



OPERATIONALISING TELECOUPLINGS FOR SOLVING
SUSTAINABILITY CHALLENGES FOR LAND USE

Deliverable D3.3

Immaterial flows are important for
understanding land use

*(Synthesis paper on processes coupling land
systems)*



This project receives funding from the European Union's Horizon 2020 research and innovation programme under Marie Skłodowska-Curie grant agreement No 765408.

Deliverable

Number	D3.3
Title	Immaterial flows are important for understanding land use (Synthesis paper on processes coupling land systems)
Lead beneficiary	UBER
Work package	WP 3. Processes
Dissemination level	Public
Nature	Report
Due date	31.12.2021
Submission date	31.12.2021
Corresponding author	Jonas Østergaard Nielsen
Contributing authors	Joel Persson, Cecilie Friis, Siyu Qin, Ole Mertz, Perrine Laroche, Pin Pravalprukskul, Simon Bager, Anna Frohn Pedersen, Johanna Coenen, Julie Zähringer, Esteve Corbera, Thomas Kastner, Nicolas Roux, Claudia Parra Paitan

Project

Acronym	COUPLED
Title	Operationalising telecouplings for solving sustainability challenges for land use
Coordinator	Humboldt-Universität zu Berlin (UBER)
Grant Agreement No	765408
Type	MSCA-ITN-ETN
Programme	HORIZON 2020
Start	01 January 2018
End	30 June 2022
Consortium	Humboldt-Universität zu Berlin (UBER), University of Bern (UNIBE), Universitat Autònoma de Barcelona (UAB), University of Copenhagen (UCPH), Institute of Social Ecology Vienna (BOKU), Vrije Universiteit Amsterdam (VUA), Leuphana University of Lüneburg (LUL), Université catholique de Louvain (UCL), Earthworm Foundation (Earthworm), Unilever U.K. (UNILEV)
E-mail	info@coupled-itn.eu

About COUPLED

Human consumption of food and agricultural products has a significant impact on the environment and the societies in the regions where they are produced. Different sectors, consumers, businesses and politicians are increasingly demanding more environmental and social sustainable land use both inside and outside Europe. Yet, there is increasing recognition of the limitations of current research approaches to adequately understand and address the increasing complexity of land system dynamics, which are often characterized by strong non-linearity, feedback mechanisms, and local contexts, and where places of production, trade, and consumption of land-based products are increasingly separated.

Coordinated by the Humboldt-Universität zu Berlin, COUPLED is a European training network in order to better integrate research, innovation and social responsibility framed around the concept of telecouplings.

COUPLED trains Early Stage Researchers capable of:

- understanding processes and actors that influence land use in an increasingly interconnected world
- considering distant, unexpected feedbacks and spillovers and to account for their social and environmental impact
- fostering new and enhanced governance measures that can shape land-use couplings to deliver more sustainable outcomes of land-use decisions

For more information see www.coupled-itn.eu

Executive Summary

The globalization of land use is often captured by tracing and measuring material flows of land-based products such as food, feed, fibre, and energy across spatial distance. The global connections between production and consumption of land-based products has in this way been identified and quantified. Less well known is how these material flows are often accompanied by immaterial flows. In this paper, we explore immaterial flows in the context of land use. We show there is a research gap within land system science concerning immaterial flows, we define characteristics and types of immaterial flows, illustrate that immaterial flows are central for understanding land use changes, and discuss the implications of better understanding immaterial flows for sustainable land use. Data from case study research focusing on land use change across the globe is used. These data highlight how different types of immaterial flows such as rules, values, and knowledge initiate and shape land use. We link these findings with existing research within land system science on immaterial land use drivers such as historical relations, potentiality, revalorization, latecomer effect, and trans-scalar land use planning.

Table of contents

EXECUTIVE SUMMARY	3
IMMATERIAL FLOWS ARE IMPORTANT FOR UNDERSTANDING LAND USE	5
1. INTRODUCTION.....	6
2. LITERATURE REVIEW	6
3. RESULTS	8
<i>Values</i>	<i>8</i>
<i>Knowledge</i>	<i>10</i>
<i>Rules</i>	<i>11</i>
4. DISCUSSION	12
5. CONCLUSION	14
6. REFERENCES.....	14
APPENDIX 1	17
<i>Contributing research projects from COUPLED.....</i>	<i>17</i>
<i>Contributing authors.....</i>	<i>17</i>

Immaterial flows are important for understanding land use¹

Jonas Østergaard Nielsen, Joel Persson, Cecilie Friis, Siyu Qin, Ole Mertz, Perrine Laroche, Pin Pravalprukskul, Simon Bager, Anna Frohn Pedersen, Johanna Coenen, Julie Zähringer, Esteve Corbera, Thomas Kastner, Nicolas Roux, Claudia Parra Paitan

Abstract

The globalization of land use is often captured by tracing and measuring material flows of land-based products such as food, feed, fibre, and energy across spatial distance. The global connections between production and consumption of land-based products has in this way been identified and quantified. Less well known is how these material flows are often accompanied by immaterial flows. In this paper, we explore immaterial flows in the context of land use. We show there is a research gap within land system science concerning immaterial flows, we define characteristics and types of immaterial flows, illustrate that immaterial flows are central for understanding land use changes, and discuss the implications of better understanding immaterial flows for sustainable land use. Data from case study research focusing on land use change across the globe is used. These data highlight how different types of immaterial flows such as rules, values, and knowledge initiate and shape land use. In the discussion, we link these findings with existing research within land system science on immaterial land use drivers such as historical relations, potentiality, revalorization, latecomer effect, and trans-scalar land use planning.

Key words

Land System Science, immaterial flows, globalisation, case studies

Highlights

- Immaterial flows such as rules, values, and knowledge shape land use systems
- Immaterial flows can be defined by generic characteristics
- Land systems science literature on immaterial flows is summarized for the first time
- Immaterial flows neglected in land system science literature on the globalisation of land use

¹ To be submitted to Journal of Land Use Science once further revised.

1. Introduction

Land use provides societies with indispensable products such as food, feed, fibre, and fuels. Yet negative local and global outcomes of agriculture and forestry are increasingly documented in land system science (LSS). Given a growing population and rapidly rising consumption, identifying and fostering more sustainable modes of land use are key challenges of the 21st century (Meyfroidt et al., 2022). This requires a systemic approach, where land use dynamics are assessed as part of coupled human-environment systems to understand the social, economic, political, and environmental drivers of land system change, and the manifold, often unwanted, and sometimes surprising consequences of those changes.

Land systems at all spatial scales are increasingly embedded in networks of long-distance flows of raw materials, energy, capital, technology and products, but also of people, history, information, discourses, and policies (Friis and Nielsen, 2019). This requires that research on land use is both place-based and flow-oriented (Sikor et al., 2013). A multiplicity of methods and data sets are needed to understand how but also why land use changes, and which impacts these changes have on societies and nature. Most research within LSS concerned with the flows that connect places of production with places of consumption have focused on material flows (Kastner et al., 2021). These are comprised of material goods that can be measured and quantified. Insights into how global trade relations, governance mechanisms, and actors such as multinational companies and NGOs shape the globalisation of land use have in this way been achieved. Research focused on how to govern, manage and shape such global flows towards larger sustainability have benefitted from such insights.

Immaterial flows and how these shape the globalisation of land use have received less attention than material flows in LSS, and proof of this is that no clear definition of immaterial flows exists in LSS to date. Such flows encompass policies, discourses, ideas, rules, plans, experiences, knowledge, and information, which often combined exert a critical influence on how land is used. Notwithstanding, making causal statements, a key component of LSS, concerning the impact of an immaterial flow on an observed land use change is challenging (Meyfroidt 2016).

Presenting data from across the globe we show that immaterial flows matter for understanding contemporary land use changes. Qualitative data from Asia, Africa, and Europe are used to illustrate this. This data was collected by different researchers all working within the same research project. Using this data, this paper attempts a first generic characterisation in LSS of immaterial flows. The importance of capturing immaterial flows for understanding and managing land use changes towards sustainability is discussed. Challenges related to research on immaterial flows are also discussed. Capturing immaterial flows and establishing causal impacts of these are here highlighted.

2. Literature review

The globalization of land use is an important research agenda within LSS (Geist and Lambin, 2002; Verburg et al., 2013; Friis and Nielsen, 2019). Land based products such as food, feed, fibre, and fuels are increasingly traded and transported across the globe (Lambin & Meyfroidt, 2011; Kastner et al., 2021). Tracing and measuring the flow of such products and how this trade cause land use changes is a key focus within LSS. Global trade databases and methods including monetary or biophysical input-output models (Yu, Feng, and Hubacek 2013; Bruckner et al. 2019) or physical trade accounting (Kastner and Nonhebel 2011; Kastner, Erb, and Haberl 2014; Roux et al. 2021) have been particularly useful in this regard. Key insights are, that drivers are often located far away from observed land use changes, that international trade is inducing a spatial disconnection between producing and consuming countries, that land-based products flows mostly from sparsely populated areas to densely populated areas and from the Global South to the Global North, and that trade reallocate production of land use products internationally.

Material flows refer in LSS to flows that involve physical matter or chemical substances. Material flows can be observed at different levels, from the object or commodity level (e.g. Soybeans) up to its chemical content (Nitrogen, Carbon, etc.). Examples of material flows include flows of biomass (food, feed, fibre, and fuels),

metals, minerals, water, as well as various substances including pollutants or nutrients. Material flows are typically described in mass units (e.g. tons of biomass) or in absolute numbers (e.g. number of tractors). Material flows are hence identifiable, measurable, and traceable across spatial distances, something initiatives like www.trase.earth exemplify. These characteristics make it possible to establish causal linkages between an observed land use change and material flows (Kastner et al., 2021). In a recent review of newly published LSS research on the globalisation of land use the emphasis within LSS on tracing material flows is evident with 74% of the papers reviewed focusing on trade of land-based products (Kapsar et al., 2019). A systematic review of telecoupling visualizations presented in scientific articles from the field of LSS further revealed that material flows (in particular commodity flows) are the most common types of flows depicted (Sonderegger et al. 2020). The sustained efforts within LSS to establish methods for quantifying and modelling trade, material, and energy flows between places of production and consumption illustrate the same trend (Seaquist et al., 2014; Bruckner et al., 2015; Henders et al., 2015; Schaffartzik et al., 2015).

The research on material flows within LSS is to some extent accompanied by research focused on immaterial flows and how these shape the globalisation of land use. In the review cited above (Kapsar et al., 2019) it is mentioned that 33% of the papers reviewed address knowledge transfers and how this influences land use decisions. Consumer preferences for non-GMO crops (Garrett et al., 2013) and organic coffee (Rueda et al., 2013) and how such preferences flow from consumers in the Global North to individual farms in the Global South subsequently shaping land use decisions there illustrate the importance of immaterial flows for causal explanation. As does research on how conservation discourses travel from the Global North to the Global South shaping where, how and when national parks are established in Laos (Persson et al., 2021). Friis & Nielsen (2017) show in their analysis of the conversion of rice fields to banana plantations in northern Laos, how multiple flows, many of which were immaterial, such as policies, discourses, and ideologies shaped this land use change.

Going through LSS research on the globalisation of land use four potentially generic immaterial flows can be identified. 1) Land use changes are often shaped by historical relations between two places. Colonial connections and personal networks facilitated by shared language, cultural references and working structures are particularly important in this respect (Brockington & Scholfield, 2010). This was seen in the way opposition to certain land uses in Mozambique was shaped by Brazilian actors using their common colonial history and shared language to facilitate flows of information and experiences from one place to the other (Oliveria & Meyfroidt, 2021). Flow 'stickiness', or the persistence of connections, between places are also often based on historical connections and personal networks going back in time (Reis et al. 2020). Material flows, for example trade relations, follow such immaterial flows as these enable contacts, shared understandings and trust. Another common immaterial flow in LSS research is the so-called 2) latecomer effect (Gerschenkron, 1962). Latecomer effect describe how earlier experiences of land use changes later flow into other places. This is seen in forestry practices but also in many other land uses (Rudel et al., 2020). Concerning forest transitions, transitions are initiated by 'pioneers.' After the first countries experienced a transition other places copy these, or learn from their mistakes, and participants in these later transitions are 'latecomers' (Rudel et al., 2020, p. 49; Gerschenkron 1962). 3) Potentiality and revalorization of land captures how global discourses about the use of a particular piece of land shape land use. Such discourses often flow from the Global North to the Global South and can revolve around the potential of a particular place for nature conservation initiatives such as REED+ or national parks. Global discourses often change over time. The same piece of land can thus be revalorized at some higher scale according to its potential to fulfil a new global, regional, or national agenda. This was seen in Indonesia where the same peat land went from a focus on local livelihoods, to large-scale plantations, to global carbon sink according to shifting global trends (Merten et al., 2021). Potentiality and revalorization often lead to competition over land (Niewöhner et al., 2016). The same tract of land cannot simultaneously maximize food production, sequester carbon in long standing forests, and preserve biodiversity, for example. Closely related to this issue is 4) trans-scalar land use planning. This refers to a planning process that incorporates the views of people living far from the affected land as well as the views of people who live in and around the affected land (Rudel and Meyfroidt, 2014). This process is about how to achieve the optimal use of a piece of land often in light of global agendas to minimise the trade-off. Planners assess the potential of different land uses with the intention of selecting 'the best land use options' for the scrutinized tracts of land creating land use plans to achieve this (Lestrelin et al., 2012). This was seen in

Burkina Faso. There global and regional trends concerning the planning of so-called Growth Pole Projects embedded concerns about food security, hydropower, organization of farmers and how shifting from maize to rice productions became a solution to such concerns and a matter of land use planning incorporating global, regional, and national stakeholders as well as local farmers (Hauer and Nielsen, 2020).

3. Results

This section highlights the importance of immaterial flows for land use. Research conducted on land use in Asia, Africa, and Europe between 2018 and 2020 form the basis of the results presented. Eight different research projects all embedded within a larger project focused on understanding the globalisation of land use provide the data. The identification of immaterial flows and the importance of such for land use was an explicit focus in some projects. In other projects, it emerged as an important explanatory factor during the research. Identifying common insights on immaterial flows across the individual projects were done during two project-wide workshops conducted in 2020 and 2021. During these workshops, three generic types of immaterial flows were identified of importance for observed land use changes: values, knowledge, and rules. The presented results are organized according to these. In the following discussion we identify what characteristics these have in common. This enables us to give a first generic characterisation of what an immaterial flow is in LSS.

Values

Values guide and motivate attitudes or actions. What is important, good, desirable or worthwhile is often guided by values. In LSS values play a fundamental role when decisions about what to do with a particular piece of land is taken (Nielsen et al., 2019). Different people hold different values, so dissent, competition and conflict over land is often related to values (Niewöhner et al., 2016). Values are intangible, immaterial, and travel or flow across distance through narratives, discourses, visions, ideologies and policies by means of language or communication.

Cocoa production is heavily influenced and shaped by a few key global companies (Research project 1, see appendix). The six largest cocoa trading companies are transnational corporations based in high-income countries of the Global North. These source cocoa mainly from Cote d'Ivoire, Ghana, and other countries from the Global South. Nevertheless, cocoa consumption is dominated by Global North countries, with The Netherlands and the USA being the largest destination of cocoa exports. The production of cacao is increasingly shaped by values pivoting around sustainability. Consumers and civil-society groups from the Global North are putting pressure on politicians and companies to halt deforestation and avoid child labour associated with cocoa production. This has generated a wave of sustainability initiatives taking multiple shapes. The Cocoa and Forest Initiative (CFI) and the cocoa sustainability boards of European Countries exemplifies this (Gisco from Germany, Swissco from Switzerland, Disco from the Netherlands, Beyond Chocolate from Belgium).

Such initiatives illustrate the growing emphasis on due diligence approaches as the instrument to govern agro-food supply chains in order to encompass all environmental, social and governance aspects of production and how this manifest in land use (Bager et al., 2021; Cossart et al., 2017; Schilling-Vacaflor and Lenschow, 2021). Certain ideas, conceptions or values about what is the right or the best approach to govern land use can quickly spread between actors, bringing different policies in and out of fashion. Zero-deforestation commitments (ZDCs) (Research project 2) embraced by public as well as private actors illustrates exactly how various values become embedded in specific instruments aimed at governing land use. ZDCs build on the idea that by addressing supply chain impacts, deforestation from agro-food production can be reduced. From the first adoption of ZDCs around 2010, ZDCs spread across companies and sectors, leading to more than 700 companies having adopted some kind of ZDC a decade later. In Research project 2, food sector companies were interviewed about their ZDC efforts. A key result from these interviews is that these actors share values about due diligence focused mainly on hindering deforestation. Ideas about how to reduce particular challenges in this respect were often shared and reinforced by their use of the same stories or narratives to

describe their efforts, results, and challenges.

The impacts of ZDCs on land use is contested but measurable and tangible results are visible, illustrating how sustainability initiatives shaped by values about how best to achieve certain goals related to land use manifest in policies and practises. A strong example of this is projects focused on Reducing Emissions from Deforestation and Degradation (REDD+) (Project 3). REDD+ is a broad policy framework aimed at stabilising deforestation and enhancing forest carbon stocks in the global South. It has travelled diffusely between policy actors throughout the global South leading to significant changes in land-use patterns (Corbera et al., 2020). Small-scale as well as large-scale REDD+ programs and projects are generally funded by governments, often with international donor support, providing direct payments to land managers in exchange of forest conservation and sustainable management practices. These so-called Payments for Ecosystem Services (PES) programs are a key policy pillar for the consecution of REDD+ objectives in many countries and, as such, they do not only transfer financial resources to land managers, but also specific ideas about forests' potentiality and value, namely that the targeted lands contribute to halt climate change by avoiding carbon emissions, ensure the conservation of specific ecosystem services (e.g. soil quality, water infiltration), and support the conservation of biodiversity (Shapiro-Garza et al., 2020).

In the study of land use changes around a cash crop bust in northern Thailand (Project 4), the immateriality of 'sustainability values' manifested in flows of conservation narratives and the value of particular types of landscapes. In the 2010s, media attention towards maize farming in conservation forest zones centred on the eyesore of "bald mountains" in what used to be "idyllic" forested landscapes, with images spreading quickly through online news outlets and social media to distant urban dwellers. Combined with historical nationalistic slogans of northern upland forests as essential to downstream water supply and "life", these modern images of forest "destruction" by maize farmers led to the organization of responses across private, public and NGO sectors. Interventions focused on the conversion of maize to agroforestry in pilot communities through financial support, training, and market development for tree crop products. The study found that while the intervention projects have been fairly successful in recruiting farmers from targeted communities into these land-use conversion initiatives, the long-term sustainability of the new land-use systems remains to be seen. Yet the speed at which these land-use interventions were organised, funded and implemented across unrelated actors through the application of conservation narratives based on particular national values related to this region is notable.

Similar findings emerged from Montenegro (Research Project 5). This research looked at the land use changes related to a large infrastructure project (construction of a highway). Here several actors at multiple scales enacted different sets of values in order to influence the decision-making process of the highway construction. These values were found to travel through official reports and policy documents authored by national and international authorities and organisations as well as civil society organisations and the media. The European Union (EU), for example, warned about the negative environmental effects associated with the highway construction in several policy reports. These reports were directed at the Montenegrin government. Likewise, the UNESCO, together with IUCN, conducted a so-called "advisory mission" to Montenegro to discuss some boundary modifications of a national park, which is under UNESCO protection (World Heritage Site). Two experts came to Montenegro for several days to review the current situation of the national park and discuss the potential boundary modification with local stakeholders. The stay of the advisory mission coincided with a public controversy around the negative environmental effects of the highway construction. Since the construction activities negatively affect a UNESCO-protected river, which flows through the UNESCO-protected national park, the mission team also reviewed the environmental effects of the highway. The mission team wrote a report with recommendations directed at the Montenegrin government. The report was also used by the World Heritage Committee to inform its position and recommendations towards Montenegro. The report did not only assess the status quo of the national park and surrounding environment (i.e., creating knowledge), but it also conveyed and highlighted international values concerning sustainable practices, governance, and transparency, and had very strong normative components (i.e., clear recommendations to national decision makers). In response to these external influences and recommendations, Montenegro started a biological monitoring programme at the construction site.

Knowledge

Knowledge is gained by experience, education or information. It can be acquired from many sources. Like values, knowledge is immaterial and travels across distance through formal and informal information flows by means of language or communication.

That flows of knowledge across distance affect land use practices was seen in Tanzania (Research Project 6). Knowledge in the artisanal and small-scale mining sector focused on transparency initiatives. Newly established markets were the mechanism to achieve this as these centralized the traders, displayed the world gold price, ensured organized and controlled measurement of gold using certified instruments and was in general commented on positively by traders, miners and government officials alike. For the small-scale miners the improved ability to negotiate a good price for their gold was a particular positive outcome of these markets. Before the markets, it was difficult to know the exact world gold spot price, especially if you did not have a smart phone with internet access. Today the gold spot price is displayed at the market on a white board and updated daily. While the ability to obtain a better price did not per se affect the land use practice of mining it did impact livelihoods partly sustained by the incomes generated by mining, especially agriculture and animal husbandry. A more direct land use impact of knowledge flows in this sector pertains to so-called gold rushes. These happen when someone, somewhere, finds gold. Knowledge spreads quickly, and in a matter of days, thousands of people rush to the area. In Rwamgasa, a gold mining village in the northern part of Tanzania, a gold rush occurred in 2017, and 10.000 people settled within the first 3 weeks. Temporary infrastructures and settlements were built of tents, timber and tarpaulin, and approximately 200 shafts were established. Gold rushes like this tend to be temporary, and when the deposits become exhausted or more promising gold rushes arise, people leave. In 2019, only 80 pits were still active, and only 4000 people continued to work in the rush. When rushes turn from boom to bust, shafts are abandoned and left unfilled and mercury used for extraction continues to contaminate the area. Indeed, gold rush landscapes are severely impacted and difficult to rehabilitate.

In the case of NEPL national park in Northern Laos, multiple nonmaterial flows shape land-use changes (Project 7). The transfer of knowledge over distance takes place through various media including policy documents, statements by government and non-governmental organisations, and through daily discourses in meetings and discussions. It is often unidirectional and targeted at the people living in the park relying on the park's resources for their daily needs. Knowledge about these people and their land use practices is strongly shaped by narratives of rapid and ongoing ecological destruction and the necessity and urgency of political intervention to educate these people, often ethnic minorities. A point also seen in Thailand (Project 4) and Madagascar (Project 8). Concerning the latter, saving biodiversity in two national parks pivoted to a large extent around changing local people's shifting cultivation practises by transferring knowledge about the supposedly harmful effects of declining forest cover and local microclimate and water cycles as well as knowledge about alternative land use practises, especially irrigated rice production and agroforestry. However, these knowledge flows, which take shape at the local level through environmental education activities in classrooms or outdoors, have little effect on actual land-use change. Land users are generally very well aware of the ecological and other values of forests, and destroying it through shifting cultivation is the consequence of the need to cover immediate needs for food production or more long term securitization of land resources for a household's descendants. In Laos, knowledge flows are purportedly based on "what works" and give rise to measures such as boundary demarcation, ecotourism design, enforcement practises, and alternative livelihoods. Knowledge on optimal land-use and appropriate ways to govern land and resource use is also circulated by actors working in the sphere of nature conservation and environmental governance in Laos affecting the land use practises of people living in the park. The perceived effectiveness of such knowledge is assembled from diverse sources but often arrive from other parks in Laos and Southeast Asia more broadly. Indeed, a broad knowledge sharing between stakeholders concerned with park management in Laos was observed.

Rules

Rules refer to laws, policies, regulatory frameworks and taxation affecting land use. Understood as an immaterial flow, rules capture here such entities as they travel between places and different regulatory territories or affect the movement of land-based products. Rules decided in one place, for example the EU, in this way impact land use in other places, for example Cote d'Ivoire. Values, knowledge and capital, are embedded in rules, highlighting the connection between various types of immaterial flows.

The largest cocoa trading companies are transnational corporations from Global North countries that have large processing facilities in those regions (or close to them) (Project 1). The two largest producing countries (Ghana and Cote d'Ivoire) want to industrialize the national cocoa sector to retain more of the value of the cocoa they produce. Currently most of the cocoa produced is exported as raw bean transformed into cocoa butter, cake, liqueur or powder in Europe, USA or Southeast Asia. However, the large capital investments and high fixed costs associated with cocoa processing create entry barriers for companies in these countries. Tariffs to technology and import taxes applied to cocoa processed overseas diminish their market competitiveness in consuming countries. Due to the strong market dominance of Ghana and Cote d'Ivoire, they have managed to impose changes by negotiating with foreign investors for the establishment of cocoa processing plants, and setting minimum quotas of nationally sourced cocoa to transnational corporations. Indonesia, one of the largest cocoa producing countries, has followed a similar approach by increasing the tax of exported cocoa beans, thus motivating companies to invest in processing facilities within the country. The flow of cocoa (material flow) is thus shaped by tariffs, taxation and national or regional legislation. This in turn shapes and hinders investments in cocoa production in producing countries. International regulations and due diligence legislation concerning child labour and deforestation and other sustainability challenges in cocoa production have also generated a wave of initiatives reshaping cocoa production.

In the late 2000s, resource policies changed in Tanzania focussing on more state control in the extractive sector (project 6). The Mining Act of 2010 aimed to increase the sectors' contribution to the GDP and improve the rights of artisanal and small-scale miners and customary land users. Tanzania Minerals Audit Agency was established and the tax and royalty requirements from multinational companies (MNCs) were raised (Pedersen and Jacob 2017). The turn towards resource nationalism, understood as a political shift towards a more domestically controlled extractive sector has resulted in new legislations, particularly the 2017 Acts and Amendments. These amendments give the Parliament the right to review international mining contracts, prioritise Tanzanian investors, ban export of raw gemstones and diamonds, reject international interference in mining disputes, and raise the mineral royalties along with the minimum requirement of state shares in mining projects (see Pedersen et al. 2019). Resource nationalism's impact on the land use of mining is yet to be fully documented in Tanzania. The above-mentioned markets (Section 3.2) illustrate, however, that immaterial values such as resource nationalism manifest in rules and legislation materialising in initiatives aimed at transforming a particular land use practice. Indeed, as a way to 'contest how benefits and harms are distributed' (Koch and Perreault 2019, pp. 612) different configurations of resource nationalism have emerged worldwide in connection with land-based products (Koch and Perreault 2019).

In the study of land use changes around a cash crop bust in northern Thailand (project 4), environmental regulations determined and flowing from elsewhere were found to influence land use outcomes. In Madagascar (Project 8), protected area codes likewise prohibited local farmers and other stakeholders from extending their agricultural land and mining sites into certain forests. The regulations, or rules for land use, were crafted by a mixture of national and international, private, and public stakeholders, institutions and NGOs. Multiple values were embedded in this regulation including a strong emphasis on changing local peoples' practises. In both cases, these values as well as related knowledge sharing did not alone suffice to change local practises and legislation became a central tool in this respect. Stringency in the regulation of conservation forest zones played a role in shaping the maize bust in northern Thailand. A 2019 law to grant land use access in conservation forest zones, for example, required farmers to plant trees on their farmland, and stipulates the minimum number of trees per unit area. However, in reality many farmers have not been informed of this requirement because of unclear implementation guidelines, leaving forestry officials to interpret and translate the regulations to the communities individually. How rules and legislation play out on the ground is hence often

very context specific, a point also highlighted in research from Laos (project 7) where the perceived effectiveness of and faith in regulations are assembled from diverse sources leading to different interpretations on the ground. Legislation and regulation concerning land use and cover is moreover heavily influenced by “conservation fads” (Lund et al., 2017) (Project 2). This is the idea that a policy or governance approach to preserve or protect forests comes in vogue for a short time-period, only to disappear a few years or a decade later. REDD and REDD+ exemplifies this. From being a highly influential international policy tool, it currently receives scant attention. This shows that certain ideas or conceptions about what is the right or the best approach to govern can spread between actors, bringing different policies in and out of fashion affecting land use and cover subsequently.

4. Discussion

How material flows facilitate the globalisation of land use change is a strong research theme in LSS. Insights into what drives contemporary land use changes have been achieved through research focusing on material and financial flow tracing and accounting. New methods, data sets and bases capture such flows and a common shared understanding of what a material flow is exists in LSS. Key insights from this research is that land use is increasingly globalised and characterised by a strong decoupling of production and consumption.

Immaterial flows have received less attention. Yet values, information, knowledge, discourses, rules and policies, shape and/or facilitate material flows of land-based products (e.g. Friis and Nielsen, 2017, Persons et al. 2020). The data presented in this paper highlight how values, knowledge and rules help shape land use decisions in diverse places such as Laos, Montenegro, Tanzania and Madagascar. The results illustrate how immaterial entities flow via networks of policy makers, NGOs, business connections, and policy initiatives. The development of the NFLP national park in Laos, the cash crop bust in northern Thailand, or infrastructure projects in Montenegro require an understanding of how multiple immaterial flows intermingle. The data illustrate also that many such flows, like material flows, originate often far from the actual land use sites. EU policies, NGO agendas, and consumer preferences were found to directly influence land use practices. In Ghana, for example, European consumers' concern about child labour and other non-sustainable practices related to the production of cocoa resulted in multiple sustainability initiatives such as Swissco from Switzerland and Beyond Chocolate from Belgium. Adopted by agro-food companies keen to practice due diligence, ideas or values related to what the best approach to govern land use is quickly spread between actors, bringing different policies in and out of fashion. Zero-deforestation commitments (ZDCs) and REDD+ projects illustrate this.

That flows of knowledge across distance affect land use practices was seen in Tanzania. In the artisanal and small-scale mining sector there, knowledge focused on transparency initiatives and how these make the livelihoods of ASMs better flowed between different actors. The power of knowledge flows to initiate land use changes were also illustrated in this data with the example of gold rushes. In Laos ‘what works’ was often transmitted between different parks in the region as well as between various stakeholders shaping concrete initiatives concerning land use practices and zoning. In Madagascar, saving biodiversity pivoted to a large extent around changing local people's shifting cultivation practises by transferring knowledge about the supposedly harmful effects of this as well as knowledge about alternative land use practises. Another immaterial flow illustrated by the presented data was rules. National stringency in the regulation of conservation forest zones played a role in shaping the maize bust in northern Thailand. National policies and rules regarding mining increasingly affected this land use in Tanzania. In both case global positioning and demands shaped such regulations. Concerning the flow of cocoa, the data presented highlighted how tariffs, taxation and national or regional legislation shaped the material flow of cocoa making it difficult for producer countries to benefit from this land use.

Such findings are supported by scattered evidence from the LSS literature. This literature has never been synthesised in one paper but going through LSS research on the globalisation of land use four generic immaterial flows are apparent. Historical relations between two places often facilitate such flows. Flow ‘stickiness’, or the persistence of connections, based on historical connections and personal networks going back in time is an example of this (Reis et al. 2020). Our data does not as such find historical relations, but

clearly, resource nationalism in Tanzania is shaped by colonial experiences. The latecomer effect (Gerschenkron, 1962) describing how earlier experiences of land use changes later flow into other places was present in Laos, 'what works' was based on previous experiences flowing between different places. Indeed forestry practices is a key example of latecomer effect (Rudel et al., 2020). More pronounced in our data is potentiality and revalorization of land. Global discourses about the use of a particular piece of land change over time and shape land use. Such discourses often flow from the Global North to the Global South. REED+ and national park developments described in this paper illustrate this generic trend. The data from Thailand also highlight how various national revalorizations over time help frame and shape land use. A point also highlighted in the data from Madagascar. Closely related to this issue is the fourth generic trend, trans-scalar land use planning. How to achieve the optimal use of a piece of land often in light of global agendas to minimise the trade-off was part of discussions in Tanzania as that country try to position itself globally via 'resource nationalism' while simultaneously reforming its mining sector. Planning the NELP park in Laos was a process including multiple actors found at different scales as was infrastructural developments in Montenegro and cacao production in, for example, the Ivory Coast.

Held together, our results and the literature allow us for the first time to give a tentative generic description and characterisation of immaterial flows in LSS. Immaterial flows depends upon people to transmit, translate and interpret them. Discourses, best practices, policies, experiences, knowledge, rules and values shape land use only when people transmit, translate, and interpret them. The transmission often initiate with actors such as international and national policy makers, institutions, NGOs, and companies, often located far away from the land systems observed. Translated and interpreted by representatives of such entities and local organizations, policy makers, NGOs, and people found in the land system, immaterial flows tend to be transformable. Immaterial flows (can) change along the networks through which it travels; it goes through multiple translations and interpretations and intended and actual land use outcomes of an immaterial flow might differ radically. This makes immaterial flows layered. Messages, understandings and outcomes mix as an immaterial flow is transmitted, translated and interpreted. The same immaterial flow can thus serve multiple purposes depending upon interpretation. Immaterial flows are hence also often latent. Meanings, purposes and outcomes might not be predictable and only become visible as a flow when a particular land use change needs to be explained. An immaterial flow can be persistent but also ephemeral. Discourses and values, for example, can change quickly or simply disappear. Immaterial flows also tend to be diffuse. Discourses, best practices, experiences, knowledge, rules and values travels freely and become directed only when inserted in a particular network. They can reach multiple destinations, also non-intended ones. As such, immaterial flows are non-exhaustive and freely reproducible. They are not subject to the laws of thermodynamics and not necessarily connected to physical or financial stocks.

These characteristics highlight that immaterial flows are hard to capture, measure and establish the importance off in connection with an observed land use change. Which flows exactly shaped the establishment of the national park in Laos, or the maize bust in Thailand? How important was national policies on resources in Tanzania for ASMs? Where did immaterial flows on sustainability originate? How were they interpreted and implemented, and how important were they for land use practices observe in places such as Tanzania, Ghana and Laos? This is of course hard to answer and much more so than material flows and their impact on land use practices. Nevertheless, in all the results presented and the wider literature immaterial flows are shown to shape land use decisions and to a significant degree. They have causal impact. If LSS, as increasingly argued, is also about managing land use changes towards sustainability (e.g. Nielsen et al., 2019) identifying the most important flows, the networks they move through and the mechanisms that facilitate them is important. Doing so, will help identify the most significant leverage points for sustainability initiatives. Stepping up the research on immaterial flows in order to better establish how such flows present challenges but certainly also opportunities for managing land in more sustainable ways is in this light crucial. With this paper, we have made a step in this direction by summarizing existing literature, presenting further evidence of immaterial flows and land use change, and attempting a first generic characterisation of what constitute such flows.

5. Conclusion

The globalisation of land based products is a dominant theme in LSS. The global disconnection of production and consumption of such products is documented by tracing the material flows of land-based products. Less attention has been given so-called immaterial flows. In LSS literature immaterial flows are not defined, but captured by research on historical relations, latecomer effect, potentiality and revalorization of land, and trans-scalar land use planning. Results from Africa, Asia and Europe support the importance of immaterial flows for land use practices. Combining these results with the literature, this paper characterised immaterial flows by a number of traits. Immaterial flows are always transmitted, translated and interpreted by people. This makes them transformable, layered and latent, and ephemeral. Being non-exhaustive and freely reproducible, they are also diffuse and can travel wide and fast. These characteristics makes immaterial flows harder to capture than material flows but potentially equally important for understanding land use and cover changes. As LSS moves forward more research on immaterial flows are needed, particularly as these might be strongly associated with sustainability initiatives and practices.

6. References

- Bager, S., Perssons, M., Reis, T. 2021. Eighty-six EU policy options for reducing imported deforestation. *One Earth* 4: 289-306. [10.1016/j.oneear.2021.01.011](https://doi.org/10.1016/j.oneear.2021.01.011)
- Brockington, D., Scholfield, K. 2010. Expenditure by conservation nongovernmental organizations in sub-Saharan Africa. *Conservation Letters* 3: 106-113. <https://doi.org/10.1111/j.1755-263X.2010.00094.x>
- Bruckner, M., Fischer, G., Tramberend, S., Giljum, S. 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>
- Bruckner, M., Häyhä, T., Giljum, S., Maus, V., Fischer, G., Tramberend, S., Börner, J. 2019. Quantifying the global cropland footprint of the European Union's non-food bioeconomy. *Env. Res. Let* 14: 045011 <https://iopscience.iop.org/article/10.1088/1748-9326/ab07f5>
- Corbera, E., Martin, A., Springate-Baginski, O., Villaseñor, A. 2020. Sowing the seeds of sustainable rural livelihoods? An assessment of Participatory Forest Management through REDD+ in Tanzania. *Land Use Policy* 97: 102962. <https://doi.org/10.1016/j.landusepol.2017.09.037>
- Coosart, S., Chaplier, J., Lomenie, T. 2017. The French law on duty of care: a historic step towards making globalization work for all. *Bus. Hum. Rights J.*, 2: 317-323. [doi:10.1017/bhj.2017.14](https://doi.org/10.1017/bhj.2017.14)
- Friis, C., Nielsen, J. Ø., 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. DOI: <https://doi.org/10.5751/ES-09480-220430>
- Friis, C., Nielsen, J.Ø. (Eds) 2019. *Telecoupling. Exploring land-use change in a globalised world.* Palgrave McMillan. <https://doi.org/10.1007/978-3-030-11105-2>
- Garrett, R., Lambin, E., Naylor, R. 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. <http://dx.doi.org/10.1016/j.landusepol.2013.03.011>
- Geist, H., Lambin, E. 2002. Proximate Causes and Underlying Driving Forces of Tropical Deforestation: Tropical forests are disappearing as the result of many pressures, both local and regional, acting in various combinations in different geographical locations. *BioScience* 52: 143-150. [https://doi.org/10.1641/0006-3568\(2002\)052\[0143:PCAUDF\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2002)052[0143:PCAUDF]2.0.CO;2)
- Gerschenkron, A. 1962. *Economic backwardness in historical perspective.* Cambridge, Ma: Harvard University Press.
- Hauer, J., Nielsen, J. Ø. 2020. Making land-use change and markets: The global-local entanglement of producing rice in Bagré, Burkina Faso. *Geografiska Annaler: Series B, Human Geography* 102 (1): 84-

- 100 <https://doi.org/10.1080/04353684.2020.1723121>
- Henders, S., Persson, M., Kastner, T. 2015. Trading forests: land-use change and carbon emissions embodied in production and exports of forest-risk commodities. *Env. Res. Let* 12: 125012 <https://iopscience.iop.org/article/10.1088/1748-9326/10/12/125012/meta>
- Kapser, K., Hovis, C., Silva, R., Buckholtz, E., Carlson, A., Dou, Y., Du, Y., Furumo, P., Li, Y., Torres, A., Wan, H., Zaehring, J., Liu, J. 2019. Telecoupling Research: The First Five Years. *Sustainability* 11: <https://doi.org/10.3390/su11041033>
- Kastner, T., Kastner, M., Nonhebel, S. 2011. Tracing distant environmental impacts of agricultural products from a consumer perspective. *Ecological Economics* 70: 1032-1040. <https://doi.org/10.1016/j.ecolecon.2011.01.012>
- Kastner, T., Erb, K., Haberl, H. 2014. Rapid growth in agricultural trade: effects on global area efficiency and the role of management. *Env. Res. Let* 9: 034015. <https://iopscience.iop.org/article/10.1088/1748-9326/9/3/034015/meta>
- Kastner, T., Chaudhary, A., Gingrich, S., Marques, A., Persson, M., Bidoglio, G., Le Provost, G., Schwarzmüller, F. 2021. Global agricultural trade and land system sustainability: Implications for ecosystem carbon storage, biodiversity, and human nutrition. *One Earth* 4: 1425-1443. <https://doi.org/10.1016/j.oneear.2021.09.006>
- Koch, N., Perreault, T. 2019. Resource nationalism. *Progress in Human Geography*, 43: 611–631. <https://doi.org/10.1177/0309132518781497>
- Lambin, E., Meyfroidt, P. 2011. Global land use change, economic globalization, and the looming land scarcity. *PNAS*: 108: 3465-3472. <https://doi.org/10.1073/pnas.1100480108>
- Lestrelin, G., Castella, J., Bourgin, J. 2012. Territorialising Sustainable Development: The Politics of Land-use Planning in Laos. *Journal of Contemporary Asia* 42:581-602 [10.1080/00472336.2012.706745](https://doi.org/10.1080/00472336.2012.706745)
- Lund, J., Sungusi, E., Mabele, M., Scheba, A. 2017. Promising Change, Delivering Continuity: REDD+ as Conservation Fad. *World Development* 89: 124-139. <https://doi.org/10.1016/j.worlddev.2016.08.005>
- Merten, J., Nielsen, J. Ø., Rosyani, F., Faust, H. 2021. Climate change mitigation on tropical peatlands: A triple burden for smallholder farmers in Indonesia. *Global Environmental Change* <https://doi.org/10.1016/j.gloenvcha.2021.102388>
- Meyfroidt, P. 2016. Approaches and terminology for causal analysis in land systems science. *Journal of Land Use Science* 11: 501-522. <https://doi.org/10.1080/1747423X.2015.1117530>
- Meyfroidt, P., Ryan, C., Bremond, A., ... Corbera, E., DeFries, R., ...Haberl, H., ...Heinimann, A., ..Kuemmerle, T., Lambin, E., Mertz, O., Messerli, P., Nielsen, J. Ø., ..Verburg, P., ... 2022. Ten facts about land systems for sustainability. *PNAS* [10.1073/pnas.2109217118](https://doi.org/10.1073/pnas.2109217118)
- Nielsen, J. Ø., Bremond, A., Chowdhury, R., Friis, C., Metternicht, G., Meyfroidt, P., Munroe, D., Pascual, U., Thomson, A. 2019. Towards a normative land system science. *COSUST* 38: 1-6 <https://doi.org/10.1016/j.cosust.2019.02.003>
- Niewöhner, J., Bruns, A., Haberl, H., Hostert, P., Krüger, T., Lauk, C., Lutz, J., Müller, D., Nielsen, J.Ø. (Eds). 2016. *Land Use Competition: Ecological, economic and social perspectives*. Dordrecht: Springer. <http://www.springer.com/in/book/9783319336268>
- Oliveira, E., Meyfroidt, P. 2021. Strategic Spatial Planning in Emerging Land-Use Frontiers—Evidence from Mozambique. <https://doi.org/10.31730/osf.io/t3anz>
- Persson, J., Mertz, O., Nielsen, J. Ø., Ford, S., Zörner, M., Thounthone, V., Keophoxay, N. 2021. Large differences in livelihood responses and outcomes to increased conservation enforcement in a protected area. *Human Ecology* <https://doi.org/10.1007/s10745-021-00267-4>
- Pedersen, R. H., Jacob, T. 2017. Reconfigured state-community relations in Africa's extractive sectors: insights from post-liberalisation Tanzania. *The Extractive Industries and Society*, 4: 915–922. <https://doi.org/10.1016/j.exis.2017.07.004>

- Pedersen, R. H., Mutagwaba, W., Jønsson, J. B., Schoneveld, G., Jacob, T., Chacha, M., Weng, X., & Njau, M. G. 2019. Mining-sector dynamics in an era of resurgent resource nationalism: Changing relations between large-scale mining and artisanal and small-scale mining in Tanzania. *Resources Policy* 62: 339–346. <https://doi.org/10.1016/j.resourpol.2019.04.009>
- Reis, T., Meyfroidt, P., Ermgassen, E., West, C., Gardner, T., Bager, S., Croft, S., Lathuiliere, M., Godar, J. 2020. Understanding the Stickiness of Commodity Supply Chains Is Key to Improving Their Sustainability. *One Earth* 3: 100-115. <https://doi.org/10.1016/j.oneear.2020.06.012>
- Roux, N., Kastner, T., Erb, K., Haberl, H. 2021. Does agricultural trade reduce pressure on land ecosystems? Decomposing drivers of the embodied human appropriation of net primary production. *Ecological Economics* 181: <https://doi.org/10.1016/j.ecolecon.2020.106915>
- Rudel, T., Meyfroidt, P. 2014. Organizing anarchy: The food security–biodiversity–climate crisis and the genesis of rural land use planning in the developing world. *Land Use Policy* 36: 239-247 <https://doi.org/10.1016/j.landusepol.2013.07.008>
- Rudel, T., Mayfroidt, P., Chazdon, R., Bongers, F., Soan, S., Grau, R., Holt, T., Schneider, L. 2020. Whither the forest transition? Climate change, policy responses, and redistributed forests in the twenty-first century. *Ambio*: 49: 74-84. <https://doi.org/10.1007/s13280-018-01143-0>
- Rueda, X., Lambin, E. 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>
- Schaffartzik, A., Haberl, H., Kastner, T., Wiederhofer, D., Eisenmenger, N., Erb, K. 2015. Trading Land: A Review of Approaches to Accounting for Upstream Land Requirements of Traded Products. *Journal of Industrial Ecology* 19: 703-714 <https://doi.org/10.1111/jiec.12258>
- Schilling-Vacaflor, A., Lenschow, A. 2021. Hardening foreign corporate accountability through mandatory due diligence in the European Union? New trends and persisting challenges. *Regulation and Governance* <https://doi.org/10.1111/rego.12402>
- Seaquist, J., Johansson, E., Nicholas, K. 2014. Architecture of the global land acquisition system: applying the tools of network science to identify key vulnerabilities. *Env. Res. Let* 9: 114006 <https://iopscience.iop.org/article/10.1088/1748-9326/9/11/114006/meta>
- Shapiro-Garza, E., McElwee, P., van Hecken, G., Corbera, E. (2020) Beyond Market Logics: Payments for Ecosystem Services as Alternative Development Practices in the Global South. *Development and Change* 51: 3-25. <https://doi.org/10.1111/dech.12546>
- Sikor, T., Auld, G., Bebbington, A., Benjaminsen, T., Gentry, B., Hunsberger, C., Izac, AM., Margulis, M., Plieninger, T., Schroeder, H., Upton, C. 2013. Global land governance: from territory to flow? *COSUST*, 4: 522-527 <https://doi.org/10.1016/j.cosust.2013.06.006>
- Sonderegger, G., Oberlack, C., Llopis, J., Verburg, P., Heinemann, A. 2020. Telecoupling visualizations through a network lens: a systematic review. *Ecology and Society* 25: 10.5751/ES-11830-250447
- Verburg, P., Erb, K., Mertz, O., Espindola, G. 2013. Land System Science: between global challenges and local realities. *COSUST* 5: 433-437. <https://doi.org/10.1016/j.cosust.2013.08.001>
- Yu, Y., Feng, K., Hubacek, K. 2013. Tele-connecting local consumption to global land use. *Global Environmental Change* 23: 1178-1186. <https://doi.org/10.1016/j.gloenvcha.2013.04.006>

Appendix 1

Contributing research projects from COUPLED

Research project 1: Claudia Parra Paitan, data used in this paper is a result of her research project on environmental impact assessments of the telecoupled indirect, distant and multi-scale land use impacts of global agricultural commodity chains.

Research project 2: Simon Bager data used in this paper is a result of his research project on how private companies can promote sustainable land use through their supply chains.

Research project 3: Esteve Corbera, data used in in this paper is a combined result of COUPLED and a decade long engagement in REDD+ and Payment for Ecosystem Services research.

Research project 4: Pin Pravalprukskul, data used in this paper is a result of her research project on sustainable sourcing of agricultural commodities, spill-over effects, and global-local relations.

Research project 5: Johanna Coenen, data used in this paper is a result of her research project on governance institutions for sustainability in globally telecoupled systems.

Research project 6: Anna Frohn Pedersen, data used in this paper is a result of her research project on global flows and local ventures in artisanal and small-scale gold mining.

Research project 7: Joel Persson, data used in this paper is a result of his research project on disentangling the links between global conservation discourses and local land-use practices in protected area governance.

Research project 8. Julie Zähringer, data used in this paper is a combined result of COUPLED and the project Managing telecoupled landscapes for the sustainable provision of ecosystem services and poverty alleviation based at Universität Bern.

Contributing authors

Jonas Østergaard Nielsen, Humboldt University Berlin, jonas.ostergaard.nielsen@hu-berlin.de

Simon Bager, Université catholique de Louvain, simon.bager@uclouvain.be

Johanna Coenen, Leuphana University of Lüneburg, johanna.coenen@leuphana.de

Esteve Corbera, Universitat Autònoma de Barcelona, esteve.corbera@uab.cat

Cecilie Friis, University of Copenhagen, cefr@ign.ku.dk

Anna Frohn Pedersen, Humboldt University Berlin, anna.frohn.pedersen@hu-berlin.de

Thomas Kastner, Senckenberg Biodiversity and Climate Research Centre, thomas.kastner@senckenberg.de

Perrine Laroche, Vrije Universiteit Amsterdam, perrine.laroche@vu.nl

Ole Mertz, University of Copenhagen, om@ign.ku.dk

Claudia Parra Paitan, Vrije Universiteit Amsterdam, claudia.parrapaitan@vu.nl

Joel Persson, University of Copenhagen, jgp@ign.ku.dk

Pin Pravalprukskul, University of Copenhagen, pinp@ign.ku.dk

Siyu Qin, Humboldt University Berlin, siyu.qin@geo.hu-berlin.de

Nicolas Roux, Institute for Social Ecology, Vienna, nicolas.roux@boku.ac.at

Julie Zähringer, University of Bern, julie.zaehring@unibe.ch