. Food Security and International Trade: Unpacking Disputed Narratives. The State of Agricultural Commodity Markets 2015–16. *Background Paper*. Food and Agriculture Organization of the United Nations. Rome: FAO.

Corong, Erwin, Thomas W. Hertel, Robert McDougall, Marinos E. Tsigas, and Dominique van der Mensbrugghe. 2017. The Standard GTAP Model, Version 7. *Journal of Global Economic Analysis* 2 (1): 1–119. https://doi.org/10.21642/JGEA.020101AF.

Da Silva, Ramon, Mateus Batistella, Yue Dou, Emilio Moran, Sara McMillan Torres, and Jianguo Liu. 2017. The Sino-Brazilian Telecoupled Soybean System and Cascading Effects for the Exporting Country. *Land* 6 (3): 53. https://doi.org/10.3390/land6030053.

Egels-Zandén, Niklas, Kajsa Hulthén, and Gabriella Wulff. 2015. Trade-Offs in Supply Chain Transparency: The Case of Nudie Jeans Co. *Journal of Cleaner Production* 107: 95–104. https://doi.org/10.1016/j.jclepro.2014.04.074.

FAO. 2003. *Trade Reforms and Food Security: Conceptualizing the Linkages*. Food and Agriculture Organization of the United Nations. Rome: FAO.

FAOSTAT. 2018. *FAOSTAT Data*. Rome: Food and Agriculture Organization of the United Nations. Accessed July 2018. http://faostat3.fao.org/.

Flach, Rafaela, Ylva Ran, Javier Godar, Louise Karlberg, and Clement Suavet. 2016. Towards More Spatially Explicit Assessments of Virtual Water Flows: Linking Local Water Use and Scarcity to Global Demand of Brazilian Farming Commodities. *Environmental Research Letters* 11 (7): 075003. https://doi.org/10.1088/1748-9326/11/7/075003.

Futures Magazine. 2010. NYSE Sees Manipulation in Cocoa Markets, September 1. http://www.futuresmag.com/2010/08/31/nyse-sees-manipulation-cocoa-markets.

Galaz, Victor, Johan Gars, Fredrik Moberg, Björn Nykvist, and Cecilia Repinski. 2015. Why Ecologists Should Care about Financial Markets. *Trends in Ecology and Evolution* 30 (10): 571–580. https://doi.org/10.1016/j.tree.2015.06.015.

Gamso, Jonas. 2017. Trade Partnerships and Environmental Performance in Developing Countries. *The Journal of Environment & Development* 26 (4): 375–399. https://doi.org/10.1177/1070496517729727.

Gardner, Toby A., Magnus Benzie, Jan Börner, Elena Dawkins, Stephen Fick, Rachael Garrett, Javier Godar, A. Grimard, S. Lake, R.K. Larsen, N. Mardas, C.L. McDermott, P. Meyfroidt, M. Osbeck, M. Persson, T. Sembres, C. Suavet, B. Strassburg, A. Trevisan, C. West, and P. Wolvekamp. 2018. Transparency and Sustainability in Global Commodity Supply Chains. *World Development*. https://doi.org/10.1016/j.worlddev.2018.05.025.

Garrett, Rachael D., Ximena Rueda, and Eric F. Lambin. 2013. Globalization's Unexpected Impact on Soybean Production in South America: Linkages between Preferences for Non-Genetically Modified Crops, Eco-Certifications, and Land Use. *Environmental Research Letters* 8 (4): 044055. https://doi.org/10.1088/1748-9326/8/4/044055.

Gereffi, Gary, and Joonkoo Lee. 2012. Why the World Suddenly Cares about Global Supply Chains. *Journal of Supply Chain Management* 48 (3): 24–32. https://doi.org/10.1111/j.1745-493X.2012.03271.x.

Godar, Javier, U. Martin Persson, E. Jorge Tizado, and Patrick Meyfroidt. 2015. Towards More Accurate and Policy Relevant Footprint Analyses: Tracing Fine-Scale Socio-environmental Impacts of Production to Consumption. *Ecological Economics* 112: 25–35. https://doi.org/10.1016/j.ecolecon.2015.02.003.

Godar, Javier, Clément Suavet, Toby A. Gardner, Elena Dawkins, and Patrick Meyfroidt. 2016. Balancing Detail and Scale in Assessing Transparency to Improve the Governance of Agricultural Commodity Supply Chains. *Environmental Research Letters* 11 (3): 035015. https://doi.org/10.1088/1748-9326/11/3/035015.

IDE-JETRO and World Trade Organization. 2011. *Trade Patterns and Global Value Chains in East Asia: From Trade in Goods to Trade in Tasks*. Geneva: World Trade Organization.

IPBES. 2018. *The Assessment Report on Land Degradation and Restoration*. Intergovernmental Platform on Biodiversity and Ecosystem Services. Bonn: IPBES Secretariat.

Kaimowitz, David, Benoit Mertens, Sven Wunder, and Pablo Pacheco. 2004. *Hamburger Connection Fuels Amazon Destruction*. Bogor: Center for International Forestry Research.

Kastner, Thomas, Michael Kastner, and Sanderine Nonhebel. 2011. Tracing Distant Environmental Impacts of Agricultural Products from a Consumer Perspective. *Ecological Economics* 70 (6): 1032–1040. https://doi.org/10.1016/J.ECOLECON.2011.01.012.

Keys, Patrick W., Lan Wang-Erlandsson, Line J. Gordon, Victor Galaz, and Jonas Ebbesson. 2017. Approaching Moisture Recycling Governance. *Global Environmental Change* 45: 15–23. https://doi.org/10.1016/J.GLOENVCHA.2017.04.007.

Khanna, Madhu, and Christine L. Crago. 2012. Measuring Indirect Land Use Change with Biofuels: Implications for Policy. *Annual Review of Resource Economics* 4 (1): 161–184. https://doi.org/10.1146/annurev-resource-110811-114523.

Klingler, Michael, Peter D. Richards, and Roman Ossner. 2018. Cattle Vaccination Records Question the Impact of Recent Zero-Deforestation Agreements in the Amazon. *Regional Environmental Change* 18 (1): 33–46.

Kwok, Roberta. 2018. Ecology's Remote-Sensing Revolution. *Nature* 556 (7699): 137–138. https://doi.org/10.1038/d41586-018-03924-9.

Lambin, Eric F., Holly K. Gibbs, Robert Heilmayr, Kimberly M. Carlson, Leonardo C. Fleck, Rachael D. Garrett, Yann le Polain de Waroux, Constance L. McDermott, David McLaughlin, Peter Newton, Christoph Nolte, Pablo Pacheco, Lisa L. Rausch, Charlotte Streck, Tannis Thorlakson, and Nathalie F. Walker. 2018. The Role of Supply-Chain Initiatives in Reducing Deforestation. *Nature Climate Change* 8: 109–116. https://doi.org/10.1038/s41558-017-0061-1.

Lambin, Eric F., and Patrick Meyfroidt. 2010. Land Use Transitions: Socio-Ecological Feedback Versus Socio-Economic Change. *Land Use Policy* 27 (2): 108–118. https://doi.org/10.1016/j.landusepol.2009.09.003.

Lambin, Eric F., Billie Turner, Helmut J. Geist, Samuel B. Agbola, Arild Angelsen, John Bruce, Oliver T. Coomes, Rodolfo Dirzo, Günther Fischer, Carl Folke, P.S. George, Katherine Homewood, Jacques Imbernon, Rik Leemans, Xiubin Li, Emilio F. Moran, Michael Mortimore, P.S. Ramakrishnan, John F. Richards, Helle Skånes, Will Steffen, Glenn D. Stone, Uno Svedin, Tom A. Veldkamp, Coleen Vogel, and Jianchu Xu. 2001. The Causes of Land-Use and Land-Cover Change: Moving Beyond the Myths. *Global Environmental Change* 11 (4): 261–269. https://doi.org/10.1016/S0959-3780(01)00007-3.

Lapola, David M., Ruediger Schaldach, Joseph Alcamo, Alberte Bondeau, Jennifer Koch, Christina Koelking, and Joerg A. Priess. 2010. Indirect Land-Use Changes Can Overcome Carbon Savings from Biofuels in Brazil. *Proceedings of the National Academy of Sciences* 107 (8): 3388–3393. https://doi.org/10.1073/pnas.0907318107.

Liu, Jianguo, Vanessa Hull, Mateus Batistella, Ruth DeFries, Thomas Dietz, Feng Fu, Thomas W. Hertel, R. Cesar Izaurralde, Eric F. Lambin, Shuxin Li, Luiz A. Martinelli, William J. McConnell, Emilio F. Moran, Rosamond Naylor, Zhiyun Ouyang, Karen R. Polenske, Anette Reenberg, Gilberto de Miranda Rocha, Cynthia S. Simmons, Peter H. Verburg, Peter M. Vitousek, Fusuo Zhang, and Chunquan Zhu. 2013. Framing Sustainability in a Telecoupled World. *Ecology and Society* 18 (2): 26. https://doi.org/10.5751/ES-05873-180226.

Liu, Jianguo, Harold Mooney, Vanessa Hull, Steven J. Davis, Joanne Gaskell, Thomas Hertel, Jane Lubchenco, Karen C. Seto, Peter Gleick, Claire Kremen, and Shuxin Li. 2015. Systems Integration for Global Sustainability. *Science* 347 (6225): 1258832. https://doi.org/10.1126/science.1258832.

Reuters, by Josephine Mason. 2018. The Fallout in Commodities from the U.S.-China Trade War: What's at Stake. *Reuters Business News*, July 6. https://www.reuters.com/article/us-usa-trade-china-commodities-explainer/the-fall-out-in-commodities-from-the-u-s-china-trade-war-whats-at-stake-idUSKBN1JW15Y.

McCarthy, John F. 2010. Processes of Inclusion and Adverse Incorporation: Oil Palm and Agrarian Change in Sumatra, Indonesia. *The Journal of Peasant Studies* 37 (4): 821–850. https://doi.org/10.1080/03066150.2010.512460.

Millington, James, Hang Xiong, Steve Peterson, and Jeremy Woods. 2017. Integrating Modelling Approaches for Understanding Telecoupling: Global

Food Trade and Local Land Use. *Land* 6 (3): 56. https://doi.org/10.3390/land6030056.

Mol, Arthur P.J. 2015. Transparency and Value Chain Sustainability. *Journal of Cleaner Production* 107: 154–161. https://doi.org/10.1016/j.jclepro.2013.11.012.

Patel, Jugal K., and Henry Fountain. 2017. As Arctic Ice Vanishes, New Shipping Routes Open. *New York Times*, May 3. https://www.nytimes.com/interactive/2017/05/03/science/earth/arctic-shipping.html.

Pokorny, Benno. 2013. *Smallholders, Forest Management and Rural Development in the Amazon*. Oxfordshire: Earthscan Forest Library/Routledge.

Rudel, Thomas K. 2007. Changing Agents of Deforestation: From State-Initiated to Enterprise Driven Processes, 1970–2000. *Land Use Policy* 24 (1): 35–41. https://doi.org/10.1016/j.landusepol.2005.11.004.

Rudel, Thomas K., Ruth Defries, Gregory P. Asner, and William F. Laurance. 2009. Changing Drivers of Deforestation and New Opportunities for Conservation. *Conservation Biology* 23 (6): 1396–1305. https://doi.org/10.1111/j.1523-1739.2009.01332.x.

Schierhorn, Florian, Patrick Meyfroidt, Thomas Kastner, Tobias Kuemmerle, Alexander V. Prishchepov, and Daniel Müller. 2016. The Dynamics of Beef Trade between Brazil and Russia and Their Environmental Implications. *Global Food Security* 11: 84–92. https://doi.org/10.1016/j.gfs.2016.08.001.

Schim van der Loeff, Wendela, Javier Godar, and Vishnu Prakash. 2018. A Spatially Explicit Data-Driven Approach to Calculating Commodity-Specific Shipping Emissions per Vessel. *Journal of Cleaner Production* 205: 895–908. https://doi.org/10.1016/j.jclepro.2018.09.053.

Scholtens, Bert. 2017. Why Finance Should Care about Ecology. *Trends in Ecology and Evolution* 32 (7): 500–505. https://doi.org/10.1016/j.tree.2017.03.013.

Srinivasan, U. Thara, Susan P. Carey, Eric Hallstein, Paul A.T. Higgins, Amber C. Kerr, Laura E. Koteen, Adam B. Smith, Reg Watson, John Harte, and Richard B. Norgaard. 2008. The Debt of Nations and the Distribution of Ecological Impacts from Human Activities. *Proceedings of the National Academy of Sciences* 105 (5): 1768–1773. https://doi.org/10.1073/pnas.0709562104.

Stadler, Konstantin, Richard Wood, Tatyana Bulavskaya, Carl-Johan Södersten, Moana Simas, Sarah Schmidt, Arkaitz Usubiaga, José Acosta-Fernández, Jeroen Kuenen, Martin Bruckner, Stefan Giljum, Stephan Lutter, Stefano Merciai, Jannick H. Schmidt, Michaela C. Theurl, Christoph Plutzar, Thomas Kastner, Nina Eisenmenger, Karl-Heinz Erb, Arjan de Koning, and

Arnold Tukker. 2018. EXIOBASE 3: Developing a Time Series of Detailed Environmentally Extended Multi-Regional Input-Output Tables. *Journal of Industrial Ecology* 22 (3): 502–515. https://doi.org/10.1111/jiec.12715.

Tekdal, Veysel. 2018. China's Belt and Road Initiative: At the Crossroads of Challenges and Ambitions. *The Pacific Review* 31 (3): 373–390. https://doi.org/10.1080/09512748.2017.1391864.

Trase. 2017. *Supply Chain Mapping in Trase Summary of Data and Methods*. Last modified November 2. http://resources.trase.earth/documents/Trase_supply_chain_mapping_manual.pdf.

———. 2018a. *The Trase Yearbook 2018, Sustainability in Forest-Risk Supply Chains: Spotlight on Brazilian Soy*. Published online in June 2018. https://yearbook2018.trase.earth/.

———. 2018b. Exploring Brazilian Soy Supply Chains for the Amsterdam Declarations' Signatories. *Trase Infobrief 4*. http://resources.trase.earth/documents/infobriefs/Infobrief4En.pdf.

Varkkey, Helena. 2017. The Politics of Fires and Haze in Southeast Asia. In *Oxford Research Encyclopedia of Politics*. New York: Oxford University Press.

Weinzettel, J., Kjartan Steen-Olsen, Edgar G. Hertwich, Michael Borucke, and Alessandro Galli. 2014. Ecological Footprint of Nations: Comparison of Process Analysis, and Standard and Hybrid Multiregional Input–Output Analysis. *Ecological Economics* 101: 115–126. https://doi.org/10.1016/j.ecolecon.2014.02.020.

Wiedmann, Thomas O., Heinz Schandl, Manfred Lenzen, Daniel Moran, Sangwon Suh, James West, and Keiichiro Kanemoto. 2015. The Material Footprint of Nations. *Proceedings of the National Academy of Sciences* 112 (20): 6271–6276. https://doi.org/10.1073/pnas.1220362110.

Wright, G.D., K.P. Andersson, C.C. Gibson, and T.P. Evans. 2016. Decentralization Can Help Reduce Deforestation When User Groups Engage with Local Government. *Proceedings of the National Academy of Sciences of the United States of America* 113 (52): 14958–14963.

WTO. 2017. World Trade and GDP Growth in 2016 and Early 2017. In *World Trade Statistical Review*. (Chapter 3). Geneva: World Trade Organization.

Xiong, Hang, James D.A. Millington, and Wei Xu. 2018. Trade in the Telecoupling Framework: Evidence from the Metals Industry. *Ecology and Society* 23 (1): 11. https://doi.org/10.5751/ES-09864-230111.

Yao, Guolin, Thomas Hertel, and Farzad Taheripour. 2018. Economic Drivers of Telecoupling and Terrestrial Carbon Fluxes in the Global Soybean Complex. *Global Environmental Change* 50: 190–200. https://doi.org/10.1016/j.gloenvcha.2018.04.005.

9

Governance for Sustainability in Telecoupled Systems

Edward Challies, Jens Newig, and Andrea Lenschow

1 Introduction

There is widespread recognition among land change science and sustainability governance scholars that social-ecological systems (SESs) are fundamentally shaped through a variety of (often distant) drivers, interactions

E. Challies (✉)
Waterways Centre for Freshwater Management, University of Canterbury, Christchurch, New Zealand

Research Group Governance and Sustainability, Leuphana University of Lüneburg, Lüneburg, Germany
e-mail: edward.challies@canterbury.ac.nz

J. Newig
Research Group Governance and Sustainability, Leuphana University of Lüneburg, Lüneburg, Germany
e-mail: newig@uni.leuphana.de

A. Lenschow
Faculty of Social Science, Jean Monnet Chair for European Politics, Osnabrück University, Osnabrück, Germany

Jean Monnet Center of Excellence in European Studies, Osnabrück University, Osnabrück, Germany
e-mail: andrea.lenschow@uos.de

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_9

and influences. Local landscapes are produced to differing degrees by global flows and connections, and land-use change in one place may be triggered by social, economic or political shifts and processes elsewhere. The sustainability of land- and natural resource-based production systems in one place may be intimately linked to sustainability of systems in other regions and localities (Adger et al. 2009; Kissinger et al. 2011; Young et al. 2006). In many respects, this phenomenon, which is increasingly referred to by land change scientists as telecoupling (see Chaps. 2 and 3), arises out of the ongoing globalisation of trade and associated material and information flows—for example, in food, feed and fuel commodity chains—, as well as a more general intensification of interconnectedness and interdependence through global financial, trade, political and environmental institutions and regimes. Whereas globalisation as such refers to an overarching and often more diffuse set of interlinkages, the concept of telecoupling points to instances of *specific* interconnections between particular distal places or SESs (Challies et al. 2014). Telecoupling poses novel challenges for governance. As Eakin et al. (2014, 143) note, interaction between telecoupled systems "emerges essentially as an 'ungoverned' process, such that the indirect outcomes of the interaction often appear unexpected or 'surprising' because they lie outside the dominion of the existing governance arrangements". While existing governance structures and institutions may not be poised to address impacts of telecoupling, we suggest that these impacts do need to be addressed, and therefore it is important for governance research to engage with and theorise the phenomenon of telecoupling.

There is a rapidly growing body of empirical case studies of telecoupling exploring the implications of the phenomenon for sustainability at multiple scales (see Chap. 2). So far, however, there have been relatively few attempts to systematically examine the challenges that telecoupling presents for governance towards sustainability. In this chapter, we address governance challenges in the face of increasing global interconnectedness as theorised from a number of distinct but related perspectives. We begin by outlining the concepts of sustainability governance and telecoupling as employed in this chapter before exploring key dimensions of governance that we argue take on new importance in light of telecoupling. We then suggest some key challenges for sustainability governance in telecoupled systems and reflect on the need for further work in this emergent subfield of governance research.

2 Sustainability Governance and Telecoupling

Questions about the social and environmental sustainability implications of globalising flows and networks have long occupied scholars from different disciplines and in different fields. In this chapter, we focus on the challenges telecoupling poses in relation to governance for sustainability. Given the variety of definitions and understandings of these key terms, we first outline the way in which they are used here before turning to the dynamics connecting these concepts in Sect. 3.

We see *governance* as collective decision-making, involving different configurations of societal actors, with the aim of striking some form of socially acceptable balance among competing interests or stakes, or some equitable distribution of environmental 'goods' and 'bads'. In this, we follow the broad definition offered by Kooiman (2003, 4), who maintains that governance encompasses "the totality of interactions [...] aimed at solving societal problems, or creating societal opportunities; attending to the institutions as contexts for these governing interactions; and establishing a normative foundation for all those activities". Insofar as we are concerned with *governance for sustainability* (we use the term *sustainability governance* here interchangeably), we also follow Meadowcroft (2007, 299), who defines the concept as governance processes encompassing "public debate, political decision-making, policy formation and implementation, and complex interactions among public authorities, private business and civil society—*in so far as these relate to steering societal development along more sustainable lines*" (emphasis in original). We understand *sustainability* as a normative principle that advocates for a balance between environment and society and for intra- and intergenerational social equity.

We use the term *telecoupling* to describe the phenomenon whereby places are connected over distance via flows of materials, capital, information, organisms or people. Places are conceptualised as complex SESs (Challies et al. 2014), with boundaries that are to some extent delimited, but also porous and elastic—and essentially analytically constructed (Friis and Nielsen 2017). Flows linking 'sending' and 'receiving' systems are not necessarily singular or unidirectional, and feedbacks—often in the form of financial or informational flows—serve, to varying degrees, to shape and sustain interconnections (see Chap. 2). Furthermore, indirect or unintended effects of such flows may materialise in other places, which can be thought of as 'spillover' systems (Liu et al. 2018).

Empirically, telecoupling may cover a very broad range of flows and systems. A great deal of work framed in terms of telecoupling has come out of land change science, and many of the most widely studied cases involve high-profile flows of agricultural and primary commodities and natural resources, which are directly implicated in global land-use change and local-level environmental impacts. However, the systems of interest may vary in scale and type, and the notion of distance may be interpreted in terms of physical/geographic distance, but also potentially in terms of social and institutional dimensions of distance (Eakin et al. 2017). While the concept of telecoupling has been gaining ground as a framing for multi-disciplinary work on global flows and environmental change, research and theorising in terms of the governance dimensions have been relatively fragmented to date. In spite of this, there are several parallel (though largely disconnected) bodies of governance research that might usefully inform a governance perspective on telecoupling.

Established work on transboundary and global environmental governance (Biermann and Pattberg 2012; Balsiger and Prys 2016) illuminates a variety of emergent approaches to governance beyond the state and explores the governance challenges posed by processes and interactions that increasingly escape or transcend nation-state borders. While this literature examines governance innovations across multiple levels (global, regional, national and subnational), it generally does not take a sufficiently specific view to speak to particular instances of telecoupling, with their specific interconnectivities, yet often disjointed, asymmetric and largely non-transparent flows and associated impacts. The primary analytical focus of work in this field is on international or multilateral regimes and treaties, or cross-border institutions, as opposed to specific connections anchored in particular places. Work that has explicitly explored the scalar dimensions of environmental governance (see Newig and Moss 2017) has focused on the question of 'fit' between the scale of the problem to be governed on one hand, and the jurisdiction of governing authorities or the scope of governance arrangements on the other. While this literature has contributed important insights into the scaling (and rescaling) of governance, it has not specifically tackled the complex scalar governance challenges posed by telecoupling.

The literature on global chains and networks (in this we include global commodity chain, global value chain and global production network analyses) is centrally occupied with global interconnectivity and new interdependencies arising out of globalising production-consumption patterns (Bair 2009, see also Chaps. 5 and 6). Work in this broad field, which draws on economic geography, economic sociology and political economy, focuses on the structure and dynamics of chains and networks, primarily through analysis of governance in the sense of interfirm relations and coordination among lead firms and various subsidiaries and suppliers. Much of this has focused on how lead firms control production practices along their supply chains via application of private codes and standards. Notwithstanding conceptual work in the field, which has long acknowledged the importance of the wider institutional context within which chains are embedded and the influence of external governing actors, studies of chain governance have generally remained narrow in practice. Only relatively recently has work in the field begun to explore governance of and through chains and networks more broadly and systematically (e.g. Bolwig et al. 2010; Bush et al. 2015). With such contributions, the field may be opening up to more integrated perspectives on sustainability governance beyond interfirm coordination and private standards.

A wider body of multi-disciplinary work, addressing market-driven, transnational private and hybrid governance (Pattberg 2005; Cashore 2002), examines a broad range of governing agents and instruments implicated in contemporary sustainability governance. While this work is also interested in private codes and standards, it focuses largely on 'hybrid' modes of governance, such as multi-stakeholder platforms (e.g. roundtables and stewardship councils), labelling schemes and third-party standards and certification, which draw in private sector, civil society and government actors in various configurations. Although much of this work is framed in terms of a shift from 'government to governance' and the associated rise of private and non-state (corporate and civil society) governing actors (Mayer and Gereffi 2017), studies are increasingly (re) examining the role of the state in hybrid governance—particularly as limitations of market-based sustainability governance emerge (Challies 2013; Dauvergne and Lister 2012).

The approaches discussed above each make valuable contributions to understanding governance challenges emerging with the intensification of global interconnectivity or globalisation. However, governance is conceptualised differently across these bodies of work and the implications that telecoupling has for governance remain rather ambiguous. Insofar as the reviewed literature addresses sustainability governance, it is not clear whether governance in relation to telecoupling is to be understood as coordinating and maintaining global connections and flows (such as supply chains and production networks), or as regulating and addressing the social and environmental impacts of global flows (as seen in a wide range of public, private and hybrid governance initiatives). Furthermore, where the literature does examine governance responses to environmental problems, a distinction is apparent between locally contained (including transboundary) problems and global problems, but reference is generally not made to specific telecoupled constellations of relations among distal actors, regions and systems. We suggest that framing such research in terms of governance challenges of telecoupled SESs offers a potentially fruitful way to integrate research in this field and can add to recent efforts to address the issue of governance in and of globally telecoupled systems (see Challies et al. 2014; Eakin et al. 2017; Lenschow et al. 2016; Liu et al. 2018; Oberlack et al. 2018).

3 Dynamics of Governance in Telecoupled Systems

Following from the definitions of sustainability governance and telecoupling outlined in the previous section, this section discusses three dimensions of governance in telecoupled systems. While these dimensions are applicable to environmental governance in complex systems generally, we suggest that they take on new significance in the context of telecoupling and pose novel challenges for governance. Numerous forms of governance arrangements are currently in place, or are being discussed, to address the environmental externalities of telecoupling. These range from unilateral action (e.g. technological cooperation, financial aid, trade policy, mandatory product labelling, production standards) to multilateral agreements (e.g. on trade or environmental standards) and private and multi-stakeholder initiatives (e.g. roundtables, labelling, certification, sustainability standards and other means of chain governance) (Newig et al. 2018). Below, we examine the variety of actors implicated in governing, the multi-scalar and multi-level nature of sustainability problems, and the range of modes or forms that sustainability governance arrangements might take in telecoupled systems. These dimensions interrelate empirically, and may best be seen as analytical axes traversing the field of governance of telecoupled systems, which can aid in making sense of the range of governance challenges posed (discussed in Sect. 4).

3.1 Multiple Potential Governing Actors

Sustainability governance potentially embraces a wide array of societal actors and groups in the process of governing, as compared to government via formal institutions of the state. In particular, in the context of globalisation and global telecouplings, where networks and flows transcend the territories and jurisdictions of states, a wider range of non-state governing actors have emerged in response to what has been seen as a governance deficit. While governments have always relied to some extent on non-state actors in governing, private and civic sector actors are being increasingly drawn into the governance of human-environment interaction. In this sense, non-state actors (such as private firms) can be seen as objects *and* subjects of sustainability governance (Lövbrand and Stripple 2012). On the other hand, coalitions of private sector actors and civil society groups also seek to hold particular sectors to certain social and environmental standards, largely independent of governments. These trends have resulted in a blurring of the boundaries between the public and the private governing spheres globally as traditional roles and responsibilities shift. Non-state actors and entities are drawn into sustainability governance for different reasons and in a variety of capacities. For example, private firms have been 'enrolled' into governing tasks through neoliberalisation (e.g. via privatisation, contracting out, marketisation and financialisation processes). However, large firms have also actively sought to insert themselves within governance structures for a variety of strategic reasons, including the pursuit of competitiveness and social legitimacy. For example, firms engage in a wide variety self-regulatory practices such as corporate social responsibility (CSR) programmes, sustainable supply chain management, supplier codes and private standards and various forms of corporate environmentalism and philanthropy. Environmental non-governmental organisations (NGOs), like firms, have in some cases been incorporated into state agendas, and steered into roles akin to public service provision. However, environmental groups, along with a wide range of international civic and philanthropic organisations and social movements, have also successfully lobbied for a great deal of influence in the design of governance for sustainability. In some ways, such deterritorialised entities as transnational corporations and NGOs are better able to operate (and potentially govern) across telecoupled systems than governments due to their resources, reach and expertise.

In parallel with the developments described above, collaborative and voluntary multi-stakeholder initiatives have emerged as a novel, hybrid form of global sustainability governance. These pool resources and expertise of diverse private, civic and (albeit less frequently) public sector groups to negotiate, design and promulgate voluntary standards, rules, codes and norms for the governance of certain industries or sectors (Busch 2010; Ponte and Daugbjerg 2015). Prominent examples include the private sustainability standards, roundtables and stewardship councils set up to govern global fisheries, palm oil, biofuels and forestry (e.g. Schouten and Glasbergen 2012). These platforms entail the negotiation of collectively binding rules and norms, and members comply in exchange for recognition via accreditation, certification and the right to label compliant products. These tools are therefore essentially market-driven (Cashore 2002), in that even where they incorporate government actors, they are driven primarily by non-state actors, and penalties for non-compliance (and rewards for compliance) are delivered by the market rather than the state (Busch 2010). Despite being described as multi-stakeholder fora, exactly who gets to participate is often tightly controlled and representativeness is sought through inclusion of large international environmental NGOs as advocates for the environment and communities. Exclusion of certain groups—particularly local NGOs and communities immediately affected by telecoupled relations—and questionable effectiveness in environmental terms are points of criticism. Conceptual work on the governance implications of telecoupling therefore needs to integrate perspectives of national and international politics (given the local effects of translocal flows), and it needs to bridge public and private (corporate and NGO) governance in order to address asymmetric power relations, deliberate or unintended gaps in transparency and shortcomings of legitimacy and accountability.

3.2 Dynamics of Spatial and Temporal Scale

The scalar aspects of sustainability governance have been widely studied. Most commonly invoked are classic cases of transboundary resource management and long-range pollution (Cash and Moser 2000). These kinds of problems pose obvious governance challenges for traditional territorial authorities and have in many cases motivated attempts to rescale governance institutions to align more with the scale of the issues at hand (Andonova and Mitchell 2010). This has occurred both as 'scaling-up' in attempts to find governance solutions for sustainability problems that escape the authority and capacities of single jurisdictions (e.g. international environmental regimes, multilateral institutions) and as 'scaling-down' under the assumption that local-level actors are better equipped to address certain localised problems.

However, in many respects, sustainability problems emerging in and across telecoupled systems pose a different kind of scalar challenge, in that the drivers of and solutions to problems may be spatially disconnected. In this sense, simply scaling up or down—in the sense of delegating authority to higher or lower level entities—is unlikely to be effective. Addressing the social and environmental impacts of telecoupling requires governance arrangements that fit with, and address, the specific actors and coupled SESs implicated in a specific telecoupling. Furthermore, sustainability governance in telecoupled systems must be scale-adaptive, given that the spatial and temporal extent of impacts may not be immediately apparent, and is also likely not static but dynamic and evolving (Liu et al. 2018). A telecoupling lens on interconnected sustainability problems implies a focus on flows, processes and relations spanning multiple scales (Sikor et al. 2013), rather than on any particular predefined scale as such.

Significant sustainability governance challenges therefore arise due to particular spatial interconnections. Insofar as telecouplings bind coupled social and ecological systems in particular places through financial and material flows, they create specific social and environmental interdependencies across space. It is in this sense that drivers of localised environmental problems are often described as stretching across spatial scales and that negative externalities of localised consumption are being 'exported' or 'globalised'. Governance responses to sustainability problems in telecoupled systems have emerged particularly from networked coalitions of governing actors via various private and multi-stakeholder efforts to govern global supply chains and production networks (as discussed above).

Temporal scales frame (relative) changes and continuities in human-environment interaction. Temporal scalar dynamics therefore also characterise important sustainability governance challenges in telecoupled systems. The SESs literature in particular has stressed the importance of different time scales to governance in coupled social and ecological systems, differentiating between short-, medium- and longer-term management strategies for different aspects of systems. This work draws on the distinction between 'fast' and 'slow' variables in SESs research (Carpenter et al. 2001), where the former are usually associated with social processes or human-induced change and disruption, while the latter refer generally to slower changes over biological, physical and even geological timescales.

Not only do telecoupled systems possess these traits, but because human-human and human-environment interactions are mediated by flows and processes over long distances, and between interdependent systems, lag-times and legacy effects play out differently than they might in localised coupled systems (Liu et al. 2018).

Because sustainability problems in telecoupled systems emerge and evolve dynamically and in response to multiple distal drivers, they may be difficult to anticipate and assess. Therefore, the speed and agility with which governance instruments and institutions can adapt and mobilise effective responses to unanticipated problems and effects is also relevant. As with fast and slow variables in ecosystems, different rates of change and response are evident in institutional settings. Certain changes (e.g. to personnel) may occur quickly, while organisational and cultural changes are usually gradual in comparison. Sudden introduction of new policies or instruments in one jurisdiction, for example, may confront quite durable and entrenched underlying structures and practices at the scale of a particular industry or economic sector (Meadowcroft 2002).

3.3 Multiple Potential Modes of Governance

From the discussion of governance actors and scales follow complex issues with regard to suitable modes of governance in addressing sustainability problems emerging from telecoupled relations. As governments, firms and civil society groups rarely possess the resources or capabilities to address complex telecoupled sustainability problems alone, governance arrangements tend to involve some degree of interaction and collaboration. Sustainability governance arrangements—particularly those oriented towards global or transnational issues—are thus often products of bargaining among multiple prospective governing actors. In the context of telecoupling, however, it is more likely that the actors implicated in a given sustainability problem are physically remote and largely unfamiliar with each other—quite possibly lacking any prior association or interaction. Significantly, these actors may be embedded in very different social, political, legal and cultural contexts, which may pose barriers to communication and cooperation in efforts to forge governance arrangements.

Furthermore, from a governance modes perspective, telecoupling implies a need to appreciate interaction of (sub)national with inter- and transnational governance formats. Whereas the former are typically state-dominated, the latter involve a wide variety of non-state actors, and modes of governance tend to be less authoritative and more collaborative.

In fact, to analyse the governance of telecoupled relations, we may use the heuristic of various types of policy instruments (modes), including legislation and regulation, economic and fiscal instruments, agreement- and incentive-based instruments, information- and communication-based instruments, as well as de facto and de jure standards of best practices (Le Galès 2011). These instruments vary in terms of the level of obligation imposed on their addressees, ranging from authoritative, legally binding instruments to soft instruments relying on voluntary behavioural change. Linked to this we distinguish three general mechanisms through which policy-makers might affect the behaviour of those they are seeking to govern: (a) they may be coerced to comply with regulation; (b) they may be incentivised to change their behaviour due to incentive effects of the regulation; and (c) they may learn, that is, redefine their interests based on new knowledge and subsequently adapt their behaviour. In addressing telecoupled situations, there is a need to consider the effectiveness of these instruments—or mixes of instruments—to address the features of disjointedness, asymmetry and non-transparency. In short, disjointedness highlights the limitations of authoritative rule beyond national boundaries. Asymmetric effects of governance tend to be related to power and diverse interest constellations, which are difficult to overcome in distant and heterogeneous contexts typical of telecoupled relations. Non-transparency of the flows connecting distant places may also make the usual information-based instruments, employed to raise awareness of unintended or poorly understood consequences, ineffective. The next section further elaborates on these challenges and highlights some governance designs that may help to address them.

4 Challenges for Legitimate and Effective Governance in Telecoupled Systems

In this section, we discuss some key challenges that telecoupling poses for legitimate and effective sustainability governance. Given the complexities of telecoupled issues on the one hand, and the relative recency of many efforts to address telecoupled phenomena, it is pertinent to examine the capacity of governance institutions to actually deliver in terms of sustainability, while also providing for accountable and legitimate decision making. In terms of who (which actors or groups of actors) can govern for sustainability in telecoupled systems, research must focus on the nature and scale of sustainability problems and the capability of various actors to effectively address these. If we are to identify to whom this task should fall, research will need to delve into questions of moral and legal responsibility in globally telecoupled systems and explore the legitimacy of public, private and hybrid modes of sustainability governance across scales. Of course, it is debatable whether global telecoupling can be truly sustainable, and whether attempts to govern telecoupling towards sustainability are viable. Certainly, some approaches seek to circumvent global flows and networks, calling for 'short' supply chains and local or alternative supply networks as a means to address social and environmental impacts. For the purposes of this chapter, however, we have assumed that telecoupling exists and produces sustainability problems that, we argue, need to be addressed.

Legitimacy and effectiveness are qualities against which governance interventions are commonly assessed. To a certain extent, these qualities are interrelated, as legitimacy can be generated in part through effectiveness, and effectiveness can in some ways hinge on the (perceived) legitimacy of a governance intervention or instrument. Telecoupling introduces some particular dynamics to the challenges of both legitimacy and effectiveness, as discussed below.[1]

Knowledge deficits. Telecoupled systems are often not obviously or visibly connected, and externalities and spillovers are therefore more likely to go undetected or unacknowledged as compared to local or transboundary issues. Chains of numerous actors spanning large distances and multiple jurisdictions in many cases thwart traceability, transparency and accountability. Where there is such a lack of knowledge or data on the drivers of environmental impacts, governance responses to telecoupling are likely to be limited to local measures. On the other hand, where telecoupled relations and flows are made explicit, and their implications known, there is at least potential for a rescaling of governance efforts and a degree of integration and cooperation across jurisdictions and sectors. To some extent knowledge deficits might be addressed by *informational governance* (Mol 2006) that makes use of information and communication technologies. Despite the considerable potential of these technologies, however, many barriers to transparency and accountability are not technical but rather social and political (Gardner et al. 2018). If more information and knowledge is to help govern telecoupling, it must be gathered and managed by legitimate entities in a transparent way, and research must explore how it might best be used to induce the changes required.

Divergent interests. Addressing telecoupled sustainability issues requires bilateral or multilateral cooperation over large distances. However, more than neighbouring territories, distant states and regions may lack shared interests or common objectives that would underpin such cooperation. Fundamental values may differ across geographical and cultural distance, and problem perceptions may differ due to rational considerations about the distribution of costs and benefits. Such divergent interests and priorities explain in part the limits of consumer-driven sustainability initiatives, which may prioritise issues that are not of primary concern in producing regions. Priorities and interests are unlikely to be easily (re) aligned in telecoupled systems. While collaborative multi-stakeholder arrangements (such as roundtables and stewardship councils) might have some potential in this regard, the legitimacy of such fora has been questioned, as has their ability to tackle more controversial issues (Mol 2016). Divergent interests, and the challenges of fostering recognition and empathy between telecoupled regions, therefore pose an important barrier to governance for sustainability.

High transaction costs. Cross-border cooperation tends to become less likely as transaction costs rise (Jager 2016). While a history of collaboration, and the resultant trust that is built up between collaborating parties, might reduce transaction costs, such a history is not necessarily likely between telecoupled territories or states. This may impede cooperation in the first instance, but may also hamper effective implementation if cooperation is established. Furthermore, a greater number of distal actors and jurisdictions further increase transaction costs of effective cooperation. Whereas 'global' environmental problems are typically addressed through established rule-making institutions, equivalent institutions do not already exist to address specific telecoupled issues. One reaction to this may be to focus more on unilateral (nation) state action. On the other hand, there may be ways in which established multilateral initiatives—including multi-stakeholder initiatives—can be reoriented to address telecoupled issues.

Weak legitimacy base. Many of the polycentric, multi-stakeholder modes of governance that have sought to address telecoupling have been questioned in terms of their legitimacy and accountability (Oosterveer 2018). Whereas national laws and international agreements rest on established sources of legitimacy, telecoupled issues present problems in this respect. Multi-stakeholder fora have proliferated as a mode of governance, but they typically lack the authority and legitimacy to take decisions that would address telecoupled sustainability issues. As a result, their membership tends to exclude those actors that are most strongly in favour of and opposed to strong environmental regulation. Private governance initiatives face even greater legitimacy challenges, as they are often weak in their procedural development, their implementation in practice and their reporting and auditing requirements. Overcoming some of these limitations may require closer linkages to state-based institutions with clearer mandates and decision-making authority (Lenschow et al. 2016)—either at the national or international level.

Policy incoherence and fragmentation. Arguably, effective environmental governance requires a degree of coherence among policies and institutions involved (May et al. 2006). This may pose particular challenges in telecoupled settings, where both vertical (in multi-level systems) and horizontal (across states and sectors) coherence may be limited. In addition, private and multi-stakeholder schemes targeting telecoupled systems are often highly fragmented, especially in sectors that have seen a rapid proliferation of competing initiatives, such as in the certification of biofuels (Schleifer 2013). While some suggest that "earth system governance" (Biermann et al. 2012) might overcome such fragmentation, it is not clear that this will be able to address specific telecouplings. Perhaps more viable would be engagement in the regulatory sphere of linked institutions such as international environmental agreements. Such 'orchestration' (Schleifer 2013) has been discussed for some time, but has not so far developed to a great extent.

The challenges outlined above intersect with the key dimensions of governance addressed in Sect. 3. The multiple, dispersed but interconnected *actors* implicated in telecoupled relations pursue a variety of objectives and the need to monitor their combined actions and responses poses a huge challenge for traceability and transparency in the governance of telecoupling. Governance must therefore grapple with the divergent interests and priorities, and the multiple roles, of numerous actors. The legitimacy of governance interventions, which are typically private or multi-stakeholder schemes, is therefore often found wanting, as these schemes are often controlled by northern interests and generally asymmetrical or unbalanced in terms of stakeholders represented. These tensions are illustrative of the question as to who should act to address sustainability issues in telecoupled systems—public governing actors, or private actors and individual consumers. Fundamental issues of *scale* are also evident in the challenges outlined—not least the question of whether states can or should govern beyond national borders. Apart from the seemingly unlikely scenario of an earth-system-scale governing authority, states might more heavily control and regulate transnational corporations, although a degree of international convergence in this direction would be required if it were to be effective. Finally, such dilemmas have important implications for the choice of appropriate *governance modes* and instruments. In the absence of a global governing authority, most tools available to address impacts of telecoupling are soft tools. While this is also the case for broadly 'global' sustainability issues, telecoupling produces specific problems associated with information gaps and asymmetries in the capabilities and institutional capacities of telecoupled regions or states, which potentially hamper effective governance.

5 Conclusion

It would seem that hybrid governance arrangements, engaging particular combinations of governing actors, might be required to govern for sustainability in globally telecoupled systems. Much recent and ongoing governance research contributes valuable insights on the promise and limits of novel modes of sustainability governance. However, while telecoupling as a phenomenon, like globalisation more generally, surely poses considerable challenges to states' legitimacy and effectiveness as governing agents, it also seems clear that voluntary private governance will not go far without the shadow of hierarchy. There is therefore a real need for research on sustainability governance in telecoupled systems to consider the full range of potential governance constellations and in particular interactions between public and private (state and non-state) actors and modes.

The task of governing telecoupling towards sustainability is complex, and the effectiveness of any given governance intervention will be difficult to determine as particular telecouplings often produce spillovers in third systems, and governance interventions themselves can produce unintended displacement and leakage effects, inducing new unsustainabilities elsewhere. Given the multitude of actors and territories potentially incorporated within telecouplings, clear win-win sustainability solutions seem rather doubtful, and costs and benefits are more likely to be unevenly (re)distributed. Telecoupling research must continue to detail the emergent complexity of global flows and telecoupled systems, but it must also tackle increasingly pressing questions of governance for sustainability. In particular, attention should be paid to which actors and groups of actors are already engaged in efforts to govern telecoupled systems, to questions around the effectiveness and legitimacy (as well as unanticipated effects) of these governance efforts, and to leverage points for more effective and legitimate governance for sustainability.

Acknowledgements This chapter draws on work funded by the German Research Foundation (DFG) under grant no. CH 1643/2-1 through the project Governance of Environmental Sustainability in Telecoupled Systems of Global Inter-Regional Connectedness (GOVERNECT). The chapter has profited considerably from discussions with Benedetta Cotta and Almut Schilling-Vacaflor, and Sect. 4 draws on ongoing work co-authored with these colleagues (see Newig et al. 2018).

Note

1. This part draws significantly on a more comprehensive discussion in Newig et al. (2018).

References

Adger, W. Neil, Hallie Eakin, and Alexandra Winkels. 2009. Nested and Teleconnected Vulnerabilities to Environmental Change. *Frontiers in Ecology and the Environment* 7 (3): 150–157.

Andonova, Liliana B., and Ronald B. Mitchell. 2010. The Rescaling of Global Environmental Politics. *Annual Review of Environment and Resources* 35 (1): 255–282.

Bair, Jennifer. 2009. Global Commodity Chains: Genealogy and Review. In *Frontiers of Commodity Chain Research*, ed. Jennifer Bair, 1–34. Stanford, CA: Stanford University Press.

Balsiger, Jörg, and Miriam Prys. 2016. Regional Agreements in International Environmental Politics. *International Environmental Agreements* 16 (2): 239–260.

Biermann, Frank, Kenneth Abbott, Steinar Andresen, Karin Bäckstrand, Steven Bernstein, Michele M. Betsill, Harriet Bulkeley, et al. 2012. Transforming Governance and Institutions for Global Sustainability: Key Insights from the Earth System Governance Project. *Current Opinion in Environmental Sustainability* 4 (1): 51–60.

Biermann, Frank, and Philipp Pattberg, eds. 2012. *Global Environmental Governance Reconsidered*. Cambridge, MA: The MIT Press.

Bolwig, Simon, Stefano Ponte, Andries Du Toit, Lone Riisgaard, and Niels Halberg. 2010. Integrating Poverty and Environmental Concerns into Value-Chain Analysis: A Conceptual Framework. *Development Policy Review* 28 (2): 173–194.

Busch, Lawrence. 2010. Standards, Law and Governance. *Journal of Rural Social Sciences* 25 (3): 56–78.

Bush, Simon R., Peter Oosterveer, Megan Bailey, and Arthur P.J. Mol. 2015. Sustainability Governance of Chains and Networks: A Review and Future Outlook. *Journal of Cleaner Production* 107: 8–19.

Carpenter, Steve, Brian Walker, J. Marty Anderies, and Nick Abel. 2001. From Metaphor to Measurement: Resilience of What to What? *Ecosystems* 4 (8): 765–781.

Cash, David W., and Susanne C. Moser. 2000. Linking Global and Local Scales: Designing Dynamic Assessment and Management Processes. *Global Environmental Change* 10 (2): 109–120.

Cashore, Benjamin. 2002. Legitimacy and the Privatization of Environmental Governance: How Non-State Market-Driven (NSMD) Governance Systems Gain Rule-Making Authority. *Governance* 15 (4): 503–529.

Challies, Edward. 2013. The Limits to Voluntary Private Social Standards in Global Agri-Food System Governance. *International Journal of Sociology of Agriculture and Food* 20 (2): 175–195.

Challies, Edward, Jens Newig, and Andrea Lenschow. 2014. What Role for Social-Ecological Systems Research in Governing Global Teleconnections? *Global Environmental Change* 27: 32–40.

Dauvergne, Peter, and Jane Lister. 2012. Big Brand Sustainability: Governance Prospects and Environmental Limits. *Global Environmental Change* 22 (1): 36–45.

Eakin, Hallie, Ruth DeFries, Suzi Kerr, Eric F. Lambin, Jianguo Liu, Peter J. Marcotullio, Peter Messerli, Anette Reenberg, Ximena Rueda, Simon R. Swaffled, Birka Wicke, and Karl Zimmerer. 2014. Significance of Telecoupling for Exploration of Land-Use Change. In *Rethinking Global Land Use in an Urban Era*, ed. Karen Seto and Anette Reenberg, 141–161. Cambridge, MA: The MIT Press.

Eakin, Hallie, Ximena Rueda, and Ashwina Mahanti. 2017. Transforming Governance in Telecoupled Food Systems. *Ecology and Society* 22 (4): 32. https://doi.org/10.5751/ES-09831-220432.

Friis, Cecilie, and Jonas Ø. Nielsen. 2017. On the System: Boundary Choices, Implications, and Solutions in Telecoupling Land Use Change Research. *Sustainability* 9 (6): 974.

Gardner, Toby A., Magnus Benzie, Jan Börner, Elena Dawkins, Stephen Fick, Rachael Garrett, Javier Godar, et al. 2018. Transparency and Sustainability in Global Commodity Supply Chains. *World Development*. https://doi.org/10.1016/j.worlddev.2018.05.025

Jager, Nicolas W. 2016. Transboundary Cooperation in European Water Governance: A Set-Theoretic Analysis of International River Basins. *Environmental Policy and Governance* 26 (4): 278–291.

Kissinger, Meidad, William E. Rees, and Vanessa Timmer. 2011. Interregional Sustainability: Governance and Policy in an Ecologically Interdependent World. *Environmental Science & Policy* 14 (8): 965–976.

Kooiman, Jan. 2003. *Governing as Governance*. London: Sage.

Le Galès, Patrick. 2011. Policy Instruments and Governance. In *The SAGE Handbook of Governance*, ed. Mark Bevir, 142–159. London: Sage.

Lenschow, Andrea, Jens Newig, and Edward Challies. 2016. Globalization's Limits to the Environmental State? Integrating Telecoupling into Global Environmental Governance. *Environmental Politics* 25 (1): 136–159.

Liu, Jianguo, Yue Dou, Mateus Batistella, Edward Challies, Thomas Connor, Cecilie Friis, James D.A. Millington, et al. 2018. Spillover Systems in a Telecoupled Anthropocene: Typology, Methods, and Governance for Global Sustainability. *Current Opinion in Environmental Sustainability* 33: 58–69.

Lövbrand, Eva, and Jannes Stripple. 2012. Disrupting the Public-Private Distinction: Excavating the Government of Carbon Markets Post-Copenhagen. *Environment and Planning C* 30 (4): 658–674.

May, Peter J., Joshua Sapotichne, and Samuel Workman. 2006. Policy Coherence and Policy Domains. *Policy Studies Journal* 34 (3): 381–403.

Mayer, Frederick, and Gary Gereffi. 2017. Regulation and Economic Globalization: Prospects and Limits of Private Governance. *Business and Politics* 12 (3): 1–25.

Meadowcroft, James. 2002. Politics and Scale: Some Implications for Environmental Governance. *Landscape and Urban Planning* 61 (2): 169–179.

———. 2007. Who is in Charge Here? Governance for Sustainable Development in a Complex World. *Journal of Environmental Policy & Planning* 9 (3–4): 299–314.

Mol, Arthur P.J. 2006. Environmental Governance in the Information Age: The Emergence of Informational Governance. *Environment and Planning C: Government and Policy* 24 (4): 497–514.

———. 2016. The Environmental Nation State in Decline. *Environmental Politics* 25 (1): 48–68.

Newig, Jens, Andrea Lenschow, Edward Challies, Benedetta Cotta, and Almut Schilling-Vacaflor. 2018. Governing Global Telecoupling Towards Environmental Sustainability. A Conceptual Review. Paper presented at the *Earth Systems Governance Conference*, Utrecht, November 5–8, 2018.

Newig, Jens, and Timothy Moss. 2017. Scale in Environmental Governance: Moving from Concepts and Cases to Consolidation. *Journal of Environmental Policy & Planning* 19 (5): 473–479.

Oberlack, Christoph, Sébastien Boillat, Stefan Brönnimann, Jean-David Gerber, Andreas Heinimann, Chinwe Ifejika Speranza, Peter Messerli, Stephan Rist, and Urs Wiesmann. 2018. Polycentric Governance in Telecoupled Resource Systems. *Ecology and Society* 23 (1): 16. https://doi.org/10.5751/ES-09902-230116.

Oosterveer, Peter. 2018. Global Environmental Networks and Flows Addressing Global Environmental Change. In *Environment and Society: Concepts and Challenges*, ed. Magnus Boström and Debra J. Davidson, 95–118. Cham: Springer.

Pattberg, Philipp. 2005. The Institutionalization of Private Governance: How Business and Nonprofit Organizations Agree on Transnational Rules. *Governance* 18 (4): 589–610.

Ponte, Stefano, and Carsten Daugbjerg. 2015. Biofuel Sustainability and The Formation of Transnational Hybrid Governance. *Environmental Politics* 24 (1): 96–114.

Schleifer, Philip. 2013. Orchestrating Sustainability: The Case of European Union Biofuel Governance. *Regulation and Governance* 7 (4): 533–546.

Schouten, Greetje, and Pieter Glasbergen. 2012. Private Multi-Stakeholder Governance in the Agricultural Market Place: Analysis of Legitimization Processes of the Roundtables on Sustainable Palm Oil and Responsible Soy. *International Food and Agribusiness Management Review* 15: 63–88.

Sikor, Thomas, Graeme Auld, Anthony J. Bebbington, Tor A. Benjaminsen, Bradford S. Gentry, Carol Hunsberger, Anne-Marie Izac, et al. 2013. Global Land Governance: From Territory to Flow? *Current Opinion in Environmental Sustainability* 5 (5): 522–527.

Young, Oran R., Frans Berkhout, Gilbert C. Gallopin, Marco A. Janssen, Elinor Ostrom, and Sander van der Leeuw. 2006. The Globalization of Socio-Ecological Systems: An Agenda for Scientific Research. *Global Environmental Change* 16 (3): 304–316.

10

Toolbox: Operationalising Telecoupling with Network Analysis

Jonathan W. Seaquist and Emma Li Johansson

1 Introduction

Telecoupling implies that land change observed at a particular location can arise from drivers originating from large geographical distances. The implication is that spatial proximity cannot adequately account for the wide variety of patterns and processes of landcover change that give rise to, or emerge out of, economic, geopolitical, or cultural ties across the world (e.g. Bergmann and O'Sullivan 2018). For example, two countries that are widely separated in geographical space, such as the United States and China, would be considered direct neighbours in agricultural trading space because they share a direct trading relationship. A full explanation of the landcover changes observed in either location would therefore need to account for this long-distance trading relationship. This conceptual recasting of space from Cartesian to *relational* is powerful because it supports the establishment of an analytical framework that enables "big

J. W. Seaquist (✉) • E. L. Johansson
Department of Physical Geography and Ecosystem Science, Lund University, Lund, Sweden
e-mail: jonathan.seaquist@nateko.lu.se; emma.johansson@nateko.lu.se

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_10

data" sets to be mined for finding complex connections regardless of geographical distance across the Earth's surface, as well as for tracing and understanding how cross-system interactions might give rise to land system change in specific locations.

A network is defined as a collection of discrete objects, often called nodes or vertices, joined together in pairs by lines dubbed links or edges (Newman 2010). Figure 10.1 shows a number of nodes, labelled A–E, connected by links. Nodes could represent individual people, institutions, states, or regions, whilst links could potentially represent flows of information, energy, or embodied land via agricultural products. When many nodes are joined together they can be statistically analysed via network analysis, enabling complex interdependences between society and nature across landscapes, to be disentangled and directly understood (Bodin and Tengö 2012). Consequently, a strong interest has developed around how network analysis can advance telecoupling research from a land system's science perspective (Liu et al. 2013; Eakin et al. 2014). Such an operationalisation could potentially yield insights into how such a system drives, or is driven by, land use and land-use change (e.g. Seaquist et al. 2014).

Our goal with this toolbox is to provide a brief taste of how network analysis could be used to assist such an operationalisation of the telecoupling framework by means of local, global, and community metrics. Silk et al. (2017) maintain that *local metrics* define some property of a node in isolation from the rest of the network, whilst *global metrics* consider how

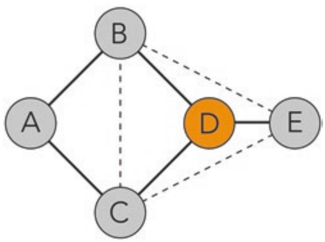


Fig. 10.1 Simple network representation consisting of nodes (labelled A to E) and links (lines connecting the nodes). Nodes can represent people, institutions, states, or governance structures, whilst links depict connections between the nodes in terms of material, people, energy, or information

nodes are indirectly connected across the network, thereby defining a property of the network as a whole. A global metric therefore incorporates some measure of network distance (e.g. the number of "hops" it takes to get to all other nodes in a network from a node of interest). Finally, *community metrics* are predicated on inspecting the connectivity status of those nodes that are neighbours (e.g. one hop away) from a node of interest. They fall between local and global metrics in terms of network scope considered (number of nodes that need to be visited for analysis). Community metrics flag nodes that have a greater number of connections with one another than with other nodes (Telesford et al. 2011).

2 Local Metrics

Local metrics define some property of a node in isolation from the rest of the network. It is local in the sense that only information in the vicinity of a target node is used for computing and evaluating the metric.

2.1 Degree Centrality

The greater number of links attached to a node, the more powerful or influential the node is. One obvious form of analysis is to simply count the number of links that are connected to each node. This metric is called degree centrality (Newman 2010). To illustrate, popular people (individuals with lots of friends) wield social capital, whilst the country with the highest number of trading partners possesses a large amount of economic clout.

The Trase initiative (Transparency for Sustainability Platform, www.trase.earth) implicitly uses a network structure to connect landscapes of production (and risks associated with production, for example, deforestation, worker's rights, greenhouse gas emissions) to far-flung sites of consumption by resolving intermediate supply chain actors such as exporters, ports, shippers, importers, and so on (Trase 2018). Inspired by Trase, node A in Fig. 10.1 might represent a soybean production site with two links, whilst nodes B and C might represent export firms (again, two links each), node D represents an import firm with three links, whilst node E with one link is a distributor in the location of consumption. The links might represent soy flows in terms of tonnage, financial transactions, contractual relationships, or any of these translated into instances of embedded deforestation. The large degree centrality associated with the import firm (node D) in Fig. 10.1 suggests that it might have a large impact on decisions taken by immediately neighbouring actors (nodes), and would therefore have a large influence on key decisions or behaviour of immediately surrounding nodes.

A histogram of the frequency distribution of degree centrality in large data sets can be inspected in order to identify and rank the activity levels of key nodes and can therefore be considered a macroscopic analysis of a network. It is well known that real-world networks are skewed, meaning the majority of nodes possess a small number of links whilst relatively few nodes possess a large number of links (Barabási and Albert 1999). Many nodes therefore show low connectivity, whilst relatively few nodes possess high connectivity. Nodes with high connectivity are called hubs. From a land system perspective, this presents an opportunity to focus on the role of highly connected nodes that drive or respond to environmental change around the globe, given the assumption that nodes with high connectivity are also powerful system drivers or sensitive responders (e.g. Lazarus 2014).

The example above could be expanded to include many sites of soy production, consumption, as well as all other intermediary agents at various tiers in order to provide a macroscopic-scale mapping of powerful actors in the network in order to support further analysis.

2.2 Adding Complexity

Additional levels of complexity can be built in to the network representation for computing more advanced metrics (Newman 2010). For example, links could be specified in terms of whether they enter or leave a node. To exemplify using land transaction data from the Land Matrix (landmatrix.org 2018), Fig. 10.2 shows that node D (Argentina) "receives" two links from nodes B and E (e.g. buys up land in Brazil and Bolivia, respectively), whilst node C "receives" a link "sent" from node D (China

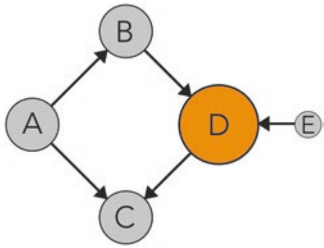


Fig. 10.2 Network representation consisting of nodes (labelled A to E) and links (arrows connecting the nodes). Nodes can represent people, institutions, states, or governance structures, whilst links depict the direction of flow of material, people, energy, or information between the nodes. Size of nodes is weighted according to the total number of links entering or leaving the node

buys up land in Argentina). Meanwhile, node A (Sudan) "sends" two links to nodes B and C (e.g. Sudan sells land to both Brazil and China). Here, node size is also scaled to total number of links associated with a node—the greater number of links, the larger the node. This directionality aspect dovetails with the idea of systems or subsystems acting as sending or receiving systems.

From a telecoupling perspective, if the links in Fig. 10.2 represent the flow of landownership, then the direction of the arrow signifies those nodes that act as sending systems (e.g. Sudan), receiving systems (e.g. China), or both receiving and sending systems simultaneously (Argentina and Brazil). But, if the links were to represent financial flows associated with land ownership as opposed to land ownership itself, the directionality of the links would be reversed. In this case, China would be a sending system as it sends financial capital to both Sudan and Argentina to purchase land. Moreover, the magnitudes of material, energy, or information associated with the links can be considered. For example, Fig. 10.3 weights link thickness in terms of the size of land area acquired. Here, the thickness of the link flowing from node B (Brazil) to node D (Argentina) is associated with a very large amount of land area. The size of nodes can also be scaled to represent this.

The concept of degree centrality can then be expanded to include directional (e.g. in-degree, out-degree) and magnitude (node strength) information, and frequency distributions analysed for large data sets.

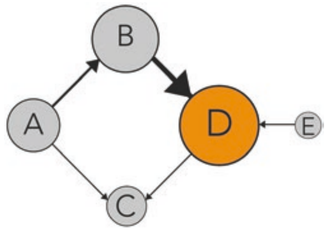


Fig. 10.3 Network representation consisting of nodes (labelled A to E) and links (arrows connecting the nodes). Nodes can represent people, institutions, states, or governance structures, whilst links depict the direction and magnitude of flow of material, people, energy, or information between the nodes. Size of nodes is weighted according to the flow magnitudes associated with the links

Again, different topologies would arise from contrasting choice of link attribute, direction, and magnitude. This could generate distinct understandings of system behaviour as it influences land transformation.

3 Global Metrics

Degree centrality (node connectivity) is a local indicator of node importance, as it depends only on the number of links that are attached to a node of interest. However, even far-flung system components (nodes) are indirectly connected, meaning that an event that affects one node may affect many other, if not all nodes in the system. Key to global metrics is the concept of *shortest path* (Newman 2010).

3.1 Betweenness Centrality

Betweenness centrality is a metric that describes the role that a particular node plays for ensuring that all other nodes are indirectly connected to one another in an unbroken sequence across a network (Konar et al. 2011). These "broker" nodes ensure that material, energy, or information can move from one end of the network to the other.

In the context of the soybean example (and referring to Fig. 10.1), node D represents a firm that imports soy products originating from a location undergoing rapid deforestation (node A). Mounting environmental awareness by consumers at the distribution site (node E) would then undermine the export firm's ability to conduct transactions with import firms (nodes B and C), resulting in an upstream disruption of the network, eventually leading to the shutdown of the production site at node A, therefore stopping deforestation. In the parlance of telecoupling, node A would be considered a spillover system (see Chaps. 2 and 3)—in this case nodes D and E. Node D, the import firm, is therefore a critical leverage point for influencing deforestation-related land-use impacts associated with the sourcing of soybeans. Although node D in Fig. 10.1 has the largest betweenness centrality as well as the largest degree centrality (they are often, but not always correlated), the two metrics have distinct definitions, interpretations, and implications.

Computationally, betweenness centrality counts the number of times a specific node is on the shortest path (minimum number of hops) between all other pairs of nodes in a network, divided by the total number of shortest paths between all nodes in the network, thereafter summing across the proportions (Newman 2010). In Fig. 10.1, it can be shown that 58% of the shortest paths between any two nodes pass through node D (see Seaquist et al. 2014, Supplementary material Part A for a worked example).

4 Community Metrics

A community implies that a subset of nodes forms dense connections amongst themselves and sparse connections with other nodes. Community metrics are predicated on counting the connectivity status of those nodes surrounding (or are connected to) a node of interest. They fall between local and global metrics in terms of network scope considered (number of nodes that need to be visited for analysis). Several such metrics exist but we profile the clustering coefficient, one of the most common.

4.1 Clustering Coefficient

"My friends are also each other's friends" is an easy way to envisage clustering. The presence of well-developed clustering structures has implications for network function. For example, node communities may provide a measure of protection to member nodes against external disturbance. If a node with high betweenness centrality were to experience a disruption, then the node communities could continue to function (e.g. continue to pass material, information, or energy between themselves) in isolation from the rest of the network.

Note that in Fig. 10.1, soybean import firm D's immediate neighbours (e.g. export firms B and C, as well as distributor E) are not connected to one another, so no clustering exists. However, if nodes B and C establish a link (see dashed line), then the number of connected node pairs that are also connected to node D is now 1. One-third of the potential total number of links between node D's neighbours have now been realised, and weak clustering has been established. But, if node pairs C–E and B–E were to establish links (see dashed lines), then strong clustering would be established. This would represent a situation where either the export firms (nodes B and C), the distributer (node E), or all in combination could take on the import function previously assumed by node E. In this case, the functioning of the network would be inoculated against targeted pressure from consumers, who would then be required to exert considerably more effort for preventing the flow of soybean products from landscapes undergoing deforestation.

Technically, the clustering coefficient is defined as the ratio between the number of links that exist between a node's immediate neighbours and the potential maximum number of links that could be found between those same neighbours (Newman 2010).

5 Perspectives

The land ownership example provided in Sect. 2.2 of this toolbox implicitly ascribes a place-based definition of system boundaries (e.g. the nation state as represented by a node). In many instances, this is a matter of convenience, as many widely available, "big data" sets (e.g. FAO data) are collated at this level of organisation. It is therefore a natural, subsequent step to analyse the data set as a network in order to tease out and understand their connectivity structures. The risk of an uncritical analysis, however, is that conventional notions of location and space are at least partially re-enforced in that nodes would be viewed simply as place-based "containers" that receive or send flows (Munroe et al. 2014). This does not fully capitalise on the potential for generating knowledge of land change drivers, as drivers might be nationless, ranging from individuals to multi/transnational arrangements, or policies.

One of the urgent requirements for telecoupling research is how to best delineate system boundaries in order to develop new understandings of how and why land is transformed (e.g. Friis and Nielsen 2017a). The ontology of the nation state as a place-based container cannot be taken for granted given the multiplicity of actors, not the least of which are firms that operate independently of the state at multiple levels and can span across geography (e.g. Seaquist et al. 2014). The soybean example (Sects. 2.1, 3.1, and 4.1) therefore shows how network analysis could be adapted and applied to a value chain that potentially drives land-use change by representing nodes with different functions in the same network. However, there is a dearth of adequate and transparent data on supply chains including cross-sector dependencies across multiple tiers (Brintrup and Ledwoch 2018). Machine learning and data mining techniques could conceivably be used to automate the collection of publically available data, and estimate node links, respectively. Alternatively, network representations could be constructed from using a case of observed land-use change as a springboard (Friis and Nielsen 2017b), followed by the identification nodes and links in consultation with local actors. Whatever the case it would be up to the telecoupling practitioner (perhaps together with other researchers and stakeholders) to decide the types of agents (nodes), flows (links), and functional levels (tiers) to include in their network maps an analyses. The same system could therefore be represented in multiple ways with distinct topologies (and thereby generating different understandings) depending on how the nodes (agents), links (flows), and functional levels (tiers) are selected. Including too much detail can mask important network properties, whilst including too little risks omitting important features that might aid in understanding land-use change drivers and mechanisms.

Importantly, network analysis also presents powerful opportunities for teasing out, distilling, and visualising latent patterns in big data sets. Not only would this support effective communication, but it would also define a critical exploratory step for hypothesis generation in order to support further quantitative analyses. In Trase, network visualisation has been used to discover rules for allocating socio-environmental indicators to specific actors (e.g. firms and countries). Moreover, in the way that the null hypothesis underlies inferential statistics, null models (random networks that match a real-world network in only some structural features) could be developed to test whether properties observed in real-world networks are meaningful or anomalous. Finally, the analysis of telecoupled systems at particular time slices in a sequence (dynamic network analysis) would lead to greater understanding of how particular telecoupled systems evolve and how they result in particular land change outcomes. Brintrup and Ledwoch (2018) discuss some of these issues in the context of network analysis applied to supply chains.

6 Conclusions

We have provided a brief, non-technical introduction to network analysis, and described, with some examples, how it could be applied in a telecoupling context. Eakin et al. (2014) lists several key questions that analytical approaches applied to telecoupled systems should be able to address, of which network analysis is a chief candidate amongst these. For example, identification of the key actors and their activities, influence, agencies, spillover effects, and leverage points can be facilitated by the measures of degree centrality (local metric) and in particular betweenness centrality (global metric). Clustering analysis (community metric) can shed light on the effects of advocacy or governance arrangements in which the various actors are embedded. Flows (both direct and indirect) and their associations can be represented and analysed at various levels of complexity (directed, weighted) in order to disentangle complex relationships between agents or sending and receiving systems. The effects of perturbations across systems due to social or natural causes can be probed by gauging (empirically or through simulation) changes in the resource status of specific actors, agents, or subsystems. Network representations would allow specific cases or collective modes of land system outcomes to be traced back (or forward) to specific drivers. In sum, network analysis has great potential for operationalising the telecoupling framework in order to test theories or provide substantial new understandings of land change and its drivers. Accomplishing this will require some pragmatic decisions about delineating system boundaries for defining nodes, as well as including an adequate level of detail in network representations.

Acknowledgements The authors are indebted to LUCID (Lund University Centre of Excellence for Integration of Social and Natural Dimensions of Sustainability) for partial support. LUCID is a Linnaeus Centre of Excellence at Lund University funded by the Swedish Research Council Formas (Grant 259-2008-1718).

References

Barabási, Albert-Lázló, and Réka Albert. 1999. Emergence of Scaling in Random Networks. *Science* 286 (5439): 509–512. https://doi.org/10.1126/science.286.5439.509.

Bergmann, Luke, and David O'Sullivan. 2018. Re-Imagining GIScience for Relational Spaces. *The Canadian Geographer* 62 (1): 7–17. https://doi.org/10.1111/cag.12405.

Bodin, Örjan, and Maria Tengö. 2012. Disentangling Intangible Socio-Ecological Systems. *Global Environmental Change* 22 (2): 430–439. https://doi.org/10.1016/j.gloenvcha.2012.01.005.

Brintrup, Alexandra M., and Anna Ledwoch. 2018. Supply Network Science: Emergence of a New Perspective on a Classical Field. *Chaos* 28 (3): 033120. https://doi.org/10.1063/1.5010766.

Eakin, Hallie, Ruth DeFries, Suzi Kerr, Eric F. Lambin, Jianguo Liu, Peter J. Marcotullio, Peter Messerli, Anette Reenberg, Ximena Rueda, Simon R. Swaffield, Birka Wicke, and Karl Zimmerer. 2014. Significance of Telecoupling for Exploration of Land-Use Change. In *Rethinking Global Land Use in an Urban Era*, ed. Karen C. Seto and Anette Reenberg, 141–162. Cambridge, MA: The MIT Press.

Friis, Cecilie, and Jonas Ø. Nielsen. 2017a. On the System. Boundary Choices, Implications and Solutions in Telecoupling Land Use Change Research. *Sustainability* 9 (6): 974. https://doi.org/10.3390/su9060974.

———. 2017b. Land Use Change in a Telecoupled World: The Relevance and Applicability of the Telecoupling Framework in the Case of Banana Plantation Expansion in Laos. *Ecology and Society* 22 (4): 30. https://doi.org/10.5751/ES-09480-220430.

Konar, Megan, Carole Dalin, Samir Suweis, Naota Hanasaki, Andrea Rinaldo, and Ignacio Rodriquez-Iturbe. 2011. Water for Food: The Global Virtual Water Trade Network. *Water Resources Research* 47: W05520. https://doi.org/10.1029/2010WR010307.

Landmatrix.org. 2018 Accessed August 31, 2018. https://landmatrix.org/en/get-the-idea/web-transnational-deals.

Lazarus, Eli D. 2014. Land Grabbing as a Driver of Environmental Change. *Area* 46 (1): 74–82. https://doi.org/10.1111/area.12072.

Liu, Jianguo, Vanessa Hull, Mateus Batistella, Ruth DeFries, Thomas Dietz, Feng Fu, Thomas W. Hertel, R. Cesar Izaurralde, Eric F. Lambin, Shuxin Li, Luiz A. Martinelli, William J. McConnell, Emilio F. Moran, Rosamond Naylor, Zhiyun Ouyang, Karen R. Polenske, Anette Reenberg, Gilberto de Miranda Rocha, Cynthia S. Simmons, Peter H. Verburg, Peter M. Vitousek, Fusuo Zhang, and Chunquan Zhu. 2013. Framing Sustainability in a Telecoupled World. *Ecology and Society* 18 (2): 26. https://doi.org/10.5751/ES-05873-180226.

Munroe, Darla K., Kendra McSweeney, Jeffrey L. Olson, and Becky Mansfield. 2014. Using Economic Geography to Re-Invigorate Land-Change Science. *Geoforum* 52: 12–21.

Newman, Mark E.J. 2010. *Networks: An Introduction*. New York: Oxford University Press.

Seaquist, Jonathan W., Emma L. Johansson, and Kimberly A. Nicholas. 2014. Architecture of the Global Land Acquisition System: Applying the Tools of Network Science to Identify Key Vulnerabilities. *Environmental Research Letters* 9 (11): 1–12. https://doi.org/10.1088/1748-9326/9/11/114006.

Silk, Matthew J., Darren P. Croft, Richard J. Delahay, David J. Hodgson, Mike Boots, Nicola Weber, and Robbie A. McDonald. 2017. Using Social Network Measures in Wildlife Disease Ecology, Epidemiology, and Management. *Bioscience* 67 (3): 245–257. https://doi.org/10.1093/biosci/biw175.

Telesford, Qawi K., Sean L. Simpson, Jonathan H. Burdette, Satoru Hayasaka, and Paul J. Laurienti. 2011. The Brain as a Complex System: Using Network Science as a Tool for Understanding the Brain. *Brain Connectivity* 1 (4): 295–308. https://doi.org/10.1089/brain.2011.0055.

Trase. 2018. *A Vision for Trase: 2016–2020*. Stockholm Environment Institute and Global Canopy Programme. Accessed August 30, 2018. http://resources.trase.earth/documents/Trase-vision-for-2020.pdf.

11

Environmental Justice in Telecoupling Research

Esteve Corbera, Louise Marie Busck-Lumholt, Finn Mempel, and Beatriz Rodríguez-Labajos

1 Introduction

In the 1980s, Vietnam was one of the few Asian countries involved in the global coffee market, but its contribution was minimal. However, by the late 1990s it had become the second largest producer and exporter of one of the most important coffee varieties (i.e. Robusta), after Brazil. Vietnam's coffee boom was accompanied by a rapid process of land-use change in the country's central highlands, particularly during the 1980s and 1990s. Originally populated by the indigenous K'ho peoples, the highlands were later colonised by the Vietnamese Kinh, who arrived in the region after

All authors have contributed equally to this chapter.

E. Corbera (✉) • L. M. Busck-Lumholt • F. Mempel • B. Rodríguez-Labajos
Institute of Environmental Science and Technology,
Universitat Autònoma de Barcelona (ICTA-UAB), Barcelona, Spain
e-mail: Esteve.Corbera@uab.cat; Louise.Lumholt@uab.cat;
Finn.Mempel@uab.cat; Beatriz.Rodriguez@uab.cat

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_11

the Vietnam War (1955–1975), incentivised by government economic reforms that subsidised agricultural expansion and export-oriented crops during the 1980s. This resulted in large-scale forest conversion, increasing soil erosion and water pollution, and a loss of access to land for the indigenous K'ho, thus benefitting the Kinh. Both the regional and national agrarian economies grew exponentially with rising levels of farmers' income, at the cost of indebtedness to intermediaries and financial institutions (Hardy 2003; De Koninck 2006). Vietnam's coffee boom also involved costs and benefits elsewhere. For example, an increased share of the world's coffee market buffered against the historical volatility of the crop's price, which is mostly determined by climatic shocks in producing countries. Conversely, an increased share of the global Robusta market also stimulated an increase of global competition, which, coupled with specific demographic and economic conditions, resulted in higher levels of poverty and abandonment of coffee cultivation elsewhere, for example, in Mexico (Eakin et al. 2009).

This case of changing patterns in coffee production and trade serves as a clear example of why justice matters in the study of telecoupled systems. In understanding the relationships between sending, receiving and spillover systems—through specific flows of coffee beans, money and information—and focusing on agents, causes and effects (see Chaps. 2 and 19), questions of justice inevitably come to the fore. For example, who has benefitted or lost the most from the changing geographies of the world's coffee market over the last three decades? Which flows of benefits across and within systems—for example coffee beans, land rights, farm income, money from trade—were derived or altered from such new geography and how have these benefits been distributed? Which environmental impacts have resulted from the expansion or contraction of coffee production, and who has borne them?

One could also ask: How are the terms of the coffee trade negotiated, and whose interests and views are ignored? Who should be involved in the design of strategic policy interventions to sustain rural livelihoods in Mexico, or to acknowledge and address the impacts of environmental change in Vietnam, both nationally and internationally? Which criteria and rules should govern these decision-making process? These are some questions related to issues of *participation*. When unravelling procedural aspects questions of *recognition* also emerge. For example, to what extent were the values and culture of various actors involved in land-use management and coffee planting recognised in the highlands' land-use change processes, or in the protection of the terms of exchange in Mexico's coffee trade?

These questions demonstrate that justice issues are important for telecoupling research, but as we will show below, they remain marginal in empirical analyses of telecoupled systems. To make telecoupling research more sensitive to justice issues, this chapter overviews the historical and theoretical foundations of environmental justice and suggests practical ways for telecoupling research to incorporate these foundations, whilst also identifying the challenges of doing so. We refer to environmental justice rather than to justice in general for three reasons. First, land- and resource-use dynamics are commonly found at the core of telecoupled systems, and such dynamics entail a (re-)distribution of property rights and environmental management approaches that can be considered by some actors unfair and detrimental to their well-being. Second, telecoupled systems usually result in environmental impacts that affect both humans and non-humans, across different spatial and temporal scales. These effects on well-being and ecosystems encourage social actors to seek compensation or to advocate for the restoration of formerly existing rights and environmental conditions. Third and finally, both environmental justice and telecoupling research deal with the management of and the interactions between coupled human-environment systems and the resulting effects of such processes, which make it possible to integrate both frameworks.

The remaining of this chapter is structured as follows. Section 2 reviews the origins of environmental justice thought and shows how it has over time transcended the study of *distribution* issues to now encompass the study of *recognition* and *participation* issues, at multiple scales and multiple contexts of environmental problems. Section 3 reviews empirical literature on telecoupled systems to illustrate how such literature has dealt with issues of distribution, recognition and participation. Section 4 sketches the analytical and practical challenges that the operationalisation of environmental justice in telecoupling research might involve. Section 5 concludes the chapter.

2 Environmental Justice: From Distribution to Recognition and Participation

In 1982, residents of Warren County, North Carolina, mobilised against the project of building a landfill for contaminated soils in their largely African-American community. The civil rights leader Benjamin Chavis coined the term "environmental racism" to describe the deliberate exposure of ethnic minority communities to environmental risks (Lazarus 2000). This event is often considered the origin of the environmental justice scholarship and activism (Fig. 11.1). Several studies later confirmed the disproportionately high number of toxic facilities in the United States (e.g. landfills, incinerators and industrial zones) located in areas with a majority of black, *latino* or other immigrant populations (Bullard 1994; Agyeman et al. 2003).

Environmental justice thus emerged as a social movement promoted by those affected by toxic facilities, led by social organisations and academics who mobilised concepts of social justice and equality in the access to a safe environment and the equal protection of all communities (Pulido 2017). In 1991, delegates from different grassroots movements adopted

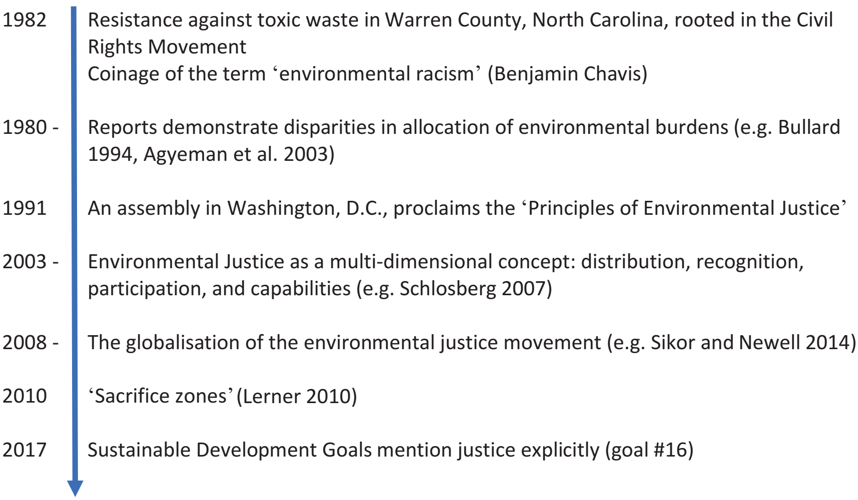


Fig. 11.1 Timeline of milestones in the recent history of environmental justice

17 "Principles of Environmental Justice" in Washington, D.C. This political agenda would progressively enter the environmental regulations and policies promoted by the US Environmental Protection Agency, which currently defines environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, colour, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies," where fair treatment means "no group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental and commercial operations or policies."[1]

Distribution has always been at the core of environmental justice scholarship and activism, yet both have evolved to incorporate other pillars of social justice in their analyses and demands, namely the recognition and participation of subjects of justice. By subjects of justice, we mean those who can make legitimate claims related to environmental and social harms in telecoupled systems and whose rights are taken into consideration in a given governance setting. These can include individuals, communities and even nature if an ecological justice perspective is also embraced. Ecological justice considers nature a moral entity for which the pillars of justice also apply (Baxter 2004; Schlosberg 2007).

Recognition appears important when the voice of those affected by a particular environmental or social outcome resulting from the (change in) management of land and natural resources is ignored, misrepresented or nullified, so it is not heard or recognised in decision-making processes (Martin et al. 2016). Indigenous communities, women or children are often found in lack of recognition. Lack of recognition can be linked to the ignorance of and disrespect for such groups' often exploited economic position, knowledge, language and claims by geographically, politically, economically and/or culturally distant actors and institutions (Fraser 1997). This is a major challenge in Africa, where approximately two-thirds of the recent global land grabs have taken place due to a lack of legal recognition of customary land rights (Kabia 2014).

A strategy to address the lack of recognition is to demand direct and meaningful participation in decision-making processes. Participation thus requires that the rules and criteria underpinning decision-making processes are not biased against specific groups or individuals and that these rules and criteria are both understood and perceived as legitimate by all participants. This request for participation, and fair and legitimate procedure, is frequent among community members or activists. However, today it remains rare; for instance, indigenous peoples participating directly in international institutions concerned with international trade or environmental governance, specifically in discussions over equitable benefit-sharing (De Jonge 2011). Where they do participate, their agency remains weak (Schroeder 2010).

Lack of recognition and participation can ultimately undermine the capabilities of those who are not being recognised as subjects of justice and thus are being excluded from decision-making processes. For example, if a large-scale deforestation process occurs on public or privately owned lands where indigenous peoples had customarily lived for years, and these peoples are not recognised as key affected actors and therefore unable to make decisions over the scale or the righteousness of the deforestation process, their food security, livelihoods, culture and well-being may be negatively impacted. If they did not find similar forests to live nearby, they might face the risk of disappearing, either figuratively or physically. This image is captured in Steve Lerner's (2010) portrayal of "sacrifice zones," where peoples from areas persistently exposed to environmental damage take action to try to avoid being forgotten.

Nowadays an increasing number of environmental and land-use related issues have been analysed through the lens of environmental justice, including mining, monoculture crops, water management, waste management, air pollution and public health. For example, the practice of biodiversity conservation in protected areas where indigenous peoples live should be sensitive to the fact that the economic benefits that protected areas generate for the affected local populations are often lower than the benefits derived from other activities, such as agriculture or logging. Inattentive conservation strategies may result in unequal development opportunities and spatial economic unfairness (Dawson and Martin 2015). Conservation practice also requires embracing the cultures and traditions of protected area inhabitants and to merge these with the scientific knowledge underpinning protected area management (Rodríguez et al. 2013). In rural China, villagers claim for their land rights to protect their livelihoods from government-driven land grabs, in a context of banned private ownership but increased land value (Grammaticas 2013). Pastoralists all around the world observe with despair how traditional tenure arrangements were disregarded in the global land acquisition rush (Elhadary and Abdelatti 2016), while indigenous peoples have been struggling for decades to recover their lands after they were seized for industrial and mining development initiatives (Overbeek et al. 2012). These examples illustrate that many environmental and land-use conflicts have distributive implications and reflect struggles over recognition and participation. The following section shows how the empirical literature on telecoupled systems has addressed matters of environmental justice to date.

3 Environmental Justice: Evidence from Telecoupling Literature

In order to identify to what extent empirical research on telecoupled systems has either explicitly integrated an environmental justice approach or implicitly engaged with the different conceptual dimensions of environmental justice, we searched for academic articles published until October 3, 2018. These were selected through Scopus, Web of Science, Google Scholar and Mendeley's catalogue of academic literature. Eighty-six academic articles were found by searching for "telecoupling" in either the article's title, abstract or keywords.

After reading the articles, we excluded those that only referred to telecoupling or telecouplings theoretically and did not use empirical findings from specific cases. Applying these criteria returned 48 journal articles, which were codified based on the following questions: (1) Does the article integrate justice in its analysis and, if so, how? (2) Does it address issues of distribution, recognition and/or participation and, if so, how? Additionally, data were collected regarding the type of methodology employed in the article. Finally, we reviewed if references were made to environmental impacts and/or whether the article embraced the notion of ecological justice more specifically (see digital repository[2]).

The reviewed articles ranged from local to global-scale analyses, dealing with anything from international trade in metals to ecosystem services provided by migratory species. Only three papers explicitly integrated justice into their analytical approach, while the rest referred to justice only implicitly: 35 articles used key terms related to distributive justice, while only 14 addressed recognition and 17 addressed participation. With respect to research methods, 25 of the reviewed papers were based only on quantitative data, three were only based on qualitative data, six used mixed methods and the remaining 14 were based on a review of documents and data sets, including peer-reviewed articles and grey literature. Purely quantitative papers did not address recognition and participation.

Table 11.1 presents keywords extracted from the reviewed articles, found to be associated with implicit accounts of environmental justice. These keywords were identified by scanning each article for words associated with distribution, recognition and participation concerns addressed in the article. We acknowledge that the words identified in Table 11.1 overlap between different dimensions of justice to some degree, which suggests that the various dimensions are often interlaced in the articles reviewed, and therefore cannot be entirely collapsed into each other. The table mirrors the many elements in existing empirical telecoupling research that can be addressed by environmental justice, thus representing the potential for integration.

An example in the use of keywords related to environmental justice approach is Eakin et al. (2017), who analyse food system governance and use terms such as “livelihood disruption,” “social exclusion,” “national food sovereignty” and “fair trade” (related, for example, to issues of distribution), “multi-stakeholder governance” and “asymmetries of influence” (related, for example, to issues of participation), and finally “accountability” and “human rights” (related, for example, to issues of recognition). Another example is Zimmerer et al. (2018), who identify the key challenges and opportunities faced by smallholders in telecoupled systems, and they implicitly address distribution with relation to “land grabbing” and “unfavourable terms of trade.” They also briefly refer to the “low capacity” to influence national and international economic policies and underscore the need to pay attention to “the needs and capacities of

Table 11.1 Keywords related to dimensions of justice in the reviewed articles

Distribution	Participation	Recognition
Fairness, winners, losers, hidden costs, economic equity, responsibilities, imbalances, displacement, access, livelihood, land grabbing, insufficient income, replacement, food insecurity, socio-economic well-being, dependencies, opportunities, unequally distributed, inequalities, compensation, food security, vulnerability, footprint, social exclusion, needs, poverty, social equity, concentrated, monopolisation, distribution, costs and benefits, positive and negative effects, land conflicts, health impacts, disadvantaging, asymmetries, disproportionally, privileged, marginalisation, externalisation, redistribute, advantageous, disadvantageous, unequal exchange, discrepancies, mismatches, unfavourable, marginal	Control, influence, hierarchy, multi-stakeholder, asymmetries, power distribution, ability, accountability, corruption, patron/client, agency, non-transparent, participation, exclusion, all-affected principle, deliberations, power-dynamics, collaborative, inequality, representation, voices, opportunities, consultation, illiteracy, inclusion, advocacy, dictate rules, fair, recourse, rights, dispositions	Cultural importance, (un)recognised, entitlement, identity, traditional livelihoods, cultural values, human rights, traditions, cultural norms, social status, symbolic meanings, place dependence, gender, customary rights, recognition, community, informal rights, attention

smallholders," which, in justice terminology, are issues that can be associated with participation and recognition respectively.

As noted above, only three of the 48 articles reviewed explicitly integrate telecoupling and justice in their analysis. Oberlack et al. (2018) integrate telecoupling with the concept of "network of action situations" to capture the dynamics of polycentric governance. They propose a framework to diagnose action situations, which depending on the given research objective potentially include elements of justice. They apply this framework to the case of a transnational biofuel investment in Sierra Leone and identify "increased inequalities within communities" as an analytical focal point (Oberlack et al. 2018, 7). Through this analytical interest they explicitly integrate the three dimensions of justice: distribution, participation and recognition. Six action situations are identified that affect community inequality and together make up the polycentric system. Zimmerer et al. (2018) draw on several case studies of smallholder telecouplings to identify challenges and opportunities for increased fairness. While not explicitly referring to the various dimensions of justice, they highlight the importance of addressing justice when studying the impacts of global socio-economic and environmental changes, since "environmental and social justice issues directly affect the majority of the world's smallholder populations" (Zimmerer et al. 2018, 12). Lastly, Schröter et al. (2018) use various examples to create a typology of interregional ecosystem flows. They establish a set of principles to guide governance arrangements for these flows, which are largely based on the three dimensions of justice: "equitable intra-generational distribution," "fair procedures" and "recognition" (Schröter et al. 2018, 238).

Many of the reviewed articles address the distribution of environmental benefits and burdens by analysing trade relationships. Their findings are closely related to the notion of "ecologically unequal exchange" (Hornborg and Martinez-Alier 2016). Xiong et al. (2018) use this term in their study of international trade in metals, in which they demonstrate that countries of the global North are frequently net importers of embedded emissions and net exporters of value added. Similarly, Kastner et al. (2015, 832) analyse land-use effects of the European Union's consumption of biomass products in terms of their embodied human appropriation of net primary production (eHANPP) and observe that "the EU benefits disproportionally in monetary terms from agricultural trade whereas ecological impacts of trade, in terms of eHANPP, occur to a disproportionately large share outside the EU." However, there are examples in the reviewed cases that demand close attention to the analysis of distributive mechanisms and outcomes to avoid falling easily for the narrative that importing countries necessarily shift environmental burdens to those exporting primary goods. For example, Sun et al. (2018) show that by importing large amounts of soybeans, China has shifted domestic cultivation from nitrogen-fixing soybeans to other crops that require large inputs of nitrogen fertiliser. This has led to increased nitrogen loads, which now threaten to intensify the pollution of the country's water bodies, soils and the atmosphere.

Conflicting views on distributive outcomes can be found depending on the analytical scale. Gasparri et al. (2016) describe the emerging soybean frontier in Southern Africa as an example of what they call "south-south telecouplings." The role of countries such as Brazil and Argentina in knowledge and technology transfers or infrastructural improvements for soy expansion in Southern Africa can be interpreted as a breaking up of core-periphery dynamics described in dependency theory, towards more multipolar constellations and therefore to a more equitable distribution of value extracted from global production processes among countries. Yet at the local scale, as mentioned by Gasparri et al. (2016), the soybean frontier in Southern Africa is likely to replicate similar dynamics of landownership concentration and conflict salient in the South American region.

While featured less frequently in the reviewed articles, issues of recognition and participation are also present in various publications. Bagstad et al. (2018, 5) estimate the ecosystem services provided by a migratory species at different locations and admit that their monetary estimate "does not address the cultural importance of pintail harvesting for indigenous communities." By treating the harvest of a migratory bird as a monetary equivalent of store-bought chicken, the methodology is not designed to account for the specific cultural value a given ecosystem service has for indigenous communities. Interestingly, the same issue of recognition that the authors address with respect to their own methodology is then also found in current policy-making: the authors observe that subsistence harvest "is currently unrecognised in harvest policy deliberations" (Bagstad et al. 2018, 7) due to its relatively minor monetary value compared to sports harvest.

Eakin et al. (2017) reflect on the importance of being sensitive to recognition and participation when devising governance mechanisms for telecoupled food systems. Discussing the case of maize production dynamics in Mexico and the United States, they argue that the deep cultural and symbolic significance of maize in Mexico has not been recognised in the governance arrangements after the implementation of the North American Free Trade Agreement. Specifically, the US farm and energy policy with its strong implications for corn prices in Mexico does not consider this cultural attachment, and Mexican smallholders have had no influence in the sectoral governance mechanisms that have been dominated by large commercial producers.

In summary, environmental justice has only been explicitly integrated into three telecoupling-focused articles to date. Many other publications have implicitly addressed matters related to the different dimensions of justice, with distributive issues being more predominant. Environmental impacts within and across systems are addressed in many of the papers reviewed, but we found no explicit attention to the concept of ecological justice. In the following section, we discuss how to further mainstream environmental justice thinking in telecoupling research and reflect upon the challenges that such mainstreaming might entail.

4 Discussion

The evolution of environmental justice movements and scholarship (Sect. 2) is similar to land system science and telecoupling in particular (see Chaps. 2, 3 and 4). Land system science research originally focused on proximate explanations of land-use manifestations, similar to the early focus of environmental justice on locally unwanted land uses and distributive issues (Freudenberg and Steinsapir 1991). The concept of telecoupling explicitly addresses both proximate and distant drivers of land use and can focus on multiple types of flows (e.g. material, information, financial) within each of the considered social-ecological systems. Environmental justice is currently similarly focused on the analysis of the causes, effects and connections of environmental problems and struggles across scales (Aydin et al. 2017). This reflects that both approaches have a systemic and global view on social-ecological systems, which has transcended the study of a single system.

These parallel developments reveal a promising potential to integrate questions of environmental justice into telecoupling research. An initial yet critical step in this direction would be to make environmental justice a central element of the telecoupling toolbox, rather than a secondary analytical approach. This would, in turn, imply adopting the language of environmental justice and an awareness that land-use and resource management processes involve more or less visible struggles over recognition, participation and distribution. Looking at telecoupled systems with the lenses of environmental justice can help to identify relevant questions. These questions can be adjusted to the nature of the study at hand, taking into account the system(s) boundaries and/or the flows chosen. This will influence which justice dimensions become relevant, which related questions matter, at which scale, and which subjects of justice and governance and legal frameworks are considered.

For example, interested in understanding how rising soy demand in China and Europe has changed rural livelihoods, Lima et al. (2011) document that soy farmers, labourers and non-soy farmers in specific regions of Brazil have a positive view of soy expansion, rooted in the fact that soy has translated in higher local incomes. The authors pay attention to the distribution of benefits derived from soy cultivation and commercialisation, which in this particular case appear to be distributed in a way perceived as fair by local agents. In contrast, Leguizamón (2016) describes how soy cultivation in Argentina's northern provinces has resulted in negative environmental and social costs mostly borne by small-scale farmers, cattle ranchers and indigenous peoples. The author underscores that these actors struggle for recognition as cost-bearers and as legitimate actors in the design of the country's agricultural development policy.

Interested in the indirect impacts of soy cultivation in other farming systems, da Silva et al. (2017) show that soy expansion in Brazil has affected domestic maize markets, leading to increased food insecurity and farmers' higher exposure to climatic risks. From a justice perspective, the authors highlight that the connection between soy and maize cultivation can have detrimental effects on food distribution resulting from escalating prices. Consequentially, these can be borne by distant actors, for example, in urban areas. Their research suggests that the network of actors to be recognised and accounted for in the distribution of the impacts of changing soy and maize cultivation patterns should be expanded to encompass those directly involved in resource management practices, in related value chains and in the more distant locales where these crops are consumed and processed.

Finally, there are also justice considerations to have in mind when analysing receiving systems. Major global receiving systems are not just passive recipients of material flows. They often drive the changes through increasing material demands that could be managed so as to promote more just exchanges (Kastner et al. 2015). The acceptance of double standards in land-use management, the design and implementation of certification schemes for imported materials, and the lack of moderation of material consumption are all mechanisms that can be observed through the lens of environmental justice.

The necessary integration of environmental justice in telecoupling research, however, is not without challenges. An important one is to overcome what to date is an almost explicit focus on distributive justice, as shown in Sect. 3. This prevalence is perhaps related to the dominance of quantitative approaches that analyse material and financial flows in telecoupled systems. However, while quantitative data can shed light on distributive issues, qualitative data is often needed to examine and address participation and recognition issues. These data can, for example, capture the views of the agents ignored or marginalised in telecoupled systems as well as the extent to which decision-making processes have contributed to change their social or political status, improved or undermined their livelihoods, well-being and environment (Boillat et al. 2018). This claim for a stronger focus on recognition and participation issues aligns with Friis et al.'s (2016, 143–144) suggestion of mainstreaming political ecology in telecoupling research in order to shed light onto the social and political relations which explain the uneven control and access to resources in a given system, including relations based on gender, caste, and economic and political power, among others.

A final remark to be made is that environmental justice adds a normative element to telecoupling research, in the sense that processes of *recognition*, *participation* and *distribution* tend to be linked to moral principles. For example, which principles should govern a fair decision-making process related to the allocation of land resources, or the distribution of specific flows? Should actors be *consulted*, *informed* or also *empowered*? How should the distribution of a given flow, or a given resource in telecoupled systems be governed, by the principle of *equality*, *merit* or *need*? What if these principles of fair procedure and distribution diverge between actors, including the researcher? Which is then the one that needs to be advocated for or deserve focus? In this regard, a researcher might prefer to approach the analysis of environmental justice without adopting any of these principles a priori and focus instead on describing the principles adopted and preferred by the subjects of justice identified, and show how these principles differ across subjects. An alternative is to approach the study of environmental justice in telecoupled systems with an a priori preferred set of principles and compare how these align or conflict with the principles governing justices observed. In summary, it is important to be aware that the relative nature of justice in telecoupling research remains an unexplored and complicated terrain, because it implies working across different cultural norms and moral systems at different scales.

5 Conclusions

This chapter has shown why questions of environmental justice matters in telecoupling research. It has been argued that the land-use processes that underpin telecoupled systems often generate or reproduce social injustices that deserve attention and scrutiny. These injustices might concern recognition, participation or distribution issues and most probably a combination of these three dimensions. Our review of literature on empirical cases of telecoupled systems indicate that distributive concerns are the most commonly addressed to date, while recognition and participation figure less prominently. Even when addressed, most of the empirical literature does not refer to these issues as environmental justice considerations and it has not systematically adopted an environmental justice lens in the research process.

Centrally adopting the language of justice in telecoupling research can contribute to devise justice-related questions according to the system and the flows of analytical concern. However, integrating environmental justice in telecoupling research is by no means an easy task. A critical reflection on the focus of the research must precede the research design. A key message from the discussion in this chapter is that raising concern related to injustices does not in itself generate an understanding of their causes, nor of the means to redress them. Integrating environmental justice in the study of telecoupled systems requires careful consideration of the analytical approach and the combination of different methods.

The normative dimension of environmental justice politicises telecoupling research. However, doing so might also increase the societal relevance of the research process. An environmental justice lens can move telecoupling research beyond a broad description of a complex world towards an in-depth normative approach that reflects upon the injustices that result from these complexities. Together, environmental justice and telecoupling can make up a strong framework for analysing a hyper-connected world and offer a detailed picture of its related social and ecological challenges.

Acknowledgements The authors would like to thank Jonas Ø. Nielsen, Dagmar Haase and Adam Searle for their comments and editions to an earlier version of this chapter. This work contributes to ICTA-UAB "Unit of Excellence" (MinECo, MDM2015-0552) and has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 765408 (COUPLED, www.coupled-itn.eu). Esteve Corbera also acknowledges the financial support of the UAB-Talent Retention Programme and BRL the support of the Marie Skłodowska-Curie Grant Agreement No. 797444 (CLAMOR).

Notes

1. See US Environmental Protection Agency. "Learn About Environmental Justice," accessed October 16, 2018. https://www.epa.gov/environmentaljustice/learn-about-environmental-justice.
2. See reviewed references listed on the digital repository of Universitat Autònoma de Barcelona, https://ddd.uab.cat/record/199238.

References

Agyeman, Julian, Robert D. Bullard, and Bob Evans. 2003. *Just Sustainabilities: Development in an Unequal World*. Cambridge, MA: The MIT Press.

Aydin, Cem I., Begum Ozkaynak, Beatriz Rodríguez-Labajos, and Taylan Yenilmez. 2017. Network Effects in Environmental Justice Struggles: An Investigation of Conflicts between Mining Companies and Civil Society Organizations from a Network Perspective. *PLoS ONE* 12 (7): e0180494. https://doi.org/10.1371/journal.pone.0180494.

Bagstad, Kenneth J., Darius J. Semmens, James E. Diffendorfer, Brady J. Mattsson, James Dubovsky, Wayne E. Thogmartin, Ruscena Wiederholt, John Loomis, Joanna A. Bieri, Christine Sample, Joshua Goldstein, and Laura López-Hoffman. 2018. Ecosystem Service Flows from a Migratory Species: Spatial Subsidies of the Northern Pintail. *Ambio*. https://doi.org/10.1007/s13280-018-1049-4.

Baxter, Brian. 2004. *A Theory of Ecological Justice*. London and New York: Routledge.

Boillat, Sébastien, Jean-David Gerber, Christoph Oberlack, Julie G. Zaehringer, Chinwe Ifejika Speranza, and Stephan Rist. 2018. Distant Interactions, Power, and Environmental Justice in Protected Area Governance: A Telecoupling Perspective. *Sustainability* 10: 3954. https://doi.org/10.3390/su10113954.

Bullard, Robert D. 1994. *Dumping in Dixie: Race, Class and Environmental Quality*. Boulder, CO: Westview Press.

da Silva, Ramon F.B., Mateus Batistella, Yue Dou, Emilio Moran, Sara McMillan Torres, and Jianguo Liu. 2017. The Sino-Brazilian Telecoupled Soybean System and Cascading Effects for the Exporting Country. *Land* 6: 53. https://doi.org/10.3390/land6030053.

Dawson, Neil, and Adrian Martin. 2015. Assessing the Contribution of Ecosystem Services to Human Wellbeing: A Disaggregated Study in Western Rwanda. *Ecological Economics* 117: 62–72. https://doi.org/10.1016/j.ecolecon.2015.06.018.

De Jonge, Bram. 2011. What is Fair and Equitable Benefit-Sharing? *Journal of Agricultural and Environmental Ethics* 24 (2): 127–146. https://doi.org/10.1007/s10806-010-9249-3.

De Koninck, Rodolphe. 2006. On the Geopolitics of Land Colonization: Order and Disorder on the Frontiers of Vietnam and Indonesia. *Moussons* 9–10: 33–59.

Eakin, Hallie, Ximena Rueda, and Ashwina Mahanti. 2017. Transforming Governance in Telecoupled Food Systems. *Ecology and Society* 22 (4): 32. https://doi.org/10.5751/ES-09831-220432.

Eakin, Hallie, Alex Winkels, and Jan Sendzimir. 2009. Nested Vulnerability: Exploring Cross-Scale Linkages and Vulnerability Teleconnections in Mexican and Vietnamese Coffee Systems. *Environmental Science and Policy* 12 (4): 398–412. https://doi.org/10.1016/j.envsci.2008.09.003.

Elhadary, Yasin, and Hillo Abdelatti. 2016. The Implication of Land Grabbing on Pastoral Economy in Sudan. *World Environment* 6 (2): 25–33. https://doi.org/10.5923/j.env.20160602.01.

Fraser, Nancy. 1997. *Justice Interrupts: Critical Reflections on the "Postsocialist" Condition*. Cambridge: Cambridge University Press.

Freudenberg, Nicholas, and Carol Steinsapir. 1991. Not in Our Backyards: The Grassroots Environmental Movement. *Society and Natural Resources* 4 (3): 235–245. https://doi.org/10.1080/08941929109380757.

Friis, Cecilie, Jonas Ø. Nielsen, Iago Otero, Helmut Haberl, Jörg Niewöhner, and Patrick Hostert. 2016. From Teleconnection to Telecoupling: Taking Stock of an Emerging Framework in Land System Science. *Journal of Land Use Science* 11 (2): 131–153. https://doi.org/10.1080/1747423X.2015.1096423.

Gasparri, Nestor Ignacio, Tobias Kuemmerle, Patrick Meyfroidt, Yann le Polain de Waroux, and Holger Kreft. 2016. The Emerging Soybean Production Frontier in Southern Africa: Conservation Challenges and the Role of South-South Telecouplings. *Conservation Letters* 9 (1): 21–31. https://doi.org/10.1111/conl.12173.

Grammaticas, Damian. 2013. Tensions Flare over Government 'Land Grabs' in China. *The Guardian* (China Blog), November 9. https://www.bbc.com/news/blogs-china-blog-24865658.

Hardy, Andrew. 2003. *Red Hills. Migrants and the State in the Highlands of Vietnam*. Copenhagen: NIAS Press.

Hornborg, Alf, and Joan Martinez-Alier. 2016. Ecologically Unequal Exchange and Ecological Debt. *Journal of Political Ecology* 23: 328–333.

Kabia, Fatmata S. 2014. Behind the Mirage in the Desert—Customary Land Rights and the Legal Framework of Land Grabs. *Cornell International Law Journal* 47: 709–734.

Kastner, Thomas, Karl Heinz Erb, and Helmut Haberl. 2015. Global Human Appropriation of Net Primary Production for Biomass Consumption in the European Union, 1986–2007. *Journal of Industrial Ecology* 19 (5): 36. https://doi.org/10.1111/jiec.12238.

Lazarus, Richard J. 2000. Environmental Racism! That's What It Is. *Georgetown Law Faculty Publications and Other Works* 160: 255–274.

Leguizamón, Amalia. 2016. Environmental Injustice in Argentina: Struggles against Genetically Modified Soy. *Journal of Agrarian Change* 16 (4): 684–692. https://doi.org/10.1111/joac.12163.

Lerner, Steve. 2010. *Sacrifice Zones. The Front Lines of Toxic Chemical Exposure in the United States*. Cambridge, MA: The MIT Press.

Lima, Mendelson, Margareth Skutsch, and Gerlane de Medeiros Costa. 2011. Deforestation and the Social Impacts of Soy for Biodiesel: Perspectives of Farmers in the South Brazilian Amazon. *Ecology and Society* 16 (4): 4. https://doi.org/10.5751/ES-04366-160404.

Martin, Adrian, Brendan Coolsaet, Esteve Corbera, Neil M. Dawson, James A. Fraser, Ina Lehman, and Iokiñe Rodriguez. 2016. Justice and Conservation: The Need to Incorporate Recognition. *Biological Conservation* 197: 254–261.

Oberlack, Christoph, Sébastien Boillat, Stefan Brönnimann, Jean David Gerber, Andreas Heinimann, Chinwe Ifejika Speranza, Peter Messerli, Stephan Rist, and Urs Wiesmann. 2018. Polycentric Governance in Telecoupled Resource Systems. *Ecology and Society* 23 (1): 16. https://doi.org/10.5751/ES-09902-230116.

Overbeek, Winfridus, Markus Kröger, and Jean-François Gerber. 2012. *An Overview of Industrial Tree Plantation Conflicts in the Global South. Conflicts, Trends, and Resistance Struggles*. EJOLT Report No. 3.

Pulido, Laura. 2017. Conversations in Environmental Justice: An Interview with David Pellow. *Capitalism Nature Socialism* 28 (2): 43–53. https://doi.org/10.1080/10455752.2016.1273963.

Rodríguez, Iokiñe, Bjorn Sletto, Bibiana Bilbao, Isabelle Sánchez-Rose, and Alejandra Leal. 2013. Speaking of Fire: Reflexive Governance in Landscapes of Social Change and Shifting Local Identities. *Journal of Environmental Policy and Planning* 20 (6): 693–712.

Schlosberg, David. 2007. *Defining Environmental Justice: Theories, Movements, and Nature*. Oxford: Oxford Scholarship Online. https://doi.org/10.1093/acprof:oso/9780199286294.001.0001.

Schroeder, Heike. 2010. Agency in International Climate Negotiations: The Case of Indigenous Peoples and Avoided Deforestation. *International Environmental Agreements* 10: 317–332.

Schröter, M., T. Koellner, R. Alkemade, S. Arnhold, K.J. Bagstad, K.H. Erb, K. Frank, T. Kastner, M. Kissinger, J. Liu, L. López-Hoffman, J. Maes, A. Marques, B. Martín-López, C. Meyer, C.J.E. Schulp, J. Thober, S. Wolff, and A. Bonn. 2018. Interregional Flows of Ecosystem Services: Concepts, Typology and Four Cases. *Ecosystem Services* 31: 231–241.

Sun, Jing, Harold Mooney, Wenbin Wu, Huajun Tang, Yuxin Tong, Zhenci Xu, Baorong Huang, Yeqing Cheng, Xinjun Yang, Dan Wei, Fusuo Zhang, and Jianguo Liu. 2018. Importing Food Damages Domestic Environment: Evidence from Global Soybean Trade. *Proceedings of the National Academy of Sciences* 115 (21): 5415–5419. https://doi.org/10.1073/pnas.1718153115.

Xiong, Hang, James D.A. Millington, and Wei Xu. 2018. Trade in the Telecoupling Framework: Evidence from the Metals Industry. *Ecology and Society* 23 (1): 11. https://doi.org/10.5751/ES-09864-230111.

Zimmerer, Karl S., Eric F. Lambin, and Steven J. Vanek. 2018. Smallholder Telecoupling and Potential Sustainability. *Ecology and Society* 23 (1): 30. https://doi.org/10.5751/ES-09935-230130.

12

Livelihoods through the Lens of Telecoupling

Yann le Polain de Waroux

1 Introduction

A livelihood is 'the way that an individual or a household "gets by"' (Rigg 2007, 32), or, in Ellis's terms, '[t]he assets, the activities and the access that determine the living gained by the individual or household' (Ellis 2000, 27). Livelihood studies emerged as a response to structural perspectives on development to 'place people back at the centre of attention and explanation, endowing them with a degree of agency to struggle against, take advantage of, and resist or rework their political, economic, social and environmental milieu' (Rigg 2007, 29). A livelihoods perspective thus addresses the complex ways in which people engage with different activities and organise themselves to earn a living, given a set of structural constraints. In their emphasis on locality and agency, livelihoods perspectives have been criticised for overlooking the importance of forces occurring at other scales and beyond the agency of local actors (Scoones 2009).

Y. le Polain de Waroux (✉)
Institute for the Study of International Development & Department of Geography, McGill University, Montreal, QC, Canada
e-mail: yann.lepolaindewaroux@mcgill.ca

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_12

In fact, livelihoods were never divorced from distant causes and structural factors, and with economic integration and globalisation, they are becoming ever less so. Rural livelihoods and poverty are increasingly decoupled from land and farming, and key developments that affect livelihoods are tied to processes beyond the local. Growing opportunities in non-farm activities; changes in global commodity prices and demand; the incursion of new corporate, political, and institutional actors; climate change and variations; or new technologies are all examples of influences from 'outside'.

The concept of telecoupling can offer a way to bridge local livelihoods with other scales, by adopting a relational perspective on livelihood activities. In that perspective, livelihoods are not 'local' activities affected by 'global' processes; they are systems or parts of systems enmeshed in a set of relations with actors and dynamics—or other 'systems'—in multiple places and at multiple scales. This systemic perspective emphasised in Chap. 2 offers an understanding of people's livelihoods as rooted in flows of people, capital (Chaps. 5 and 6), policies (Chap. 9), discourses (Chaps. 11 and 17), or information (Chaps. 15 and 19), while also embedded in particular places. What makes livelihood research interesting from a telecoupling perspective is that people, through their livelihood choices, articulate these flows at the local level, making decisions about how to engage in them. In doing so, they change the nature of places, potentially causing spillover effects and initiating feedbacks, and give us as researchers an excellent vantage point to explore telecoupling at the local scale.

Take a fictional Bolivian farmer who produces quinoa, a cereal in increasing demand from health-conscious Northern consumers, and sells most of it for export. Let us imagine that she also produces handicrafts to sell to tourists at a local market. One of her sons works in Buenos Aires, Argentina, and sends remittances home every month. When the Argentine economy is doing well, her son sends more money home. She might reinvest that money in agricultural inputs for quinoa or in materials to produce more handicrafts. Alternatively, she might decide to quit these activities, because remittance money is sufficient to sustain her family. If Peru's quinoa harvest increases, prices may fall, as happened in 2014–2015 (The Economist 2016). She may then switch to another crop, produce more handicrafts, or send another son or daughter to work abroad so they can send more remittances. To avoid this, a local advocacy group might work with an NGO in Europe to design a 'fair trade' label that would protect prices for farmers like her, or perhaps lobby for land reform in order to provide access by these farmers to land appropriated by local elites. This example could be tweaked in many more directions, but it illustrates the multiple ways in which ties to distant systems can influence local livelihoods, and vice versa.

A central premise of telecoupling research is the definition of a system of interest, often in terms of sending, receiving, or spillover system (Chap. 3), and the analysis of flows between that system and other, distant systems, to infer causal explanations (Chap. 4). Defining the system, and deciding what flows and what other systems to consider, as illustrated by the example above, is a difficult, contextual, and partly subjective matter (Friis and Nielsen 2017; see also Chap. 18). When looking at livelihoods, the initial system of interest will often, though not always, be rural households in a specific place, the land they use, and the constraints or structures under which they operate (Friis and Nielsen 2017). Distance with other systems can be geographical, or it can be social or institutional (Eakin et al. 2014), so that distant systems are systems over which the people whose livelihoods we consider have no direct influence—be it economic or political. As to the relevant flows and other systems to consider, they will depend on the initial system of interest—for example smallholders engaged in quinoa production.

Arguably though, for the telecoupling framework to be a useful lens, there should be clear ties (e.g. sending, receiving, or spillover ties) to other specific places or systems, rather than the undifferentiated influence of 'global' processes. The telecoupling lens can usefully characterise the coupling of local livelihoods in a Bolivian village through quinoa trade with a small market of health-conscious consumers in the United States, because the two systems are relatively bounded, so that we can actually examine the influence of one over the other. It may be less useful to describe the influence, for example, of global corn trade on local livelihoods, because global corn prices do not tend to depend on any one particular system (more on this below). By identifying ties to distant systems, we can start to disentangle the complex fabric of the 'global', thus transcending localism in livelihood studies while also going beyond mere 'globalisation'. The telecoupling framework provides tools to describe and understand more concretely how livelihoods are relational and embedded in a specific network of influences (see Chap. 16).

2 Multiple Ties to Distant Places

There can be many relevant flows and systems to consider when examining livelihoods. However, there are some recurrent themes. Below, I discuss some key sending, receiving, and spillover links and feedback loops between distal systems—migration, trade, resource control, and ecosystem externalities—and their manifestations as telecoupling in the context of livelihoods. The chapter does not deal with some other important determinants of livelihood choices, such as household composition, access to markets and infrastructure, or education, but focuses exclusively on how distant drivers manifest in, and impact, local livelihoods, and on how the telecoupling framework can help us capture these effects analytically.

2.1 Migration and Remittances

Migration is a key part of rural livelihoods in the Global South. It constitutes perhaps the most straightforward manifestation of livelihood telecoupling. Migrants do not move to 'the world', they move to specific places, and often do so in cohorts. Their destinations can be linked to work opportunities: when recruiters for Northern France's coal mines and industries hired young men in the Moroccan countryside in the 1950s and 1960s, groups of people from the same Moroccan villages ended up in the same French towns. Migration destinations are also determined by immigration policies, for example preferential treatment of groups of a certain ethnicity, language, or religion. Quebec, in Canada, has favoured immigration from French-speaking countries, encouraging immigrants from Haiti, whereas Toronto's Caribbean immigrants have tended to come from English-speaking Jamaica. Most of these migrants send remittances to their home countries, so that changes in Quebec's or Ontario's economy are likely to affect people in Haiti or Jamaica, respectively (Todoroki et al. 2009). Migrants are also more likely to move where they know someone who can inform them about opportunities, help them to figure out ways to get and stay there, or offer a job, which reinforces existing ties between origins and destinations.

These migratory processes create telecouplings involving exchanges of people, capital, and ideas between distant systems. Depending on the flow of interest, the origin can be the sending system and the destination the receiving system (e.g. for flows of people), or the contrary (e.g. for flows of capital). If one enlarges the analytic lens, these flows can also function as a spillover system of other telecouplings. For example, the large influx of migrants from Syria to Germany in 2016 helped trigger a backlash against immigration (i.e. a feedback) that also affected migrant flows from other countries, potentially altering the telecoupling between these countries and Germany.

What are the effects of these telecouplings on local livelihoods? When people leave to work elsewhere, they no longer accomplish whatever tasks they were doing locally. This can cause a restructuring of livelihood activities in the household and a decline in labour-intensive activities. Another manifestation of migration is remittances, often a key component of local livelihoods. In some economies, such as Nepal or Haiti, they constitute one of the main sources of national income.

Financial remittances from migration can articulate with other dimensions of local livelihoods in various ways, depending on context. They can complement other income sources as part of a diversification strategy (the income effect), or be reinvested in other livelihood strategies, for example setting up a business (the investment effect). The income effect's impact on local natural resources depends on whether income is used to consume more of these resources or to purchase substitutes for them (e.g. natural gas instead of fuelwood). The investment effect can likewise differ. People may abandon livelihood activities that are based on resource extraction, which may potentially alleviate resource pressure, but also increase their external dependence on monetary income and external resources. They may also invest in land-based activities, which may or may not be compatible with the conservation of natural resources.

The greater the amount of the remittances, the more likely they will have disruptive effects on the receiving system (positive or negative). Temporal patterns, and especially the regularity and dependability of remittances, can also influence the choices people make as to how to use them. It is unlikely that households would abandon other activities and become entirely reliant on remittances if these are erratic or uncertain. Irregular and small remittances may also more readily be used for consumption in the absence of banks or other ways to accumulate savings.

Along with financial capital, migrants also send home ideas, norms, and social capital. These social remittances can sometimes have even greater impacts on livelihoods in the receiving system than do financial remittances. For example, Montefrio et al. (2014) showed that Filipino migrant workers in Malaysian oil palm plantations brought back 'ideas of prosperity linked to the development of land for oil palm, as well as knowledge of production practices that support the operations of palm oil companies in Palawan' (Montefrio et al. 2014, 237), thus encouraging palm oil development at home.

Finally, migration telecouplings inevitably fade, as migrants either return or integrate in their host countries, loosening ties with their places of origin. The Moroccan government, very aware of the country's reliance on remittances, has actively tried to prevent this decline by organising 'Opération Marhaba'. Every summer, when millions of Moroccans living abroad come back to visit, the government organises large concerts and puts up 'Welcome Home' banners along major roads, in order to 'encourage a feeling of belonging and a sense of honour to returning nationals, on whom the country continues to depend financially' (Collyer 2013, 187). Telecoupling research, by examining all potentially relevant flows (of capital, knowledge, values, etc.), rather than focusing on single causal explanations, can help us articulate insights into their role in shaping local livelihoods.

2.2 Trade

Livelihoods often involve trading things—handicrafts or agricultural products, for example—for money. Rarely is that trade limited to the immediate geographic vicinity of a place (see Chap. 3). With economic globalisation, an increasing number of rural households have gone from producing for themselves to producing for often distant markets, reflecting a worldwide process of decoupling of production from consumption in which livelihoods become tied to other actors—consumers, but also middlemen, trading companies, policy makers, and various institutions. Trade linkages influence livelihoods through prices (because livelihood choices depend on expected gain), and by shaping the range of available livelihood options (e.g. if new demand emerges for a new commodity).

For many agricultural commodities, because of the large number of producers and consumers integrated in a common market, no particular system can sufficiently influence prices to affect local livelihoods much—unless one takes a whole continent as the telecoupled system. There are cases, though, in which one system does act as a price-setter, for example when commodities are sold through specific marketing channels, creating de facto local monopsonic situations (i.e. with one buyer and many sellers). Banana growers in Northern Laos are highly dependent on Chinese markets, even though bananas are a global commodity, because the trading networks there are set up to serve these markets. The same is true if products are differentiated, that is, they have attributes that render them not fully substitutable with similar products (e.g. an organic label), and they serve smaller markets. The prices and demand faced by a producer of fair trade or organic coffee, for example, are not quite the same as those of a mainstream coffee producer (Rueda and Lambin 2013).

An extreme case of market differentiation is niche products. Niche products are specialised goods sold to a limited number of consumers at high prices, which can be manufactured, mineral, or biological. Biological niche products command high prices because they are scarce and valued highly for their attributes, typically related to beliefs about their quality, their positive environmental, social, and health impacts, and their links to certain traditions (le Polain de Waroux and Lambin 2013). Because several of these characteristics are closely linked to a specific territory (e.g. tradition), their substitutability with other products is usually very low, so that the size of the producer system cannot grow much. High prices give a similarly limited system of consumers' great influence over livelihoods in producer systems (in theory, the reverse is also possible, but this is rarely observed in practice, because niche products are rarely as essential for consumers as the income they generate is for producers). These characteristics—the limited scale of both sending and receiving system and the strength of the interaction—make niche products particularly interesting to study through the telecoupling framework.

The first effect of the trade in niche products, in cases where their market is new (most of them), is through an expansion of livelihood opportunities. In the 1990s, cosmetic firms and the German development agency GTZ (now GIZ) took interest in argan oil, produced for local consumption in Southern Morocco, as a potential 'triple win' for conservation, rural development, and economic growth. The product's narrative as traditional, women-empowering, healthy, and sustainable appealed to a certain kind of Northern consumers. A niche market emerged rapidly, illustrating how telecouplings can be initiated strategically by actors with certain interests (here, in profit and development). In this process, argan oil production became a much more prominent livelihood option for households in the region, with impacts on social relations, land tenure, and even school enrolment, though evidence of its impacts on rural poverty was mixed (le Polain de Waroux and Lambin 2013).

Once a trade linkage is established, the main influence of niche product trade on livelihoods is through prices. High prices, if sustained, can result in the accumulation of financial capital—such is the hope, at least, of producers and development agencies. Whether it does so depends, in addition to prices, on stable and abundant supply, equitable access, efficient value transfer to producers, and low barriers of entry in producing regions (le Polain de Waroux and Lambin 2013). Just like for remittances, households may choose to invest this capital to support other livelihood activities, or they may increase their reliance on niche product trade, abandoning other livelihood activities, and therefore allowing increasing influence of telecoupled regions.

In addition to prices, livelihoods can also be tied to distant consumer systems through sets of norms (non-material flows) associated with niche products. Since the attributes that make niche products valuable often include specific notions of tradition, demand comes with certain prescriptions as to how they should be produced. In the case of argan oil, Simenel et al. (2009) highlight contradictions between the mechanisation of production needed to meet the high standard of a growing international market, and a narrative focused on tradition; and between a narrative of argan oil forests as 'natural' and the reality that they have long been managed by local populations. Thus, to ensure the persistence of their trade relations to a niche market, households have to shape their practices to respond to the desires and imaginaries of Northern consumers.

Over time, various forces will tend to weaken or erode the telecoupling by enlarging the producer base and depressing prices. First, if niche products are profitable, new actors will naturally step in to produce them, thereby increasing competition. If the resource is limited to a certain geographical range, this competition will be between local actors, as more people will seek to claim access to the resource. This is particularly salient, for example, in the case of caterpillar fungus, a precious fungus harvested in parts of Tibet and the Himalayas that has alleged medical properties and sells for several thousands of US dollars per kilogram in Chinese cities (Hopping et al. 2018). Due to the extremely high value of the fungus, people have flocked from all around the Himalayas to collect it, intensifying conflicts over access and blurring the boundaries of the sending system.

A second factor is geographic expansion. Quinoa was once only produced in the Andes, but its success has encouraged farmers in different places to experiment, and now quinoa is produced in many countries including Canada, China, and the United States (Bazile et al. 2016). There have also been various attempts to produce argan oil in the Negev Desert of Israel, though so far Morocco remains the only source. These processes can be conceptualised as the formation of new telecouplings between consumer systems and competing producer systems (e.g. Israel), of which the original producing region becomes a spillover system.

Finally, because the high price of niche products is partly based on narratives, they are also vulnerable to substitution with other products that can fit these narratives. For example, shea butter fits almost all the same narratives as argan oil, as does the oil produced from prickly pear seeds. All three are found in western cosmetics, sometimes mixed together. All three can be considered spillover systems of the others' ties to the same consumer system. If one becomes cheaper, therefore, the others are likely to suffer.

These challenges trigger institutional responses aimed at protecting the niche market by limiting access and preventing competition with other geographies or products. In the case of caterpillar fungus, communities have designed new access rules to limit harvest by outsiders. In the case of argan oil, quinoa, and other products, countries have set up denominations of origin ('quinoa real', 'IGP argane') to differentiate their product from existing or potential competitors. Ultimately, however, niche products, and their associated livelihoods, remain vulnerable to these eroding forces, particularly product substitution, and constant feedbacks are required to maintain these special telecouplings.

2.3 Resource Control

Livelihoods are embedded in institutional structures that determine resource ownership and access, as well as organising human relations. These structures can be subject to influences from distant systems in sometimes unexpected ways. One example that has attracted a lot of attention in the last ten years is changes in land tenure triggered by large-scale land acquisitions by outsiders, often referred to as 'land grabs'. While these acquisitions are usually profit-motivated, a variant is 'green grabbing', in which NGOs, companies, or wealthy individuals claim land for conservation. In both these situations, systems are linked through a telecoupling involving a 'flow' of control from the sending to the receiving system, against a flow of benefits, be it profit or conservation.

Land acquisitions by outsiders, whether they are long-term or short-term, and formal or informal, modify access to land for local people. Even when temporary, these telecouplings can have lasting effects on livelihoods. For example, in Northern Laos, the informal acquisition of land by Chinese companies for banana production transformed subsistence rice farmers into 'rentiers' leasing out their land for export banana production. Land conversion to banana plantations involved the destruction of networks of traditional irrigation channels and plot boundaries, making conversion back to rice farming much more difficult (Friis and Nielsen 2016). Land acquisitions can also affect livelihoods indirectly. McKay and Colque (2015), for example, have highlighted processes of *productive exclusion* linked to the modernisation of agriculture under massive influxes of foreign capital in the Bolivian lowlands, by which small-scale producers are gradually pushed out of agriculture. These transformation, however, may also sometimes create new livelihood opportunities for households and generate positive spillovers, for example on the adoption of agricultural practices and inputs (Deininger and Xia 2016).

These acquisitions and investments respond to changes and pressures in distant systems, of which the local livelihoods system is but a recipient, either as a receiving or as a spillover system. For example, in the 2010s, massive land investments by Uruguayan ranchers in the Paraguayan Chaco have contributed to reducing the area of forest available to indigenous households. These investments are in no small part due to the acquisition by Argentine companies of large extends of farmland for soy cultivation in Uruguay, displacing Uruguayan ranchers and endowing them with capital to invest elsewhere (le Polain de Waroux et al. 2017). Thus, in this case, indigenous households, through these acquisitions, are suffering a spillover effect of another telecoupling between Argentina and Uruguay, ultimately caused by the Argentine soy boom and connected to increasing global demand for soy.

In some cases, feedbacks are transmitted from the households whose livelihoods are affected back to the source of these often undesired telecouplings, typically through advocacy organisations. For example, the Oakland Institute, in association with local and international NGOs, has been denouncing a land deal on 73,000 hectares of Cameroonian forest by Herakles, a New York–based firm (Oakland Institute 2017)—so far with limited success in halting its development. In the Paraguayan Chaco, Survival International, a UK-based organisation, has been similarly denouncing an 80,000 hectares land deal by a Brazilian investor on grounds of concern for the livelihoods of indigenous populations living on the land, and has managed to cause the government to suspend deforestation permits for that property, albeit only temporarily (Survival International 2018). As we expose these multiple causal linkages through a systemic lens, we see that the telecoupling framework opens up new perspectives on the causes of local changes by increasing the 'granularity' of our understanding of global processes.

2.4 Ecosystem Externalities

A final category of distant linkages I consider here is ecosystem externalities, or 'the negative impacts of human actions on other aspects of ecosystem function that, in turn, affect people' (Cease et al. 2015, 551). People's livelihoods benefit from various kinds of ecosystem services, for example soil formation and retention, or food and fibre production. Ecosystem dynamics can also provide what could be considered as disservices, such as pest outbreaks and invasions of exotic species. Since human actions affect ecosystems, the effects of these actions in one system can ripple through to other systems, generating impacts for livelihoods. Because these effects are often unintended, unexpected, and distant, such ecosystem externalities make for another interesting case of telecoupling.

One clear example of this is the case of locust outbreaks. Locust plagues can originate in human-dominated landscapes where range management decisions create the ecological conditions for grasshoppers to transform into migrating swarms of locusts (Cease et al. 2015). These swarms can then move hundreds of kilometres, destroying crops in their wake. Range management decisions made as part of some household livelihood strategies in a sending system thus end up causing the failure of other households' livelihoods in distant receiving systems, through ecosystem externalities. Because impacted households in the receiving system have no direct control over management practices in the sending system, they depend on structures put in place by local or national governments to monitor and control outbreaks. Such structures existed, for example, in the Soviet Union, which seemingly managed to keep locust populations at manageable levels. In post-Soviet Kazakhstan, the collapse of these structures created the conditions for a massive outbreak in 1998–2001 (Toleubayev et al. 2007).

Another example is river pollution. The Ok Tedi Mine, an open pit mine in the Western Province of Papua New Guinea, released millions of tons of mine tailings into the Ok Tedi and Fly river systems in the 1980s and 1990s. This severely disrupted downstream ecosystems on hundreds of kilometres, destroying riverine forests, killing and poisoning fish, and ultimately obliterating the livelihoods of countless people. Progressively, advocacy campaigns and lawsuits brought the issue to the attention of the national and global community. The companies responsible for the damage were forced to pay a compensation to downstream inhabitants, and the mine was seized by the government of Papua New Guinea (Kirsch 2007). In this case, the telecoupling between the mine (sending system) and downstream villages (receiving systems, some as far as 1000 km away from the mine) through ecosystem externalities was also a spillover system of the trade telecoupling between the mine and distant consumers of copper and gold.

3 Conclusion: Vulnerabilities and Feedbacks

In this chapter, I have discussed various ways in which local livelihoods are linked to distant systems, and highlighted how the telecoupling framework can provide a useful analytical lens to look at these linkages. I first examined how heterogeneous migration flows created telecouplings between specific places, involving exchanges of people, capital, and ideas. Second, I showed that differentiated markets for goods created another type of telecouplings, in which certain groups of consumers have influence over livelihoods in producer systems through trade, and presented the case of niche products as an extreme example of trade telecoupling. Third, I discussed large-scale land acquisitions as another way in which telecouplings could affect local livelihoods, this time by restricting access to resources, and the feedback responses that could emerge in the system. Finally, I discussed a type of telecoupling in which the central flow is an ecosystem externality that affects livelihoods through its impacts on natural resources.

Telecouplings, in a way, are good news and bad news for local livelihoods. Bad news, because even when they provide opportunities, telecouplings mean that livelihoods are increasingly affected by conditions in areas over which people have no control. Because political representation is typically spatially bounded, people may have some amount of agency over conditions in their village, region, or country. They do not, however, have any direct control over the preferences of distant consumers, or over range management practices in a neighbouring country, even though these can have impacts on their lives. Telecouplings, in that sense, create new vulnerabilities. The good news, though, is that this situation is still arguably better than 'classical' globalisation, in which livelihoods are also deeply affected by distant dynamics, but there is no one entity or system that can be singled out and potentially addressed to tackle this problem—a situation in which there basically is no possibility for feedback. In fact, the more a system can be circumscribed, the more it becomes possible for people whose livelihoods depend on such telecouplings, and for organisations, policy makers, or consumers that care about them, to generate feedbacks that will either seek to prevent, strengthen, or control the flows associated with these telecouplings.

Such feedback occurred in every system I reviewed in this chapter. In the case of the Moroccan government's 'courting' of Moroccans living abroad, these were mediated by institutions jumping scales to address distant causes on behalf of their constituents, with the intention of ensuring the persistence of remittance flows. For niche and differentiated products, we saw that feedbacks also aimed at controlling and strengthening flows—efforts to protect geographic indications and keep the market differentiated can be interpreted in that light. There, again, it falls largely to local institutions, rather than households themselves, to ensure the persistence of these flows. On the contrary, in the cases of the Herakles farm and of the Brazilian farmer in Paraguay, feedback attempted to block the flow of investment, rather than sustain it, because it was considered as potentially threatening to local livelihoods. Here, the possibility of identifying a single 'culprit', that is, of clearly identifying the telecoupled system, made it easier for local and international organisations to raise concerns on behalf of rural households. The case of locusts in Kazakhstan also shows that in order for such undesired telecouplings to remain 'blocked', feedbacks sometimes need to be sustained over time by appropriate institutional structures.

Beyond its analytical use, the telecoupling framework thus also offers a way of identifying leverage points for action. This might seem straightforward when considering a single telecoupling, but it becomes less evident when local livelihoods are affected by spillover effects from one or multiple other telecouplings. The Ok Tedi Mine is interesting in this respect. Protests against the mine started in the 1980s, but '[a]s long as the protests […] remained local, […] they failed to achieve their objective' (Kirsch 2007, 305). It is only when local activists paired up with international NGOs and went 'global', that the protests started having an impact. What these NGOs did, essentially, was mapping the telecouplings of which local livelihoods were a spillover system, and reaching out to those telecoupled systems that could be influenced, such as German shareholders, to pressure them into disinvesting from the mine. This shows that understanding the nature of the system is essential in order to identify the proper scale and platform of action. The telecoupling, framework offers one way to do this, and thus, ultimately to leverage local agency, the original focus of the livelihoods approach, in the context of globalisation.

Acknowledgements I am grateful to Cecilie Friis and Jonas Ø. Nielsen for helpful comments on earlier versions of this chapter.

References

Bazile, Didier, Sven-Erik Jacobsen, and Alexis Verniau. 2016. The Global Expansion of Quinoa: Trends and Limits. *Frontiers in Plant Science* 7: 622. https://doi.org/10.3389/fpls.2016.00622.

Cease, Arianne J., James Elser, Eli P. Fenichel, Joleen C. Hadrich, Jon Harrison, and Brian E. Robinson. 2015. Living with Locusts: Connecting Soil Nitrogen, Locust Outbreaks, Livelihoods, and Livestock Markets. *Bioscience* 65 (6): 551–558. https://doi.org/10.1093/biosci/biv048.

Collyer, Michael. 2013. *Emigration Nations: Policies and Ideologies of Emigrant Engagement*. Houndmills, UK: Palgrave Macmillan. https://doi.org/10.1057/9781137277107.

Deininger, Klaus, and Fang Xia. 2016. Quantifying Spillover Effects from Large Land-Based Investment: The Case of Mozambique. *World Development* 87: 227–241. https://doi.org/10.1016/j.worlddev.2016.06.016.

Eakin, Hallie, Ruth DeFries, Suzi Kerr, Eric F. Lambin, Jianguo Liu, Peter J. Marcotullio, Peter Messerli, Anette Reenberg, Ximena Rueda, Simon R. Swaffled, Birka Wicke, and Karl Zimmerer. 2014. Significance of

Telecoupling for Exploration of Land-Use Change. In *Rethinking Global Land Use in an Urban Era*, ed. Karen Seto and Anette Reenberg, 141–161. Cambridge, MA: The MIT Press.

Ellis, Frank. 2000. *Rural Livelihoods and Diversity in Developing Countries*. New York: Oxford University Press.

Friis, Cecilie, and Jonas Ø. Nielsen. 2016. Small-Scale Land Acquisitions, Large-Scale Implications: The Case of Chinese Banana Investments in Northern Laos. *Land Use Policy* 57: 117–129. https://doi.org/10.1016/j.landusepol.2016.05.028.

———. 2017. On the System. Boundary Choices, Implications, and Solutions in Telecoupling Land Use Change Research. *Sustainability* 9 (6): 974. https://doi.org/10.3390/su9060974.

Hopping, K.A., S.M. Chignell, and E.F. Lambin. 2018. The Demise of Caterpillar Fungus in the Himalayan Region due to Climate Change and Overharvesting. *Proceedings of the National Academy of Sciences* 115 (45): 11489–11494.

Kirsch, Stuart. 2007. Indigenous Movements and the Risks of Counterglobalization: Tracking the Campaign against Papua New Guinea's Ok Tedi Mine. *American Ethnologist* 34 (2): 303–321. https://doi.org/10.1525/ae.2007.34.2.303.

le Polain de Waroux, Yann, Matthias Baumann, Nestor I. Gasparri, Gregorio I. Gavier-Pizarro, Javier Godar, Tobias Kuemmerle, Robert Müller, Fabricio Vázquez, José N. Volante, and Patrick Meyfroidt. 2017. Rents, Actors, and the Expansion of Commodity Frontiers in the Gran Chaco. *Annals of the American Association of Geographers* 108 (1): 204–225. https://doi.org/10.1080/24694452.2017.1360761.

le Polain de Waroux, Yann, and Eric F. Lambin. 2013. Niche Products and Rural Poverty Alleviation: Contextualizing the Contribution of Argan Oil to Rural Livelihoods in Morocco. *Annals of the American Association of Geographers* 103: 589–607. http://dx.doi.org/10.1080/00045608.2012.720234.

McKay, Ben, and Gonzalo Colque. 2015. Bolivia's Soy Complex: The Development of 'Productive Exclusion'. *Journal of Peasant Studies* 43 (2): 583–610. https://doi.org/10.1080/03066150.2015.1053875.

Montefrio, Marvin J.F., Yasmin Y. Ortiga, and M. Rosy C. Josol. 2014. Inducing Development: Social Remittances and the Expansion of Oil Palm. *International Migration Review* 48 (1): 216–242. https://doi.org/10.1111/imre.12075.

Oakland Institute. 2017. Herakles Farms is Destroying Rainforests and Local Livelihoods in Cameroon for Palm Oil Plantations. Accessed September 6,

2017. https://www.oaklandinstitute.org/herakles-farms-destroying-rainforests-and-local-livelihoods-cameroon-palm-oil-plantations.
Rigg, Jonathan. 2007. *An Everyday Geography of the Global South*. New York: Routledge.
Rueda, Ximena, and Eric F. Lambin. 2013. Linking Globalization to Local Land Uses: How Eco-Consumers and Gourmands are Changing the Colombian Coffee Landscapes. *World Development* 41: 286–301. https://doi.org/10.1016/j.worlddev.2012.05.018.
Scoones, Ian. 2009. Livelihoods Perspectives and Rural Development. *Journal of Peasant Studies* 36: 171–196. http://dx.doi.org/10.1080/03066150902820503.
Simenel, Romain, Geneviève Michon, Laurent Auclair, Yildiz Thomas, Bruno Romagny, and Marion Guyon. 2009. L'Argan : l'Huile qui Cache la Forêt Domestique. De la Valorisation du Produit à la Naturalisation de l'Écosystème. *Autrepart* 50 (2): 51–73. https://doi.org/10.3917/autr.050.0051.
Survival International. 2018. Yaguareté Porã. Accessed November 9, 2018. http://www.survivalinternational.org/about/yaguarete.
The Economist. 2016. Why the Price of Quinoa has Fallen. *The Economist*, May 24. https://www.economist.com/blogs/economist-explains/2016/05/economist-explains-17.
Todoroki, Emiko, Matteo Vaccani, and Wameek Noor. 2009. The Canada-Caribbean Remittance Corridor: Fostering Formal Remittances to Haiti and Jamaica through Effective Regulation. *World Bank Working Paper 163*. Washington, DC: The World Bank.
Toleubayev, Kazbek, Kees Jansen, and Arnold van Huis. 2007. Locust Control in Transition: The Loss and Reinvention of Collective Action in Post-Soviet Kazakhstan. *Ecology and Society* 12 (2): 38. https://doi.org/10.5751/ES-02229-120238.

13

Toolbox: Spatial Analysis and Modelling

Peter H. Verburg

1 Introduction

There is a long tradition of studying land-use change by conducting spatial analysis and land-use modelling. Telecoupled land-use change challenges the traditional methods for spatial analysis and modelling, as that change is no longer only dependent on the local and neighbouring conditions of the socio-ecological system, but connected to global flows of information, power, governance and trade. This chapter provides a brief introduction to these challenges, addressing (1) the ways in which telecoupled systems can be addressed in spatial analysis, (2) how land-use modelling can capture telecoupling and (3) the conceptual challenges of database structures and analytic tools to represent connected places in spatial analysis and modelling.

P. H. Verburg (✉)
Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Birmensdorf, Switzerland

Institute for Environmental Studies, VU University Amsterdam, Amsterdam, The Netherlands
e-mail: peter.verburg@vu.nl

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_13

2 Spatial Analysis and Telecoupling: *People and Pixels* Revisited

Most spatial analysis in land science focusses on studying the changes and spatial pattern of land cover over a time period. Many land-use changes affect land cover or the structure of the vegetation directly. Therefore, land-cover change can be identified from remote sensing images or aerial photographs. Spatial analysis uses classified remote sensing images or land-cover maps to identify the quantity and location of the identified changes in land cover. Using these techniques, we have been able to locate changes in, for example, forest cover, arable fields, grasslands and urban areas. For land-use changes that do not directly affect land cover, such as land management changes, remote sensing image interpretation is generally considered less suited (Verburg et al. 2011). The high spatial resolution and temporal frequency of new remote sensing products has, however, made it possible to also deduct a number of specific land management changes from spatial reflectance data. Examples include the detection of mowing frequency from temporal variations in high temporal resolution data, the identification of fallow cycles, multiple cropping cycles, irrigation, various types of grassland management and agricultural abandonment (Dara et al. 2018). In spite of these advances, it should be noted that not all land management changes result in clear and consistent physical changes of the earth surface. Examples include the adoption of more sustainable management practices such as precision farming and organic agriculture. While such changes in management may have profound benefits for the environment or social conditions of an area, they are often not addressed in spatial analysis, as they are not easily mapped with traditional methods for spatial analysis.

Spatial analysis has limitations for studying telecoupled systems. Land cover is mapped at the location where it is actually found on the earth service and can, using spatial analysis techniques, be linked to the biophysical and socio-economic conditions at that location. However, in telecoupled systems the connections of local land use to distant locations are of primary importance. Such distant connections cannot easily be observed from the reflectance of a local agricultural field and are thus often not accounted for in spatial analysis.

To overcome these obvious shortcomings of traditional spatial analysis, advances have been made over the past decades. The need to connect the analysis of underlying processes with spatial data of land-cover change was pushed forward by the notion of *people and pixels*, which was published about two decades ago (National Research Council 1998). The idea was to use two approaches, called “Socialising the Pixel” and “Pixelising the Social” towards better connecting the social sciences that were concerned with understanding the social processes underlying land-use change and the natural sciences that were focussing on the physical changes resulting from changed land use. “Pixelising the Social” referred to approaches to better consider social data in spatial analyses to move this field beyond the study of remote sensing data. In this case one can think, for example, of spatialising survey and census data, either by using administrative units or the more detailed linkages between survey locations, the location of households and the plots they manage. Not only observed or stated land management activities can be included through such methods, but also linked to variations in social and demographic conditions.

With “Socialising the Pixel”, the underlying idea was to take remote sensing imagery beyond its use in the applied sciences towards its application in addressing the concerns of the social sciences. This was operationalised by approaches aimed at “Mining the Pixel” (National Research Council 1998, 53). This means that the spatial and temporal arrangement of land use is used to provide hints to the underlying processes that are causing this land use. As an example, spatial patterns of land reclamation may reveal if we are dealing with a smallholder frontier or deforestation as result of the establishment of large commercial plantations.

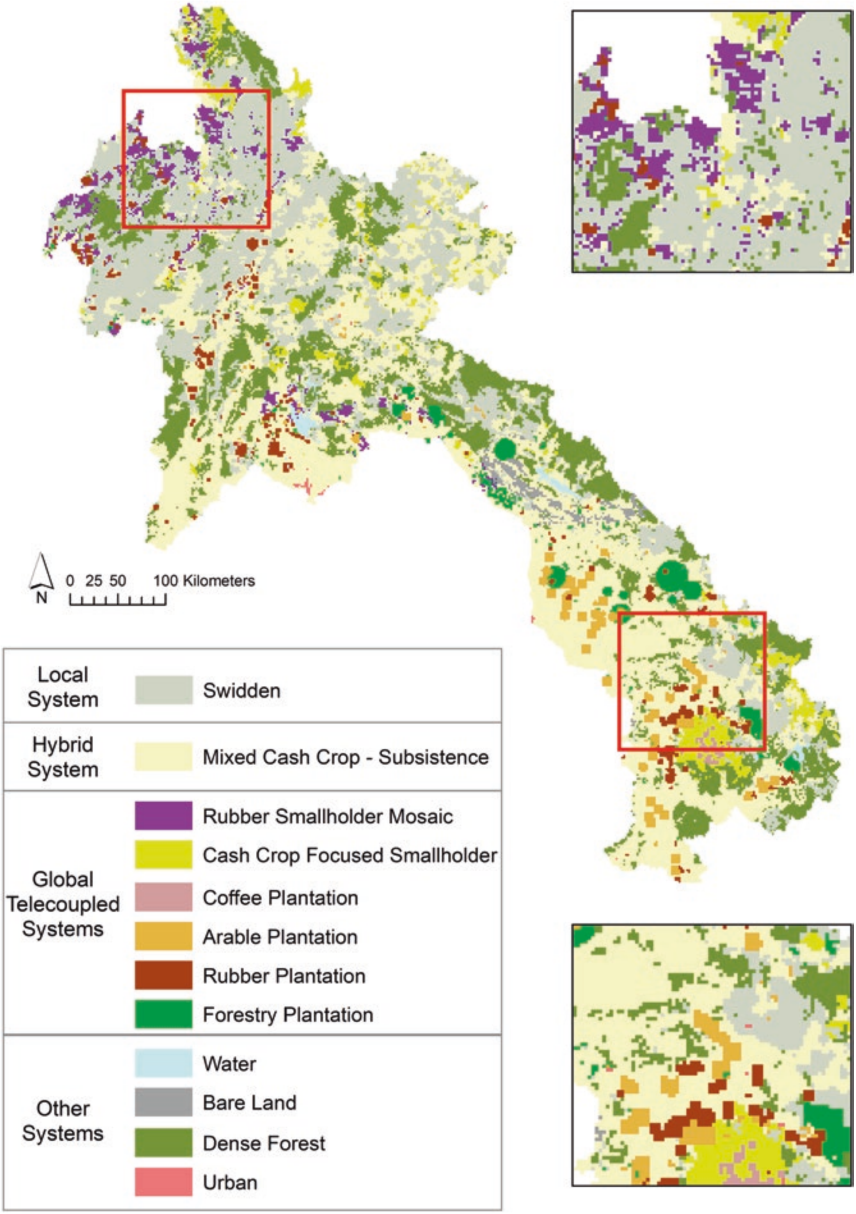
Progress in linking *people and pixels* has advanced a more integral perspective in land system research, and it can also play a role in studying telecoupled land systems through spatial analysis. Telecoupled systems, by definition, require an understanding beyond the location of the affected land use and are intricately linked to socio-economic systems beyond the local land user. Examples of applications of the *people and pixels* idea in spatial analysis of telecoupled systems are found across the literature. “Pixelising the Social” has been applied by using the location information in databases of large-scale land acquisitions to map these and study the location preferences of foreign entities as well as the environmental and social impacts (Messerli et al. 2014). "Socialising the Pixel" is exemplified by data mining of remote sensing information to distinguish oil palm plantations from forest, enabling the mapping of this telecoupled land-use type (Torbick et al. 2016).

3 Land-Use Modelling in Telecoupled Systems

A variety of land-use models are used in land system science as tools to synthesise knowledge, explore system functioning or assess possible impacts of future conditions or policies (Verburg et al. 2016). Land-use models range from agent-based models representing individual land-use decision-makers over spatial models to global computational general equilibrium models that use world regions or large countries as units of simulation. Agent-based models, often for small case studies, represent actor decision-making on land use and can be of relevance to telecoupled systems in representing decision-making towards different markets. They may help conceptualising the decision-making processes and analysing the land-use consequences of these. As an example, Magliocca et al. (2014) used a generic agent-based model to better understand how contextual differences across sites, such as access to markets, influence the land-use outcomes. An agent-based model by Hailegiorgis and Cioffi-Revilla (2018) simulated the different ways that different rural household types are affected by foreign large-scale land acquisitions in Ethiopia. Most spatial land-use models (i.e. models using spatial entities as units of simulation) are implemented at the regional level and are focussed on the spatial allocation of land-use change in response to exogenous demands. In most instances, telecoupling is implicitly represented in the exogenous demand for specific land uses and not explicitly modelled. However, these models are useful to explore and visualise the land-use consequences of changes resulting from such global demands. Sohl et al. (2014) use a spatial land-use model to visualise the land-use futures of the United States based on different scenarios of external demand and domestic consumption, showing rather different outcomes in terms of land use.

Computable general equilibrium models represent both the supply and demand site of the system while accounting for global trade. They are suited to represent trade flows and are able to capture many dimensions of telecoupled systems as they rely on input-output tables of major commodities. As an example, Yao et al. (2018) applied a computational general equilibrium model to analyse the spillover effects of productivity growth in soybean production in Brazil. It was shown that this productivity growth displaced the United States in the Chinese market and reduced overall growth in soybean output in the United States. Furthermore, the strong soybean productivity growth was shown to contribute to cropland expansion in Brazil. At the same time, these models often lack spatial detail and have strongly simplified and aggregated representations of decision-making.

Depending on the objective of the modelling in the study of telecoupled systems the appropriate type of model must be chosen. At the same time, all model types can be improved to better represent telecoupled systems. Most models rely on land-cover data while land-cover data do not represent telecoupling. In other words, it is not indicated in the land cover if a plot of agricultural land is used for either subsistence farming or for export to another part of the globe. In some new modelling approaches the focus on land-cover types is replaced by distinguishing different land systems driven by different (telecoupled) drivers. This approach allows for assessing the impacts of increased telecoupling more explicitly. In a study for Laos, Debonne et al. (2018) model the spatial patterns of land-use change emerging from changes between swidden systems aimed at subsistence, commercially oriented smallholders and large-scale land acquisitions (Fig. 13.1). To distinguish these different land systems data from agricultural statistics, contracts for large-scale land acquisitions and remote sensing data were combined into a consistent dataset. Such data fusion takes the best information from the different sources to better distinguish differences in land systems. In the simulation model, the different land systems respond to different demands for goods and services. Hence, the dynamics of these different land systems can respond to changes in the level of telecoupling of agricultural and forest commodities and be translated in spatial patterns of land system change.



(Fig. 13.1 continued)

None of the described modelling approaches addresses both local impacts/responses and the process of global displacement and spillover effects. Coupling of different models has been suggested as a way forward, but is not straightforward (Millington et al. 2017). In most cases a top-down coupling is proposed in which global equilibrium models assess the global flows and spillovers, while more regional to local approaches, constrained by these results, study the land-use implications of these. Theoretically, agent-based and spatial modelling approaches can inform the aggregate representations of the global models. They may indicate feedbacks on resource limitations and societal responses from the regional level to the global trade system. However, in a telecoupled system, with distant drivers and impacts, such top-down coupling is not easily implemented and would require complex nested models.

4 Representing Connected Places in Spatial Analysis and Land-Use Modelling

The traditional geographic approach to spatial analysis uses maps to capture variations in the landscape and land use. In telecoupled systems, social, economic and institutional distance do not respect geographic distance: lands are governed from across the world and produce is shipped to distant locations for processing and then again shipped for consumption. It is possible to visualise some of these connections in traditional

Fig. 13.1 Land-use model results for Laos in 2030 using a land system classification. In this model application, land systems with different degrees of telecoupling are defined, ranging from a locally driven system (swidden agriculture) to explicitly globally driven telecoupled systems (large-scale land acquisitions (plantations) and export commodity-oriented small-scale producers). Upper panel: The Chinese border region Northern Laos is characterised by a matrix of swidden agriculture (local system) with centres of both small- and large-scale rubber production, driven by nearby Chinese demands (telecoupled systems). Lower panel: Southern Laos is projected to form a mosaic pattern of hybrid systems producing for both local and telecoupled demands, combined with large-scale land acquisition areas producing for global demands (and some areas remaining swidden). Large-scale land acquisitions are represented by clumped forms, as their actual shape is unknown. Figure is based on Debonne et al. (2018)

maps. The Telecoupling Toolbox—a Geographic Information System application based on the analytical components of the telecoupling framework—provides a number of useful tools to represent distant interactions (Tonini and Liu 2017). However, in spite of these efforts to visualise telecoupled systems, we may also need different database structures and representations that more easily integrate local places as part of a global telecoupled system. Such representations should go beyond the visualisation challenge and have conceptual and analytic implications.

Geographic Information Software is fully based on the concept of geographical distance and many of the analysis tools are not directly suited for analysing telecoupled systems. This especially relates to the notion of system boundaries, which, in a spatial analysis context, are often based on either administrative or physical boundaries such as districts or watersheds. In a telecoupled system, we need to define these boundaries in different ways that no longer follow the traditional geographic boundaries based on geographic proximity (Friis and Nielsen 2017). Similar challenges are encountered in the research community on ecosystem services, where the flow of goods and services between service-producing locations and the locations that benefit from the services is given increasing attention (Koellner et al. 2018). Relating the flow of ecosystem services to the state of land use and the actors involved requires new analytical tools that go beyond spatial analysis, as we currently know it. This is a conceptual and technical challenge that resembles the previous challenge of connecting *people and pixels*. Flow-based approaches need to integrate location, while location-based approaches need to better integrate flows. One step forward, within conventional database structures, may be to connect locations with a specific land cover with an attribute that indicates the connected location, either by ownership or by value chain. Such a task is not trivial, as the nature of the connection needs to be specified to make such information valuable. Similarly, in non-spatial methods such as input-output analysis, the database structure should better link back to the geographical context. Such efforts require disaggregation of data that are currently lumped at national level. The Trase initiative (www.trase.earth, see also Chap. 8) is one example of such an effort to disaggregate input-output data and link this to the geographies of production while naming the actors in the import and export of the commodities. Another example of such analysis and novel database structures is the use of coding systems that allow consumers to trace back the origin of food products (Badia-Melis et al. 2015), for example, by the use of blockchain.

As tools to address these challenges are only recently emerging and certainly not mainstreamed in geographic information software, there is still a major challenge to further develop spatial analysis and land-use modelling to help understand, analyse and visualise telecoupled land-use systems.

Acknowledgements Thanks to Niels Debonne for preparing the figure in this chapter. Funding was obtained from the European Commission for funding through the European Research Council under the European Union's Seventh Framework Programme project ID 311819 (GLOLAND).

References

Badia-Melis, Ricardo, Puneet Mishra, and Luis Ruiz-García. 2015. Food Traceability: New Trends and Recent Advances. A Review. *Food Control* 57: 393–401. https://doi.org/10.1016/j.foodcont.2015.05.005.

Dara, Andrey, Matthias Baumann, Tobias Kuemmerle, Dirk Pflugmacher, Andreas Rabe, Patrick Griffiths, Norbert Hölzel, Martin Freitag JohannesKamp, and Patrick Hostert. 2018. Mapping the Timing of Cropland Abandonment and Recultivation in Northern Kazakhstan Using Annual Landsat Time Series. *Remote Sensing of Environment* 213: 49–60. https://doi.org/10.1016/j.rse.2018.05.005.

Debonne, Niels, Jasper van Vliet, Andreas Heinimann, and Peter Verburg. 2018. Representing Large-Scale Land Acquisitions in Land Use Change Scenarios for the Lao PDR. *Regional Environmental Change* 18 (6): 1–13. https://doi.org/10.1007/s10113-018-1316-8.

Friis, Cecilie, and Jonas Ø. Nielsen. 2017. On the System. Boundary Choices, Implications, and Solutions in Telecoupling Land Use Change Research. *Sustainability* 9 (6): 974. https://doi.org/10.3390/su9060974.

Hailegiorgis, Atesmachew B., and Claudio Cioffi-Revilla. 2018. Agent-Based Modeling of Large-Scale Land Acquisition and Rural Household Dynamics. In *GeoComputational Analysis and Modeling of Regional Systems*, ed. Jean-Claude Thill and Suzana Dragicevic, 101–119. Cham: Springer.

Koellner, Thomas, Matthias Schröter, Catharina J.E. Schulp, and Peter H. Verburg. 2018. Global Flows of Ecosystem Services. *Ecosystem Services* 31 (Part B): 229–230. https://doi.org/10.1016/j.ecoser.2018.04.012.

Magliocca, Nicholas R., Daniel G. Brown, and Erle C. Ellis. 2014. Cross-Site Comparison of Land-Use Decision-Making and Its Consequences across Land Systems with a Generalized Agent-Based Model. *PLoS One* 9 (1): e86179. https://doi.org/10.1371/journal.pone.0086179.

Messerli, Peter, Markus Giger, Michael B. Dwyer, Thomas Breu, and Sandra Eckert. 2014. The Geography of Large-Scale Land Acquisitions: Analysing Socio-Ecological Patterns of Target Contexts in the Global South. *Applied Geography* 53: 449–459. https://doi.org/10.1016/j.apgeog.2014.07.005.

Millington, James D.A., Hang Xiong, Steve Peterson, and Jeremy Woods. 2017. Integrating Modelling Approaches for Understanding Telecoupling: Global Food Trade and Local Land Use. *Land* 6 (3): 56. https://doi.org/10.3390/land6030056.

National Research Council. 1998. *People and Pixels: Linking Remote Sensing and Social Science*. Washington, DC: The National Academies Press.

Sohl, Terry L., Kristi L. Sayler, Michelle A. Bouchard, Ryan R. Reker, Aaron M. Friesz, Stacie L. Bennett, Benjamin M. Sleeter, Tamara Wilson, Chris Soulard, Michelle Knuppe, and Travis Van Hofwegen. 2014. Spatially Explicit Modeling of 1992–2100 Land Cover and Forest Stand Age for the Conterminous United States. *Ecological Applications* 24 (5): 1015–1036. https://doi.org/10.1890/13-1245.1.

Tonini, Francesco, and Jianguo Liu. 2017. Telecoupling Toolbox: Spatially Explicit Tools for Studying Telecoupled Human and Natural Systems. *Ecology and Society* 22 (4): 11. https://doi.org/10.5751/ES-09696-220411.

Torbick, Nathan, Lindsay Ledoux, William Salas, and Meng Zhao. 2016. Regional Mapping of Plantation Extent Using Multisensor Imagery. *Remote Sensing* 8 (3): 236. https://doi.org/10.3390/rs8030236.

Verburg, Peter H., John A. Dearing, James G. Dyke, Sander van der Leeuw, Sybil Seitzinger, Will Steffen, and James Syvitski. 2016. Methods and Approaches to Modelling the Anthropocene. *Global Environmental Change* 39: 328–340. https://doi.org/10.1016/j.gloenvcha.2015.08.007.

Verburg, Peter H., Kathleen Neumann, and Linda Nol. 2011. Challenges in Using Land Use and Land Cover Data for Global Change Studies. *Global Change Biology* 17 (2): 974–989. https://doi.org/10.1111/j.1365-2486.2010.02307.x.

Yao, Guolin, Thomas W. Hertel, and Farzad Taheripour. 2018. Economic Drivers of Telecoupling and Terrestrial Carbon Fluxes in the Global Soybean Complex. *Global Environmental Change* 50: 190–200. https://doi.org/10.1016/j.gloenvcha.2018.04.005.

14

Urban Telecouplings

Dagmar Haase

1 Introduction

Urbanisation, the way by which cities are formed and grow, is both a process and a spatial-temporal pattern. Global urbanisation is a multifaceted phenomenon, with profound and ongoing changes in land use, economics, environment and environmental resources, social structures, behaviour, consumption, as well as political and administrative contexts [adapted after Friedmann (2006) and Bai et al. (2011)]. Soil sealing and respective land take are possibly the most obvious and visible of these changes (Nuissl et al. 2009), but urbanisation has profound and deep impacts on all dimensions of nature and ecosystems, including energy flows, nutrient cycling, food webs and biodiversity (Elmqvist et al. 2013).

Within urbanisation studies, the *urban* as an entity has long been defined and delineated using the administrative borders of cities (Seto et al. 2012), giving rise to a predominant focus on the local, regional or peri-urban scale, being a very pragmatic approach with a clear lack of

D. Haase (✉)
Geography Department, Humboldt-Universität zu Berlin, Berlin, Germany
e-mail: dagmar.haase@ufz.de

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_14

focus on remote interactions of cities with other places. The latter are specific for each city; they can be product, flow, culture and decision related, as well as long-distance or delayed with regard to their impact. Thus, distant interactions of cities cannot be simply captured by the definitions of globalisation or global urbanisation (Elmqvist et al. 2018). In addition, discrete approaches run the risk of homogenising information across different types of land use, including livelihoods along an urban-rural gradient, on the one hand, and heterogenising the places of the sending-receiving UT system only because of their spatial distance, on the other.

Recently, the concept of *urbanity* was proposed to deal with this lack by defining urbanisation and urban space as "[…] the magnitude and qualities of livelihoods, lifestyles, connectivity, and place that create urban-ness of intertwined human experiences and land configurations […]" (Boone et al. 2014, 314). The authors of the urbanity concept argue that fixed borders no longer serve for a sustainability-oriented and impact-focussed view of urbanisation and its result, cities. Contrariwise, urbanisation should be seen as a built and agency continuum, or gradient, which can be applied to spaces outside the administrative boundaries of cities and include multiple spatial and temporal dimensions, including livelihoods, lifestyles, uses of land, attitudes towards nature and economies (Haase 2013). What is more, the urbanity concept can be used to explain how land use has been changing and will change in the future in (non-)urban, remote areas that are connected to underlying urbanisation dynamics (Qureshi and Haase 2014; Boone et al. 2014).

Similar to the new understanding of urbanisation through the lens of urbanity, the conceptual framework of *urban land teleconnections* (Seto et al. 2012), or in the context of this book *urban telecouplings* (UTs), explicitly focus on remote interactions of cities. UTs seek to link land-use and land-cover change to underlying urbanisation dynamics including several local and remote drivers and impacts (Seto et al. 2012; Güneralp et al. 2013): "[…] urban land teleconnections refer to the distal flows and connections of people, economic goods and services, and land-use change processes that drive and respond to urbanisation […]" (Seto et al. 2012, 1). This way, UT expresses that both urban land (use) change and the usage of environmental, economic and cultural resources by urban dwellers cannot be found exclusively in cities or their direct surroundings—in other words short distance and place based—but in the global network of cities themselves. To understand contemporary sustainability challenges driven by urbanisation, one has to consider the many processes and patterns that cities and urban agencies initiate and cause in distant locations (Seto et al. 2012). Two classical examples are first the deforestation in the Amazon caused meat-based diets popular in Europe and, second, the replacement of Indonesian and Malayan primary tropical forests by palm oil plantations caused by multiple palm oil needs (diets, fuel, cosmetics) in the urban world (Boone et al. 2014; Meyfroidt et al. 2010).

UTs allow shedding light on hidden urban drivers of rural land-use change and the resulting migration that are often discussed as the outcomes of regional climate change or local/regional factors such as a failing economy, corruption or armed conflicts, but which are actually initiated and catalysed by distal urban systems, cities with their concentration of power and decision-making abilities in the headquarters of international companies, financial institutes and industries, and their concentration of consumers of attractive bets, food and other land-impacting or land-based products.

Additionally, the UT concept is able to link decision-making, actions, government, agency and land (use) changes at both urban and rural ends of the pathway, so, for example, the adoption of new diets and consumption styles (Chaudhary and Kastner 2016; Deines et al. 2015) by people in both sending and receiving systems at local level can be understood as drivers of increased consumption at global level (Rueda and Lambin 2013; Liu et al. 2013; Liu 2014). This has enormous implications on human well-being and equity in cities as the sending and in distal (rural) locations as the receiving systems.

2 Urbanisation and UT: A Brief State of the Art

In the following, a brief state of the art follows about the prevailing UT analytical framework and how it can be embedded in the overall telecoupling and land-change discussion. Globalisation, namely the increasing global connectivity of economy, technology, transportation, communication, trade, but also politics and culture, adds to and produces novel multiple complexities of causalities in land (use, intensity, agency) change (Lambin and Meyfroidt 2011). This becomes most obvious in cities and urban areas as they exhibit higher than global average connectivity in combination with a huge variety and mixture of land uses such as those of housing, production, commercial activities or those for mobility such as roads, airports or railways and last, but not least, green land uses for recreation and leisure such as parks, cemeteries or gardens (Haase 2013). Moreover, cities as physical expressions and places of urbanisation are the major drivers and catalysts of globalisation and thus create multiple local and distal feedbacks. In other words, many processes of global connectivity, communication and innovation emerge from cities and as direct effects of urban (population, activity, energy) density and urban life (Haase et al. 2018). Compared to rural UTs, urban ones always include a city as the sending system in the coupling; the receiving system can be either one or more rural areas or one or more urban areas (Seto et al. 2012).

The importance of UT for global connectivity and sustainability raises the question of how specific UTs are created, maintained and potentially dissolved. Novel ways of land appropriation including land(use) change emerge along with new land agents (owners, users, stewards) and agency (capacity to act, moral, reflexivity, learning; Frantzeskaki et al. 2017), regardless whether rural or urban and regardless where these new land agents are placed. They overcome the "local" and the "global" aspects of land-use change in all its dimensions and go beyond (Seto and Reenberg 2014), becoming "the telecoupled" ignoring typical urban or rural features of density, forms of built space or administrative boundaries, for example.

Wireless, extremely fast information access and exchange, social and quasi-flat hierarchy communication networks, trade liberalisation and speedy advancing transportation infrastructure have massively increased a spatial and temporal connection between places of similar behaviour and/or interest. In the same way, they have catalysed the disconnection between urban and peri-urban places within one urban region, places of demand and supply of natural resources such as food (Erb et al. 2009; Kastner et al. 2015; Chaudhary and Kastner 2016), income patterns (Boone et al. 2014) and social or behavioural issues such as habits, view-points, communication and life satisfaction (Boone et al. 2014; Garrett et al. 2013). In addition, due to prevalent flows of people, communication, interests, goods and products, UTs connect formerly non-connected distal and remote places as rapidly and completely as it disconnects cities and their close peri-urban hinterlands (Seto et al. 2012), converting the latter literally speaking into "flyover areas." To put it differently, one could argue that UTs create a kind of "meta-regions" without real places and distances that are wireless and matter-free connected, treated and governed.

Primary urban land decision-makers, for example, multinational consortia, and beneficiaries of land-related resources, in most cases the people living in the city, are increasingly not living in the same place (Niewöhner et al. 2016). Consequently, impacts on land and the perceptions of these impacts involve at least two or often more very different and distal places and create both direct and indirect outcomes (material, virtual) of these impact processes complicating the distinction between proximate and underlying drivers and adding displacement and rebound effects to the land-use and land-change processes and patterns (Liu et al. 2013). Former comparatively clear spatial-temporal scales and delineations of urban systems started to become obsolete in a telecoupled world of network actors and network agency (Gentry et al. 2014) deciding upon distal parcels of land (Seto and Reenberg 2014). Studies dealing with the change from "classical" place-based urban land system analysis towards more flow-based approaches discuss a number of negative consequences and sustainability challenges of urbanisation, such as massive land take and local inequality or injustice in (land, water, flora, fauna) resource access (Rueda and Lambin 2013; Seitzinger et al. 2012; Güneralp et al. 2013); issues receiving global attention as well, through, for example, the new Global Sustainable Development Goals (SDGs). Section 2.1 introduces a story that nicely illustrates the framing and the related concerns of UT.

2.1 British Second Homes in Portugal as an Example Illustrating the Usefulness of Urban Telecouplings

The idea of UT as explored above suggests that a high degree of urbanity connects traditional urban places in the United Kingdom with places traditionally labelled as rural in Portugal (Fig. 14.1). The shared urbanity of these seemingly different places is established by teleconnections between them. Wealthy people in the United Kingdom become aware, through travel or media, of the pleasures of living in a sunny, warm place. This creates a desire, reflecting the lifestyle of these people, to have a second home in Portugal. The actors who originate this demand are distant

Fig. 14.1 An example of UTs and their typical land use features in Southern Europe: The "urbanised" Mediterranean coast exhibiting distal ways of life and respective land uses. Source: Own photo

urban dwellers with high incomes, or with livelihoods capable of satisfying the demand. Through modern communication networks they contact developers and mediators, who often participate as actors outside the immediate vicinity of either the rural Portuguese or the city-dwelling UK residents, who in turn connect buyers and sellers to satisfy UK residents' desire for sunny places on the Portuguese coastline (Seto et al. 2012).

Changing livelihoods and lifestyles on the Portuguese coast have been generating a stock of vacant houses associated with an out-migration of the young due to dwindling or no interest in farming. The coastal places were traditionally rural, or have a low degree of urbanity. The houses are bought from local actors (farmer families) by British urbanites mediated by the developers and this leads to a further change of livelihood along the Portuguese coast as the lifestyle of the second homeowners requires development of the infrastructure for health, transport, leisure and also leads to more consumption of energy and water, to land consumption, air pollution and noise as well as effects on ecosystems and biodiversity (Boone et al. 2014).

At the same time, the livelihoods of the local population changes, which might lead to further unemployment on the one hand, such as loss of agricultural livelihoods through competition for land. However, on the other hand, lead to new jobs in the service sector. New sources of income may be created by the presence and needs of new house owners. This further affects and changes the lifestyle of the local population. Overall, the new type of connectivity between the two places and their actors leads to a higher degree of urbanity along the Portuguese coastline and creates urban patterns or spread urbanity that did not exist there before and which are different from a traditional city (Boone et al. 2014). The change in urbanity on the Portuguese coast has causal teleconnections back to the United Kingdom. Flows of investment and people between the new vacation settlements and the UK residences creates temporary vacancy of houses in Britain, which opens the door for new influxes of students and tourists that provides income to the second homeowners and impacts livelihoods and lifestyles in UK cities.

Second homeowners may return to Britain taking along diets and habits from Portugal, which can increase demands for the import of new foods/food ingredients but also cultural artefacts to satisfy a Mediterranean style diet and eating habits. The new patterns of actors at both places and the impacts on the livelihoods can be detected and measured using prevailing, traditional spatial conceptualisations. However, to more fully understand the process of land change in an urban era, the multiple and interacting variables of urbanity are useful. The framework helps tease apart this complex example to show how urbanity extends over great distances based on telecouplings of different actors located far from each other, and following or adjusting their own livelihoods and lifestyles (Seto et al. 2012).

3 Beyond the State of the Art: Urban Telecouplings as a Novel Way to Approach Sustainable Land Change Related to Cities and Urbanisation

A number of studies have so far been focussing predominantly on rather negative impacts of UT in the receiving systems (destination, distal areas), including issues related to land-use and land-cover change. Mainly negative impacts of the urban on remote ecosystems such as coastal or rural landscapes and livelihoods have been discussed in relation to the decline of biodiversity, soil erosion or monoculture plantations (Seto et al. 2012; Güneralp et al. 2013; Boone et al. 2014). In addition, concern has been raised in relation to land consumption in and around cities by international—in the truest sense telecoupled—real estate consortia (Haase et al. 2018), technology and communication companies, banks or investments in smart growth originating in other urban areas (Elmqvist et al. 2018).

Such urban-to-urban UT can challenge the sustainability of receiving cities, where city governments often are under pressure to sell or provide the land for such development due to the promise of new jobs and the attractiveness of such investments, while at the same time having clear and declared goals of promoting smart and high education-based development. The challenge arises when more marginal parts of the urban population (the poor, the elderly) are squeezed in such new development schemes. In the same vein, distal investments of large state or private

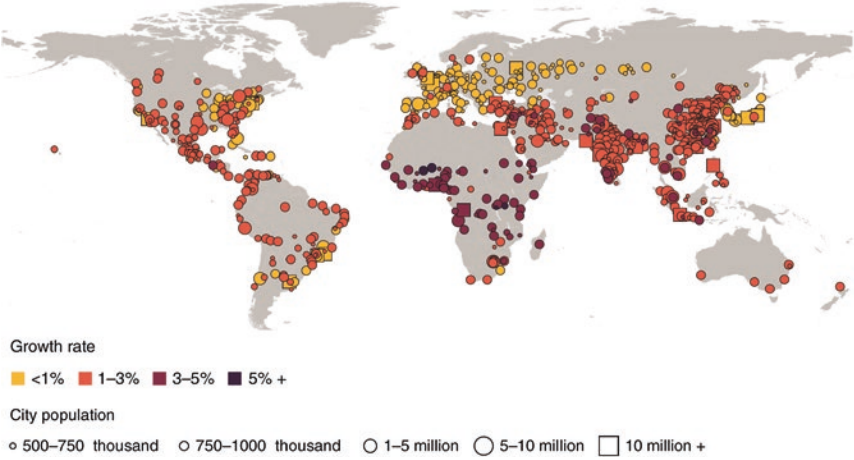


Fig. 14.2 Global distribution of hot spot cities. Hotspot cities' growth rates, 2014–2030. Cities of 500,000 or more people projected to sprawl into remnant habitat in the world's biological hot spots (Haase et al. 2018)

companies (here acting as the sending system) in the peri-urban space (here the receiving system) for intensive agriculture and horticulture in fertile areas have been increasingly occurring and expanding in the last decades (Boone et al. 2014). All these processes of land sales and land conversion lead to (a) the loss of open land, (b) the decline and loss of distal ecosystems (Meyfroidt 2013) and (c) in most cases also the loss of original biodiversity which were found highly correlated to the places of past and current of urbanisation (Elmqvist et al. 2018; see Fig. 14.2).

However, the impact-focussed discussion of UT sparks the suspicion that urban-driven telecouplings are something exclusively non-sustainable and therefore not desirable.

But is that really the case?

The following examples provide some novel arguments that UT could also act as a catalyst for sustainability transitions and a more sustainable way of land change rather than being exclusively a threat or harm as discussed above. Underlying assumptions hereby are that UT can initiate and foster urban sustainability transitions and new development pathways (as understood by Frantzeskaki et al. 2012) at both ends of the coupling itself.

3.1 Urban Telecouplings with Positive Sustainability Implications

The way land is used and populated by humans, including individual actors or companies, is far from static or linear. At a systemic level, concepts such as biocultural diversity suggest that particularly cities are places of constant and immanent co-evolution of all the different manifestations of life—biological, cultural and linguistic—and thus places of cultural interactions of and with land and biodiversity at place and as catalyst between/across places (Elands et al. 2018; Díaz et al. 2018). In earlier discussions of urbanisation and sustainability, this co-evolution was often overlooked, because cities and their peri-urban surroundings were traditionally conceived of as antipodes of nature. Lately, however, it is gradually being recognised that urban land and urban landscapes need to be considered as *cultural landscapes* embodying a specific type of co-evolution between natures and cultures (Elands et al. 2018; Vierikko et al. 2016). Culture to some extent permeates all ecosystems, their land use and their services to humans (Díaz et al. 2018).

Here, UTs come into play as a new conceptualisation that is needed to better understand and recognise the processes that shape, take place on and are facilitated by human agency on the one hand and land including its ecosystems on the other. This statement is especially important for global urbanisation, where the structure and function but also mental models of and attitudes towards land (use) may affect one another even at great distances and at near instantaneous speeds (Boone et al. 2014). The impacts in telecoupled remote or rural areas as well as feedback effects on the origin cities that triggered the respective UT and, consequently, the related land change have to be analysed both concerning moments and characteristics of change and of transformation.

What is important for the discussions of urban sustainability is that such change of land and land-use activities can be of positive character as the following examples including (a) how such positive effects can be initiated, (b) in which way they occur (the flows), (c) what agents might be involved and thus are the “carrier” of such positive change and (d) what are the respective positive effects on land and land change at both places, the sending system (city) and the distant place (receiving system) show.

First, the new understanding of urban green space in the cities of the Global South including the greening of local economies there and a better conservation of the high biodiversity as shown in Fig. 14.2 (see manifold examples from South America, Asia or Africa in the latest Cities and Biodiversity Outlook by Elmqvist et al. 2013). This greening is a positive UT of type (a) from the Global North cities as sending and the Global South cities as receiving system.

Second, the diffusion and adoption of "green" lifestyles and consumption behaviour that were born in origin cities of the Global North and get adopted in the Global South cities, but also in rural, and remote tourist areas, a UT of type (b) (Braun et al. 2017). Food is a very good example here: It can be a provisioning service, it can be a material benefit, but food is at the same time also a cultural adaptation (Díaz et al. 2018) and thus can mutually happen at both ends of a UT, and makes the sending system a receiving one and vice versa. The fact that we finally have hybrid diets within an urban telecoupled system is a form of cultural adaptation. Culture this way can be understood as a non-material driver within UT transversal across the globe.

Third, different forms of ecotourism and respective land change and nature conservation (e.g. ECO-INDIA, Brazil Nature Tours), which became popular also among the locals at distal places in relation to the Global North, for example, in Argentina or Brazil (South America). Again, this UT of type (d) comes from the Global North cities (where most backpacker and ecotourists come from) as sending and had been received by the Global South.

Fourth, the usage of alternative (low or zero carbon) energies, such as solar power which is already spreading in sub-Saharan Africa (Elmqvist et al. 2018), bioenergy farms or wind energy implementation such as in Comodoro Rivadavia, Argentina (Elmqvist et al. 2018). The UT of type (b) here is a bit more complicated as it comes as idea from scientific and developer institutions situated in the Global North cities and had been further developed and tested/implemented in rural (non-urban) regions close to these Global North cities and found afterwards entry in the energy mix of the Global South.

Fifth, non-car-based transport systems, including rickshaws introduced as flexible and emission-free transport means, originating in cities in the Global South (sending system) that are increasingly being adopted in cities in the Global North (receiving system) such as in the city of Berlin, Germany. The same UT also works from northern Europe to southern Europe highlighting the example of rental bikes in Tirana, Albania, as a consequence of international tourism UTs [type (c)].

Finally, sixth, localised supply chains or other attitudes towards nature that are changing in response to tourist interests, such as nature conservation in East or West African National Parks, but which tie in with and co-evolve with novel understandings of nature and its stewardship at place. This last example is again a UT of types (a) and (c) and of predominantly non-material character.

Set against the prevailing discussion of the system of telecouplings, including sending, receiving and spillover subsystems, these examples help to shed light on the fact that so far, a lot of attention has been paid to UTs' origins in the Global North, that is northern/western cities are viewed as de facto functioning sending systems driving mostly negative, although also some positive change elsewhere. What is interesting, however, is the emerging recognition that positive UTs may increasingly originate in megacities or urban lifestyles/processes from the Global South "sending out" new sustainable trends to be adopted in the northern urban areas/cities. This emerging trend represents particularly a type of urban to urban telecoupling that is worth substantial more attention in the future.

3.2 Diet UTs Feed More Sustainable Land Use

As discussed in the example of UK residential tourism in Portugal, travelling or migrating people bring with them novel lifestyles and attitudes towards environmental resources and nature to the "receiving" areas (Banuri 1990; Tomlinson 1991). This can have important implications for perceptions and opinion formation among local people. As known from many tourist destinations, urbanites travelling there export dynamic lifestyles and the image of the western "throwaway society," on the one hand. On the other, they can also be the carriers of *surprising* new ideas of "green," "slow," "non-meat" food, including vegetarian and vegan diets with them. Recent studies have shown how particularly the latter are increasingly copied by local people in the destination areas: Vegetarianism is now being adopted by an increasing number of people in some classical meat-diet regions such as urban Argentina, Uruguay and Chile, for example (Ruby et al. 2016), resulting from a massive increase of international tourism since the year 2000.

However, change in both diets and transportation systems can also provoke negative changes in urban/non-urban land-use patterns in the receiving system of UT (Seto et al. 2012) and, consequently, affect natural resources and ecosystems including the ecosystem services they supply. This way, for example, agricultural land has been lost in the Barcelona region as a result of the massive expansion of the tourist sector, and forest declines or wetlands have been drained in other parts of the world (Haase 2016). How far the findings discussed in this section could be also true for non-tourist (poverty-driven) migrant movement needs to be empirically elaborated before making similar statements.

Following this argumentation, UT also include another aspect: The feedbacks from the distant receiving locations on the origin urban areas and cities, in most of the cases discussed in this chapter European cities, in terms of, for example, modified diets which result from a hybridisation of those diets European tourists bring to the receiving system (e.g. in the Global South) and those diets they are confronted with in the distant area which influences their future diets when back home (sending system) which again trigger new UT or, alternatively, a new aspect of an existing UT, in terms of imports of new types of food including chia seeds, acai, goji berries or avocado fruits in the origin areas of the UT. Examples are different types of so-called Super Food originating in South America, Asia or Africa and being a market hit for the European educated and high income classes in cities (Brown et al. 2017), which have been shown to have both positive economic impacts on distant producing regions and negative environmental outcomes such as deforestation.

3.3 Underestimated Effects: Urban Community and Guerrilla Gardening

Cities as origins of UT and distal places as receiving systems of UT, be they urban or rural, occur via the new formation, momentum and movement of a new "global community." A very prominent example is the (global) urban community of *guerrilla gardening*. Such place-based actions on urban land seem to have the potential to develop into a cross-place, really symmetric UT where urban people from Europe or the United States, for example, learn from a place like La Habana, Cuba, about gardening between houses and in backyards. Vice versa, gardeners from La Habana can share experiences of European guerrilla gardening groups and can thus advance their gardening in terms of giving more attention to the social cohesion aspects of garden use and of environmental education that is intrinsic for European or US community gardens. Thus, the UT is not realised via the food products themselves—as conceptualised, for example, in Erb et al. (2009) or discussed by Niewöhner et al. (2016)—but in the way of "action-on-urban-land" or going into the different flows that constitute a telecoupling including, for example, discursive flows (see also Chaps. 15 and 17). A great example is the Brooklyn Grange Farm (https://www.brooklyngrangefarm.com/) in New York, which cooperates with many gardens and urban farms worldwide in a more *dépense* (see *Degrowth Handbook* by D'Alisa et al. n.d.) or *commons* type of way. What is more, urban gardening UTs, particularly in the United States, in the United Kingdom but also at Cuba, include next to highly educated, resource-full, young and middle-class people also those groups of urban actors that are often underprivileged, low-income or otherwise deprived, at both ends of the UT and in contrary to the prevailing understanding of telecouplings where the "origin system" is almost always characterised by large profit (see Liu et al. 2013 or Erb et al. 2009).

4 In Lieu of a Conclusion

In this chapter, I have discussed the way in which cities and urban areas and respective new processes of urbanisation create telecouplings with sustainability implications for land-use change elsewhere. In this regard, the concept of UT was introduced in order to specify what specifically urban telecouplings are, how they differ from "rural" telecouplings, that urban telecouplings can appear in the form of different flows and, most importantly, that urban telecouplings are not only negatively but also positively impacting land use in the receiving systems.

In addition to existing impact discussions of telecouplings on remote receiving areas that provide a rather critical view on telecouplings as a form of far-distance land exploitation or land take, this chapter presents some novel ideas on how particularly urban telecouplings can—next to the same exploitative impact on land they definitely have—contribute to more sustainable land usage and land transformation. A range of representative examples were discussed, including (a) how such positive effects can be initiated, (b) in which way they occur (the flows), (c) what agents might be involved and thus are the carrier of such positive change, and (d) what are the respective positive effects on land and land change at both places, the sending system (city) and the distant place (receiving system). Examples include UT involving local product diets, and new ways of greening cities, alternative low carbon economies and transport systems that can be understood as products of global telecoupled acting.

In order to venture into new territories, UTs possibly represent a novel type of hybridisation of attitudes and environmental behaviour (Pieterse 1994) that are traditionally seen as a by-product of globalisation but might be one core property of the telecouplings-urbanisation system. Exploring UT more systematically concerning its harmful but also positive effects on land is fertile ground for quantitative and qualitative studies of UT, starting from different urban systems or cities across the globe. If we will be successful in merging individual experiences and still fragmentary evidence to a more complete picture, we will be able to amplify the UT concept regarding its transformative potential.

Acknowledgements I wish to thank our colleagues from the BiodivERsA project ENABLE (COFUND 2015-16), and the Horizon 2020 innovation action CONNECTING (COproductioN with NaturE for City Transitioning, Innovation and Governance; No. 730222-2) for fruitful discussions and comments.

References

Bai, Xuemei, Jing Chen, and Peijun Shi. 2011. Landscape Urbanisation and Economic Growth in China: Positive Feedbacks and Sustainability Dilemmas. *Environmental Science & Technology* 46: 132–139.

Banuri, Tariq. 1990. Modernisation and Its Discontents. A Cultural Perspective on Theories of Development. In *Dominating Knowledge. Development, Culture, and Resistance*, ed. Frédérique Apffel Marglin and Stephen A. Marglin, 73–101. Oxford: Clarendon Press.

Boone, Christopher G., Charles L. Redman, Hilda Blanco, Dagmar Haase, Jennifer Koch, Shuaib Lwasa, Harini Nagendra, Stephan Pauleit, Steward T.A. Pickett, Karen C. Seto, and Makoto Yokohari. 2014. Reconceptualizing Urban Land Use. In *Rethinking Global Land Use in an Urban Era*, ed. Karen Seto and Anette Reenberg, 313–330. Cambridge, MA: The MIT Press.

Braun, T., M. Cajias, and R. Hohenstatt. 2017. Societal Influence on Diffusion of Green Buildings: A Count Regression Approach. *Journal of Real Estate Research* 39 (1): 1–38.

Brown, Rachel C., Lee Ching Yong, Andrew R. Gray, Siew Ling Tey, Alexandra Chisholm, and Sook Ling Leong. 2017. Perceptions and Knowledge of Nuts amongst Health Professionals in New Zealand. *Nutrients* 9 (3): 220.

Chaudhary, Abhishek, and Thomas Kastner. 2016. Land Use Biodiversity Impacts Embodied in International Food Trade. *Global Environmental Change* 38: 195–204.

D'Alisa, Giacomo, Federico Demaria, and Giorgios Kallis. (n.d.). Degrowth: A Vocabulary for a New Era. Accessed November 13, 2018. https://vocabulary.degrowth.org/.

Deines, Jillian M., Xiao Liu, and Jianguo Liu. 2015. Telecoupling in Urban Water Systems: An Examination of Beijing's Imported Water Supply. *Water International* 41 (2): 251–270. https://doi.org/10.1080/02508060.2015.1113485.

Díaz, Sandra, Unai Pascual, Marie Stenseke, Berta Martín-López, Robert T. Watson, Zsolt Molnár, Rosemary Hill, Kai M.A. Chan, Ivar A. Baste, Kate A. Brauman, Stephen Polasky, Andrew Church, Mark Lonsdale, Anne Larigauderie, Paul W. Leadley, Alexander P.E. van Oudenhoven, Felice van der Plaat, Matthias Schröter, Sandra Lavorel, Yildiz Aumeeruddy-Thomas, Elena Bukvareva, Kirsten Davies, Sebsebe Demissew, Gunay Erpul, Pierre Failler, Carlos A. Guerra, Chad L. Hewitt, Hans Keune, Sarah Lindley, and Yoshihisa Shirayama. 2018. Assessing Nature's Contributions to People. *Science* 359: 270–272. https://doi.org/10.1126/science.aap8826.

Elands, Birgit H.M., Kati Vierikko, Erik Andersson, Leonie K. Fischer, Paula Goncalves, Dagmar Haase, Ingo Kowarik, Ana Catarina Luz, Jari Niemelä, Margarida Santos-Reis, and K.F. Wiersum. 2018. Biocultural Diversity: A Novel Concept to Assess Human-Nature Interrelations, Nature Conservation and Stewardship in Cities. *Urban Forestry & Urban Greening*. https://doi.org/10.1016/j.ufug.2018.04.006.

Elmqvist, Thomas, Xuemei Bai, Niki Frantzeskaki, Corrie Griffith, David Maddox, Timon McPhearson, Susan Parnell, Patricia Romero-Lankao, David Simon, and Mark Watkins, eds. 2018. *The Urban Planet: Patterns and Pathways to the Cities We Want*. Cambridge: Cambridge University Press.

Elmqvist, Thomas, Michail Fragkias, Julie Goodness, Burak Güneralp, Peter J. Marcotullio, Robert I. McDonald, Susan Parnell, Maria Schewenius, Marte Sendstad, Karen C. Seto, and Cathy Wilkinson, eds. 2013. *Global Urbanisation, Biodiversity and Ecosystem Services: Challenges and Opportunities. A Global Assessment*. Dordrecht, Heidelberg, New York, London: Springer.

Erb, Karl-Heinz, Fridolin Krausmann, Veronika Gaube, Simone Gingrich, Alberte Bondeau, Marina Fischer-Kowalski, and Helmut Haberl. 2009. Analyzing the Global Human Appropriation of Net Primary Production—Processes, Trajectories, Implications. An Introduction. *Ecological Economics* 69: 250–259.

Frantzeskaki, Niki, Dagmar Haase, Michail Fragkias, and Thomas Elmqvist. 2017. Editorial Overview: System Dynamics and Sustainability: Urban Transitions to Sustainability and Resilience. In *Current Opinion in Environmental Sustainability*, vol. 22, iv–viii. https://doi.org/10.1016/j.cosust.2017.05.001.

Frantzeskaki, Niki, Deerk Loorbach, and James Meadowcroft. 2012. Governing Transitions to Sustainability: Transition Management as a Governance Approach towards Pursuing Sustainability. *International Journal of Sustainable Development* 15 (12): 19–36.

Friedmann, John. 2006. Four Theses in the Study of China's Urbanisation. *International Journal of Urban and Regional Research* 30: 440–451.

Garrett, Rachael D., Ximena Rueda, and Eric F. Lambin. 2013. Globalization's Unexpected Impact on Soybean Production in South America: Linkages between Preferences for Non-genetically Modified Crops, Eco-Certifications, and Land Use. *Environmental Research Letters* 8 (4): 044055. https://doi.org/10.1088/1748-9326/8/4/044055.

Gentry, Bradford S., Thomas Sikor, Graeme Auld, Anthony J. Bebbington, Tor A. Benjaminsen, Carol A. Hunsberger, Anne-Marie Izac, Matias E. Margulis, Tobias Plieninger, Heike Schroeder, and Caroline Upton. 2014. Changes in Land-Use Governance in an Urban Era. In *Rethinking Global Land Use in an Urban Era*, ed. Karen Seto and Anette Reenberg, 239–271. Cambridge, MA: The MIT Press.

Güneralp, B., K.C. Seto, and M. Ramachandran. 2013. Evidence of Urban Land Teleconnections and Impacts on Hinterlands. *Current Opinion in Environmental Sustainability* 5 (5): 445–451.

Haase, Dagmar. 2013. Shrinking Cities, Biodiversity and Ecosystem Services. In *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities*, ed. Thomas Elmqvist, Michail Fragkias, Julie Goodness, Burak Güneralp, Peter J. Marcotullio, Robert I. McDonald, Susan Parnell, Maria Schewenius, Marte Sendstad, Karen C. Seto, and Cathy Wilkinson, 253–274. Dordrecht, Heidelberg, New York, London: Springer.

———. 2016. Urban Wetlands and Riparian Forests as a Nature-Based Solution for Climate Change Mitigation and Adaptation in Cities and Their Surroundings. In *Nature-based Solutions to Climate Change in Urban Areas—Linkages between Science, Society and Practice*, ed. Nadja Kabisch, Aletta Bonn, Horst Korn, and Jutta Stadler. Dordrecht, Heidelberg, New York, London: Springer.

Haase, Dagmar, Burak Güneralp, Bharat Dahiya, Xuemei Bai, and Thomas Elmqvist. 2018. Different Pathways of Global Urbanisation. In *The Urban Planet: Patterns and Pathways to the Cities We Want*, ed. Thomas Elmqvist, Xuemei Bai, Niki Frantzeskaki, Corrie Griffith, David Maddox, Timon McPhearson, Susan Parnell, Patricia Romero-Lankao, David Simon, and Mark Watkins, 17–146. Cambridge: Cambridge University Press.

Kastner, Thomas, Karl-Heinz Erb, and Helmut Haberl. 2015. Global Human Appropriation of Net Primary Production for Biomass Consumption in the European Union, 1986–2007. *Journal of Industrial Ecology* 19: 825–836.

Lambin, Eric F., and Patrick Meyfroidt. 2011. Global Land Use Change, Economic Globalisation, and the Looming Land Scarcity. *Proceedings of the National Academy of Sciences* 108 (9): 3465–3472.

Liu, Jianguo. 2014. Forest Sustainability in China and Implications for a Telecoupled World. *Asia & the Pacific Policy Studies* 1: 230–250.

Liu, Jianguo, Vanessa Hull, Mateus Batistella, Ruth DeFries, Tom Dietz, Fu Feng, Thomas W. Hertel, R. Cesar Izaurralde, Eric F. Lambin, Shuxin Li, Luiz A. Martinelli, William J. McConnell, Emilio F. Moran, Rosamond Naylor, Zhiyun Ouyang, Karen R. Polenske, Anette Reenberg, Gilberto de Miranda Rocha, Cynthia S. Simmons, Peter H. Verburg, Peter M. Vitousek, Fusuo Zhang, and Chunquan Zhu. 2013. Framing Sustainability in a Telecoupled World. *Ecology and Society* 18 (2): 26. https://doi.org/10.5751/ES-05873-180226.

Meyfroidt, Patrick. 2013. Environmental Cognitions, Land Change and Social-Ecological Feedbacks: Local Case Studies of Forest Transition in Vietnam. *Human Ecology* 41: 367–392.

Meyfroidt, P., Thomas K. Rudel, and Eric F. Lambin. 2010. Forest Transitions, Trade, and the Global Displacement of Land Use. *Proceedings of the National Academy of Sciences* 107: 20917–20922.

Niewöhner, Jörg, Jonas Ø. Nielsen, Ignacio Gasparri, Yaqing Gou, Mads Hauge, Neha Joshi, Anke Schaffartzik, Frank Sejersen, Karen C. Seto, and Chris Shughrue. 2016. Conceptualizing Distal Drivers in Land Use Competition. In *Land Use Competition*, ed. Jörg Niewöhner, Antje Bruns, Patrick Hostert, Tobias Krueger, Jonas Ø. Nielsen, Helmut Haberl, Christian Lauk, Juliana Lutz, and Daniel Müller, 21–40. Cham: Springer.

Nuissl, Henning, Dagmar Haase, Martin Lanzendorf, and Heidi Wittmer. 2009. Environmental Impact Assessment of Urban Land Use Transitions—A Context-Sensitive Approach. *Land Use Policy* 26 (2): 414–424.

Pieterse, Jan Nederveen. 1994. Globalisation as Hybridisation. *International Sociology* 9 (2): 161–184.

Qureshi, Salman, and Dagmar Haase. 2014. Compact, Eco-, Hybrid or Teleconnected? Novel Aspects of Urban Ecological Research Seeking Compatible Solutions to Socio-Ecological Complexities. *Ecological Indicators* 42: 1–5.

Ruby, Matthew B., Marle S. Alvarenga, Paul Rozin, Teri A. Kirby, Eve Richer, and Guillermina Rutsztein. 2016. Attitudes toward Beef and Vegetarians in Argentina, Brazil, France, and the USA. *Appetite* 96 (1): 546–554.

Rueda, Ximena, and Eric F. Lambin. 2013. Linking Globalisation to Local Land Uses: How Eco-Consumers and Gourmands Are Changing the Colombian Coffee Landscapes. *World Development* 41: 286–301.

Seitzinger, Sybil P., Uno Svedin, Carole L. Crumley, Will Steffen, Saiful Arif Abdullah, Christine Alfsen, Wendy J. Broadgate, Frank Biermann, Ninad R. Bondre, John A. Dearing, Lisa Deutsch, Shobhakar Dhakal, Thomas Elmqvist, Neda Farahbakhshazad, Owen Gaffney, Helmut Haberl, Sandra Lavorel, Cheikh Mbow, Anthony J. McMichael, Joao M.F. deMorais, Per Olsson, Patricia Fernanda Pinho, Karen C. Seto, Paul Sinclair, Mark Stafford Smith, and Lorraine Sugar. 2012. Planetary Stewardship in an Urbanizing World: Beyond City Limits. *Ambio* 41: 787–794.

Seto, Karen C., and Anette Reenberg, eds. 2014. *Rethinking Global Land Use in an Urban Era*. Cambridge, MA: The MIT Press.

Seto, Karen C., Anette Reenberg, Christopher G. Boone, Michail Fragkias, Dagmar Haase, Tobias Langanke, Peter Marcotullio, Darla K. Munroe, Branislav Olah, and David Simon. 2012. Teleconnections and Sustainability: New Conceptualizations of Global Urbanisation and Land Change. *Proceedings of the National Academy of Sciences* 109 (20): 7687–7692.

Tomlinson, Johm. 1991. *Cultural Imperialism. A Critical Introduction*. Baltimore, MD: John Hopkins University Press.

Vierikko, Kati, Birgit Elands, Jari Niemelä, Erik Andersson, Arjen Buijs, Leonie Katharina Fischer, Dagmar Haase, Nadja Kabisch, Ingo Kowarik, Ana Catarina Luz, Anton Olafsson Stahl, Luca Száraz, Alexander Van der Jagt, and Cecil Konijnendijk van den Bosch. 2016. Considering the Ways Biocultural Diversity Helps Enforce Urban Green Infrastructure in Times of Urban Transformation. *Current Opinion in Environmental Sustainability* 22: 7–12. https://doi.org/10.1016/j.cosust.2017.02.006.

15

Conservation Telecouplings

Tobias Kuemmerle, Thomas Kastner, Patrick Meyfroidt, and Siyu Qin

1 Introduction

The Anthropocene is characterised by widespread defaunation, by extinction rates about 1000 times higher than background rates, and by the extensive transformation of natural ecosystems (Pimm et al. 2014).

T. Kuemmerle (✉) • S. Qin
Geography Department, Humboldt-Universität zu Berlin, Berlin, Germany
e-mail: tobias.kuemmerle@hu-berlin.de; siyu.qin@geo.hu-berlin.de

T. Kastner
Senckenberg Biodiversity and Climate Research Centre (BiK-F), Frankfurt am Main, Germany
e-mail: thomas.kastner@senckenberg.de

P. Meyfroidt
Fund for Scientific Research F.R.S.–FNRS, Brussels, Belgium

Georges Lemaître Centre for Earth and Climate Research (TECLIM), Earth and Life Institute, UCLouvain, Louvain-la-Neuve, Belgium
e-mail: Patrick.Meyfroidt@uclouvain.be

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_15

Humanity has caused this biodiversity crisis, mainly via habitat loss, overexploitation, climate change, pollution, and fostering invasive species (Maxwell et al. 2016). Given continued human population growth and surging consumption, the outlook for biodiversity is grim. This is worrisome, as biodiversity underpins nature's contributions to people (Díaz et al. 2018) and as biodiversity loss amplifies other drivers of global change (Hooper et al. 2012).

Identifying effective strategies for lessening biodiversity loss and for balancing human resource use and conservation is therefore a central sustainability challenge. Yet, despite strong and increasing conservation efforts, societies have thus far not succeeded in reversing declining biodiversity trends (Butchart et al. 2010). This is in part due to the sheer magnitude and footprint of some extinction drivers, especially land use and overexploitation (Maxwell et al. 2016; Venter et al. 2016). Conservation efforts also fall short in part due to the difficulty and complexity of many conservation problems (Game et al. 2014). Approaching conservation problems from the perspective of social-ecological systems might improve conservation outcomes by better considering local contexts, agency, system dynamics, or feedback between actors, threats, and conservation actions.

Social-ecological systems around the world are increasingly interconnected through flows of commodities, information, people, or capital (Liu et al. 2013; Eakin et al. 2014; Friis et al. 2016). For example, according to the Food and Agriculture Organization (FAO), international agricultural commodity trade has grown by 4% annually from 1961 to 2016, twice the annual production increase in that period.[1] New technologies for sharing information are spreading rapidly (e.g. mobile phone coverage has increased from 60% of the world population in 2003 to 90% in 2010[2]). Local land-use decisions are increasingly caused by and modulated through distal actors, capital inflows, and distal markets (see Chaps. 2 and 3). As regions become increasingly interconnected, the threats to biodiversity, which always play out locally, are thus ever more linked to distal rather than local causes (Lenzen et al. 2012; Carrasco et al. 2017).

Our understanding of conservation challenges and opportunities brought by such distal connections, however, remains poor. Ignoring distal feedbacks and cross-scale linkages likely often undermines conservation effectiveness. For instance, investing in intensification may escalate, not lower, conservation costs (Phelps et al. 2013). Intensification, to spare land for nature, might also lead to higher, not lower, pressure on land due to rebound effects (Hertel et al. 2014; Meyfroidt et al. 2018). Similarly, agroecological landscapes that balance conservation and agriculture locally might lead to rising pressure on biodiversity at broader scales when food imports to such landscapes rise (Carrasco et al. 2017; Phalan et al. 2016). Conservation thus urgently needs to more deeply consider the spatial decoupling of local threats and distal root causes of these threats.

Studying and addressing distal links also opens up new avenues for conservation. Historically, conservation planning and action have focussed on populations of species or ecosystems of conservation concern in a particular place and on the conservation actions to be implemented there (e.g. protected areas, anti-poaching patrols, reintroduction projects, educational programmes). Recognising telecouplings may bring about new entry points and opportunities for conservation, or allow the strengthening of existing conservation efforts. For example, as information on environmental degradation and biodiversity loss in far-away regions percolates to consumers and companies, the demand for and willingness to implement clean supply chain mechanisms, such as zero-deforestation commitments, grows (Gibbs et al. 2016; Lambin et al. 2018). Understanding supply chain structures may also allow focussing on key actors, such as traders, which might be more effective than addressing large numbers of producers and consumers directly, and may allow the creation of synergies between place-based conservation efforts and other flow-based approaches.

Conservation itself is globalising and responses to local threats to biodiversity increasingly come from afar (Carrasco et al. 2017; Waldron et al. 2017). Such conservation feedbacks can take a range of forms, from inflowing conservation funding, to the engagement of international conservation organisations, capacity building in biodiversity loss regions, land acquisitions by distal conservation-minded individuals and organisations, or supply chain mechanisms such as certification (Fairhead et al. 2012; Tscharntke et al. 2015; Lambin et al. 2018). Conservation planning, policy-making, and on-the-ground action have become major factors forging telecoupled social-ecological systems, and conservation is reshaping interactions and power constellations among actors in these systems. Despite their increasing importance, we still lack a proper conceptual and empirical assessment of distal causes of threats and distal conservation responses.

Here, we define conservation telecouplings as *the coupling of social-ecological systems through distal, conservation-related responses to local threats to biodiversity*. These distal conservation responses are triggered through flows of information from the system undergoing biodiversity loss and environmental degradation to the system that includes conservation-minded societies and actors (and that then link to such actors in the source system). Importantly, the root causes of biodiversity losses can be either local or distal. In the following, we will discuss how conservation telecouplings can be framed and how they might help to identify more effective conservation strategies.

2 Conceptualising Conservation Telecouplings

Biodiversity loss occurs when biodiversity facets (e.g. species populations, particular ecosystems, genetic diversity, or functional diversity) dwindle in response to rising threats. For this chapter, we follow the joint threat definition of the International Union for the Conversation of Nature (IUCN) and the Conservation Measures Partnership (CMP), which defines direct threats as the proximate human activities or processes that cause the destruction or degradation of biodiversity facets of conservation concern (Salafsky et al. 2008). In an increasingly interconnected world, commodities are transported flexibly across the world and flows of information, capital, people, and norms now link formerly remote and distal places (Carrasco et al. 2017). Thus, although threats are often the result of direct actions carried out by actors *within* a social-ecological system undergoing biodiversity loss, the root causes of threats are increasingly situated *outside* that system. For example, growing coffee consumption in the Western world leads to deforestation in Vietnam (Meyfroidt et al. 2013), or the use of wildlife parts in Asia leads to pangolin or rhino poaching in Africa (Wilcove et al. 2013).

The telecouplings framework, that describes linkages between distal, yet clearly defined social-ecological systems (see Chaps. 2, 3, and 4 in this book), could be a useful heuristic to more fully embrace the "distal nature" of what threatens local biodiversity. A starting point is to distinguish threats linked to root causes that are part of the same system (Fig. 15.1A, left)

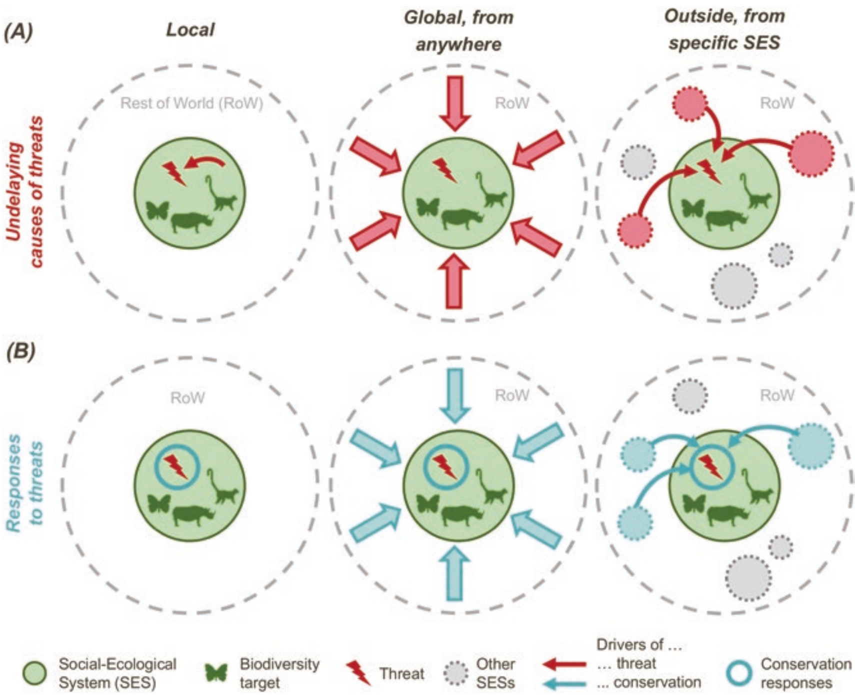


Fig. 15.1 Origins of biodiversity threats and conservation responses. (**A**) Threats to species or ecosystems of conservation concern (i.e. biodiversity targets) play out locally but can be caused by processes and actors that are inside a specific social-ecological system (e.g. shifting cultivation; left), that are outside that system but cannot be traced back easily (e.g. ocean acidification; centre), or that are outside that system but originate from another specific and distal social-ecological system (e.g. the expansion of cash crops for a specific consumer market; right). (**B**) Conservation responses to threats can either originate within a social-ecological system (e.g. cultural taboos; left), originate from elsewhere in an unspecified manner (e.g. global agreements; centre), or originate from specific social-ecological systems (e.g. inflow of conservation funding for a specific project, land purchase for private protected areas, a country's legal framework; right)

from situations where the root causes for local threats are outside of that system. It is often difficult to trace back the distal root causes to a particular source system, as in the case of ocean acidification leading to coral bleaching or global warming leading to changes in mountain vegetation (Fig. 15.1A, centre). However, tracing back distal root causes through actor networks to a specific system is possible and can improve the understanding of the direct drivers of threats, such as in the case of traded agricultural or wildlife products that exert pressure on biodiversity in their source regions (Fig. 15.1A, right, see also Chap. 4).

Similarly, conservation responses to local threats to biodiversity can be local or distal (Fig. 15.1B). Sometimes, responses emerge from within a social-ecological system (Fig. 15.1B, left), for example where ecosystem degradations trigger local communities to manage resources as commons (Rudel 2011), to organise resistance against external drivers of biodiversity loss (e.g. land purchases by actors seeking to expand agriculture), or to establish no-take zones or taboos to prevent over-utilisation of valued species (Daw et al. 2015). Conservation responses can also come from outside of a social-ecological system, again either in a diffuse or ubiquitous manner (i.e. from *anywhere* in the "outside world," Fig. 15.1B, centre). For example, in the form of international agreements (e.g. CITES agreement regulating wildlife trade, REDD+ mechanism). Commonly however, conservation responses to local threats originate from *somewhere* (i.e. another social-ecological system; Fig. 15.1B, right), for example, where foreign conservation organisations raise funds to invest in conservation planning, protected areas, or capacity building in a specific place that is undergoing biodiversity loss, where governmental bodies enact conservation legislation or implement a protected area, or where foreign actors purchase land for nature protection.

Classifying root causes of threats and conservation responses into local versus diffuse versus originating from a specific social-ecological system allows the identification of distinct combinations of threats and responses. We understand conservation telecouplings as the coupling of two or more social-ecological systems through *distal* conservation responses to threats to biodiversity. Proximate drivers of these threats are always local (e.g. agricultural expansion) and ultimately lead to missing local (and possibly global) biodiversity targets. The underlying causes of these

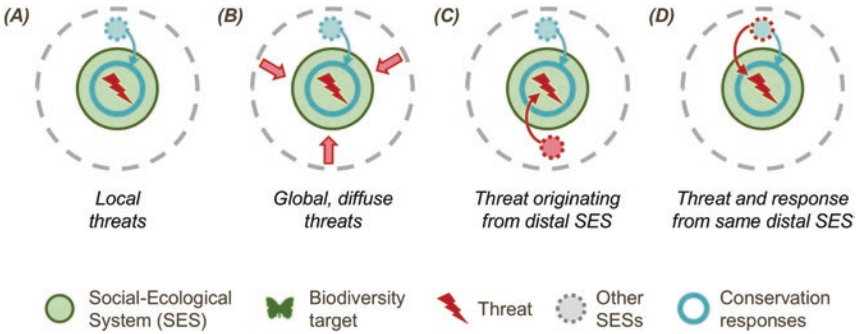


Fig. 15.2 Types of conservation telecouplings. We here define conservation telecouplings as the coupling of *distal* social-ecological systems through *distal* conservation responses to threats to biodiversity. The underlying drivers of these threats can originate from within the social-ecological system where biodiversity loss takes place (**A**), from the outside in a ubiquitous manner (**B**), or from a specific, distal social-ecological system (SES). Threats and conservation responses can originate from different (**C**) or identical (**D**) social-ecological system (legend: see Fig. 15.1)

threats, however, can originate from within the social-ecological system where biodiversity loss takes place (Fig. 15.2A), from the outside, in a diffuse manner (Fig. 15.2B), or from a specific, distal social-ecological system (Fig. 15.2C and D). As information about local biodiversity loss percolates to other systems, concerns about these losses trigger responses of distal actors (e.g. through campaigning, financing conservation action, policy discussions and forging conservation telecouplings). Threats and conservation responses can originate from different (Fig. 15.2C) or identical (Fig. 15.2D) social-ecological systems.

Conservation telecouplings are thus characterised by two types of flows: a flow of information about ongoing biodiversity loss to a distal system containing actors concerned about these losses (Fig. 15.3) and feedback flow in the form of a conservation response. Information flows about biodiversity loss (e.g. rhino poaching, deforestation) can percolate through the press, through social media, or targeted information campaigns by conservation actors in the source system A (Carrasco et al. 2017). As this information reaches system B, concern about these losses arises, which in turn mobilises distal conservation actors (e.g. international conservation organisations, conservation-minded individuals, sustain-

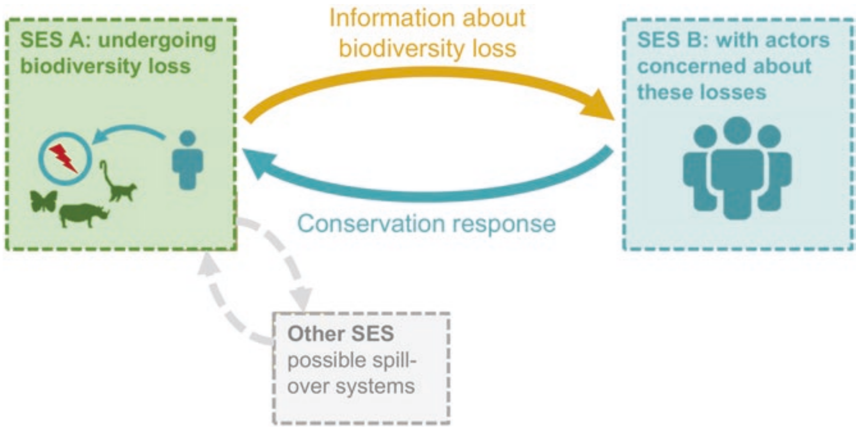


Fig. 15.3 Systems in conservation telecouplings. One social-ecological system (SES A) experiences biodiversity loss and sends an information flow to another system (SES B) that contains actors concerned about these losses. This triggers feedback in the form of mobilising conservation actors in that system. These actors might link to, and work together with, local conservation actors to implement actions. These actions (e.g. new protected areas) might trigger unintended spillover effects to other SES (e.g. relocation of land-use pressure to another region)

ability branches of companies). This triggers distal conservation response, such as conservation funding or supply chain mechanisms, which typically flow through local conservation actors in system A (e.g. local NGOs or an indigenous community). As conservation actions are implemented (e.g. the creation of a protected area), spillovers to other systems might happen (Liu et al. 2015). From a conservation perspective, these spillovers can be negative (e.g. leakage of land-use pressure to other regions) or positive (e.g. mobilisation of conservation in another region).

Importantly, all arrows linking systems are simplifications of interactions that occur within and along actor networks (Eakin et al. 2014). The coupling of distal systems is initiated once these interactions reach critical levels. For instance, information about biodiversity losses spreading from system A might mobilise distal actors only when these losses are stark, or if the local institutions and governance mechanisms in social-ecological system A are unable to address these losses effectively. Similarly, distal conservation responses might only be triggered if the awareness in social-ecological system B reaches certain thresholds (e.g. attention or mobilisation among consumers, funders), or if organisations aiming at addressing biodiversity loss in system A are able to build coalitions with other organisations in system B (Rudel 2011).

3 Local versus Distal Causes of Threats to Biodiversity

Understanding whether the root causes of threats to biodiversity are local or distal is important (Fig. 15.2), because different conservation responses are possible or necessary depending on whether the actors driving these threats are embedded in the system undergoing biodiversity loss, in a distant system, or if they cannot easily be located (e.g. in the case of diffuse threats such as ocean acidification). Examining the threats listed in the Unified Classifications of Threats and Actions (Salafsky et al. 2008)[3] reveals that eight out of eleven main threat categories listed are potentially or dominantly "telecoupled," that is, originating from and driven by actors in another, distal social-ecological system.[4] Only three main threat categories appear to be solely due to either local causes (i.e. pollution, geological events) and/or distal, but diffuse causes (e.g. climate change, pollution).

Out of the eight "telecoupled" threat categories, most occur in relation to some form of land use, particularly the threat categories of *residential and commercial development*, *agriculture and aquaculture*, and *energy production and mining*. Most of the land uses causing these threats (e.g. agricultural expansion leading to habitat loss) are expected to become more telecoupled in the future. For example, agro-industrial farming and aquaculture will continue to expand in many regions of the world, due to structural change in agriculture, whereas the importance of subsistence farming (e.g. shifting cultivation) and smallholder agriculture is expected to decline (Haberl et al. 2014). As a result, the rapidly growing international trade in agricultural and forestry commodities is an increasingly important driver of biodiversity loss. While few studies have addressed biodiversity loss embodied in trade, existing work clearly highlights the key role of agricultural exports for threatening local biodiversity (Lenzen et al. 2012; Chaudhary and Kastner 2016), especially in the tropics (Fig. 15.4).

Fig. 15.4 Biodiversity loss embodied in agricultural exports from Indonesia. Threats to biodiversity (expressed as the number of mammals, birds, reptiles, and amphibians committed to extinction) are largely caused by distal consumption (highlighted in red, with the strength of the arrows indicating relative pressure). The largest threat originates from the European Union's collective consumption of Indonesian agricultural products (committing 28 species to extinction). Source: Chaudhary and Kastner (2016)

Other telecoupled threats include *transportation and service corridors* (e.g. road construction, shipping lanes, air traffic), *biological resource use* (e.g. hunting, logging, collection of plants), *human intrusion and modifications* (e.g. recreational activities, armed conflict), *natural system modification* (e.g. dam building, fire suppression), and *invasive and other problematic species and genes* (e.g. alien species or diseases). While all of these can be driven by both local and distant actors or phenomena, the importance of the telecoupled version of these threats is expected to increase. For instances, as urbanisation progresses (e.g. 68% of the global population are expected to live in cities by 2050[5]), hunting for meat in the tropics increasingly occurs in order to satisfy urban demands rather than for the subsistence of rural populations (Brashares et al. 2011; Ripple et al. 2016).

Finally, there are often large synergistic effects among threats (Dirzo et al. 2014; Maxwell et al. 2016), particularly between land-use and other telecoupled threats. For example, the expanding trade of agricultural commodities does not only embody major biodiversity losses via habitat destruction in source regions (Chaudhary and Kastner 2016; Chaudhary et al. 2017), but also plays a key role in wildlife trafficking and the invasions of exotic species (e.g. through creating options for smuggling or species translocations via agricultural trade). Analysing such links through the lens of telecouplings can promote a better understanding of synergies among threats.

4 Conservation Responses in Telecoupled Systems

The key element of conservation telecouplings is the distal conservation response (Fig. 15.3). Reviewing commonly implemented conservation actions, as categorised by the Unified Classifications of Threats and Actions (Salafsky et al. 2008),[6] reveals that, in principle, all actions can occur at least partly through conservation telecouplings. In other words, there is no category of conservation action that is necessarily always initiated, driven and implemented from within a social-ecological system.

Distal conservation responses occur in relation to all types of threats—be they local, diffuse, or telecoupled (Fig. 15.2). For example, expanding smallholder farming (a largely local threat) might trigger foreign conservation actors to fund protected area expansion, such as in the case of Gorongosa National Park in Mozambique.[7] Likewise, diffuse threats, such as rising temperature due to climate change that shifts the climate niche of species faster than they can disperse, might trigger assisted recolonisation projects in areas where climate will become suitable in the future, such as in the case of the Western larch (*Larix occidentalis*) in British Columbia (Klenk and Larson 2015). Finally, as an example of a telecoupled threat, increasing concerns about deforestation in Amazonia due to the production of agricultural commodities for global markets have triggered almost all large international conservation organisations to engage in this region, at various institutional levels, which has played a part in the major expansion of the protected area network there since the 1990s (Walker et al. 2009).

As the importance of telecoupled threats increases in the Anthropocene, so does the relevance of conservation telecouplings. For example, the world's largest international conservation organisations, World Wildlife Fund (WWF), Conservation International (CI), The Nature Conservancy (TNC), and Wildlife Conservation Society (WCS), all of them originating from the Global North, have grown substantially during the last 30 years (e.g. the total programme expenses of these four NGOs have almost doubled since 2001[8]) and are more than ever engaging in the Global South (e.g. WCS works in 15 African countries, 16 Asian countries, and 12 Latin American and Caribbean countries).

Similarly, as the volume of conservation funding spent by countries has increased (e.g. the United Kingdom's public spending on conservation increased by 76% between 2000 and 2012[9]), so has the share of conservation funding spent abroad. While exact numbers are not readily available, recent estimates suggest that US$840 million of foreign aid went into biodiversity-related projects in lower-income countries between 2002 and 2008, a sum similar to the domestic conservation spending (US$904 million) in these countries (Waldron et al. 2013). Multilateral organisations (e.g. The World Bank, the European Union, Global Environment Facility) contributed US$548 million, with another US$290 million coming from individual countries in the EU and North America. In the Amazon Basin alone, international donors contributed at least US$215 million annually during 2007–2012 (De La Mata and Riega-Campos 2014) and US$357 million annually during 2013–2015 (Strelneck and Vilela 2017) (Fig. 15.5).

Telecouplings also can be leveraged for renewing the pathways for conservation actions. New conservation-minded individuals, companies, and states can create new conservation telecouplings. For example, private investments in conservation lands, such as those that led to the establishment of the Iberá Reserve in Argentina or a number of Andean National Parks in Chile,[11] have become common phenomena recently (Stolton et al. 2014). Distal actors, from cities or abroad, now frequently invest in ecotourism infrastructure partly to provide incentives to maintain natural areas via alternative income strategies (Brandt and Buckley 2018). Countries now actively engage and invest in international conservation funds, such as Norway's massive contributions to the REDD programme.[12]

Perhaps most importantly, as consumer pressure on companies rises, incentives to clean supply chains and to source raw materials and

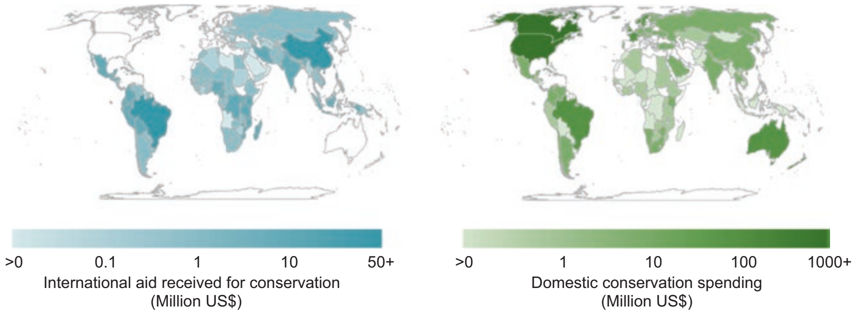


Fig. 15.5 Foreign and domestic conservation spending. Conservation spending has increased substantially recently, with major funding flowing from the Global North to the Global South. The top five recipients in 2002–2008 were China, Brazil, India, Mexico, and Colombia. Indonesia, a country experiencing substantial threats to local biodiversity (see Fig. 15.4), received US$500 million for conservation purposes during 2000–2013.[10] Data source: Waldron et al. (2013)

commodities in sustainable ways are increasing, spawning a wide range of certification and labelling schemes (Lambin et al. 2018). Such supply chain mechanisms can be grouped into four main categories: (1) collective aspirations by multi-stakeholder groups, such as the Consumer Goods Forum, the Tropical Forest Alliance 2020, the 2014 New York Declaration on Forests, and the 2015 Amsterdam Declarations; (2) company pledges such as zero-deforestation commitments by Wilmar, GAR, APP, Unilever, Cargill, and McDonalds; (3) company codes of conduct such as Unilever's Responsible Sourcing Policy; and (4) sector standards including incentive-based mechanisms (e.g. the Forest Stewardship Council certification for timber, the Rainforest Alliance for coffee and other tropical products, or those developed by roundtables), and sanction-based mechanisms such as moratoria on purchases from suppliers that do not comply with standards (e.g. the Soy and the Beef Moratoria).

Monitoring the effectiveness of such supply chain initiatives is far from trivial and requires combining distinct sets of information on traceability of the different actors involved in a supply chain, transactions and investment decisions, social and environmental impacts, actors' policies and commitments, actual actions undertaken, and the effectiveness of distinct interventions and actions (Gardner et al. 2018). Information is currently scarce, but supply chain monitoring initiatives are gaining momentum. These include platforms to inform on the most influential actors in supply chains and their commitments (e.g. Forest 500 and Company Action on Deforestation by Global Canopy or Supply Change), the impacts of key commodities (e.g. Global Forest Watch Commodities), or supply chain connections (e.g. TRASE). Most data and initiatives still focus on a few commodities (i.e. soy, palm oil, and beef) produced in a few countries (e.g. Brazil and Indonesia) but coverage remains scarce in countries where deforestation rates are increasing rapidly (e.g. Paraguay, many African countries), and on most other commodities (Grimard et al. 2017). Current research suggests that supply chain mechanisms offer real opportunities, but key challenges related to both scientific (e.g. coverage, precision, and detail of the monitoring) and political aspects (how to govern increased data availability and transparency) remain.

5 Conservation Opportunities in Telecoupled Systems

Globalisation and the corresponding increasing interconnectedness of places and people alter the context in which conservation is taking place, yet conservation action and planning are poorly equipped to deal with such distal phenomena at the present time. Conservation telecouplings, as introduced here, provide a conceptual framework that can be used to identify and account for such distal phenomena—specifically on how information flows about biodiversity loss link systems across large distances, and how this triggers distal conservation actions. Considering the distal nature of threats and conservation responses can help to identify new entry points for conservation approaches (e.g. along supply chains), for increasing conservation effectiveness (e.g. by combining area-based and supply chain-based tools), and for avoiding unwanted conservation outcomes (e.g. avoiding leakage).

Mainstream conservation has predominantly focussed on populations, species, or ecosystems of conservation concern in a particular place, and sometimes been criticised for ignoring people and their agency (Stephanson and Mascia 2014; Iwamura et al. 2018). As new approaches for considering human agency in biodiversity models are emerging

(Grimm et al. 2017), a conservation telecouplings framework could build on them to consider both the distal nature of threats and conservation responses, and the actor networks through which these distal links affect biodiversity. Figure 15.2 provides a starting point for typifying different conservation responses and to identifying which combinations of conservation responses are most appropriate for distinct configurations of distal versus local threats. For example, place-based conservation such as protected areas and zoning might be effective where threats are diffuse, while supply chain interventions appear more appropriate where threats are clearly linked to particular actors (Piquer-Rodríguez et al. 2018). Merging analytical lenses that are place based and that are focussed on actor networks can also help to identify key entry points for conservation (e.g. where supply chains narrow down to just a few traders or retailers) and to decide where, in space and in actor networks, interventions are promising.

Conservation actions are often less effective than expected or fail altogether (Butchart et al. 2010). Ignoring the distal nature of threats and conservation responses might be a key reason for this. For instance, implementing strict protected areas might increase competition for land, thereby escalating the costs of future conservation efforts (Armsworth et al. 2006). Likewise, considering the actor networks linked to threats (e.g. agricultural expansion into the forests of the South American Chaco) can highlight which actors are more or less flexible in relocating their activities to other regions once conservation actions are implemented (e.g. the relocation of activities from the Brazilian Amazon to the Cerrado or the Chaco in response to tightening regulation). This, in turn, can help in the avoidance of leakage effects. The growing importance of distal links also highlights the need to develop a new generation of conservation planning tools that can build on recent advances in conservation prioritisation to help decide which combinations of place-based, actor-based, or supply chain-based interventions are most likely to maximise conservation outcomes, to minimise conflicts between conservation and other goals, or to minimise conservation costs (Wilson et al. 2010; Cattarino et al. 2015; Hanson et al. 2017; Law et al. 2017).

Finally, a conservation telecoupling framework can provide a better understanding of the nature of distal conservation interventions. Some regions, such as Amazonia, Madagascar, or Indonesia, have received considerable attention globally, with many conservation telecouplings emerging in response, while other biodiverse regions, such as the Cerrado, the Chaco, or Africa's rainforests, have not yet been focussed on. Understanding when and how conservation efforts are triggered, which actors are most likely to engage under which conditions, and how conservation interventions can lead to snowball effects and positive spillovers (e.g. the mobilisation of conservation actors and actions) are important knowledge gaps in an increasingly telecoupled world undergoing accelerating biodiversity loss.

Acknowledgements This work has received support from the European Union's Horizon 2020 research and innovation programme under Marie Skłodowska-Curie Actions grant agreement No. 765408 (COUPLED, http://coupled-itn.eu) and from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme grant agreement No. 677140 (MIDLAND, https://erc-midland.earth). This work contributes to the Global Land Programme (www.glp.earth).

Notes

1. Food and Agricultural Organization: www.fao.org/faostat.
2. The World Bank (2012): *Maximising Mobile*. Information and Communications for Development 2012. Washington, DC: International Bank for Reconstruction and Development/The World Bank.
3. Full list: www.iucnredlist.org/technical-documents/classification-schemes/threats-classification-scheme.
4. When carrying out this categorisation, we adhered to a Euclidean concept of distance, meaning that different social-ecological systems are separate geographic spaces (e.g. cities linked to rural systems in their hinterland or too far-away regions through trade). Other concepts of distance, such as social or institutional distance, might be equally relevant (see Chaps. 3, 9, and 18) but are omitted here.
5. UN World Urbanization Prospects 2018: https://esa.un.org/unpd/wup/.
6. Full list: www.iucnredlist.org/technical-documents/classification-schemes/conservation-actions-classification-scheme-ver2.

7. www.gorongosa.org/our-story.
8. Charity Navigator. Historical Data: www.charitynavigator.org.
9. JNCC. 2014. *Fifth. National Report to the United Nations Convention on Biological Diversity: United Kingdom*. Peterborough: JNCC. https://www.cbd.int/doc/world/gb/gb-nr-05-en.pdf.
10. http://aiddata.org/realizing-agenda-2030.
11. www.tompkinsconservation.org/home.htm.
12. www.regjeringen.no/en/topics/climate-and-environment/climate/climate-and-forest-initiative/kos-innsikt/samarbeidspartnere/id2345203/.

References

Armsworth, Paul R., Gretchen C. Daily, Peter Kareiva, and James N. Sanchirico. 2006. Land Market Feedbacks Can Undermine Biodiversity Conservation. *Proceedings of the National Academy of Sciences* 103: 5403–5408.

Brandt, Jodi S., and Ralph C. Buckley. 2018. A Global Systematic Review of Empirical Evidence of Ecotourism Impacts on Forests in Biodiversity Hotspots. *Current Opinion in Environmental Sustainability* 32: 112–118.

Brashares, J.S., C.D. Golden, K.Z. Weinbaum, C.B. Barrett, and G.V. Okello. 2011. Economic and Geographic Drivers of Wildlife Consumption in Rural Africa. *Proceedings of the National Academy of Sciences* 108: 13931–13936.

Butchart, Stuart H.M., Matt Walpole, Ben Collen, Arco van Strien, Jörn P.W. Scharlemann, Rosamunde E. Almond, Jonathan E.M. Baillie, Bastian Bomhard, Claire Brown, John Bruno, Kent E. Carpenter, Geneviève M. Carr, Janice Chanson, Anna M. Chenery, Jorge Csirke, Nick C. Davidson, Frank Dentener, Matt Foster, Alessandro Galli, James N. Galloway, Piero Genovesi, Richard D. Gregory, Marc Hockings, Valerie Kapos, Jean-Francois Lamarque, Fiona Leverington, Jonathan Loh, Melodie A. McGeoch, Louise McRae, Anahit Minasyan, Monica Hernández Morcillo, Thomasina E.E. Oldfield, Daniel Pauly, Suhel Quader, Carmen Revenga, John R. Sauer, Benjamin Skolnik, Dian Spear, Damon Stanwell-Smith Simon N. Stuart, Andy Symes, Megan Tierney, Tristan D. Tyrrell, Jean-Christophe Vié, and Reg Watson. 2010. Global Biodiversity: Indicators of Recent Declines. *Science* 328: 1164–1168.

Carrasco, L. Roman, Joleen Chan, Francesca L. McGrath, and T.P. Nghiem Le. 2017. Biodiversity Conservation in a Telecoupled World. *Ecology and Society* 22 (3): 24. https://doi.org/10.5751/ES-09448-220324.

Cattarino, Lorenzo, Virgilio Hermoso, Josie Carwardine, Mark J. Kennard, and Simon Linke. 2015. Multi-Action Planning for Threat Management: A Novel Approach for the Spatial Prioritization of Conservation Actions. *PLoS One* 10: e0128027.

Chaudhary, Abhishek, L. Roman Carrasco, and Thomas Kastner. 2017. Linking National Wood Consumption with Global Biodiversity and Ecosystem Service Losses. *Science of the Total Environment* 586: 985–994.

Chaudhary, Abhishek, and Thomas Kastner. 2016. Land Use Biodiversity Impacts Embodied in International Food Trade. *Global Environmental Change* 38: 195–204.

Daw, Tim M., Sarah Coulthard, William W.L. Cheung, Katrina Brown, Caroline Abunge, Diego Galafassi, Garry D. Peterson, Tim R. McClanahan, Johnstone O. Omukoto, and Lydiah Munyi. 2015. Evaluating Taboo Trade-Offs in Ecosystems Services and Human Well-Being. *Proceedings of the National Academy of Sciences* 112: 6949–6954.

De La Mata, Gonzales C., and Sait Riega-Campos. 2014. *An Analysis of International Conservation Funding in the Amazon*. Palo Alto, CA: Gordon and Betty Moore Foundation.

Díaz, Sandra, Unai Pascual, Marie Stenseke, Berta Martín-López, Robert T. Watson, Zsolt Molnár, Rosemary Hill, Kai M.A. Chan, Ivar A. Baste, Kate A. Brauman, Stephen Polasky, Andrew Church, Mark Lonsdale, Anne Larigauderie, Paul W. Leadley, Alexander P.E. van Oudenhoven, Felice van der Plaat, Matthias Schröter, Sandra Lavorel, Yildiz Aumeeruddy-Thomas, Elena Bukvareva, Kirsten Davies, Sebsebe Demissew, Gunay Erpul, Pierre Failler, Carlos A. Guerra, Chad L. Hewitt, Hans Keune, Sarah Lindley, and Yoshihisa Shirayama. 2018. Assessing Nature's Contributions to People. *Science* 359: 270.

Dirzo, Rodolfo, Hillary S. Young, Mauro Galetti, Gerardo Ceballos, Nick J.B. Isaac, and Ben Collen. 2014. Defaunation in the Anthropocene. *Science* 345: 401–406.

Eakin, Hallie, Ruth DeFries, Suzi Kerr, Eric F. Lambin, Jianguo Liu, Peter J. Marcotullio, Peter Messerli, Anette Reenberg, Ximena Rueda, Simon R. Swaffled, Birka Wicke, and Karl Zimmerer. 2014. Significance of Telecoupling for Exploration of Land-Use Change. In *Rethinking Global Land Use in an Urban Era*, ed. Karen Seto and Anette Reenberg, 141–161. Cambridge, MA: The MIT Press.

Fairhead, James, Melissa Leach, and Ian Scoones. 2012. Green Grabbing: A New Appropriation of Nature? *The Journal of Peasant Studies* 39: 237–261.

Friis, Cecilie, Jonas Ø. Nielsen, Iago Otero, Helmut Haberl, Jörg Niewöhner, and Patrick Hostert. 2016. From Teleconnection to Telecoupling: Taking Stock of an Emerging Framework in Land System Science. *Journal of Land Use Science* 11: 131–153.

Game, Edward T., Erik Meijaard, Douglas Sheil, and Eve McDonald-Madden. 2014. Conservation in a Wicked Complex World; Challenges and Solutions. *Conservation Letters* 7: 271–277.

Gardner, Toby A., Magnus Benzie, Jan Börner, Elena Dawkins, Stephen Fick, Rachael Garrett, Godar Javier, A. Grimard, S. Lake, R.K. Larsen, N. Mardas, C.L. McDermott, P. Meyfroidt, M. Osbeck, M. Persson, T. Sembres, C. Suavet, B. Strassburg, A. Trevisan, C. West, and P. Wolvekamp. 2018. Transparency and Sustainability in Global Commodity Supply Chains. *World Development*. https://doi.org/10.1016/j.worlddev.2018.05.025.

Gibbs, Holly K., Jacob Munger, Jessica L'Roe, Paulo Barreto, Ritaumaria Pereira, Matthew Christie, Ticiana Amaral, and Nathalie F. Walker. 2016. Did Ranchers and Slaughterhouses Respond to Zero-Deforestation Agreements in the Brazilian Amazon? *Conservation Letters* 9: 32–42.

Grimard, A., S. Lake, N. Mardas, J. Godar, and T. Gardner. 2017. *Supply Chain Transparency Network: State of Play*. Stockholm: Global Canopy Programme and Stockholm Environment Institute.

Grimm, Volker, Daniel Ayllón, and Steven F. Railsback. 2017. Next-Generation Individual-Based Models Integrate Biodiversity and Ecosystems: Yes We Can, and Yes We Must. *Ecosystems* 20: 229–236.

Haberl, Helmut, Cheikh Mbow, Xiangzheng Deng, Elena G. Irwin, Suzi Kerr, Tobias Kuemmerle, Ole Mertz, Patrick Meyfroidt, and Benjamin L. Turner II. 2014. Finite Land Resources and Competition. In *Rethinking Global Land Use in an Urban Era*, ed. Karen C. Seto and Anette Reenberg, 34–69. Cambridge, MA: The MIT Press.

Hanson, J., R. Schuster, N. Morrell, M. Strimas-Mackey, M. Watts, P. Arcese, J. Bennett, and H.P. Possingham. 2017. Prioritizr: Systematic Conservation Prioritization in R. Version 4.0.2.7. Available at https://github.com/prioritizr/prioritizr.

Hertel, Thomas W., Navin Ramankutty, and Uris Lantz C. Baldos. 2014. Global Market Integration Increases Likelihood That a Future African Green Revolution Could Increase Crop Land Use and CO_2 Emissions. *Proceedings of the National Academy of Sciences* 111: 13799–13804.

Hooper, David U., E. Carol Adair, Bradley J. Cardinale, Jarrett E.K. Byrnes, Bruce A. Hungate, Kristin L. Matulich, Andrew Gonzalez, J. Emmett Duffy, Lars Gamfeldt, and Mary I. Connor. 2012. A Global Synthesis Reveals Biodiversity Loss as a Major Driver of Ecosystem Change. *Nature* 486: 105–108.

Iwamura, Takuya, Yann le Polain de Waroux, and Michael B. Mascia. 2018. Considering People in Systematic Conservation Planning: Insights from Land System Science. *Frontiers in Ecology and the Environment* 16: 388–396.

Klenk, Nicole L., and Brendon M.H. Larson. 2015. The Assisted Migration of Western Larch in British Columbia: A Signal of Institutional Change in Forestry in Canada? *Global Environmental Change* 31: 20–27.

Lambin, Eric F., Holly K. Gibbs, Robert Heilmayr, Kimberly M. Carlson, Leonardo C. Fleck, Rachael D. Garrett, Yann le Polain de Waroux, Constance L. McDermott, David McLaughlin, Peter Newton, Christoph Nolte, Pablo Pacheco, Lisa L. Rausch, Charlotte Streck, Tannis Thorlakson, and Nathalie F. Walker. 2018. The Role of Supply-Chain Initiatives in Reducing Deforestation. *Nature Climate Change* 8: 109–116.

Law, Elizabeth A., Brett A. Bryan, Erik Meijaard, Thilak Mallawaarachchi, Matthew J. Struebig, Matthew E. Watts, and Kerrie A. Wilson. 2017. Mixed Policies Give More Options in Multifunctional Tropical Forest Landscapes. *Journal of Applied Ecology* 54: 51–60.

Lenzen, M., D. Moran, K. Kanemoto, B. Foran, L. Lobefaro, and A. Geschke. 2012. International Trade Drives Biodiversity Threats in Developing Nations. *Nature* 486: 109–112.

Liu, Jianguo, Vanessa Hull, Mateus Batistella, Ruth DeFries, F. Fu Tom Dietz, Tom W. Hertel, E.F. Izaurralde, S.L. Lambin, Shuxin Li, Luis A. Martinelli, William J. McConnel, Emilio F. Moran, R. Naylor, Z. Ouyang, K.R. Polenske, Aneta Reenberg, G. de Miranda Rocha, C.S. Simmons, Peter H. Verburg, Peter M. Vitousek, Fusuo Zhang, and Chunquan Zhu. 2013. Framing Sustainability in a Telecoupled World. *Ecology and Society* 18 (2): 26. https://doi.org/10.5751/ES-05873-180226.

Liu, Jianguo, Harold Mooney, Vanessa Hull, Steven J. Davis, Joanne Gaskell, Thomas Hertel, Jane Lubchenco, Karen C. Seto, Peter Gleick, Claire Kremen, and Shuxin Li. 2015. Systems Integration for Global Sustainability. *Science* 347: 1258832.

Maxwell, Sean L., Richard A. Fuller, Thomas M. Brooks, and James E.M. Watson. 2016. Biodiversity: The Ravages of Guns, Nets and Bulldozers. *Nature* 536: 143–145.

Meyfroidt, Patrick, Rinku Roy Chowdhury, Ariane de Bremond, Erle C. Ellis, Karl-Heinz Erb, Tatiana Filatova, Rachael D. Garrett, Morgan Grove, Andreas Heinimann, Tobias Kuemmerle, Christian A. Kull, Eric F. Lambin, Y. Landon, Yann le Polain de Waroux, Peter Messerli, Daniel Müller, Jonas Ø. Nielsen, Garry D. Peterson, V. Rodriguez García, Maja Schlüter, Benjamin L. Turner II, and Peter H. Verburg. 2018. Middle-Range Theories of Land System Change. *Global Environmental Change* 53: 52–67.

Meyfroidt, Patrick, Tan Phuong Vu, and Viet Anh Hoang. 2013. Trajectories of Deforestation, Coffee Expansion and Displacement of Shifting Cultivation in the Central Highlands of Vietnam. *Global Environmental Change* 23: 1187–1198.

Phalan, Ben, Rhys E. Green, Lynn V. Dicks, Graziela Dotta, Claire Feniuk, Anthony Lamb, Bernardo B.N. Strassburg, David R. Williams, Erasmus K.H.J. zu Ermgassen, and Andrew Balmford. 2016. How Can Higher-Yield Farming Help to Spare Nature? *Science* 351: 450.

Phelps, Jacob, Luis Roman Carrasco, Edward L. Webb, Lian Pin Koh, and Unai Pascual. 2013. Agricultural Intensification Escalates Future Conservation Costs. *Proceedings of the National Academy of Sciences* 110: 7601.

Pimm, S.L., C.N. Jenkins, R. Abell, T.M. Brooks, J.L. Gittleman, L.N. Joppa, P.H. Raven, C.M. Roberts, and J.O. Sexton. 2014. The Biodiversity of Species and Their Rates of Extinction, Distribution, and Protection. *Science* 344: 1246752.

Piquer-Rodríguez, M., M. Baumann, V. Butsic, H.I. Gasparri, G. Gavier-Pizarro, J.N. Volante, D. Müller, and T. Kuemmerle. 2018. The Potential Impact of Economic Policies on Future Land-Use Conversions in Argentina. *Land Use Policy* 79: 57–67.

Ripple, William J., Katharine Abernethy, Matthew G. Betts, Guillaume Chapron, Rodolfo Dirzo, Mauro Galetti, Taal Levi, Peter A. Lindsey, David W. Macdonald, Brian Machovina, Thomas M. Newsome, Carlos A. Peres, Arian D. Wallach, Christopher Wolf, and Hillary Young. 2016. Bushmeat Hunting and Extinction Risk to the World's Mammals. *Royal Society Open Science* 3: 160498.

Rudel, Thomas K. 2011. Local Actions, Global Effects? Understanding the Circumstances in which Locally Beneficial Environmental Actions Cumulate to Have Global Effects. *Ecology and Society* 16 (2): 19.

Salafsky, Nick, Daniel Salzer, Alison J. Stattersfield, Craig Hilton-Taylor, Rachel Neugarten, Stuart H.M. Butchart, Ben Collen, Neil Cox, Lawrence l. Master, Sheila O'Connor, and David Wilkie. 2008. A Standard Lexicon for Biodiversity Conservation: Unified Classifications of Threats and Actions. *Conservation Biology* 22: 897–911.

Stephanson, Sheri L., and Michael B. Mascia. 2014. Putting People on the Map through an Approach That Integrates Social Data in Conservation Planning. *Conservation Biology* 28: 1236–1248.

Stolton, Sue, Kent H. Redford, and Nigel Dudle. 2014. *The Futures of Privately Protected Areas*. Gland: IUCN.

Strelneck, D., and T. Vilela. 2017. *International Conservation Funding in the Amazon: An Updated Analysis*. Palo Alto: Gordon and Betty Moore Foundation.

Tscharntke, Teja, Jeffrey C. Milder, Götz Schroth, Yann Clough, Fabrice DeClerck, Anthony Waldron, Robert Rice, and Jaboury Ghazoul. 2015. Conserving Biodiversity Through Certification of Tropical Agroforestry Crops at Local and Landscape Scales. *Conservation Letters* 8: 14–23.

Venter, O., E.W. Sanderson, A. Magrach, J.R. Allan, J. Beher, K.R. Jones, H.P. Possingham, W.F. Laurance, P. Wood, B.M. Fekete, M.A. Levy, and J.E.M. Watson. 2016. Sixteen Years of Change in the Global Terrestrial Human Footprint and Implications for Biodiversity Conservation. *Nature Communications* 7: 12558.

Waldron, Anthony, Daniel C. Miller, Dave Redding, Arne Mooers, Tyler S. Kuhn, Nate Nibbelink, J. Timmons Roberts, Joseph A. Tobias, and John L. Gittleman. 2017. Reductions in Global Biodiversity Loss Predicted from Conservation Spending. *Nature* 551: 364–367.

Waldron, Anthony, Arne O. Mooers, Daniel C. Miller, Nate Nibbelink, David Redding, Tyler S. Kuhn, J. Timmons Roberts, and John L. Gittleman. 2013. Targeting Global Conservation Funding to Limit Immediate Biodiversity Declines. *Proceedings of the National Academy of Sciences* 110: 12144–12148.

Walker, Robert, Nathan J. Moore, Eugenio Arima, Stephen Perz, Cynthia Simmons, Marcellus Caldas, Dante Vergara, and Claudio Bohrer. 2009. Protecting the Amazon with Protected Areas. *Proceedings of the National Academy of Sciences* 106: 10582–10586.

Wilcove, David S., Xingli Giam, David P. Edwards, Brendan Fisher, and Lian Pin Koh. 2013. Navjot's Nightmare Revisited: Logging, Agriculture, and Biodiversity in Southeast Asia. *Trends in Ecology & Evolution* 28: 531–540.

Wilson, K.A., E. Meijaard, S. Drummond, H.S. Grantham, L. Boitani, G. Catullo, L. Christie, R. Dennis, I. Dutton, A. Falcucci, L. Maiorano, H.P. Possingham, C. Rondinini, W.R. Turner, O. Venter, and M. Watts. 2010. Conserving Biodiversity in Production Landscapes. *Ecological Applications* 20: 1721–1732.

16

Toolbox: Capturing and Understanding Telecoupling through Qualitative Research

Jonas Ø. Nielsen, Janine Hauer, and Cecilie Friis

1 Introduction

Telecoupling research is the study of land-use change in the context of globalisation. The concept of telecoupling describes combined socio-economic and environmental interactions, feedback mechanisms, and spillover effects over distance and across scales that cause change in otherwise separated human-environment systems (see Chaps. 2 and 3). Thus, a central, if not *the* central, question for telecoupling research is how remotely connected actors, trends, processes, policies, and material flows impact land use and land cover in specific places and vice versa. This implies a need to, at the same time, pay attention to flow-based and

J. Ø. Nielsen (✉) • J. Hauer • C. Friis
IRI THESys & Geography Department, Humboldt-Universität zu Berlin, Berlin, Germany
e-mail: jonas.ostergaard.nielsen@hu-berlin.de; janine.hauer@hu-berlin.de; cecilie.friis@hu-berlin.de

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_16

place-based aspects of land-use change, and how they intermingle. What happens on a particular piece of land is neither globally nor locally determined, but rather an outcome of particular (global) flows and specific places.

But how does one study global flows and local places at the same time? While advancements have been made in studies addressing this question through quantitative and modelling approaches that can capture, for example, trade, material, and energy flows at regional and global scales (see Chaps. 7, 10, and 13), less attention has been paid to the contribution of qualitative research. In this chapter, we briefly clarify what qualitative research brings to the study of telecoupling, but our main ambition is to provide methodological insights on *how* to do qualitative research on land-use change in a globalised world. While qualitative research can refer to a wide range of methodologies used across the social sciences, here we focus on empirical qualitative research, and more specifically on what an ethnographic mode of fieldwork can bring to telecoupling research. First, we will describe place-based qualitative fieldwork and so-called zooming techniques, and then focus on what the anthropologist George Marcus (1995) calls multi-sited ethnography or 'ethnography *in*/*of* the world system' before presenting collaborative research.

2 Capturing Telecoupling through Qualitative Research

The term *research* is often used in qualitative research to refer to the entire process of researching—from defining a question and doing fieldwork, to analysis and interpretations. Many methods can be applied during such a research process. During fieldwork, various types of interviews are often used in combination with questionnaires, participant observation, and document and archival work in order to elucidate 'what the devil is going on' (Geertz 1973, 27) on the level of everyday practices of people-in-places. Rather than applying a predetermined set and order of methods, as well as analytical categories, this mode of research is characterised by its openness to surprises.

A long-standing focus in qualitative research is the relationship between individuals, groups, and social processes more broadly in various political, economic, environmental, social, cultural, and/or historical contexts. Generally, a key guiding question is how, through their agency, human beings individually or collectively create, negate, oppose, or are subjected to different large 'phenomena' or 'structures'. Because globalisation does 'not actually make everything everywhere the same' (Tsing 2005, 1), this question is explored in multiple settings and from multiple viewpoints so that generalised statements are not necessarily sought, but rather 'situated knowledges' (Haraway 1988) are being produced. In the context of telecoupling research, what qualitative research thus allows for is an understanding of how global phenomena through distal environmental, political, economic, social, and cultural flows are received, mediated, and contested by different actors in specific places across the world.

2.1 Place-based Qualitative Fieldwork and Zooming Techniques

In order to understand the large phenomena or, for telecoupling research, distal interactions at play and how people understand and enact them differently, qualitative research strives for proximity to the lives and practices of particular people situated in time and place. Researchers working in an ethnographic mode strive for 'thick descriptions' (Geertz 1973) by taking multiple points of view into account, and qualitative research is therefore often place-based and time consuming as it requires the researcher to build trust and rapport with informants.

However, understanding the local context is often not enough if we want to explain what goes on somewhere, or why, for example, rice fields are converted into banana fields in northern Laos. The emergence of telecoupling research is an answer to the recognition of the need for considering related processes that take place over distance. To understand the rice-to-banana land-use change, we need to include events and processes such as increasing urban demand for fresh fruit, geopolitical conflicts around territorial rights, and land degradation in existing banana-producing regions taking place elsewhere as far away as Beijing, the South

China Sea, and the Philippines (Friis and Nielsen 2017a). This gives rise to a central challenge, namely, how to combine grounded place-based research with 'mobile' analytical approaches?

One form of analytical tools that are useful in this regard are the so-called zooming techniques. Drawing on very different disciplinary and thematic backgrounds including geography and organisational ethnography, approaches such as progressive contextualisation (Vayda 1983), causal-historical analysis (Walters 2017; Walters and Vayda 2009), and zooming (Nicolini 2009) explicitly aim at analytically tracing practices that are temporally and spatially distant. Despite their different theoretical underpinnings and assumptions, what these approaches share is a basic analytical operation: a specific observable practice or event is put at the centre of inquiry and then its causes and consequences are traced back and forth in time, as well as centripetally and centrifugally in space. The basic tenet is that by asking who, what, where, and when, the analyst is able to get to the how and the why of a certain event or change. Thus, such techniques are well-suited to capturing the historical dimensions and spatial entanglements that are crucial for an understanding of the emergence and de/stabilisation of specific telecoupled phenomena. For building an understanding of a particular land-use change, for example, the rice-to-banana conversion considered above, the analytical task of the researcher is to iterate between zooming in on the place-based empirical reality of the case and zooming out to take into account the processes that this change is embedded in.

The analytical resolution of such an approach can differ, depending on the focus and capacity of the researcher, as can the methods used and data considered, and the potential components of a practice or event that are taken into account. An important aspect of this analytical movement then becomes openness regarding the questions asked in the field, as well as of the data when coding and analysing, and a flexibility and willingness to follow unexpected threads of analysis. For telecoupling research in particular, such zooming techniques allow the researcher to avoid pre-defined definitions of the boundary of the event or problem, the prioritisation of particular flows, as well as any (hypothesised) causal relationships behind it (Friis 2017; Friis and Nielsen 2017b). Instead, such issues are left to empirical investigation and analytical construction.

An in-depth place-based study combined with zooming techniques might also enable the researcher to identify further important sites for telecoupling analysis. Figure 16.1 illustrates the results of an analysis

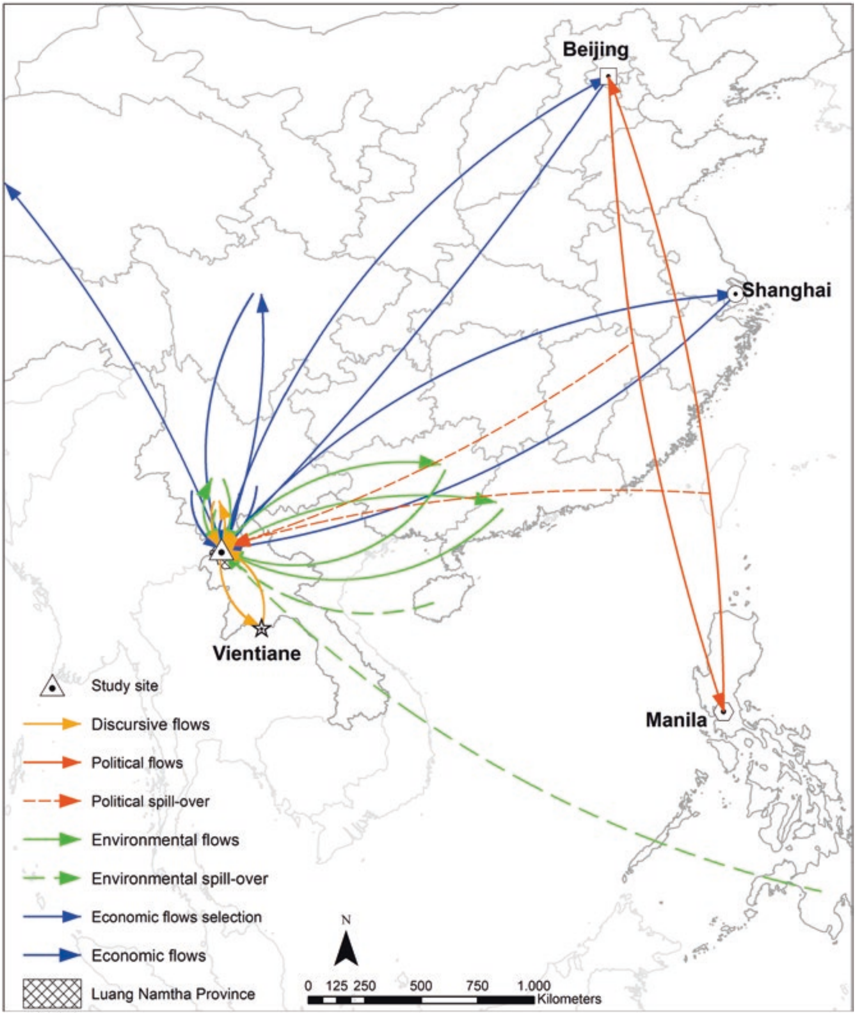


Fig. 16.1 Sketch of telecoupled banana land system. Analytical starting point in banana plantations in northern Laos and flows identified and traced through progressive contextualisation. Flows pointing to potentially relevant additional sites for research (adapted from Friis and Nielsen 2017a)

based on these techniques (Friis and Nielsen 2017a). Starting with two banana plantations in northern Laos and progressively contextualising outwards in space and backwards in time, Friis and Nielsen (2017a) identify a number of important flows with connections to distant locations that might be of importance for a better understanding of this land-use change. In a larger research group and with long-term research projects, this type of research outcome can thus be used as the starting point for additional analysis.

2.2 Multi-sited Ethnography and Collaboration

While 'zooming' techniques lend themselves well to exploring globalised land-use change in projects where fieldwork is limited to one or only a few places, another set of methodological tools are available to deal with the challenge of how to combine in-depth context-specific description and spatial coverage—that is, multi-sited ethnography (Marcus 1995). Multi-sited ethnography is, simply put, a method of data collection that literally follows *something* through different geographic or social fields in order to grasp a given event, topic, or process, for example, a land-use change. This something can be the commodity produced on the land. It can also be a policy facilitating the production of it, the demand for it, a discourse surrounding its use and benefits, an individual person facilitating it, or a mix of all of these and/or other factors. To illustrate, if a researcher is not only interested in why farmers replace rice with cash crops, but why they replace it with banana specifically, it will be crucial to understand how the banana is connected to different sites of market and trade, sale and consumption, each of them embedded in specific rules and regulation—to *follow* the banana so to speak. Doing this forces the researcher to pursue data not necessarily found in and around the banana plantations, but to become multi-sited. The point of multi-sited research is thus that it requires the researcher to 'break free' from being bound to one place in order to explore and explain a given phenomenon. Understanding the land-use change from rice to banana thus becomes a matter of stringing together geographies, or sites, by strands of connections followed by the researcher.

A recent example of such multi-sited research is anthropologist Anna L. Tsing's book *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins* (2015). In this book, Tsing and her co-researchers follow the matsutake mushrooms from Oregon, USA, to Japan, to market stalls in China. Throughout the book, she sketches patches of practices that are partially connected. Doing so she shows how the mushrooms along the way are transformed from wild plants, to commodities, to gifts and how this transformation depends on and interacts with the production of particular landscapes and land uses in each site. In showing how mushrooms go through complex transformations of meaning and value as they journey from location to location around the world, such research thus has the potential to provide very complex and rich descriptions of global conditions and entanglements and how these manifest in, for example, actual land-use changes somewhere in the world.

Following the banana, or the mushrooms, makes a lot of sense for telecoupling research, but it comes with some obvious methodological and practical challenges. First, it clearly takes the researcher to potentially very dissimilar places. In Nancy Scheper-Hughes's words, multi-sited research means 'to travel, observe, respond, reflect and write more quickly' than place-based research (2004, 45). Time at any given location is naturally limited. Multi-sited research therefore carries the danger of losing detailed contextual 'thick' descriptions. Second, the possibility of creating rapport with people often necessary for qualitative data is likewise affected, and multi-sited research multiplies the problem of gaining access to informants and field sites—a notoriously difficult issue in qualitative fieldwork. Pragmatic issues such as visas, research permits, travel costs, different languages, and decisions on how much time to spend at each site are similarly unavoidable challenges for multi-sited research. Third, decisions on *what* to follow *where* present substantial methodological challenges, especially when the research object or flow in question is less tangible than a commodity, for example, a discourse or policy.

So, what to do? Collaborative research projects obviously offer considerable advantages with regard to many of the practical challenges mentioned above, for example, time limits and the skills needed to do research in very different countries and regions. Indeed Tsing's aforementioned book was largely based on team research by the Matsutake Worlds

Research Group (Choy et al. 2009; Tsing 2015). Still, even with collaborative research projects, choices regarding study sites and their connections need to be made and, importantly, made explicitly in order to limit the risk of letting practical barriers steer the course of inquiry. Narrowing down the scope of the research, for example, by thoroughly following just one flow across space, is one option. However, this might still invite research in far more places than is practically possible. Systematic site selection in conjunction with a focus on a particular flow is therefore necessary. Everts's (2016) three criteria of guidance are helpful for such a systematic selection. First, the selection could be accomplished by focusing on sites that share certain comparable features in relation to the phenomenon in question. For the banana example, this could mean following the banana to a selection of comparable traders or wholesalers in China. Second, sites could be chosen because they differ maximally in order to display a continuum of a phenomenon, for example, organically certified banana supply chains and conventional banana supply chains. Third, sites could be selected according to qualitative distinctions such as dependencies or inequalities, for example, bananas produced in the small and newly established banana-producing sector in Laos and the large and well-established sector in the Philippines. These criteria are by no means exhaustive, but provide a point of orientation for researchers facing the challenge of studying telecoupled phenomena qualitatively.

3 Conclusion

Telecoupled land-use change forces place-based qualitative researchers to think along flows and global connections. Ethnographic fieldwork and qualitative inquiry are very suited to capture such connections. Grounded fieldwork combined with analytical 'zooming' techniques and multi-sited research allows the researcher to trace and follow the important processes determining a particular land-use change as they travel through space. Both 'zooming' techniques and multi-sited research are valuable methodological tools for combining place- and flow-based research. Whereas 'zooming' techniques have a clearer focus on temporal dimensions, multi-sited research clearly enables spatially mobile research design.

Overall, qualitative research allows the researcher to get to some of the more elusive and immaterial interactions such as social relations, trust, discourses, and information that are difficult to arrive at with other methodologies that rely on more quantitative data. There are, however, some practical trade-offs connected to following processes outwards in space and backwards in time. Highlighting those, as well as the benefits of multi-sited and temporal qualitative research, this chapter should be seen as a potential place to start when thinking of designing a qualitative research project on telecoupling.

References

Choy, Timothy, Lieba Faier, Michael Hathaway, Miyako Inoue, Shiho Satsuka, and Anna Tsing. 2009. Strong Collaboration as a Method for Multi-Sited Ethnography: On Mycorrhizal Relations. In *Multi-Sited Ethnography: Theory, Praxis and Locality in Contemporary Research*, ed. Mark-Anthony Falzon, 197–214. Farnham: Ashgate.

Everts, Jonathan. 2016. Connecting Sites: Practice Theory and Large Phenomena. *Geographische Zeitschrift* 104 (1): 50–67.

Friis, Cecilie. 2017. Land Use Change in a Globalised World. PhD diss., Humboldt-Universität zu Berlin.

Friis, Cecilie, and Jonas Ø. Nielsen. 2017a. Land-Use Change in a Telecoupled World: The Relevance and Applicability of the Telecoupling Framework in the Case of Banana Plantation Expansion in Laos. *Ecology and Society* 22 (4): 30. https://doi.org/10.5751/ES-09480-220430.

———. 2017b. On the System. Boundary Choices, Implications, and Solutions in Telecoupling Land Use Change Research. *Sustainability* 9 (6): 974.

Geertz, Clifford. 1973. *The Interpretation of Cultures*. New York: Basic Books.

Haraway, Donna. 1988. Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. *Feminist Studies* 14 (3): 575–599. https://doi.org/10.2307/3178066.

Marcus, George E. 1995. Ethnography in/of the World System: The Emergence of Multi-Sited Ethnography. *Annual Review of Anthropology* 24 (1): 95–117. https://doi.org/10.1146/annurev.an.24.100195.000523.

Nicolini, Davide. 2009. Zooming In and Out: Studying Practices by Switching Theoretical Lenses and Trailing Connections. *Organization Studies* 30 (12): 1391–1418.

Scheper-Hughes, Nancy. 2004. Parts Unknown: Undercover Ethnography of the Organs-Trafficking Underworld. *Ethnography* 5 (1): 29–73.

Tsing, Anna. 2015. *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins*. Princeton, NJ: Princeton University Press.

Tsing, Anna Lowenhaupt. 2005. *Friction: An Ethnography of Global Connection*. Princeton, NJ and Oxford: Princeton University Press.

Vayda, Andrew P. 1983. Progressive Contextualization: Methods for Research in Human Ecology. *Human Ecology* 11 (3): 265–281. https://doi.org/10.1007/BF00891376.

Walters, Bradley B. 2017. Explaining Rural Land Use Change and Reforestation: A Causal-Historical Approach. *Land Use Policy* 67 (Suppl. C): 608–624. https://doi.org/10.1016/j.landusepol.2017.07.008.

Walters, Bradley B., and Andrew P. Vayda. 2009. Event Ecology, Causal Historical Analysis, and Human. Environment Research. *Annals of the Association of American Geographers* 99 (3): 534–553. https://doi.org/10.1080/00045600902931827.

17

Discursive Telecouplings

Joel Persson and Ole Mertz

1 Introduction

Globalisation is causing unprecedented flows of people, resources, and goods across the world, accelerating interactions between distal land systems. While creating unprecedented levels of material wealth, the resultant exploitation of the world's natural resources has led to persistent calls for global environmental conservation efforts that reduce pressures on the natural environment. These flows between distant places are produced and sustained by multifaceted and complex causal relationships that require analytical devices that can capture this complexity.

The telecoupling approach offers a framework appropriate to this task as it emerged partly in response to calls for better inclusion of extra-local and process-based influences on human-environment dynamics (Friis et al. 2016). It does so by analysing the environmental and socio-economic interactions between distal places, focusing on the material and

J. Persson (✉) • O. Mertz
Department of Geosciences and Natural Resource Management, University of Copenhagen, Copenhagen, Denmark
e-mail: jgp@ign.ku.dk; om@ign.ku.dk

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_17

immaterial flows between sending, receiving, and spillover systems (see Chaps. 2 and 3). Though acknowledging that immaterial flows such as discourses and information play an important role in this process, most telecoupling literature has so far focused mainly on material flows of goods and resources between large-scale systems defined by administrative boundaries (Garrett et al. 2013; Reenberg and Fenger 2011; Liu et al. 2013). In the meantime, Friis and Nielsen (2017a, b) and Eakin et al. (2014) have framed telecouplings as a heuristic tool for reducing highly complex processes into tractable units of analysis in order to explain land-use change processes. This provides for a more qualitative engagement with the process-oriented influences of land-use change. However, there are still limited analytical tools available for capturing and explaining the immaterial flows between systems and how they manifest in local land-use change.

Moreover, while there is a large body of research on the drivers and causes of land-use change in a multi-level and interconnected world (Adger et al. 2005; Meyfroidt et al. 2013; Lambin et al. 2001), there are relatively few in-depth studies on how policy discourses at the international level affect local land-use decisions, particularly the more site-specific mechanisms and interactions that produce changes in forest landscapes (Atmadja and Verchot 2012; Thiha and Honda 2007). This calls for greater attention to be paid to how discourses enable mechanisms of influence across distal land systems. In this chapter, we develop the concept of *discursive telecoupling*, which was first introduced by Friis and Nielsen (2017a), and has been implicit in much of the telecoupling literature. It encompasses the notion that discourses accompanying material flows connecting land systems play an important role in influencing local land-use change processes, for instance by legitimising certain policy models, intervention designs, and land-use decisions while rendering others more or less unviable.

Our central argument is that the local heterogeneity in responses to and the subsequent outcomes of discursive telecouplings is an important component of how telecouplings may generate social and institutional distance, impact equality relations, and produce unintended socio-ecological outcomes. Improved understanding of the discursive dynamics of telecouplings can enable decision-makers to better balance trade-offs and improve information flows between socially, spatially, and institutionally distant actors. Making the potential influences of discourses and information flows on land use apparent can help create a stronger basis for cross-sector coalitions and more sustainable interventions. We begin by establishing the conceptual foundations of discursive telecouplings and then, in Sect. 3, we demonstrate the concept by analysing the emergence of a "win-win" conservation and development discourse in the forest conservation literature. Based on an analysis of this literature, Sect. 4 highlights four factors that influence the outcomes of a discursive telecoupling. These include (1) assumptions about the agent in global discourses and narratives of human-environment interactions, (2) the role of intermediaries and actor networks in mediating global discourses, (3) how discourses structure feedback opportunities from local system experiences, and (4) that multiple competing and interacting discourses on land and the use of natural resources prevail in local systems.

2 Discursive Telecouplings

Discourse analysis centres on the use of language as a reflection and representation of power in social relations and its reproduction in social context. Whether connected to sustainable development, green growth, or environmental conservation, global discourses travel through a variety of mechanisms and channels to influence the forums in which actors make decisions on land use (Feindt and Oels 2005). While texts and narratives are usually the main units of analysis, the contexts in which particular discourses emerge and concepts are contested and negotiated, as well as how they become institutionalised in decision-making, are equally important (Besten et al. 2014). Discursive-institutionalism, one prominent approach in discourse analysis, focuses on how a particular discourse "'disciplines' the thinking, speaking and acting" of human agents, how it can make certain interests more prominent than others, and how it constrains policy and behavioural choices (Arts and Buizer 2009, 342), thereby emphasising two-way interplay between discourses and social practice (Di Gregorio et al. 2017). Discourses shape actors' understanding of socio-economic and environmental problems as well as the rationalisation of policy solutions, and it guides the formation and representation of actor interests and preferences over time. Discourse analysis thus adds an important dimension to institutional analysis of socio-ecological systems (Ostrom 2009; Berkes 2007) and polycentric governance (Oberlack et al. 2018) by highlighting the role of ideas, concepts, and narratives in institutional dynamics and cross-scale interactions between actors in natural resource governance and how these concepts may be employed in decision-making arenas (Besten et al. 2014).

Some authors challenge the notion that discourses are institutionalised in a predictable manner in policy and practice (Faggin and Behagel 2017; Gebara and Agrawal 2017). More critical analysis might be needed to understand how a discourse is interpreted, negotiated, and acted upon by different actors, particularly in spaces where informal institutional arrangements for natural resource use prevail (Parnell 2015; Pasgaard 2015). Otherwise, an official discourse may prevail that masks power relations tied to "hidden" or off-script discourses (Peck and Theodore 2012). Moreover, as Leipold (2014) highlights, discourses can help generate mechanisms of exclusion and inclusion, partly by structuring information flows and interactions in ways that favour certain interests over others. In addition to physical distance, telecoupled systems are characterised by institutional and social distance (Eakin et al. 2017; Friis and Nielsen 2017a). Discourses may thus help shape the mechanisms that constrain groups from or enable them to influence political responses to telecoupled outcomes by shaping agency and structures of information flows between actors.

Discourses often underlie unequal power relations that help produce heterogeneous outcomes and responses to a discursive telecoupling. Power in the context of discursive telecouplings refers to (1) discursive power to shape the language used to frame socio-environmental problems and the institutional logic of their solutions, (2) decision-making power including capacities to influence political and collective choice procedures, and (3) regulatory powers to (re)craft and enforce rules on human-environment interactions within local land-use systems (Petursson and Vedeld 2017). Possessing discursive and decision-making powers enables certain actors to justify particular interventions or changes to policy and legislation in order to address observed socio-environmental problems (Benjaminsen and Svarstad 2010; Pasgaard 2015; Pereira 2010). The discursive framing of these problems risk masking underlying complexities and resource struggles, often to the detriment of less powerful actors (Di Gregorio et al. 2017; Somorin et al. 2012). Moreover, experts serve a legitimising role for the institutionalisation of global discourses in policy and practice by (re)producing knowledge regimes that underpin dominant discourses, for instance, by framing environmental debates in terms of depoliticised technocratic concepts and solutions (Medina et al. 2009; Aicher 2014; Arts et al. 2010). Awareness of the knowledge regimes and discursive dynamics that are involved in framing human-environment relationships can improve understanding of how these processes create (un)intended outcomes and shape intervention designs.

As local socio-ecological systems become connected to market and policy processes on different levels, competing discourses may emerge that influence land-use practices in the local context. The basic concepts of global discourses are contested in a number of arenas based on material and institutional conditions that are "rooted in specific cultural and political formations" (Feindt and Oels 2005, 163). Importantly, contestations, negotiations, and adaptations of global discourses play out in a variety of interactions, domains, and forums (Oberlack et al. 2018), and are renegotiated and reinterpreted over time in local systems (Nygren 2000). Global discourses influence land-use outcomes partly by shaping the formulation of global and local socio-environmental problems as well as the logic of their proposed solutions, with diverse and unanticipated outcomes for changes in land use.

3 Global Conservation Discourses: Linking Discursive Telecouplings to Local Land-Use Change

This section develops our notion of discursive telecoupling through application to the case of forest conservation discourses and related interventions. The aim of this is to demonstrate the channels through which global discourses shape land-use outcomes in forest frontiers. We focus on the emergence of a "win-win" discourse on enhancing local development and conservation outcomes within the forest conservation literature. After providing a brief background, we illustrate the operationalisation of discursive telecouplings and highlight four issues that can help to account for the heterogeneous outcomes in local land-use systems that arise from global discourses on socio-environmental change in the discussion.

Although international debates on forest conservation have been shaping public opinion and decision-making for many decades, the sense of urgency is only increasing, particularly in the regions of the Global South with large areas of remaining forest landscapes. While in the past such global discourses would typically only have reached local people through a long series of intermediaries, today, local land and forest users have a much broader information base for decision-making. There is a rich body of literature that looks at how global forest conservation discourses influence negotiations and policymaking at the national and international levels (Faggin and Behagel 2017; Nielsen 2016) and examines the role of the media as a platform for actors to engage with discourses (Sadath et al. 2013; Ludwig et al. 2012). These studies have produced insights into how language reflects power relations and how they constrain and frame policy options for environmental conservation. However, less attention has been paid to the mechanisms through which global discourses influence land-use practices in local forest areas (Leipold 2014).

Historically, biodiversity and ecosystem conservation took a largely top-down approach based on rationally optimising land use within a particular geographic area. Often labelled fortress conservation, measures include zoning land areas for their conservation value, imposing restrictions on natural resource use, or otherwise circumventing local populations through, for instance, relocation and eviction (Hutton et al. 2005). After growing evidence of negative social impacts, and with the merging of conservation and development as policy goals in the 1987 UN Brundtland report and the 1992 Convention on Biological Diversity, a win-win discourse began to emerge that envisioned the integration of ecosystem conservation and human well-being outcomes in intervention areas (Berkes 2007; Hutton et al. 2005; Petursson and Vedeld 2017).

This discourse was enthusiastically embraced as it created space for actors with diverse interests to form coalitions, which are usually organised along cross-scale networks (Di Gregorio et al. 2017; Somorin et al. 2012). An example of a win-win narrative is the idea that sustainable agricultural intensification can lead to increased well-being as well as spared land for conservation purposes (Mertz and Mertens 2017), but such desirable win-win outcomes are unfortunately not very common (Rasmussen et al. 2018).

The market has become a central mechanism for merging development and conservation in forest frontier communities, for example, through agricultural intensification, ecotourism, and, more recently, Payment for Ecosystem Services (PES) and carbon-offset projects (Pereira 2010). These are typically operationalised through Integrated Conservation and Development Projects (ICDPs), pro-poor conservation and community conservation interventions. Actor networks are rolling out ambitious large-scale and multilateral forest conservation programmes such as Reducing Emissions from Deforestation and Forest Degradation (REDD+) in developing countries. Utilising new mechanisms and channels, including reward-based mechanisms, media and communication channels, and interdisciplinary forums and cross-sector working groups, these environmental conservation programmes are creating new forces to enable discursive telecouplings to influence local land use.

The salience of global discourses lies in their capacity to integrate emerging prescient issues related to environmental sustainability. In the process, however, this can potentially mask underlying contestations (Benjaminsen and Svarstad 2010; Buizer et al. 2014) and produce unintended win-lose or lose-lose outcomes (Rasmussen et al. 2018), partly by propagating narratives that simplify causal relationships in human-environment interactions (Aicher 2014; Lestrelin et al. 2012b; Pereira 2010). For instance, Pereira (2010) finds that two PES programmes in the Amazon were modelled on a simplified narrative of human-environment interactions by forest users to motivate the rationale behind the intervention. However, in the process these programmes neglect the complex and layered interests of local actors. Meanwhile, in the context of a carbon offset project in Costa Rica, Lansing (2011) argues that the discursive framing of human-environment interactions, based on a simplified representation of land uses and agents, was necessary to ensure the viability of the proposed solution and the legitimacy of the implied institutional logic. There is moreover a risk that global discourses may serve as a basis for avoiding considerations of trade-offs and criticisms when they are translated into interventions through their appeal to legitimisation (McShane et al. 2011; Pasgaard 2015). These tendencies to construct socio-environmental problems to suit a global discourse can inadvertently problematise the institutionalisation of win-win solutions in local socio-ecological systems over time.

While the win-win discourse on conservation and development contains compelling rationales and serves to accommodate disparate interests, some authors note that the discourse is dominated by a knowledge regime that depoliticises decision-making on forest issues and reduces highly complex and contested development processes, which in turn influences land-use change in unpredictable ways (Aicher 2014; Arts and Buizer 2009; Benjaminsen and Svarstad 2010; Gebara and Agrawal 2017). In the context of an ecotourism initiative in a Tanzanian national park, for instance, Miller (2016) argues that, in seeking to achieve win-win outcomes, the intervention's incentive scheme overlooked the political complexity in the local system and ended up creating outcomes that were not anticipated by the intervention. Other unintentional impacts could include, for instance, relocations and migration to other socio-ecological systems; restricted access to land and natural resources; enhanced dependence on markets for subsistence; erosion of customary institutions for natural resource governance; and increased environmental conflicts (Temudo 2012; Petursson and Vedeld 2017). We can better understand these very diverse sets of outcomes arising from conservation interventions, if we look at them as partly resulting from discursive telecouplings that connect global discourses to local land systems.

4 Discussion

While studies have shown that win-win discourses create complex and heterogeneous outcomes when translated and adapted to local systems, the mechanisms and interactions through which such a discursive telecoupling influences land use and livelihoods are less well understood. From our analysis of the literature on forest conservation discourses, four considerations emerge that can help account for the heterogeneous outcomes of a global discourse on local land-use outcomes: (1) the assumptions about the agents and causes of land-use change, (2) the role of intermediaries and networks in institutionalising global discourses in local systems, (3) how discursive telecouplings shape the nature of feedback responses from local systems, and (4) the fact that local systems are characterised by competing discourses.

4.1 Assumptions about the Agent in Land-Use Change Can Create Unanticipated Outcomes

The assumptions embedded in the prevailing discourse, and how related interventions reflect particular logics of behavioural change, are important considerations for understanding the outcomes of conservation telecouplings (see also Chap. 15). Gebara and Agrawal (2017) argue that the a priori assumptions of the agent embedded in a particular discourse can have unintended consequences by not only informing the institutional design of an intervention, but also by implicitly reshaping the agent to conform to this preconception. For instance, Temudo (2012) shows how the socio-environmental problem that legitimised a conservation intervention was discursively constructed and based on behavioural assumptions of self-interested natural resource use that disregarded traditional institutions for resource governance. This framing helped to motivate the imposition of restrictions on land and resource use, which in turn incentivised the self-interested behaviours on which the intervention was modelled. The case illustrates the importance of recognising the opportunity costs of the imposed restrictions and power imbalances between actors.

Reducing the complex and multidimensional causality of land-use change to rational and linear simplicity in order to incentivise behavioural change engenders a generic conceptualisation of the agent. This may facilitate assimilation of global discourses, but can create complications when meeting local systems with heterogeneous conditions, institutions, and historical legacies that constrain land-use and livelihood options for local decision-makers (Biddulph and Amberntsson 2016; Lambin et al. 2001). As Biddulph and Amberntsson (2016) argue, environmental conservation programmes that do not take into account local contextual factors can be largely meaningless in forest landscapes where influences tied to distant processes, such as timber logging networks and marketisation of commercial crops, shape individual livelihood trajectories, incentives, and agency. Adapting global discourses to local conditions of land-use and livelihood trajectories may help make trade-offs and intersecting influences on land and forest use more apparent.

There is considerable diversity in how actors are telecoupled to distant processes and systems. This can occur, for instance, due to power asymmetries tied to official positions, wealth disparities, and access to information and actor networks (Pereira 2010). The assumption that agents are ontologically divisible from their social context does not help in the recognition of the causes or consequences of such relative telecoupling. In the context of the win-win conservation discourse, for instance, the representation of communities as homogenous entities in order to create a discursive fit with a simplified narrative of community agency and decision-making can obscure underlying power asymmetries (Travers et al. 2015; Milne and Adams 2012; Temudo 2012; Pasgaard and Nielsen 2016). While this facilitates the practical implementation of an intervention or the construction of a compelling narrative of socio-environmental change to access donor funding, justify policy implementations, or raise awareness, recognition of how agents are discursively framed in conservation programmes and policy can help reduce some of these unintended biases that may unintentionally propagate win-lose or lose-lose land and forest-use outcomes.

Moreover, access to information dissemination and stakeholder engagement events may affect individual agency. In the case of a REDD+ project intervention in Cambodia, agents with more discursive power were able to position themselves with reference to the win-win discourse for strategic purposes (Pasgaard 2015). In addition, unintended biases in information dissemination mechanisms may influence agency based on, for instance, procedures for inviting members to meetings, or a tendency to emphasise written dissemination channels (Persson and Prowse 2017). Recognising that access to information on conservation programmes is an asset that enhances individual capacities to engage with a conservation telecoupling can mitigate some of the power dynamics involved. Individual responses to discursive telecouplings are thus highly complex and difficult to predict (Nygren 2000; Gebara and Agrawal 2017; Petursson and Vedeld 2017). The strategies employed by individuals are likely to be dynamic as these individuals adapt to new interactions and information to navigate a discursive telecoupling.

4.2 Intermediaries and Networks Shape the Institutionalisation of Global Discourses

To understand how multidirectional flows and networked interactions help create heterogeneous outcomes for land-use change, we turn our attention to the role of intermediaries and actor networks in a discursive telecoupling. As we have seen, the notion that global discourses are transmitted to national and local contexts in a predictable manner for policy and practice is a simplification (Petursson and Vedeld 2017; Salo et al. 2013). So is the assumption that intermediaries and transnational actors play a neutral role in the process. Peck and Theodore (2010) argue that policy transfer across borders is a political process of fragmented policy diffusion through which sociologically complex actors operating in networks and utilising a diversity of mechanisms and channels to mediate global discourses are engaged. Intermediaries can hence play an important role in co-constructing socio-environmental problems and presenting proposed solutions as technical and apolitical (Salo et al. 2013; Sadath et al. 2013). As Leipold (2014) holds, however, this is a political process in which difficult questions of power generally remain unanswered. Indeed, important decisions are often made in arenas beyond the reach of local actors who must negotiate their position through networked interactions and other channels.

Transnational actors similarly wield considerable power to influence discursive telecouplings and the resulting institutionalisation in policy and practice (Petursson and Vedeld 2017; Faggin and Behagel 2017). For instance, in the context of debates on conservation policy in the Brazilian Amazon, private sector actors in the agribusiness sector succeeded in reframing the discourse on sustainable forest management, which translated into a policy more favourable to private sector interests (Faggin and Behagel 2017). Moreover, win-win ambitions often give way to the practical, yet largely unrecognised, realities of the social and political contexts in which decisions on natural resource use are made. Pasgaard and Mertz (2016) highlight how informal networks influenced decision-making on the location of a conservation intervention in Cambodia. Indeed, less powerful local actors often end up compromising their own interests to accommodate those of powerful actors in order to engage with the discursive telecoupling. Medina et al. (2009) show, for example, how communities in four sites across the Amazon adjusted their initial demands to the interests, perspectives, and narratives of intermediaries of a global environmental discourse. Although this new coalition enabled community actors to get their interests onto the agenda, it did lead to unanticipated restrictions on land and natural resource use. Understanding the role of discursive power in the formation of new coalitions between actors involved in a land-use change can help to ensure expectations on trade-offs and interests are better accounted for in policy and programme interventions and design.

4.3 Discursive Telecouplings Shape Feedback Responses

Intermediaries play an important role in transmitting feedback across the chain of interactions and media communication channels that engender and sustain a discursive telecoupling. Garnering donor support is crucial for the success of narratives around win-win conservation policy and interventions, as well as for access to donor funds (Hutton et al. 2005;

Petursson and Vedeld 2017). There is a risk that intermediaries employ their discursive power to represent interventions in win-win terms and bias information flows to highlight successes over failures. This strategic use of information and manipulation of feedback can create a cycle of conservation funding regardless of whether the particular intervention adds value (Temudo 2012). In such instances, a positive feedback loop—between incentives for organisational survival and dependence on external (project-based) sources of funding—reinforces the use of dominant discourses to justify the logic of particular policy solutions and incentivises the manipulation of information flows to other arenas of decision-making. While such outcomes are not necessarily intentional, the forest conservation literature provides compelling evidence that control of information flows and distribution of discursive power between actors involved in a telecoupling have important consequences for land-use outcomes and agency to influence related feedback responses.

It is thus important to acknowledge the multi-layered interests of forest actors that are connected through networks, linkages, and flows to processes originating from distal locations (Pereira 2010; Friis and Nielsen 2017b). Agents are not passively responding, as is sometimes assumed, to various signals with extra-local influences that have causes confined to that particular scale (Munroe et al. 2014; Nygren 2000; Taylor 2016). For instance, by investigating community-managed forest reserves in Tanzania, Funder et al. (2013) show how a monitoring scheme was shaped through daily practice and became an important factor for the emergence of a local conservation elite that asserted some control over information flows and feedback mechanisms. This case demonstrates the need to consider how conservation telecouplings produce information flows that are integrated into the daily practices of local actors with complex and multi-layered interests.

Studies also point to the potential of alternative mechanisms to bypass traditional feedback channels in order for people to engage more directly with a discursive telecoupling. In the case of one conservation intervention in Guinea-Bissau, local people negatively impacted by a project that used a local radio channel to express criticisms as institutional incentives in the context of the conservation programme were not conducive of open feedback (Temudo 2012). In addition, social media and other communication tools can be used to organise a network of communities and mobilise collective action on shared concerns across scales. The concerted use of a variety of channels to voice feedback on socio-environmental pressures in the Prey Lang forest landscape in Cambodia, for instance, coupled with a refusal to engage with prevailing environmental conservation programmes, is a key factor for the Prey Lang Network's relative success in resisting external pressures (Parnell 2015). This case illustrates the empowering potential of discursive telecouplings and the importance of considering feedback, where network members negotiate and integrate discursive elements of forest conservation with local discourses in order to rationalise observed socio-environmental change and further their interests. Given the prevalence of tools today that can link local land users to donors and decision-makers, there are substantial opportunities to create more direct feedback links with local people impacted by an intervention and arenas of decision-making that circumvent the institutional incentives embedded in cross-scale environmental conservation programmes.

4.4 Competing Discourses in Local Systems

Most discourse are set in their respective policy environments and competition between discourses, for example on economic growth and environmental conservation, can result in incoherent policy making and conflicts in decision-making arenas, as well as decisions being based on institutional inertia and informal networked interests (Sullivan 2015; Lestrelin et al. 2012b; Broegaard et al. 2017). These arenas can include ministerial decrees, informal agreements between companies and political decision-makers, village committee meetings, community forest meetings, households, company board meetings, and so on. Institutional and social distance between decision-making arenas and the actors involved arise partly due to the mechanisms of influence created by discursive telecouplings. In these arenas, competing logics for legitimising decisions on socio-environmental change may dominate, although they refer to changes in the same geographically bounded system. For instance, forest conservation interventions funded by donors and implemented by technical agencies are tied to global discourses that may occupy entirely different arenas compared to infrastructure construction investments by foreign companies. Lacking conducive information flows and cohesive processes for institutionalising discourses on socio-environmental change, however, the polity, including legislation and policies that are intended to coordinate decision-making and enforce national laws, may struggle in creating a coherent institutional context. Funding flows are an important aspect of this dynamic as the institutionalisation of discourses depends on the viability and sustainability of sources of financing and the incentives embedded in such system dynamics.

As an example of these dynamics, in Cambodia there are sophisticated policy and legal documents that prescribe environmental criteria for decisions on large-scale land investments. One of these criteria is proximity to national protected areas. Findings from Beauchamp et al. (2018), however, show that there is no evidence that the existence of a protected area deters land allocation for concessions, indicating that decision-making in the natural resource sector is influenced by other considerations than those formally prescribed and that reflect a land sparing approach to forest conservation. In such cases, global conservation discourses seem to influence the formulation of legal and policy documents that are driven by one set of national actors, but with only partial institutionalisation of these discourses in practice, at least in the short term, as existing actor interests and power dynamics shape outcomes on land use. These findings are echoed in other contexts such as the Brazilian Amazon (Gebara and Agrawal 2017; Faggin and Behagel 2017).

Such dynamics do not just play out at the national scale. In the case of forest conservation, communities of ethnic minorities may have distinct discourses on land and forests that are rooted in particular historical and socio-cultural contexts and expressed in myths, stories, and narratives. Such local discourses likely have a mutually constitutive relationship with the customary institutions that regulate land and forest-use patterns, thus helping to provide the language and logic for crafting and enforcing rules (Pereira 2010; Parnell 2015; Temudo 2012). As discursive telecouplings tied to distal processes influence opportunities and constraints for land and forest use, local people must accommodate new ways of thinking about socio-environmental change, collectively and individually.

Situating these dynamics from a telecoupling perspective helps to understand how individuals navigate competing pressures.

Another issue is the strategic use of arguments in forest conservation discourses by government actors to justify the imposition of state-led approaches to fortress conservation that masks underlying power struggles in the institutionalisation of natural resource access. Laos, for instance, is a prominent example of how a land degradation narrative feeds into a modernist land rationalisation discourse based on land sparing that constrains policy options and potential logics for environmental conservation (Lestrelin et al. 2012a, b). In another case, during a conflict over forest access in rural Thailand, both the government and opposing ethnic minorities positioned themselves with respect to narratives of forest conservation discourses by framing forest inhabitants as enemies of the forest and forest protectors respectively (Ganjanapan 1998). Global forest conservation discourses thus became a tool in the political struggle over natural resource access. Despite the rhetorical references to win-win discourses, when access to land and natural resources is highly politicised, government actors tend to appeal to modernist underpinnings of economic development discourses to use traditional channels of coercion (Milne 2015).

5 Conclusion

The way environmental problems are constructed and their solutions rationalised can be a powerful constraining force for how people respond to changing conditions in their external environment. However, while language can limit available options by rendering certain modes of thinking more actionable and legitimate, it can also open up new possible ways forward by enabling communities of people to make sense of observed socio-ecological change and organise collective responses. At the same time, globalisation is accelerating socio-economic and environmental interactions between distal land systems through processes that are underpinned by intersecting and distinct discourses for socio-ecological change. Highlighting the role of ideas, concepts, and narratives in these distal interactions, we developed the notion of *discursive telecouplings* to guide analysis of immaterial flows in telecoupled land systems. Reviewing the literature on forest conservation discourses and policy translations, we used the concept to analyse the interactions and channels through which global discourses influence local land-use systems and livelihood outcomes, and vice versa.

As forest frontiers become increasingly connected to global mechanisms and processes, discourses are playing a stronger role in influencing land-use and livelihood outcomes. When such discourses are interpreted and translated into local land-use systems, however, they must accommodate local power asymmetries, cross-scale networks, and heterogeneous conditions. Local systems are characterised by institutional legacies and local discourses that shape socio-ecological interactions, as well as the existence of competing discourses for land and natural resource use. Asymmetries in discursive, decision-making, and regulatory power between actors involved in a telecoupling influence capacity to shape the land-use and livelihood outcomes of a discursive telecoupling.

Explicitly integrating the role of immaterial and discursive flows between distant systems can thus help further our understanding of the heterogeneous outcomes of telecoupling. Improved understanding of the discursive dynamics of telecouplings can enable decision-makers to better balance socio-environmental trade-offs and improve information flows between socially, spatially, and institutionally distant actors in order to create stronger foundations for coalition formation. Achieving the ideal of preserving ecological conditions of forest landscapes, for the benefit of wildlife, biodiversity, and forest landscapes, while maximising opportunities for local development, will require institutionalising the win-win discourse in environmental governance practice on all levels and effectively scaling up win-win solutions. As we have sought to demonstrate, recognising the ways in which discursive dynamics influence forest and land use can help decision-makers be aware of the risks involved in this complex process and to build policies, programmes and interventions that more effectively accommodate the complexity of local socio-ecological systems.

Acknowledgements This work has received support from the European Union's Horizon 2020 research and innovation programme under Marie

Skłodowska-Curie Actions grant agreement No. 765408 (COUPLED, http://coupled-itn.eu).

References

Adger, Neil, Katrina Brown, and Emma Tompkins. 2005. The Political Economy of Cross-Scale Networks in Resource Co-Management. *Ecology and Society* 10 (2): 9. https://doi.org/10.5751/ES-01465-100209.

Aicher, Christoph. 2014. Discourse Practices in Environmental Governance: Social and Ecological Safeguards of REDD. *Biodiversity and Conservation* 23 (14): 3543–3560. https://doi.org/10.1007/s10531-014-0812-5.

Arts, Bas, Marie Appelstrand, Daniela Kleinschmit, Helga Pülzl, Ingrid Visseren-Hamakers, R. Eba'a Atyi, Thomas Enters, Kathleen McGinley, and Yurdi Yasmi. 2010. Discourses, Actors and Instruments in International Forest Governance. In *Embracing Complexity: Meeting the Challenges of International Forest Governance. A Global Assessment Report*, prepared by the Global Forest Expert Panel on the International Forest Regime, 57–74. International Union of Forest Research Organizations (IUFRO).

Arts, Bas, and Marleen Buizer. 2009. Forests, Discourses, Institutions. *Forest Policy and Economics* 11 (5–6): 340–347. https://doi.org/10.1016/j.forpol.2008.10.004.

Atmadja, Stibniati, and Louis Verchot. 2012. A Review of the State of Research, Policies and Strategies in Addressing Leakage from Reducing Emissions from Deforestation and Forest Degradation (REDD+). *Mitigation and Adaptation Strategies for Global Change* 17 (3): 311–336. https://doi.org/10.1007/s11027-011-9328-4.

Beauchamp, Emilie, Tom Clements, and E.J. Milner-Gulland. 2018. Exploring Trade-Offs between Development and Conservation Outcomes in Northern Cambodia. *Land Use Policy* 71: 431–444. https://doi.org/10.1016/j.landusepol.2017.11.021.

Benjaminsen, Tor A., and Hanne Svarstad. 2010. The Death of an Elephant: Conservation Discourses Versus Practices in Africa. *Forum for Development Studies* 37 (3): 385–408. https://doi.org/10.1080/08039410.2010.516406.

Berkes, Fikret. 2007. Community-Based Conservation in a Globalized World. *Proceedings of the National Academy of Sciences* 104 (39): 15188–15193.

den Besten, Jan Willem, Bas Arts, and Patrick Verkooijen. 2014. The Evolution of REDD+: An Analysis of Discursive-Institutional Dynamics. *Environmental Science & Policy* 35: 40–48. https://doi.org/10.1016/j.envsci.2013.03.009.

Biddulph, Robin, and Pelle Amberntsson. 2016. Whose Reality Counts? Critical Junctures in Livelihood Trajectories Under Deforestation: Whose Reality Counts? *Tijdschrift Voor Economische En Sociale Geografie* 8: 540–553. https://doi.org/10.1111/tesg.12214.

Broegaard, Rikke, Thoumthone Vongvisouk, and Ole Mertz. 2017. Contradictory Land Use Plans and Policies in Laos: Tenure Security and the Threat of Exclusion. *World Development* 89: 170–183.

Buizer, Marleen, David Humphreys, and Wil de Jong. 2014. Climate Change and Deforestation: The Evolution of an Intersecting Policy Domain. *Environmental Science & Policy* 35: 1–11. https://doi.org/10.1016/j.envsci.2013.06.001.

Di Gregorio, Monica, Caleb Tyrell Gallemore, Maria Brockhaus, Leandra Fatorelli, and Efrian Muharrom. 2017. How Institutions and Beliefs Affect Environmental Discourse: Evidence from an Eight-Country Survey on REDD+. *Global Environmental Change* 45: 133–150. https://doi.org/10.1016/j.gloenvcha.2017.05.006.

Eakin, Hallie, Ruth DeFries, Suzi Kerr, Eric F. Lambin, Jianguo Liu, Peter J. Marcotullio, Peter Messerli, et al. 2014. Significance of Telecoupling for Exploration of Land-Use Change. In *Rethinking Global Land Use in an Urban Era*, ed. Karen C. Seto and Anette Reenberg, 141–163. Cambridge, MA: The MIT Press.

Eakin, Hallie, Ximena Rueda, and Ashwina Mahanti. 2017. Transforming Governance in Telecoupled Food Systems. *Ecology and Society* 22 (4): 32. https://doi.org/10.5751/ES-09831-220432.

Faggin, Joana Mattei, and Jelle Hendrik Behagel. 2017. Translating Sustainable Forest Management from the Global to the Domestic Sphere: The Case of Brazil. *Forest Policy and Economics* 85: 22–31. https://doi.org/10.1016/j.forpol.2017.08.012.

Feindt, Peter H., and Angela Oels. 2005. Does Discourse Matter? Discourse Analysis in Environmental Policy Making. *Journal of Environmental Policy & Planning* 7 (3): 161–173. https://doi.org/10.1080/15239080500339638.

Friis, Cecilie, and Jonas Ø. Nielsen. 2017a. Land-Use Change in a Telecoupled World: The Relevance and Applicability of the Telecoupling Framework in the Case of Banana Plantation Expansion in Laos. *Ecology and Society* 22 (4): 30. https://doi.org/10.5751/ES-09480-220430.

———. 2017b. On the System. Boundary Choices, Implications, and Solutions in Telecoupling Land Use Change Research. *Sustainability* 9 (6): 974. https://doi.org/10.3390/su9060974.

Friis, Cecilie, Jonas Ø. Nielsen, Iago Otero, Helmut Haberl, Jörg Niewöhner, and Patrick Hostert. 2016. From Teleconnection to Telecoupling: Taking Stock of an Emerging Framework in Land System Science. *Journal of Land Use Science* 11 (2): 131–153. https://doi.org/10.1080/1747423X.2015.1096423.

Funder, Mikkel, Yonika Ngaga, Martin R. Nielsen, Michael K. Poulsen, and Finn Danielsen. 2013. Reshaping Conservation: The Social Dynamics of Participatory Monitoring in Tanzania's Community-Managed Forests. *Conservation and Society* 11 (3): 218. https://doi.org/10.4103/0972-4923.121011.

Ganjanapan, Anan. 1998. The Politics of Conservation and the Complexity of Local Control of Forests in the Northern Thai Highlands. *Mountain Research and Development* 18 (1): 71. https://doi.org/10.2307/3673869.

Garrett, Rachael D., Ximena Rueda, and Eric F. Lambin. 2013. Globalization's Unexpected Impact on Soybean Production in South America: Linkages between Preferences for Non-Genetically Modified Crops, Eco-Certifications, and Land Use. *Environmental Research Letters* 8 (4): 044055. https://doi.org/10.1088/1748-9326/8/4/044055.

Gebara, Maria, and Arun Agrawal. 2017. Beyond Rewards and Punishments in the Brazilian Amazon: Practical Implications of the REDD+ Discourse. *Forests* 8 (3): 66. https://doi.org/10.3390/f8030066.

Hutton, Jon, William M. Adams, and James C. Murombedzi. 2005. Back to the Barriers? Changing Narratives in Biodiversity Conservation. *Forum for Development Studies* 32 (2): 341–370. https://doi.org/10.1080/08039410.2005.9666319.

Lambin, Eric F., B.L. Turner, Helmut J. Geist, Samuel B. Agbola, Arild Angelsen, John W. Bruce, Oliver T. Coomes, Rodolfo Dirzo, Günther Fischer, Carl Folke, P.S. George, Katherine Homewood, Jacques Imbernon, Rik Leemans, Xiubin Li, Emilio F. Morano, Michael Mortimore, P.S. Ramakrishnanq, John F. Richards, Helle Skåness, Will Steffen, Glenn D. Stone, Uno Svedin, Tom A. Veldkamp, Coleen Vogel, and Jianchu Xu. 2001. The Causes of Land-Use and Land-Cover Change: Moving beyond the Myths. *Global Environmental Change* 11 (4): 261–269. https://doi.org/10.1016/S0959-3780(01)00007-3.

Lansing, David M. 2011. Realizing Carbon's Value: Discourse and Calculation in the Production of Carbon Forestry Offsets in Costa Rica. *Antipode* 43 (3): 731–753. https://doi.org/10.1111/j.1467-8330.2011.00886.x.

Leipold, Sina. 2014. Creating Forests with Words—A Review of Forest-Related Discourse Studies. *Forest Policy and Economics* 40: 12–20. https://doi.org/10.1016/j.forpol.2013.12.005.

Lestrelin, Guillaume, Jean-Christophe Castella, and Jeremy Bourgoin. 2012a. Territorialising Sustainable Development: The Politics of Land-Use Planning in Laos. *Journal of Contemporary Asia* 42 (4): 581–602. https://doi.org/10.1080/00472336.2012.706745.

Lestrelin, Guillaume, Olga Vigiak, Aurélie Pelletreau, Bounmy Keohavong, and Christian Valentin. 2012b. Challenging Established Narratives on Soil Erosion and Shifting Cultivation in Laos: Challenging Established Narratives on Soil Erosion and Shifting Cultivation in Laos. *Natural Resources Forum* 36 (2): 63–75. https://doi.org/10.1111/j.1477-8947.2011.01438.x.

Liu, Jianguo, Vanessa Hull, Mateus Batistella, Ruth DeFries, Tom Dietz, F. Fu, Tom W. Hertel, E.F. Izaurralde, S.L. Lambin, Shuxin Li, Luis A. Martinelli, William J. McConnel, Emilio F. Moran, R. Naylor, Z. Ouyang, K.R. Polenske, Aneta Reenberg, G. de Miranda Rocha, C.S. Simmons, Peter H. Verburg, Peter M. Vitousek, Fusuo Zhang, and Chunquan Zhu. 2013. Framing Sustainability in a Telecoupled World. *Ecology and Society* 18 (2): 26. https://doi.org/10.5751/ES-05873-180226.

Ludwig, Melanie, Friederike Grüninger, Eberhard Rothfuss, and Marco Heurich. 2012. Discourse Analysis as an Instrument to Reveal the Pivotal Role of the Media in Local Acceptance or Rejection of a Wildlife Management Project: A Case Study from the Bavarian Forest National Park. *Erdkunde* 66 (2): 143–156.

McShane, Thomas O., Paul D. Hirsch, Tran Chi Trung, Alexander N. Songorwa, Ann Kinzig, Bruno Monteferri, David Mutekanga, et al. 2011. Hard Choices: Making Trade-Offs between Biodiversity Conservation and Human Well-Being. *Biological Conservation* 144 (3): 966–972. https://doi.org/10.1016/j.biocon.2010.04.038.

Medina, Gabriel, Benno Pokorny, and Jes Weigelt. 2009. The Power of Discourse: Hard Lessons for Traditional Forest Communities in the Amazon. *Forest Policy and Economics* 11 (5–6): 392–397. https://doi.org/10.1016/j.forpol.2008.11.004.

Mertz, Ole, and Charlotte F. Mertens. 2017. Land Sparing and Land Sharing Policies in Developing Countries—Drivers and Linkages to Scientific

Debates. *World Development* 98: 523–535. https://doi.org/10.1016/j.worlddev.2017.05.002.

Meyfroidt, Patrick, Eric F. Lambin, Karl-Heinz Erb, and Thomas W. Hertel. 2013. Globalization of Land Use: Distant Drivers of Land Change and Geographic Displacement of Land Use. *Current Opinion in Environmental Sustainability* 5 (5): 438–444. https://doi.org/10.1016/j.cosust.2013.04.003.

Miller, Joseph Ellis. 2016. Local Agency at the Intersection of Global Conservation Discourse and the Political Economy of Wildlife in Tanzania. *World Development Perspectives* 1: 33–35. https://doi.org/10.1016/j.wdp.2016.05.002.

Milne, Sarah. 2015. Cambodia's Unofficial Regime of Extraction: Illicit Logging in the Shadow of Transnational Governance and Investment. *Critical Asian Studies* 47 (2): 200–228. https://doi.org/10.1080/14672715.2015.1041275.

Milne, Sarah, and Bill Adams. 2012. Market Masquerades: Uncovering the Politics of Community-Level Payments for Environmental Services in Cambodia: Politics of Community-Level PES in Cambodia. *Development and Change* 43 (1): 133–158. https://doi.org/10.1111/j.1467-7660.2011.01748.x.

Munroe, Darla K., Kendra McSweeney, Jeffrey L. Olson, and Becky Mansfield. 2014. Using Economic Geography to Reinvigorate Land-Change Science. *Geoforum* 52: 12–21. https://doi.org/10.1016/j.geoforum.2013.12.005.

Nielsen, Tobias D. 2016. From REDD+ Forests to Green Landscapes? Analyzing the Emerging Integrated Landscape Approach Discourse in the UNFCCC. *Forest Policy and Economics* 73: 177–184. https://doi.org/10.1016/j.forpol.2016.09.006.

Nygren, Anja. 2000. Development Discourses and Peasant-Forest Relations: Natural Resource Utilization as Social Process. *Development and Change* 31 (1): 11–34. https://doi.org/10.1111/1467-7660.00145.

Oberlack, Christoph, Sébastien Boillat, Stefan Brönnimann, Jean-David Gerber, Andreas Heinimann, Chinwe Ifejika Speranza, Peter Messerli, Stephan Rist, and Urs Wiesmann. 2018. Polycentric Governance in Telecoupled Resource Systems. *Ecology and Society* 23 (1): 16. https://doi.org/10.5751/ES-09902-230116.

Ostrom, Elinor. 2009. A General Framework for Analyzing Sustainability of Social-Ecological Systems. *Science* 325 (5939): 419–422. https://doi.org/10.1126/science.1172133.

Parnell, Terry. 2015. Story-Telling and Social Change: A Case Study of the Prey Lang Community Network. In *Conservation and Development in Cambodia*

Exploring Frontiers of Change in Nature, State and Society, ed. Sarah Milne and Sango Mahanty. London: Routledge.

Pasgaard, Maya. 2015. Lost in Translation? How Project Actors Shape REDD+ Policy and Outcomes in Cambodia: Lost in Translation? *Asia Pacific Viewpoint* 56 (1): 111–127. https://doi.org/10.1111/apv.12082.

Pasgaard, Maya, and Ole Mertz. 2016. Desirable Qualities of REDD+ Projects Not Considered in Decisions of Project Locations. *Environmental Research Letters* 11 (11): 114014. https://doi.org/10.1088/1748-9326/11/11/114014.

Pasgaard, Maya, and Tania Fredborg Nielsen. 2016. A Story of 'Communities': Boundaries, Geographical Composition and Social Coherence in a Forest Conservation Project, Northern Cambodia. *Geografisk Tidsskrift-Danish Journal of Geography* 116 (2): 134–146. https://doi.org/10.1080/00167223.2016.1182440.

Peck, Jamie, and Nik Theodore. 2010. Mobilizing Policy: Models, Methods, and Mutations. *Geoforum* 41 (2): 169–174. https://doi.org/10.1016/j.geoforum.2010.01.002.

———. 2012. Follow the Policy: A Distended Case Approach. *Environment and Planning A* 44 (1): 21–30. https://doi.org/10.1068/a44179.

Pereira, Simone Novotny Couto. 2010. Payment for Environmental Services in the Amazon Forest: How Can Conservation and Development Be Reconciled? *The Journal of Environment & Development* 19 (2): 171–190. https://doi.org/10.1177/1070496510368047.

Persson, Joel, and Martin Prowse. 2017. Collective Action on Forest Governance: An Institutional Analysis of the Cambodian Community Forest System. *Forest Policy and Economics* 83: 70–79. https://doi.org/10.1016/j.forpol.2017.06.008.

Petursson, Jon Geir, and Paul Vedeld. 2017. Rhetoric and Reality in Protected Area Governance: Institutional Change under Different Conservation Discourses in Mount Elgon National Park, Uganda. *Ecological Economics* 131: 166–177. https://doi.org/10.1016/j.ecolecon.2016.08.028.

Rasmussen, Laura V., Brendan Coolsaet, Adrian Martin, Ole Mertz, Unai Pascual, Esteve Corbera, Neil Dawson, Janet A. Fisher, Phil Franks, and Casey M. Ryan. 2018. Social-ecological Outcomes of Agricultural Intensification. *Nature Sustainability* 1 (6): 275–282. https://doi.org/10.1038/s41893-018-0070-8.

Reenberg, Anette, and Nina A. Fenger. 2011. Globalizing Land Use Transitions: The Soybean Acceleration. *Geografisk Tidsskrift-Danish Journal of Geography* 111 (1): 85–92. https://doi.org/10.1080/00167223.2011.10669524.

Sadath, Nazmus, Daniela Kleinschmit, and Lukas Giessen. 2013. Framing the Tiger—A Biodiversity Concern in National and International Media Reporting. *Forest Policy and Economics* 36: 37–41. https://doi.org/10.1016/j.forpol.2013.03.001.

Salo, Matti, Jukka-Pekka Puro, and Karoliina Knuuti. 2013. Control and Intimacy in the Amazonian Reality: Newspaper Rhetoric on Forest Sector Reform in Peru. *Land Use Policy* 35: 226–236. https://doi.org/10.1016/j.landusepol.2013.05.022.

Somorin, Olufunso A., H. Carolyn Peach Brown, Ingrid J. Visseren-Hamakers, Denis J. Sonwa, Bas Arts, and Johnson Nkem. 2012. The Congo Basin Forests in a Changing Climate: Policy Discourses on Adaptation and Mitigation (REDD+). *Global Environmental Change* 22 (1): 288–298. https://doi.org/10.1016/j.gloenvcha.2011.08.001.

Sullivan, Michael. 2015. Contested Development and Environment: Chinese-Backed Hydropower and Infrastructure Projects in Cambodia. In *Conservation and Development in Cambodia Exploring Frontiers of Change in Nature, State and Society*, ed. Sarah Milne and Sango Mahanty, 120–138. London and New York: Routledge.

Taylor, Philip. 2016. Frontier Commoditisation in Post-Socialist Southeast Asia: Frontier Commoditisation. *Asia Pacific Viewpoint* 57 (2): 145–153. https://doi.org/10.1111/apv.12125.

Temudo, MarinaPadrão. 2012. 'The White Men Bought the Forests': Conservation and Contestation in Guinea-Bissau, Western Africa. *Conservation and Society* 10 (4): 354. https://doi.org/10.4103/0972-4923.105563.

Thiha, Edward L. Webb, and Kiyoshi Honda. 2007. Biophysical and Policy Drivers of Landscape Change in a Central Vietnamese District. *Environmental Conservation* 34 (2): 164–172. https://doi.org/10.1017/S037689290700389X.

Travers, Henry, Kyle Winney, Tom Clements, Tom Evans, and E.J. Milner-Gulland. 2015. A Tale of Two Villages: An Investigation of Conservation-Driven Land Tenure Reform in a Cambodian Protection Forest. *Land Use Policy* 43: 186–196. https://doi.org/10.1016/j.landusepol.2014.11.007.

Part III

Agenda

18

Beyond Integration: Exploring the Interdisciplinary Potential of Telecoupling Research

Jonas Ø. Nielsen, Cecilie Friis, and Jörg Niewöhner

1 Introduction

The telecoupling framework represents a clear and concrete response to the scientific and political need for interdisciplinary thought and practice to address the environmental and developmental challenges of the twenty-first century (e.g. Brondizio et al. 2016; Verburg et al. 2015; Moran and Lopez 2016). Within the contemporary global research agenda, it has been increasingly emphasised that these challenges require thinking that links the social and ecological spheres (Turner et al. 2007, www.futureearth.org, www.glp.earth). A growing number of recent

J. Ø. Nielsen (✉) • C. Friis
IRI THESys & Geography Department,
Humboldt-Universität zu Berlin, Berlin, Germany
e-mail: jonas.ostergaard.nielsen@hu-berlin.de; cecilie.friis@hu-berlin.de

J. Niewöhner
IRI THESys & Institute for European Ethnology,
Humboldt-Universität zu Berlin, Berlin, Germany
e-mail: Joerg.niewoehner@hu-berlin.de

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_18

papers (e.g. Fischer et al. 2015; Kramer et al. 2017; Lövbrand et al. 2015; Brondizio et al. 2016) advocate for a more organised and programmatic interdisciplinary approach to social-ecological research that systematically incorporates the physical, biological and social sciences (Moran and Lopez 2016). Such an approach should focus on priority areas (Fischer et al. 2015), the most pressing problems (Kramer et al. 2017) and new directions in social-ecological research as well as how to extend the conversation to policy makers and other stakeholders (Lövbrand et al. 2015). Some of the priority areas and pressing problems identified specifically relate to how to understand and govern interactions between regions and across large distances, how to understand causation in complex coupled socio-ecological systems and how to deal with diverging understandings of human-environment interactions in inter- and trans-disciplinary research groups. As discussed throughout this book, the telecoupling framework and the emerging field of telecoupling research steps into these discussions. It explicitly sets out to explore complex, distal and cross-scalar causal relations (see Chaps. 2 and 3), and the intertwinement of nature and society in a systemic, yet open way, which makes engagement with a multiplicity of scientific disciplines and methods possible and, indeed, necessary (see also Chaps. 2, 3, 7, 10, 13 and 16).

The telecoupling framework is thus inherently interdisciplinary in its ambitions. In the initial publication on the framework, Liu et al. (2013, 8) heralded the "uniquely integrative" nature of the framework that "provides a common language, logical consistency, systematic approach, and holistic guidance for researchers" to analyse both socioeconomic and environmental interactions, flows and feedbacks between multiple systems. Eakin et al. (2014) also stressed "a need for integrating diverse epistemological perspectives, methodolog[ies], and analytical approaches" for researching telecoupling in order to "complement the long-standing focus of land science on place-based research with a new focus on the networks and system interactions involved in land change" (p. 142). This push for integration of perspectives finds resonance in the wider literature on land system science and human-environment change (e.g. Brondizio et al. 2016; Abson et al. 2017). In this literature, substantial efforts are currently being made to integrate methods and synthesise knowledge produced through various methods, from situated case studies to spatial and economic modelling (Magliocca et al. 2018; Verburg et al. 2016), as well as to develop the techniques of meta-study analysis (Magliocca et al. 2015; van Vliet et al. 2016).

Yet, two issues challenge these efforts towards interdisciplinarity. First, while there is clearly a need and willingness amongst human-environment researchers to be open to accepting new approaches and to be epistemologically flexible in adapting multiple methods in their own research; in practice, it is difficult to achieve interdisciplinarity. The capacity to speak across disciplinary boundaries and to understand the assumptions of other research domains, the ability to use multiple conceptual frameworks and methods, and a shift away from studying different resources and sectors separately towards "a more holistic focus on multifunctional systems" (Fischer et al. 2015, 146) are difficult and require both modesty regarding one's own position and openness to others (Roy et al. 2013). Second—and perhaps even more crucial—achieving interdisciplinary collaboration through integration may not always be what is needed or indeed what is feasible. On an epistemological level, different ways of knowing the world may not add up to a more comprehensive understanding of the world. Instead, frictions between thought styles may arise that are productive or otherwise (Tsing 2005). On an ontological level, current social science thinking suggests that people often inhabit vastly different worlds that are not readily commensurable (e.g. de Castro 2015). Hence, data, analysis, methods and approaches might not be integrable at all, but rather stand in contrast to each other: contrasts that need to be explored to turn them productive (see Chap. 3).

This represents a challenge for telecoupling research, as it requires a new mode of interdisciplinarity that moves beyond methodological and analytical integration. In this chapter, we begin the discussion on how to go about this by engaging with insights from the sociology of science. Specifically, we draw on Barry and Born (2013) and their discussion of an agonistic (combative)–antagonistic (hostile) mode of interdisciplinarity and the logic behind it. Based on this perspective, we argue that interdisciplinarity should not only be a matter of integration but also be a process that depends on scientific differences, so that the goal of interdisciplinary exchanges is to find ways of exploring productive tensions rather than smoothing them over (Barry and Born 2013; Niewöhner et al. 2016a).

Examples from telecoupling research will be used to illustrate how this mode of interdisciplinarity pushes knowledge production forward. This approach requires an understanding of theory as not simply an ever more encompassing body of general principles. Rather, this approach suggests that theoretical concepts deliver specific analytical sensitivities to the researcher; analytical sensitivities that have the potential to set telecoupling research off on the right interdisciplinary track. Our main aim in this chapter is therefore not to evaluate the state of interdisciplinarity in current telecoupling research, but rather, to provide suggestions for avenues that it needs to follow if it is to become a meaningful interdisciplinary research framework capable of addressing the manifold current and future challenges in social-ecological research.

2 New Directions for Interdisciplinary Research

2.1 Modes of Interdisciplinarity

Due to a "paucity of empirical studies of how interdisciplinarity unfolds in practice" little is actually known about how best to do interdisciplinary work (Barry and Born 2013, 2). However, it is increasingly acknowledged that interdisciplinary research can be more than simply the integration or synthesis of two or more disciplines in a relatively symmetrical form *or* a research process in which one or more disciplines make up for, or fill in for, "an absence or lack in the other, (master) discipline/s" (Barry and Born 2013, 11). Such *integrative-synthesis* and *subordination-service* modes of interdisciplinarity, as Barry and Born label them, are not outdated or useless, as bringing together disparate data and knowledge is needed for tackling today's sustainability challenges around land use. Within land system science, for example, studies have shown how integrating geographical spatial models of land-cover change and economic models of land-use decision making in an interdisciplinary integration-synthesis mode provide useful knowledge on land-use and land-cover changes (e.g. Verburg et al. 2016). As for the subordination-service mode, a social science perspective is sometimes added to otherwise largely natural science-based land-use change studies in order to discuss drivers of consumption changes, for example (Nelson et al. 2006). Yet, the limiting interdisciplinary exchanges often taking place in these two modes make it less likely that radically different understandings of a given research object are achieved since the basic assumptions of the participating scientists are left unchallenged (Barry and Born 2013). For social-ecological research, such as telecoupling research, a different mode of interdisciplinarity is needed in striving to achieve a "radical recasting" of the "dualistic ways that researchers, analysist, and commentators think about interactions between two historically distinct worlds: the world of social, economic and political systems and processes, and biophysical systems of the planet" (Brondizio et al. 2016, 319).

This mode should strive to contest and transcend the given epistemological and/or ontological assumptions of "specific historical disciplines" within interdisciplinary projects (Barry and Born 2013, 12)—that is, it should challenge their established methodological and theoretical positions. Driven by agonistic (combative) or even antagonistic (hostile) relations to exciting forms of disciplinary knowledge and practice such an *agonistic-antagonistic* mode of interdisciplinarity should strive to create knowledge "irreducible to its antecedent disciplines" (Barry and Born 2013, 12). This mode is relevant when an interest in shared research objects or boundary objects (Star 2010) brings together diverse and contesting perspectives on knowledge production. Boundary objects are best described as objects with a large amount of interpretive flexibility that allows different disciplines to discuss the same object but from different positions (Star and Griesemer 1989). For example, a forest is a boundary object from the research field of land-use and land-cover change. A forest has multiple meanings at the same time and, depending on whether the forest is described by a biologist, an economist or an anthropologist, it can be said to be a biome, an economic resource or a site of recreation and/or cultural meaning. That is, each disciplinary perspective assigns different ontological status to the forest (see also Niewöhner et al. 2016a, 12–13). In an agonistic-antagonistic mode of interdisciplinarity, the aim is not to settle upon the right definition or understanding of what a forest is, as this carries the risk of a "spurious unity" or a false idea of agreement (Barry and Born 2013, 13). Rather, it is a process focused on changing (or at least challenging) the respective researcher's stance as this might lead to "novel research questions, objects and practices" around the shared research object (Niewöhner et al. 2016a, 12). The irreducibility of new knowledge to the participating disciplinary perspectives also implies that researchers engaging in this mode of interdisciplinarity must be ready to accept that the knowledge generated by their own discipline may be revealed to be inadequate, faulty or even unreliable (Penny 2006, as cited in Barry and Born 2013, 12). In this sense, agonistic-antagonistic interdisciplinarity depends on a "self-conscious dialogue with, criticism of or opposition to" established disciplines (Barry and Born 2013, 12). The drive within an agonistic-antagonistic mode is hence a wish to supersede prior knowledge commitments in a dialogical way. As such, this mode should be understood diachronically, or as in constant formation, defined and facilitated by the multiplicity of researchers engaging in it.

Within telecoupling research, this is exemplified by the discussions around the concept of scale. While it is beyond the scope of this chapter to provide a thorough review of the papers discussing scale within telecoupling research (e.g. Friis and Nielsen 2017a, b; Friis et al. 2016; Liu et al. 2013; Niewöhner et al. 2016a; Eakin et al. 2014), it is fair to say that something resembling an agonistic-antagonistic discussion about this concept has taken place as researchers, with very different perspectives compared to the one traditionally held in land system science, have started engaging in telecoupling research. Conventionally, land system science has approached scale from a Euclidian perspective, where scale is determined by spatial extent relative to the planet as a whole, and scales, such as local, regional, national or global, are understood as existing independently of the object of research and of the observer. In contrast, human geography and anthropology have largely developed a relational perspective on space and scale (Friis and Nielsen 2017a, b; see Chap. 3). Insisting on an analytical engagement with how different phenomena, objects, events, places or processes are constituted in space in relation to each other, a relational perspective does not necessarily limit scale to a specific spatial extent. Rather, the scale of a particular object of study is determined by the perspective from which it is studied, the methodology used, who is using it and for what purpose. Whereas the Euclidian perspective on scale adopted in land system science often leads to a scale-dependent view of different phenomena and drivers, which are understood to be tied to and represented as operating at specific scales, a relational perspective argues that these different phenomena have to be related to each other and to the methods by which they are represented, since these shape the nature of the particular phenomena.

In an example from recent telecoupling research, Friis and Nielsen (2017a, b) illustrate this move between different understandings of scale. Exploring the conversion of land from rice to banana in northern Laos, they show how the spatial boundaries of the telecoupled banana system were determined by the methodological scale choices, analytical interests and empirical observations, rather than by a priori scalar definitions such as fields, village, region or nation. At the same time, such scalar units of analysis remained important too since, for example, government policies targeting a regional scale played a role in the land-use conversion. The implications of this are manifold, as becomes evident throughout the chapters in this book, but one clear outcome is that scales simultaneously exist (in the case of the region) and do not exist (in the case of the banana system) independently of the observing scientists (Friis and Nielsen 2017a, b; Niewöhner et al. 2016a). As such, telecoupling research can embrace both a positivist and a social constructivist understanding of scale that cannot be reduced to either the natural or the social sciences collaborating within the framework. Adopting an agonistic-antagonistic mode of interdisciplinarity implies that discussions on scale, as exemplified here, should lead to new questions, discussions and eventually understandings concerning system boundaries and spatiotemporal scale (mis) matches between social and ecological processes without necessarily reaching consensus on a new "scale definition."

2.2 Logics of Interdisciplinarity

Engaging in an agonistic-antagonistic of interdisciplinarity, or any other mode, does not in and of itself ensure new knowledge or new understandings of a boundary object. To reach new knowledge positions that allow researchers to both transcend and confirm traditional understandings of a forest or scale, for example, Barry and Born (2013) argue that reflexivity is required regarding more than the mode, or the how to, of interdisciplinarity. It is equally important to understand the *logic* behind it, or which (social-economic-political-scientific) agendas drive the current push for interdisciplinarity as these might delimit the scope and freedom of the research.

Barry and Born (2013) describe three such logics: a *logic of accountability*, a *logic of innovation* and an *ontological logic*. In the two first logics, interdisciplinarity is understood as fostering a culture of accountability for science with respect to society because science can deliver innovative solutions needed by society to tackle the multidimensional problem of environmental change. These logics of interdisciplinary collaboration are thus justified on the basis that they "encourage publics and governments to 'buy into' the results of the research, and [because] they can make scientific institutions more responsive to the demands and concerns of non-scientists" (Barry and Born 2013, 15). Telecoupling research aligns well with these two logics as it strives to achieve a high level of accountability towards and relevance for society by arriving at innovations that push land use onto a more sustainable path both locally and globally (see also Chaps. 1, 9, 11 and 19). The recently funded European Union project *COUPLED—Operationalising Telecouplings for Solving Sustainability Challenges Related to Land Use* is a clear example of this, connecting stakeholders from large multinational companies, NGOs, international organisations and policymakers with academic partners around the issue of sustainable land use (www.coupled-itn.eu). While there is nothing wrong with this, Barry and Born (2013, see also the authors they cite in support of this argument) caution that an exclusive focus on these two logics invariably results in a situation where science loses some of its autonomy, and potentially has to adjust its aims according to funding bodies that are increasingly oriented towards innovative research that is applicable to the public and private sectors. The risk is that interdisciplinary collaboration arises "primarily in response to wider social and economic demands" rather than as a result of a need to actually develop new knowledge about a research object (Barry and Born 2013, 17). This is something we should be aware of as we push telecoupling research forward.

Interestingly, Barry and Born (2013) note that "what is striking across a range of interdisciplinary fields today is how they are understood to be governed not only by a logic of accountability and innovation but [also by] an ontological logic" (p. 17). Socio-political and economic demands are not the major drive behind this third logic. Nor is being "of service," but rather, it is driven by a desire and a need to engage with the world in radically new ways. In human-environment research, this is of immediate relevance as any efforts to foster sustainability needs to address environmental, social and economic dimensions of human-environment systems symmetrically. Telecoupled dynamics, in addition, foreground the increasingly diverse and multi-scalar sets of drivers that underpin plural engagements with particular sites. Four major scientific positions of relevance for telecoupling research characterise this logic. First, research driven by an ontological logic takes as a given that knowledge practices intervene in the world and thereby bring research subjects and objects into relational existence. This means, for example, that the manner in which a research object, for example a specific land-use change, is framed, problematised and analysed contributes to the production of the research object. Second, the logic of ontology is found in the interdisciplinary practices that are concerned with the creation of hybrid or relational objects that "cannot be broken down into distinct natural, technical and social components" (Barry and Born 2013, 19). Land use represents such a relational research object. It cannot be distilled into distinct natural or social components and, as emphasised by Barry and Born (2013), it is exactly this hybridity that spurs interdisciplinary interest in the first place. Third, it addresses the division between reality as conceived by science and reality as experienced by humans—meaning that we need to attend to the "aesthetics, affective or social qualities of events as well as their physical or biological dynamics" (Barry and Born 2013, 20) in order, for example, to grasp what "land" is. Fourth, and lastly, this logic emphasises how the involvement of non-scientists, citizens or lay publics may not only revolve around fostering accountability but also help "enlarge and enrich what must be taken into account" (Barry and Born 2013, 20) and thus what constitutes the problem of a given land-use change that is influenced by distal processes and telecoupling.

Barry and Born (2013) note that, for research facilitated by an agonistic-antagonistic mode of interdisciplinarity, there is almost invariably a privileged relation to the logic of ontology because the contestations and arguments around a common research object aim to change respective knowledge positions and facilitate new understandings of the object. As the telecoupling framework might already be fostering such agonistic-antagonistic interdisciplinary exchanges, it is worth reflecting upon the particular logics driving different parts of telecoupling research, as well as their potential consequences for how and what we study and the results we produce. In interdisciplinary projects that focus on addressing complex issues such as social-ecological interactions, we need to be aware of these modes and logics and how they shape ways of working as well as knowledge outcomes (Fischer et al. 2015; Moran and Lopez 2016).

3 Discussion: Telecoupling as a Mode and Logic of Interdisciplinarity

Telecoupling is only just emerging as a framework for analysing globalised land-use change. As such, it is too early to fully evaluate whether telecoupling research as an interdisciplinary practice will manage to set up and develop new ways of systematically exploring cross-scale relations, complex causation, bridge place-based research with network and flow perspectives, as well as capture how the intertwinement of nature and society manifests in land-use changes. Indeed, fundamental questions about what telecoupling research is and how it will develop as an interdisciplinary endeavour are currently being asked, as illustrated in the present work and recent papers (e.g. Eakin et al. 2014; Friis and Nielsen 2017a, b; Niewöhner et al. 2016b). In this sense, telecoupling is very much a "framework in the making," in which several interdisciplinary tracks are being pursued. It defines a space and terms of engagement rather than attempting to characterise a particular stance.

The distinction between different modes and logics of interdisciplinarity as presented by Barry and Born (2013) is helpful for disentangling *how* as well as *why* different approaches to interdisciplinarity arise and (co-)exist. Substantial focus has so far been given to the telecoupling framework's potential for the scientific integration of processes, perspectives and methods (Liu et al. 2013). As such, much effort has gone into developing its potential for facilitating an *integration-synthesis* mode of interdisciplinarity and for "operationalising" it through mixed-method approaches including both qualitative and quantitative approaches (see Chaps. 7, 10, 13 and 16).

In this chapter, we have explored how telecoupling might productively (remain) open up for an additional interdisciplinary path. That is, if it is committed to and engages in critical reflection on the core components and assumptions of the framework, telecoupling research also invites an agonistic-antagonistic mode of interdisciplinarity. More concretely, early conceptual, methodological and empirical work around the framework has initiated discussions of key elements of telecoupling that have led to insights not reducible to either the social or natural sciences engaged within it (e.g. Friis and Nielsen 2017a, b; Friis et al. 2016; Niewöhner et al. 2016a; Eakin et al. 2014). The example of scale discussed above highlights this and shows how telecoupling research accommodates a position where scale is understood as both geographically real and socially constructed. Similarly, recent work has explored how to approach systems as both epistemological constructs and empirically founded (e.g. Friis and Nielsen 2017b). This discussion allows critical reflection on how we delimit, define, describe and use sending, receiving and spillover systems in telecoupling analysis (see Chap. 3). Another related discussion enabled by the agonistic-antagonistic mode of exchange concerns distance. While the prefix "tele" in telecoupling implicitly invokes a sense of geographical and spatial distance between the systems that are interacting to produce a connection, telecoupling research also incorporates an understanding of space whereby distance is also measured in institutional, cultural and political terms (Eakin et al. 2014). Various actors creating a telecoupling might, for example, be distant in terms of institutional settings yet physically close, or vice versa (Niewöhner et al. 2016b). In telecoupling research, distance is, like scale and systems, neither reducible to a social or natural science definition, nor is a "spurious unity" or consensus sought. By focusing on identifying and discussing key shared boundary objects with interpretive flexibility in terms of scale, system and distance, research around telecoupling can allow for *agonistic-antagonistic* contestations that might lead to new research questions and research objects and ultimately result in a better understanding of global land use.

Moreover, the explicit focus within telecoupling research and land system science on developing interventions towards more sustainable land use have led to an acute awareness of the fact that decisions concerning land use are embedded in political, financial, scientific and discursive (global) power relations and flows that need to be understood. This has fostered calls (Eakin et al. 2014; Friis et al. 2016) and research designs (e.g. www.coupled-itn.eu) that are attentive to critical social science including critical and economic geography and political ecology insights on justice, power and social complexity. By being open to and inviting such perspectives however, the current embedding of the telecoupling framework in land system science and coupled human-environment systems literature with its general post-positivist position on knowledge production is challenged by the more constructivist approaches found in the critical social sciences (see also Chap. 3). This is likely to result in further *agonistic-antagonistic* interdisciplinary exchanges around the direction and position of telecoupling research. The work of Friis and Nielsen (2017a, b) and Niewöhner et al. (2016a, b), as well as this book, illustrate how these debates are already unfolding.

The productive interdisciplinary momentum that we believe characterises telecoupling research is supported by loud calls by scientists and from politicians and institutions concerned with global social and environmental problems for inclusive and innovative interdisciplinary frameworks (e.g. Fischer et al. 2015; Kramer et al. 2017; Moran and Lopez 2016; www.glp.earth). Responding to a global research agenda obviously supports the framework, yet also positions and potentially drives the research in specific directions. As we advance telecoupling research, we need to be aware of this and critically discuss not only *how to* do interdisciplinary research but also *why* and *for* whom we do it. We believe that Barry and Born's (2013) description of different logics of interdisciplinarity can help researchers who are engaged with understanding telecoupled land-use change critically reflect upon their research practices and its consequences. In particular, we need to make sure that, in the race for funding and political, economic and social legitimacy, we are not caught up in an interdisciplinary endeavour that strives towards the delivery of innovations and solutions that are only useful to economic and political interests. Clearly this is important, but if telecoupling research aims to push for more sustainable land use (see Chaps. 9, 11, 17 and 19), we should seriously consider how we not only deliver solutions to policy-makers and industry, but also how we provide challenging suggestions that question the institutional, political and economic status quo. While the chapters in this book to a large extent demonstrate that telecoupling can encompass all three logics described by Barry and Born (2013), the large challenge of how to balance the three logics remains. Interdisciplinary telecoupling research is currently located at the border between applied and pure research domains, dependent upon third-party funding, driven by a problem-solving agenda and concerned with sustainability and the trade-offs between various demands, agendas and actors claiming interest in land use. Thus, this research is likely to be advanced predominantly by a logic of accountability and of innovation. Yet, pursuing research through an agonistic-antagonistic mode of interdisciplinarity driven by a *logic of ontology*, as we have tried to illustrate in this chapter, has perhaps the larger potential to foster truly novel understandings of key research objects vital for tackling today's problems around land use and (un) sustainability.

4 Conclusion

Telecouplings represent a fundamental challenge to explanations of land-use change that requires an interdisciplinary practice or mode that can accommodate and facilitate new ways of thinking and conducting research. For telecoupling research to succeed in its interdisciplinary ambition, there is a need for a more systematic and conscious recognition of the limits of specific research approaches and disciplines, be it network-science, flow-analysis or ethnographic modes of fieldwork. As well as knowledge of how to go about working together across such divides, in this chapter we have argued that an *agonistic-antagonistic* mode of interdisciplinarity driven by a *logic of ontology* is rewarding. We have highlighted that discussions around scale, distance and systems indicate that the framework is already to some extent engaging in this type of interdisciplinary work. However, advancement in this respect also depends on the adoption of a critically reflexive approach to science production that acknowledges the manner in which scientific knowledge and practices intervene in the world. This research foregrounds the need to engage more consequentially in a combination of different modes and logics of interdisciplinarity and emphasises joint problematisation, understanding and problem solving. Telecoupling research should not only be regarded as a response to those who call for a more integrated scientific agenda to meet the challenges of the Anthropocene, but should also be seen as a research domain that holds the potential to actively shape this agenda and develop formats that can appropriately address it.

Acknowledgement This work has received support from the European Union's Horizon 2020 research and innovation programme under Marie Skłodowska-Curie grant agreement No. 765408 (COUPLED, www.coupled-itn.eu). This work contributes to the Global Land Programme (www.glp.earth).

References

Abson, David J., Joern Fischer, Julia Leventon, Jens Newig, Thomas Schomerus, Ulli Vilsmaier, and Henrik von Wehrden. 2017. Leverage Points for Sustainability Transformation. *Ambio* 46 (1): 30–39. https://doi.org/10.1007/s13280-016-0800-y.

Barry, Andrew, and Georgina Born, eds. 2013. *Interdisciplinarity. Reconfigurations of the Social and Natural Sciences*. London: Routledge.

Brondizio, Eduardo S., Karen O'Brien, Xuemei Bai, Frank Biermann, Will Steffen, Frans Berkhout, Chrisopher Cudennec, et al. 2016. Re-Conceptualizing the Anthropocene: A Call for Collaboration. *Global Environmental Change* 39: 318–327. https://doi.org/10.1016/j.gloenvcha.2016.02.006.

De Castro, Eduardo V. 2015. *The Relative Native. Essays on Indigenous Conceptual Worlds*. Chicago: Hau Books.

Eakin, Hallie, Ruth DeFries, Suzi Kerr, Eric F. Lambin, Jianguo Liu, Peter J. Marcotullio, Peter Messerli, et al. 2014. Significance of Telecoupling for Exploration Of Land-Use Change. In *Rethinking Global Land Use in an Urban Era*, ed. Karen C. Seto and Anette Reenberg, 141–163. Cambridge, MA: The MIT Press.

Fischer, Joern, Toby A. Gardner, Elena M. Bennett, Patricia Balvanera, Reinette Biggs, Stephen Carpenter, Tim Daw CarlFolke, Rosemary Hill, Terry P. Hughes, Tobias Luthe, Manuel Maass, Megan Meacham, Albert

V. Norström, Garry Peterson, Cibele Queiroz, Ralf Seppelt, Marja Spierenburg, and John Tenhunen. 2015. Advancing Sustainability through Mainstreaming a Social-Ecological Systems Perspective. *Environmental Sustainability* 14: 144–149. https://doi.org/10.1016/j.cosust.2015.06.002.

Friis, Cecilie, and Jonas Ø. Nielsen. 2017a. On the System. Boundary Choices, Implications and Solutions in Telecoupling Land Use Change Research. *Sustainability* 9 (6): 974. https://doi.org/10.3390/su9060974.

———. 2017b. Land Use Change in a Telecoupled World: The Relevance and Applicability of the Telecoupling Framework in the Case of Banana Plantation Expansion in Laos. *Ecology and Society* 22 (4): 30. https://doi.org/10.5751/ES-09480-220430.

Friis, Cecilie, Jonas Ø. Nielsen, Iago Otero, Helmut Haberl, Jörg Niewöhner, and Patrick Hostert. 2016. From Teleconnection to Telecoupling: Taking Stock of an Emerging Framework in Land System Science. *Journal of Land Use Science* 11 (2): 131–153. https://doi.org/10.1080/1747423X.2015.1096423.

Kramer, Daniel B., Joel Hatter, Angela E. Boag, Meha Jain, Kara Stevens, Kimberly A. Nicholas, William J. McConnell, and Jianguo Liu. 2017. Top 40 Questions in Coupled Human and Natural Systems (CHANS) Research. *Ecology and Society* 22 (2): 44. https://doi.org/10.5751/ES-09429-220244.

Liu, Jianguo, Vannessa Hull, Mateus Batistella, Ruth DeFries, Thomas Dietz, F. Feng, Thomas W. Hertel, R. Cesar Izaurralde, Eric F. Lambin, Shuxin Li, Luiz A. Martinelli, William J. McConnell, Emilio F. Moran, Rosamond Naylor, Zhiyun Ouyang, Karen R. Polenske, Anette Reenberg, Gilberto de Miranda Rocha, Cynthia S. Simmons, Peter H. Verburg, Peter M. Vitousek, Fusuo Zhang, and Chunquan Zhu. 2013. Framing Sustainability in a Telecoupled World. *Ecology and Society* 18 (2): 26. https://doi.org/10.5751/ES-05873-180226.

Lövbrand, Eva, Silke Beck, Jason Chilvers, Tim Forsyth, Johan Hedrén, Mike Hulme, Rolf Lidskog, and Eleftheria Vasileiadou. 2015. Who Speaks for the Future of Earth? How Critical Social Science Can Extend the Conversation on the Anthropocene. *Global Environmental Change* 32: 211–218. https://doi.org/10.1016/j.gloenvcha.2015.03.012.

Magliocca, Nicholas R., Erle C. Ellis, Ginger R.H. Allington, Ariane de Bremond, Jampel Dell'Angelo, Ole Mertz, Peter Messerli, Patrick Meyfroidt, Ralf Seppelt, and Peter H. Verburg. 2018. Closing Global Knowledge Gaps: Producing Generalized Knowledge from Case Studies of Social-Ecological Systems. *Global Environmental Change* 50: 1–14. https://doi.org/10.1016/j.gloenvcha.2018.03.003.

Magliocca, Nicholas R., Thomas K. Rudel, Peter H. Verburg, William J. McConnell, Ole Mertz, Katharina Gerstner, Andreas Heinimann, and Erle C. Ellis. 2015. Synthesis in Land Change Science: Methodological Patterns, Challenges, and Guidelines. *Regional Environmental Change* 15 (2): 211–226. https://doi.org/10.1007/s10113-014-0626-8.

Moran, Emilio F., and Maria C. Lopez. 2016. Future Directions in Human-Environment Research. *Environmental Research* 144: 1–7. https://doi.org/10.1016/j.envres.2015.09.019.

Nelson, Gerald C., Elena Bennett, Asmeret A. Berhe, Kenneth Cassman, Ruth DeFries, Thomas Dietz, Achim Dobermann, Andrew Dobson, Anthony Janetos, Marc Levy, Diana Marco, Nebojsa Nakicenovic, Brian O'Neill, Richard Norgaard, Gerhard Petschel-Held, Dennis Ojima, Prabhu Pingali, Robert Watson, and Monika Zurek. 2006. Anthropogenic Drivers of Ecosystem Change: An Overview. *Ecology and Society* 11 (2): 29. http://www.ecologyandsociety.org/vol11/iss2/art29/.

Niewöhner, Jörg, Antje Bruns, Helmut Haberl, Patrick Hostert, Tobias Krueger, Christian Lauk, Julian Lutz, Daniel Müller, and Jonas Ø. Nielsen. 2016a. Land Use Competition. Ecological, Economic and Social Perspectives. In *Land Use Competition. Ecological, Economic and Social Perspectives*, ed. Jörg Niewöhner, Antje Bruns, Patrick Hostert, Tobias Krueger, Jonas Ø. Nielsen, Helmut Haberl, Christian Lauk, Julian Lutz, and Daniel Müller, 1–17. Cham: Springer.

Niewöhner, Jörg, Jonas Ø. Nielsen, Ignacio Gasparri, Yaqing Gou, Mads Hauge, Neha Joshi, Anke Schaffartzik, Frank Sejersen, Karen C. Seto, and Chris Shughrue. 2016b. Conceptualizing Distal Drivers in Land Use Competition. In *Land Use Competition. Ecological, Economic and Social Perspectives*, ed. Jörg Niewöhner, Antje Bruns, Patrick Hostert, Tobias Krueger, Jonas Ø. Nielsen, Helmut Haberl, Christian Lauk, Julian Lutz, and Daniel Müller, 21–40. Cham: Springer.

Roy, Eric D., Anita T. Morzillo, Francisco Seijo, Sheila M.W. Reddy, Jeanine Rhemtulla, Jeffrey C. Milder, Tobias Kuemmerle, and Sherry L. Martin. 2013. The Elusive Pursuit of Interdisciplinarity at the Human-Environment Interface. *BioScience* 63 (9): 745–753. https://doi.org/10.1525/bio.2013.63.9.10.

Star, S.L. 2010. This Is Not a Boundary Object: Reflections on the Origin of a Concept. *Science, Technology, and Human Values* 35 (5): 601–617. https://doi.org/10.1177/0162243910377624.

Star, Susan L., and James Griesemer. 1989. Institutional Ecology. 'Translation' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of

Vertebrate Zoology, 1907–39. *Social Studies of Science* 19 (3): 387–420. https://doi.org/10.1177/030631289019003001.
Tsing, Anna L. 2005. *Friction: An Ethnography of Global Connection*. Princeton, NJ: Princeton University Press.
Turner, Billy L., II, Eric F. Lambin, and Anette Reenberg. 2007. The Emergence of Land Change Science for Global Environmental Change and Sustainability. *Proceeding of the Nation Academy of the Sciences* 104 (52): 20666–20671. https://doi.org/10.1073/pnas.0704119104.
Van Vliet, Jasper, Nicholas R. Magliocca, Bianka Büchner, Elizabeth Cook, José M. Rey Benayas, Erle C. Ellis, Andreas Heinimann, Eric Keys, Tien Mieng Lee, Jianguo Liu, Ole Mertz, Patrick Meyfroidt, Mark Moritz, Christopher Poeplau, Brian Robinson, Ralf Sepplelt, Karen Seto, and Peter H. Verburg. 2016. Meta-studies in Land Use Science: Current Coverage and Prospects. *Ambio* 45 (1): 15–28. https://doi.org/10.1007/s13280-015-0699-8.
Verburg, Peter H., Neville Crossman, Erle Ellies, Andreas Heinimann, Patrick Hostert, Ole Mertz, Harini Negendra, Thomas Sikor, Karl-Heinz Erb, Nancy Golubiewski, Ricardo Grau, Morgan Grove, Souleymane Konote, Patrick Meyfroidt, Dawn Parker, Rinky Roy Chowdhury, Hideaki Shibata, Alison Thomson, and Lin Zhen. 2015. Land System Science and Sustainable Development of the Earth System: A Global Land Project Perspective. *Anthropocene* 12: 29–41. https://doi.org/10.1016/j.ancene.2015.09.004.
Verburg, Peter H., John A. Dearing, James G. Dyke, Sander van der Leeuw, Sybil Seitzinger, Will Steffen, and James Syvitski. 2016. Methods and Approaches to Modelling the Anthropocene. *Global Environmental Change* 39: 328–340. https://doi.org/10.1016/j.gloenvcha.2015.08.007.

19

Co-producing Knowledge for Sustainable Development in Telecoupled Land Systems

Julie G. Zaehringer, Flurina Schneider, Andreas Heinimann, and Peter Messerli

1 Introduction

Land—with its multiple functions that provide benefits to humans and enable millions of other species to thrive—is at the heart of global sustainable development challenges and the United Nations' 2030 Agenda (Sachs 2017). With a growing world population and declining natural resources, we are facing a tremendous challenge to reconcile human demands for productive functions of land with the maintenance of biodiversity and many regulating and cultural ecosystem services (Raworth 2017). This challenge is further augmented by the fact that different actors at different scales may simultaneously prioritise different functions and benefits of the same land or, in other words, have different and potentially competing claims on land. The way land is used and managed

J. G. Zaehringer (✉) • F. Schneider • A. Heinimann • P. Messerli
Centre for Development and Environment (CDE),
University of Bern, Bern, Switzerland
e-mail: julie.zaehringer@cde.unibe.ch; flurina.schneider@cde.unibe.ch;
andreas.heinimann@cde.unibe.ch; peter.messerli@cde.unibe.ch

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2_19

locally will eventually determine which of these functions can be provided at the same time, leading to co-benefits if uses are compatible or to trade-offs if they are mutually exclusive. However, local land users are becoming increasingly connected to various actors in distant locations.

In this complex setting, how can we progress towards reconciliation between local and distant actors' demands? Land-use change is happening at such a rapid pace that we cannot rely on incremental change. We need transformative change based on scientific evidence and social deliberation. Land system science is at the forefront of finding solutions by producing knowledge on and for sustainable development in telecoupled land systems. Tackling the telecoupling challenge from a sustainable development perspective requires that we explore how methodological innovations and creative ways of fostering fair and equitable actor negotiations can support transformation. Transdisciplinary research approaches aim at co-production of knowledge with a wide range of academic and non-academic partners. They help to maximise the relevance of findings for different actors and the contribution of research to sustainable development.

In 2015, the 193 member states of the United Nations agreed on a globally negotiated normative framework, the 2030 Agenda for Sustainable Development, which can be considered a compass to guide global development efforts for the coming years (United Nations 2015). The 17 sustainable development goals (SDGs) and 169 targets defined in the 2030 Agenda encompass key dimensions of human well-being and ecosystem stewardship. Importantly, many of these SDGs are directly or indirectly linked to land and its use. In light of the challenges sketched out above, the SDGs can hence be seen as a set of claims on land made by the global community. Acknowledgement in the 2030 Agenda that the 17 SDGs are indivisible and universal has important implications for their implementation. For the use of land in an increasingly hyperconnected world, it means that different claims on land are inextricably linked across sectors, places, and scales. Just as a given claim may lead to unintended trade-offs in another sector in a distant place, the solution to a land-use problem may arise from activities in another sector at a different scale. This creates new challenges and opportunities for the sustainable use of land—which needs to be contextualised for specific places together with local actors and at the same time should add up to global solutions.

Taking a sustainability perspective, and hence an explicitly normative perspective, land system science acknowledges that each change in land use inevitably leads to co-benefits and trade-offs among different claims on land. Accordingly, land system science also addresses the question of who wins and who loses as a result of these co-benefits and trade-offs. At the same time, by considering land-use change not only as a consequence but also as a solution to global change problems, land system science is committed to guiding land-use change towards more sustainable outcomes (Global Land Programme 2016). Land system science is hence excellently placed to respond to the unique opportunity provided by the 2030 Agenda and produce much-needed scientific evidence that can help in charting pathways towards sustainable development in a rapidly changing world. Yet, as land system scientists striving to contribute to the Agenda's implementation, we are faced with two pressing questions: What knowledge and knowledge production processes can support sustainable development? And, in producing this knowledge, how do we account for the ever-increasing connections and feedbacks between distant places (i.e. telecoupling)?

In this chapter, we aim to conceptualise land system science as a research field that emerges at the intersection between the study of land systems, sustainable development, telecoupling, and knowledge production (see Fig. 19.1). The chapter begins with (1) a brief review of the intrinsic linkages between land systems and sustainable development, for which we draw on the ecosystem services framework. Next, we discuss (2) how telecoupling challenges these linkages. We conclude by reflecting on (3) what knowledge is relevant for sustainable development of telecoupled land systems, and how it can be produced.

To illustrate our arguments, we reflect on a case study from Madagascar based on ongoing fieldwork in a research project on "Managing telecoupled landscapes" (Messerli et al. 2014). Madagascar provides a fitting example of the challenges associated with sustainable development of telecoupled land systems and the resulting need for transdisciplinary research. The island's very remote north-eastern escarpment hosts some of the world's most biodiversity-rich forests (Fig. 19.2) and is therefore a global

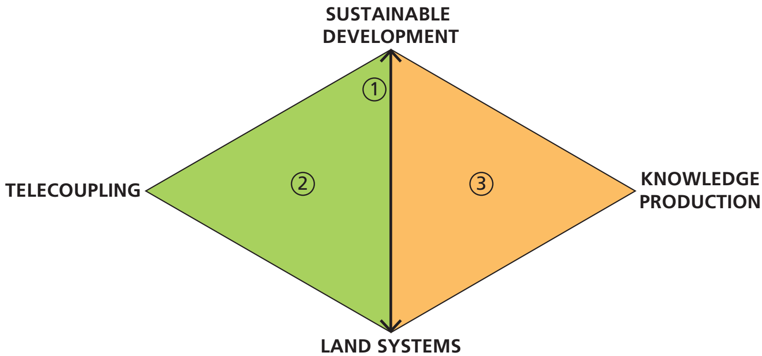


Fig. 19.1 The main topics of this chapter revolve around the important interfaces between land systems, sustainable development, telecoupling, and knowledge production and include (1) the challenge of achieving sustainable development of land systems, (2) the complexity added by the increasing telecoupling of systems, and (3) the ways of producing relevant knowledge for sustainable development

Fig. 19.2 This typical hill rice field in north-eastern Madagascar is part of a shifting cultivation system directly bordering a remaining fragment of old-growth forest (Photo: Julie G. Zaehringer)

conservation priority (Myers et al. 2000). In light of growing threats to global common goods like biodiversity and carbon sequestration, conservation actors succeeded in establishing protected areas, thus fulfilling their goal of preserving forested land. The establishment of Masoala National Park and Makira Natural Park in 1997 and 2012, respectively, led to the closure of large tracts of agricultural frontier, causing many local land users to lose current and future access to agricultural land.

Besides engaging in shifting cultivation to produce rice for their own subsistence, local land users are closely linked to international markets through the cultivation of high-value cash crops—foremost cloves and vanilla—and through mining of quartz crystals. The cash crops are going through typical boom-and-bust cycles that make land users' earnings unreliable and investments risky (Zhu 2018); at the time of writing, in fall 2018, vanilla prices have reached an all-time high. In addition, the region is highly prone to tropical cyclones, which have repeatedly destroyed land users' harvests and settlements over the past decades. Overall, people in this region face manifold challenges of sustainable development, of which the trade-off between forest conservation and agricultural development is probably the most pressing (Zaehringer et al. 2018).

2 Sustainable Development of Land Systems

2.1 Land as a Social-Ecological System

Land systems are generally understood as social-ecological systems (Reenberg 2009; Turner et al. 2007; Verburg et al. 2013) that are connected to other social-ecological systems and governed by multiple actors and institutions (Graham et al. 2003). In this chapter, we use the term institutions to refer to *agreed rules of the game*—be they formal or informal. Land use is at the centre of any terrestrial social-ecological system. To capture interactions between the social and the ecological spheres of a social-ecological system, we can draw on the key concept of ecosystem services (Daily 1997; Costanza et al. 1997). In its most basic form, this concept connects biophysical structures and processes to benefits and people's values (Haines-Young and Potschin 2010). As proposed by Fisher et al. (2009, 645), "ecosystem services are the aspects of ecosystems utilised (actively or passively) to produce human well-being". This means that ecosystem services only exist if there is a human beneficiary who values them. The concept of ecosystem services thus offers a useful lens for looking at different actors' claims on land and making them explicit. Each type of land use provides a specific bundle of ecosystem services (Raudsepp-Hearne et al. 2010a), connecting natural resources to multiple actors' benefits and their different underlying values and claims. A change in land use hence implies a reshuffle of the various bundles of ecosystem services. Following the above differentiation between ecosystem services and their human beneficiaries, a change in land use alters not only the ecosystem services provided by land resources, but also the benefits people derive from them and, hence, the satisfaction of people's values. These values may be expressed as goals. Accordingly, the SDGs can be understood as embodying the codified values of the countries who endorsed the 2030 Agenda; and vice versa, land use is an expression of how we are implementing the 2030 Agenda. However, the values people attach to land may change over time, for example, because people in many places are becoming less dependent on land for their livelihoods (Raudsepp-Hearne et al. 2010b). Land-use change reshuffles not only ecosystem services, but also who wins and who loses from the use of a specific piece of land. Land-use change will therefore always lead to trade-offs, and trade-offs need to be negotiated among the different actors concerned. The left part of Fig. 19.3 (A) illustrates different actors' competing claims on land and resulting ecosystem service trade-offs in a local social-ecological system, such as the one in north-eastern Madagascar.

In north-eastern Madagascar, land systems encompass different combinations of a highly diverse set of land uses, ranging from cultivated hill rice plots and surrounding herbaceous and tree fallows forming highly adapted shifting cultivation systems to irrigated paddy rice fields, agroforestry plots for cash crop production, zebu cattle pastures, and forest fragments (Zaehringer et al. 2017). Land tenure in Madagascar is characterised by a pluralistic legal system. Most rural land in our remote case study region is managed under a customary system that recognises land as "land of the ancestors" (*tanindrazana* in Malagasy) (Keller 2015, 154). In the case of forest, this often conflicts with the national government's treatment of forested land as state property, as well as with international

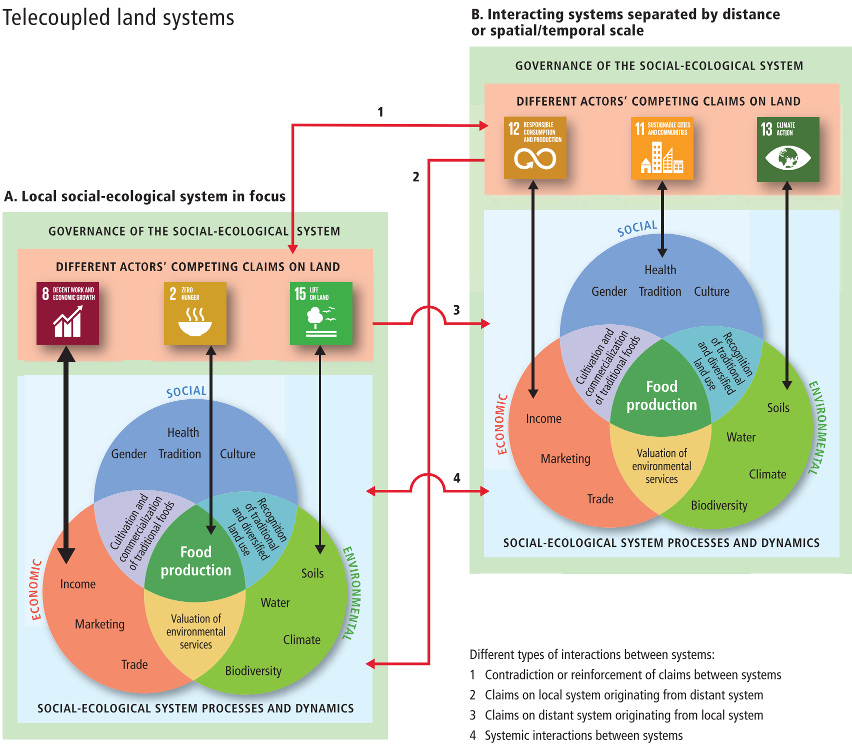


Fig. 19.3 Different actors' competing claims on land and systemic interactions within and between telecoupled land systems (based on IAASTD 2009)

conservation actors' perception of biodiversity-rich tropical forests as a global good. The same land use may be valued differently by different actors, and different actors will prioritise different ecosystem services based on the values they attach to them. A forest fragment, for example, might be valued by a local land user for providing timber, firewood, and an ancestral burial ground, whereas a cash crop trader might value it for its contribution to a favourable microclimate for clove production, and a conservation non-governmental organisation (NGO) for its importance in providing a habitat for a rare bird species. If, for example, the conservation NGO restricts access to this forest fragment and local land users are forbidden from extracting timber, this leads to a trade-off between different benefits from the ecosystem services that the forest fragment provides. In recent years, many shifting cultivation fallows in our case study area were converted into vanilla plantations. On the one hand, this reduced the availability of non-timber forest products and firewood as well as the cultivation of rice—the main staple food crop in the area. On the other hand, it substantially increased the financial resources available to those land users who had sufficient land and resources to implement this land-use change. The increased availability of money caused some land users' values to shift away from the main goal of producing enough rice for subsistence towards the goal of investing in a wooden house in the city or in solar panels for use in the village. The more marginalised land users, however, lost out, as the decrease in subsistence rice production and the increased availability of money in the local social-ecological system led to a general increase in the costs of living.

How can we define sustainable development of land systems, taking into account the fact that land-use change always entails trade-offs in terms of ecosystem service provision related to different actors' claims on land? Different claims on land often arise from actors' differing valuations of individual SDGs: While some actors most value production of staple food, a precondition for achieving SDG2 (zero hunger), others might prioritise biodiversity conservation, which is crucial to achieving SDG15 (life on land). It is thus impossible to satisfy the full range of sustainability requirements and values that actors attach to land resources. Indeed, trade-offs between the different SDGs are inherent in the 2030 Agenda. These trade-offs require detailed characterisation in specific local contexts (Nilsson et al. 2016). Accordingly, sustainable land use does not imply the absence of conflict between different actors or complete harmony between nature and people. Rather, it refers to a process of decision-making that is guided by equity and fairness and informed by evidence. In order to orient land system science towards sustainability, we must do the following:

- Ensure that we leave no one behind—by identifying marginalised actors and empowering them to participate in negotiations over land use and ecosystem services.
- Explicitly take into account those sustainability dimensions that tend not to have a voice, such as future generations or the intrinsic values of nature.

- Improve governance of land resources and their productive potentials so as to maximise co-benefits and mitigate trade-offs based on equitable and inclusive negotiations and agreements among different actors.

From this perspective, the 2030 Agenda presents a sustainability vision that serves as an overarching guide for development, but may never be fully attained. Sustainable development is a process that aims at approximating this vision by aligning the systemic potentials of the Earth system with the claims of different actors in a transparent and equitable way (Schneider et al., under review).

2.2 Systemic and Power Perspectives of Research

Our understanding of the 2030 Agenda as a shared global vision for sustainable development and the Agenda's strong dependency on land has important implications for land system science. If we want land system science to make relevant contributions to achieving the SDGs, we need to produce knowledge that better supports the identification of co-benefits while helping to navigate trade-offs among changing land uses. Such knowledge must be developed from both a systemic and a power perspective. Although the two perspectives overlap to some degree, they provide different entry points into knowledge production for sustainable development of land systems—and both are key.

The systemic perspective: On the one hand, we need to gain an in-depth systemic understanding of how, in a given social-ecological system, land use translates into bundles of ecosystem services and how ecosystem services are arranged spatially within the wider landscape. This requires, first, an assessment of ecological functions and their potentials and limitations with regard to ecosystem services provisioning; second, a stakeholder analysis identifying different actors' demands for various ecosystem services; and, third, an investigation of land governance looking at actors' networks, their interactions in terms of goods, money, information, and other flows, as well as the institutions they share or do not share. Combining these aspects, we can then assess whether the bundles of ecosystem services provided by a specific land use or the wider landscape satisfy different actors' claims, and who these actors collaborate with to further their interests. For example, shifting cultivation fallows in north-eastern Madagascar have the function of restoring soil nutrients (e.g. nitrate and phosphorus) required for rice production—a function that is highly important when chemical fertilisers are not an option (Brand and Pfund 1998). However, depending on how long a plot is left fallow and how many times it has been cultivated before that (and many other factors), the level of soil nutrients might not recover sufficiently to support a plentiful rice yield for the land user. Furthermore, a conservation actor might support land users in planting clove trees and vanilla vines in their fallows, with the aim of transforming the overall land system from shifting cultivation for subsistence rice production—which is perceived as detrimental to forest protection in the long term—into a permanent commercial farming system. Land users might do exactly this, establishing links to cash crop exporters through a network of intermediaries and collectors. However, encouraged by the increase in production and income, they might subsequently seek to expand their permanent plantations into forested areas. Local land users often ignore institutions supporting forest protection and carbon storage schemes, such as REDD+, because, in their view, these institutions—which were introduced by external actors—lead to access restrictions without offering benefits.

The power perspective: On the other hand, to foster fair and transparent negotiation and planning of land systems, we must begin by asking who has the power to shape the future of land use. This means that we need to understand different actors' visions of sustainable development and the power they have to defend their interests. This will enable us to unravel who ultimately decides on what is sustainable or unsustainable. Explicit inclusion of such a power perspective is essential if land system science is to live up to its commitment to sustainability. However, many land system scientists are unsure or uneasy about addressing the power perspective and tend to omit this dimension. For this reason, in the following sections we aim to highlight the concepts and methods available in land system science to support such indispensable analyses of who shapes and prescribes land futures.

Different actors hold different degrees of power to pursue their specific claims on land (Eakin et al. 2014; Fischer et al. 2016). We understand power as the capacity or ability to direct or influence the behaviour of others in the context of land governance (Berbés-Blázquez et al. 2016). Actors' power is largely determined by their agency (Wiesmann et al. 2011). Land system scientists understand agency as actors' capacity to play an independent role in matters of land use, based on the means they have and the meanings they attribute to their actions (Eakin et al. 2014; Seto and Reenberg 2014). Actors' agency thus determines the range of options they have. Accordingly, we argue that assessment of a land system from a power perspective requires analysis of the different actors' agency and of influencing factors such as the social networks they are embedded in and the institutions that regulate their activities. Based on this knowledge, we can then identify actors who have the power to guide land-use change towards more sustainable trajectories, or actors who are marginalised and face difficulties in making their voices heard. In north-eastern Madagascar, we can observe huge power differentials between NGOs, government agencies, commercial actors, and local land users, on the one hand, and between different local land users, on the other hand. For example, at the height of illegal rosewood extraction during the political crisis between 2009 and 2013, Chinese businesspeople used their financial power to pay hundreds of local land users to enter the forest and fell rosewood trees, for direct export to China (Zhu 2017). At the same time, other local land users were arrested for extracting timber from their agricultural plots, which they considered their ancestral land—because these plots had come to lie inside the buffer zone of Masoala National Park, which is managed with funding from international conservation and development agencies and multilateral organisations (Boillat et al. 2018). This illustrates that we need to be aware of power differentials between actors linked to different land systems in order to devise strategies for guiding these systems towards more sustainable development pathways.

Historically, research, and even more so planning and implementation, have focused more on the systemic perspective. This focus manifested itself in research and implementation approaches surrounding ecosystem, land, or watershed management (e.g. Grumbine 1994; Heathcote 2009), which largely ignored related actors, their interests, and their power to decide on the future development of the land and water systems concerned (Ferreyra et al. 2008). Later, the focus has shifted to finding political solutions that take into account questions of power and access (e.g. Ribot and Peluso 2003), including questions of land tenure and land rights. However, they often overlook systemic constraints and opportunities (e.g. the ecological potential of certain land uses to provide ecosystem services in the short and long term). We therefore believe that we must consider and combine the systemic and the power perspectives when producing knowledge on land systems. Only this combined perspective will enable us to reflect on opportunities to improve the overall benefit of land use in a socially fair and environmentally safe manner.

3 The Telecoupling Challenge

While considering these two analytical perspectives will be key in enabling land system science to tackle urgent sustainability challenges, we must acknowledge one overarching and sometimes overwhelming challenge: the increasing interconnectedness of social-ecological systems across distance, or the phenomenon of telecoupling (see Chaps. 2 and 3). So far, telecoupling studies have largely focused on flows of agricultural commodities and on land-use changes (e.g. Friis and Nielsen 2017; Gasparri et al. 2016; Baird and Fox 2015; Leisz et al. 2016; Zimmerer et al. 2018) and have mostly taken a systemic perspective. However, based on our understanding of sustainable development in land systems presented above, we suggest approaching the key features of telecoupling not only from a systemic, but also from a power perspective. As shown in Fig. 19.3, this implies consideration of analytically different types of interactions between systems separated by distance or scale. Furthermore, we also need to reflect on the implications telecoupling has for the delineation of spatiotemporal system boundaries, as this is crucial when it comes to adapting land governance.

3.1 Studying Telecoupling from a Systemic Perspective

When investigating telecoupled land systems from a systemic perspective, land system scientists mainly study flows of inputs like production capital or information entering a social-ecological system and flows of agricultural commodities and goods leaving that same social-ecological system towards others. These studies tend to focus on flows of single commodities and the social-ecological systems that initiate these flows or are affected by them (e.g. Silva et al. 2017; Torres et al. 2017; Garrett et al. 2013). However, the spillovers of such interactions onto other systems have not yet received sufficient attention (Liu et al. 2018). Another strand of land-focused systemic telecoupling studies places greater emphasis on local effects of distant decision-making (e.g. Baird and Fox 2015; Friis and Nielsen 2017; Zimmerer et al. 2018). In our own ongoing project, we are using social network analysis to investigate, based on the identified flows entering and leaving the social-ecological systems studied, actors related to these flows and their links to other actors.

In north-eastern Madagascar, financial flows enter the local social-ecological system via sales of cash crops or international support for management of the Makira and Masoala protected areas. Associated incoming information flows include information on cash crop prices and environmental education. In return, agricultural commodities such as vanilla pods or clove flower buds leave the system to meet the demand from various social-ecological systems around the globe. With respect to conservation activities, flows leaving Masoala National Park mostly consist in experiences that tourists take home with them after having visited the Park, while flows leaving Makira Natural Park are mostly made up of emissions from deforestation that are avoided thanks to the associated REDD+ project. However, important impacts on the local social-ecological system come from restrictions of access to forestland, which severely curtail local land users' livelihood opportunities.

3.2 Studying Telecoupling from a Power Perspective

Systemic analysis of a telecoupled social-ecological system lays the basis for investigating the same system from a power perspective. An assessment of the agency of individual and organisational actors including their aims and means can help to explain how some actors succeed in influencing others in order to enforce their own interests. Further, an analysis of institutions regulating the flows between telecoupled systems and actors' activities is needed to understand new power differentials that may have emerged as a result of telecoupling. As land system scientists, we need to find out in particular who dominates decision-making on land use, and whether telecoupling creates new dependencies. Dependencies on single value chains and external market demand can have a major impact on actors' options, especially when they involve irreversible conversions of land use.

In north-eastern Madagascar, the vanilla trade is controlled by a few very powerful private exporters, who seek to monopolise these highly valuable cash crop flows for their own profit and benefit. They may go as far as to try to undermine existing institutions, such as the government's authority to set the date of the official annual vanilla market. This regulation is aimed at preventing theft and premature harvesting and the associated loss of quality. Vanilla exporters operate through a network of local intermediaries. These establish long-term trust relations with individual small-scale farmers, who then sell their produce exclusively to the same person for many years. Since the sharp rise in global vanilla prices in 2016, many small-scale farmers have abandoned subsistence rice cultivation in favour of vanilla cultivation and have become highly dependent on the volatile market conditions. The risks associated with largely vanilla-based livelihoods are further exacerbated by the fact that the local vanilla market serves as a money laundering opportunity for some exporters who are also involved in illegal export of precious rosewood, which is in high demand in Chinese furniture markets (Zhu 2018). However, since vanilla plantations can theoretically be converted back into shifting cultivation systems for subsistence rice production at any time, local land users do not seem to be significantly reducing their future options.

3.3 Spatiotemporal System Boundaries

Telecoupled land systems present significant challenges for land governance due to the associated difficulty of delineating system boundaries. According to Graham et al. (2003), actors and institutions constitute the governance arena where decision-making takes place. Today, land governance is mostly organised along different territories and sectors. Territories are spatially explicit entities, such as a watershed or an administrative unit, whereas sectors group actors according to topics. This is often reflected in the organisation of government agencies (e.g. ministry of agriculture vs. ministry of the environment). In a telecoupled land system, however, the spatiotemporal system boundaries—which we can trace by taking a network approach and following the flows leading to different actors—are usually very different from the traditional land governance territories (Friis and Nielsen 2017; Lenschow et al. 2016). Considering that transformations to sustainable development depend on bringing together a systemic and a power perspective, this lack of congruence between flow-based spatiotemporal system boundaries, on the one hand, and territorially based land governance and its actors and institutions (especially at the national and subnational levels), on the other hand, is a source of misunderstanding and confusion that needs to be addressed. We agree with Eakin et al. (2017) that the key challenge is hence to conceptualise new spatiotemporal boundaries for more effective land governance by identifying those actors and institutions that influence local land systems along the detected flows.

Empirical results from our study region in north-eastern Madagascar indeed reveal major mismatches between social-ecological system boundaries and existing governance territories. We adopted a social network approach to map flows and actors linked to local land-use changes and found that incongruences between system boundaries and governance territories have in fact been a major obstacle to sustainable regional development. For example, regional government regulations are inadequate to govern the land-use change towards more vanilla production. Vanilla prices and their variability are a result of the (partly illegal) activities and interactions between actors along the value chain from the local to the international level. A move towards more sustainable land governance in this region requires measures to divert some of the financial flows generated by the vanilla trade into funds for sustainable regional development initiatives. This, in turn, can only be achieved if future policy interventions target the distant actors driving demand for valuable vanilla products.

4 What Knowledge Is Needed for Sustainable Development in Telecoupled Land Systems, and How Can We Produce It?

4.1 Different Dimensions of Knowledge

Understanding land-related sustainability issues in the context of telecoupling has important implications for knowledge production in land system science. The preceding sections have shown that to produce actionable knowledge—also referred to as "transformation knowledge"—for sustainable development, the common practice of producing "systems knowledge" should be broadened to include a power perspective and production of the so-called target knowledge (Proclim and CASS 1997, 15). Target knowledge is concerned with different actors' visions of a desired future, in our case of land systems (Schneider and Rist 2014). Importantly, the globally relevant values, goals, and targets expressed in the 2030 Agenda need to be contextualised in each local situation, considering local actors' interpretations and priorities. In our research project, we aimed to produce such target knowledge by contextualising the SDGs for land systems in north-eastern Madagascar. Together with national-level stakeholders from different sectors including academia, government, and NGOs, we carried out a participatory evaluation of the most important land-use changes in the country's forest frontier landscapes and their impact on the different SDGs. In addition, we conducted a survey among actors from different levels and sectors who are involved in local land-use changes to explore their visions regarding the development of these forest frontier landscapes in terms of their prioritisation of different SDGs. But even if we understand a system's opportunities and limitations and its actors' normative targets, we will still not know how to induce the systemic changes required to achieve those targets. A third dimension of knowledge is required to answer this question: so-called transformation knowledge (Proclim and CASS 1997, 15), which is concerned with strategies and pathways for implementation. Eventually, all three dimensions of knowledge need to be addressed in order to tackle the great societal transformation required to achieve sustainable development (Fazey et al.

2018). However, to date the pathways to transformation remain the biggest unknown in our efforts to understand and tackle sustainable development challenges.

Telecoupling represents a specific challenge with respect to the necessary interplay of these three dimensions of knowledge. In telecoupled systems, each dimension—systems, target, and transformation knowledge—may refer to different spatiotemporal system boundaries. For this reason, it is essential to delineate system boundaries in a way that makes it possible to relate different dimensions of knowledge surrounding a sustainability challenge. While the combination of place-based and process-based perspectives is imperative, it does not provide sufficient guidance to make the right choices. As any kind of system delineation depends on the research question, and the research question in turn depends on the problem statement, the sustainability orientation of land system science points to the solution. A careful and participatory definition of the sustainability problem—understood as inequality with respect to benefits from land use—should be the starting point for defining system boundaries.

4.2 Approaches to Knowledge Production

Research approaches that contribute to these three dimensions of knowledge combine disciplinary with inter- and transdisciplinary research and feature co-production of knowledge with a wide range of academic and non-academic partners (Schneider et al. under review). Developing a joint problem definition as an entry point to research for sustainable development and understanding different actors' visions of sustainable development (target knowledge) both require a transdisciplinary approach that involves different academic and non-academic actors. In a telecoupled situation, this presents a special challenge, as actors linked to a certain land system are distributed across scales and places. As face-to-face meetings and workshops might not be feasible, land system scientists need to explore new forms of exchange and consultation, including use of various new media and online platforms. In our research project in

Madagascar, we took a multilevel approach involving the local, district, regional, national, and international levels. To facilitate exchanges between these levels, we formed a stakeholder platform at the regional level, which convened regularly and invited stakeholders from different other levels to jointly discuss the sustainability challenges detected by means of empirical research. Additionally, we tested the use of video as a method to convey questions of local land users to specific actors at different other levels. We then filmed the responses and brought them back to the respective land users in the village. This triggered a (limited) dialogue, as some local land users were not satisfied with the replies and asked follow-up questions, which we then again brought back to the higher levels.

Disciplinary and interdisciplinary approaches are mainly required for the production of systems knowledge, which includes an understanding of land and its various functions, of actors' agency, of power differentials, and of the governance situation. From the point of view of telecoupling, it is important that systemic interactions across distance and distant actors' claims are taken into account at different levels. This requires advances in the development of new concepts and methods that link place-based with process-based research. One example is to integrate spatially explicit and remotely sensed land-use change information with social network approaches. However, production of systems knowledge might also benefit from transdisciplinary approaches, particularly in situations such as land-use conflicts, where "facts" concerning land-use classifications, access to land, complex relations between formal and informal institutions, and land sovereignty are highly contested.

Transformation knowledge needs to be co-produced with the actors concerned if it is to support sustainable development. A transdisciplinary approach is therefore key. The task is to design processes that foster negotiations among actors, which will eventually lead to improved land governance. Enabling and facilitating social learning in multi-stakeholder platforms can be one approach to tackling this challenge, but many more need to be explored. Furthermore, we need to embrace the empirical phenomenon of telecoupling and devise and test innovative mechanisms of land governance. For example, the different flows connecting telecoupled systems across distance need to be made more transparent to both consumers and producers. Based on our empirical results on actor networks linked to the vanilla trade and on the impacts that the vanilla boom has on local social-ecological systems, we plan to hold a regional workshop with the different actors along the vanilla value chain as well as conservation actors who are concerned about small-scale farmers' vanilla plantations contributing to deforestation. The aim of the workshop will be to discuss how proceeds from the vanilla trade could be diverted into regional-level sustainable development initiatives that would benefit a wider range of land users as well as the environment. To include the voices of distant actors, we plan to capture their visions in videos beforehand and screen them during the workshop.

Embracing all three knowledge dimensions in a single research project is difficult. As land scientists concerned with sustainability issues, we need to move from individual to collective action, or—to put it simply—from land science as a sprint discipline to land science as a team sport. If we want to design new research endeavours capable of contributing to solutions for the most pressing sustainability issues, we need to (1) progress from individual research projects to a programme structure, (2) implement sequential phases of research, combining disciplinary with inter- and transdisciplinary approaches, and (3) plan for longer time horizons to achieve lasting impacts.

In view of the specific challenges that telecoupling poses to such inter- and transdisciplinary research initiatives, we should regard the analysis of actor networks across space and scale as an entry point to establishing innovative partnerships between science and stakeholders from the civil society, the public sector, and the private sector. Researchers can benefit from the credibility and the convening power of science to initiate multilevel and multi-stakeholder dialogues. Knowledge diplomacy in such dialogues represents an important means of creating level playing fields in negotiations over diverging claims on land.

5 Conclusion

In this chapter, we have outlined the challenges that land system science faces in its endeavour to contribute to sustainable development in telecoupled land systems. In an increasingly connected world, answers to the questions of how to delineate land systems and what knowledge to produce about them have become less obvious. Appropriate system delineation depends on our problem definition and research questions, which in turn are guided by the telecoupling concept. Land system science offers a unique opportunity to explicitly adopt a normative perspective, based on the 2030 Agenda as the globally agreed vision for sustainable development. We have unpacked this largely under-researched aspect and pointed out the challenges it poses to knowledge production for sustainable development. While the SDGs represent the dimension of target knowledge, we need to expand the production of systems knowledge from a systemic to a power perspective. In an increasingly connected world, the only way of delineating land systems meaningfully is by combining place-based approaches with process-based ones that are capable of spanning places and scales. Furthermore, understanding the agency of actors and power differentials among them is a key prerequisite for co-producing transformation knowledge with non-academic actors. As land system scientists, we need to work towards all three knowledge dimensions in order to produce evidence that can guide us in navigating the trade-offs inherent in any land-use change. It is time for the land system science community to form new collaborations across scientific disciplines and with non-academic actors to produce the knowledge needed to implement the United Nations' 2030 Agenda.

Acknowledgements This work was conducted as part of the Swiss Programme for Research on Global Issues for Development within the project "Managing telecoupled landscapes for the sustainable provision of ecosystem services and poverty alleviation". It was funded by the Swiss National Science Foundation and the Swiss Agency for Development and Cooperation (grant number 400440 152167). Elements of this work were undertaken by the first author whilst as a visiting scholar in the Department of Geography, University of Cambridge (May 2018–April 2019). We are grateful to the entire project team for inspiring discussions and to the three reviewers and the editor for their constructive comments and support. We thank Marlène Thibault for copyediting our manuscript.

References

Baird, Ian G., and Jefferson Fox. 2015. How Land Concessions Affect Places Elsewhere: Telecoupling, Political Ecology, and Large-Scale Plantations in Southern Laos and Northeastern Cambodia. *Land* 4 (2): 436–453. https://doi.org/10.3390/land4020436.

Berbés-Blázquez, Marta, José A. González, and Unai Pascual. 2016. Towards an Ecosystem Services Approach That Addresses Social Power Relations. *Current Opinion in Environmental Sustainability* 19: 134–143. https://doi.org/10.1016/j.cosust.2016.02.003.

Boillat, Sébastien, Jean-David Gerber, Christoph Oberlack, Julie G. Zaehringer, Chinwe Ifejika Speranza, and Stephan Rist. 2018. Distant Interactions, Power, and Environmental Justice in Protected Area Governance: A Telecoupling Perspective. *Sustainability* 10 (11): 3954. https://doi.org/10.3390/su10113954.

Brand, Jürg, and Jean-Laurent Pfund. 1998. Site-and Watershed-Level Assessment of Nutrient Dynamics under Shifting Cultivation in Eastern Madagascar. *Agriculture, Ecosystems & Environment* 71 (1–3): 169–183. https://doi.org/10.1016/S0167-8809(98)00139-X.

Costanza, Robert, Ralph d'Arge, Rudolf de Groot, Stephen Farber, Monica Grasso, Bruce Hannon, Karin Limburg, Shahid Naeem, Robert V. O'Neill, Jose Paruelo, Robert G. Raskin, Paul Sutton, and Marjan van den Belt. 1997. The Value of the World's Ecosystem Services and Natural Capital. *Nature* 387 (6630): 253–260. https://doi.org/10.1038/387253a0.

Daily, Gretchen C. 1997. *Nature's Services: Societal Dependence on Natural Ecosystems*. Washington, DC: Island Press.

Eakin, Hallie, Ruth DeFries, Suzi Kerr, Eric F. Lambin, Jianguo Liu, Peter J. Marcotullio, Peter Messerli, Anette Reenberg, Ximena Rueda, Simon R. Swaffled, Birka Wicke, and Karl Zimmerer. 2014. Significance of Telecoupling for Exploration of Land-Use Change. In *Rethinking Global Land Use in an Urban Era*, ed. Karen Seto and Anette Reenberg, 141–161. Cambridge, MA: The MIT Press.

Eakin, Hallie, Ximena Rueda, and Ashwina Mahanti. 2017. Transforming Governance in Telecoupled Food Systems. *Ecology and Society* 22 (4): 32. https://doi.org/10.5751/ES-09831-220432.

Fazey, Ioan, Peter Moug, Simon Allen, Kate Beckmann, David Blackwood, Mike Bonaventura, Kathryn Burnett, et al. 2018. Transformation in a Changing Climate: A Research Agenda. *Climate and Development* 10 (3): 197–217. https://doi.org/10.1080/17565529.2017.1301864.

Ferreyra, Cecilia, Rob C. de Loë, and Reid D. Kreutzwiser. 2008. Imagined Communities, Contested Watersheds: Challenges to Integrated Water Resources Management in Agricultural Areas. *Journal of Rural Studies* 24 (3): 304–321. https://doi.org/10.1016/j.jrurstud.2007.11.001.

Fischer, Lisa-Britt, and Jens Newig. 2016. Importance of Actors and Agency in Sustainability Transitions: A Systematic Exploration of the Literature. *Sustainability* 8 (5): 476. https://doi.org/10.3390/su8050476.

Fisher, Brendan, R. Kerry Turner, and Paul Morling. 2009. Defining and Classifying Ecosystem Services for Decision Making. *Ecological Economics* 68 (3): 643–653. https://doi.org/10.1016/j.ecolecon.2008.09.014.

Friis, Cecilie, and Jonas Ø. Nielsen. 2017. On the System. Boundary Choices, Implications, and Solutions in Telecoupling Land Use Change Research. *Sustainability* 9 (6): 974. https://doi.org/10.3390/su9060974.

Garrett, Rachael D., Ximena Rueda, and Eric F. Lambin. 2013. Globalization's Unexpected Impact on Soybean Production in South America: Linkages between Preferences for Non-Genetically Modified Crops, Eco-Certifications, and Land Use. *Environmental Research Letters* 8 (4): 044055. https://doi.org/10.1088/1748-9326/8/4/044055.

Gasparri, Nestor Ignacio, Tobias Kuemmerle, Patrick Meyfroidt, Yann le Polain de Waroux, and Holger Kreft. 2016. The Emerging Soybean Production Frontier in Southern Africa: Conservation Challenges and the Role of South-South Telecouplings. *Conservation Letters* 9 (1): 21–31. https://doi.org/10.1111/conl.12173.

Global Land Programme. 2016. *Science Plan and Implementation Strategy 2016–2021*. Bern: Centre for Development and Environment, University of Bern.

Graham, John, Bruce Amos, and Timothy Wynne Plumptre. 2003. *Governance Principles for Protected Areas in the 21st Century*. Ottawa: Institute on Governance, Governance Principles for Protected Areas.

Grumbine, Edward R. 1994. What Is Ecosystem Management? *Conservation Biology* 8 (1): 27–38. https://doi.org/10.1046/j.1523-1739.1994.08010027.x.

Haines-Young, Roy, and Marion Potschin. 2010. The Links between Biodiversity, Ecosystem Services and Human Well-Being. In *Ecosystem Ecology. A New Synthesis*, ed. David G. Raffaelli and Christopher L.J. Frid, 110–139. Cambridge: Cambridge University Press.

Heathcote, Isobel W. 2009. *Integrated Watershed Management: Principles and Practice*. Hoboken, NJ: John Wiley & Sons.

IAASTD. 2009. *Agriculture at a Crossroads. International Assessment of Agricultural Knowledge, Science and Technology for Development. Global Report*. Washington, DC: Island Press.

Keller, Eva. 2015. *Beyond the Lens of Conservation: Malagasy and Swiss Imaginations of One Another*. New York and Oxford: Berghahn Books.

Leisz, Stephen J., Eric Rounds, Ngo The An, Nguyen Thi Bich Yen, Tran Nguyen Bang, Souvanthone Douangphachanh, and Bounheuang Ninchaleune. 2016. Telecouplings in the East-West Economic Corridor within Borders and Across. *Remote Sensing* 8 (12): 1012. https://doi.org/10.3390/rs8121012.

Lenschow, Andrea, Jens Newig, and Edward Challies. 2016. Globalization's Limits to the Environmental State? Integrating Telecoupling into Global Environmental Governance. *Environmental Politics* 25 (1): 136–159. https://doi.org/10.1080/09644016.2015.1074384.

Liu, Jianguo, Yue Dou, Mateus Batistella, Edward Challies, Thomas Connor, Cecilie Friis, James D.A. Millington, et al. 2018. Spillover Systems in a Telecoupled Anthropocene: Typology, Methods, and Governance for Global Sustainability. *Current Opinion in Environmental Sustainability, System Dynamics and Sustainability* 33: 58–69. https://doi.org/10.1016/j.cosust.2018.04.009.

Messerli, Peter, Adrienne Gret-Regamey, Bruno Ramamonjisoa, Khamla Phanvilay, San Win Myint, Karin Ingold, and Gudrun Schwilch. 2014. Managing Telecoupled Landscapes for the Sustainable Provision of Ecosystem Services and Poverty Alleviation. A Proposal for an R4D Project Submitted to the Swiss National Science Foundation (SNSF).

Myers, Norman, Russell A. Mittermeier, Cristina G. Mittermeier, Gustavo A.B. da Fonseca, and Jennifer Kent. 2000. Biodiversity Hotspots for Conservation Priorities. *Nature* 403 (6772): 853–858. https://doi.org/10.1038/35002501.

Nilsson, Måns, Dave Griggs, and Martin Visbeck. 2016. Policy: Map the Interactions between Sustainable Development Goals. *Nature News* 534 (7607): 320. https://doi.org/10.1038/534320a.

Proclim and CASS. 1997. *Research on Sustainability and Global Change—Visions in Science Policy by Swiss Researchers*. Bern: ProClim—Forum for Climate and Global Change, and Swiss Academy of Sciences SAS.

Raudsepp-Hearne, Ciara, Garry D. Peterson, and Elena M. Bennett. 2010a. Ecosystem Service Bundles for Analyzing Tradeoffs in Diverse Landscapes. *Proceedings of the National Academy of Sciences* 107 (11): 5242–5247. https://doi.org/10.1073/pnas.0907284107.

Raudsepp-Hearne, Ciara, Garry D. Peterson, Maria Tengö, Elena M. Bennett, Tim Holland, Karina Benessaiah, Graham K. MacDonald, and Laura Pfeifer.

2010b. Untangling the Environmentalist's Paradox: Why Is Human Well-Being Increasing as Ecosystem Services Degrade? *BioScience* 60 (8): 576–589. https://doi.org/10.1525/bio.2010.60.8.4.

Raworth, Kate. 2017. *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist*. Hartford, VT: Chelsea Green Publishing.

Reenberg, Anette. 2009. Land System Science: Handling Complex Series of Natural and Socio-Economic Processes. *Journal of Land Use Science* 4 (12): 14. https://doi.org/10.1080/17474230802645618.

Ribot, Jesse C., and Nancy Lee Peluso. 2003. A Theory of Access. *Rural Sociology* 68 (2): 153–181. https://doi.org/10.1111/j.1549-0831.2003.tb00133.x.

Sachs, Jeffrey. 2017. Land and the SDGs—Land Portal—Securing Land Rights Through Open Data. https://landportal.org/blog-post/2017/09/land-and-sdgs.

Schneider, Flurina, Andreas Kläy, Anne Zimmermann, Thomas Buser, Micah L. Ingalls, and Peter Messerli. under review. How Can Science Support the 2030 Agenda for Sustainable Development? Four Tasks to Deal with the Normative Dimension of Sustainability. *Sustainability Science*.

Schneider, Flurina, and Stephan Rist. 2014. Envisioning Sustainable Water Futures in a Transdisciplinary Learning Process: Combining Normative, Explorative, and Participatory Scenario Approaches. *Sustainability Science* 9 (4): 463–481. https://doi.org/10.1007/s11625-013-0232-6.

Seto, Karen C., and Anette Reenberg. 2014. Rethinking Global Land Use in an Urban Era. In *Rethinking Global Land Use in an Urban Era*, Strüngmann Forum Reports, ed. Karen C. Seto and Anette Reenberg. Cambridge, MA: The MIT Press.

Silva, Ramon Felipe Bicudo da, Mateus Batistella, Yue Dou, Emilio Moran, Sara McMillan Torres, and Jianguo Liu. 2017. The Sino-Brazilian Telecoupled Soybean System and Cascading Effects for the Exporting Country. *Land* 6 (3): 53. https://doi.org/10.3390/land6030053.

Torres, Sara M., Emilio F. Moran, and Ramon Felipe Bicudo da Silva. 2017. Property Rights and the Soybean Revolution: Shaping How China and Brazil Are Telecoupled. *Sustainability* 9 (6): 954. https://doi.org/10.3390/su9060954.

Turner, Billie L., II, Eric F. Lambin, and Anette Reenberg. 2007. The Emergence of Land Change Science for Global Environmental Change and Sustainability. *Proceedings of the National Academy of Sciences* 104 (52): 20666–20671. https://doi.org/10.1073/pnas.0704119104.

United Nations. 2015. *Transforming Our World: The 2030 Agenda for Sustainable Development*. New York: United Nations.

Verburg, Peter H., Karl-Heinz Erb, Ole Mertz, and Giovana Espindola. 2013. Land System Science: Between Global Challenges and Local Realities. *Current Opinion in Environmental Sustainability, Human Settlements and Industrial Systems* 5 (5): 433–437. https://doi.org/10.1016/j.cosust.2013.08.001.

Wiesmann, Urs, Cordula Ott, Ch. Ifejika Speranza, U. Müller-Boeker, Peter Messerli, and Jakob Zinsstag. 2011. A Human Actor Model as a Conceptual Orientation in Interdisciplinary Research for Sustainable Development. In *Research for Sustainable Development: Foundations, Experiences, and Perspectives*, Perspectives of the Swiss National Centre of Competence in Research (NCCR) North-South, University of Bern, ed. Urs Wiesmann and Hans Hurni, 231–256. Bern: Geographica Bernensia.

Zaehringer, Julie G., Bruno Ramamonjisoa, Peter Messerli, and Anu Lannen. 2018. Conservation Versus Local Livelihoods? Sustainable Development Challenges in Madagascar. *CDE Policy Brief 12*. Bern: Centre for Development and Environment (CDE).

Zaehringer, Julie G., Gudrun Schwilch, Onintsoa R. Andriamihaja, Bruno Ramamonjisoa, and Peter Messerli. 2017. Remote Sensing Combined with Social-Ecological Data: The Importance of Diverse Land Uses for Ecosystem Service Provision in North-Eastern Madagascar. *Ecosystem Services* 25: 140–152. https://doi.org/10.1016/j.ecoser.2017.04.004.

Zhu, Annah. 2017. Rosewood Occidentalism and Orientalism in Madagascar. *Geoforum* 86 (Suppl. C): 1–12. https://doi.org/10.1016/j.geoforum.2017.08.010.

———. 2018. Hot Money, Cold Beer: Navigating the Vanilla and Rosewood Export Economies in Northeastern Madagascar. *American Ethnologist* 45 (2): 253–267. https://doi.org/10.1111/amet.12636.

Zimmerer, Karl, Eric Lambin, and Steven Vanek. 2018. Smallholder Telecoupling and Potential Sustainability. *Ecology and Society* 23 (1): 30. https://doi.org/10.5751/ES-09935-230130.

Index[1]

A

[1] Note: Page numbers followed by ‘n’ refer to notes.

C. Friis, J. Ø. Nielsen (eds.), *Telecoupling*, Palgrave Studies in Natural Resource Management, https://doi.org/10.1007/978-3-030-11105-2

J

K

L