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Published in:
Global Environmental Change : Human and Policy Dimensions

DOI:
10.1016/j.gloenvcha.2021.102306

Publication date:
2021

Document Version
Publisher's PDF, also known as Version of record

Global Environmental Change 69 (2021) 102306

Contents lists available at ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

When the whole is less than the sum of all parts – Tracking global-level impacts of national sustainability initiatives

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ARTICLE INFO

Keywords:
Sustainable Development Goals
China
Telecoupling framework
Reforestation
Trade routes
Cross-system social-ecological burdens

ABSTRACT

The United Nations' Sustainable Development Goals (SDGs) are described as integrated and indivisible, where sustainability challenges must be addressed across sectors and scales to achieve global-level sustainability. However, SDG monitoring mostly focuses on tracking progress at national-levels, for each goal individually. This approach ignores local and cross-border impacts of national policies and assumes that global-level progress is the sum of national, sector-specific gains. In this study, we investigate effects of reforestation programs in China on countries supplying forest and agricultural commodities to China. Using case studies of rubber and palm oil production in Southeast Asian countries, soy production in Brazil and logging in South Pacific Island states, we investigate cross-sector effects of production for and trade to China in these exporting countries. We use a three-step multi-method approach. 1) We identify distal trade flows and the narratives used to justify them, using a telecoupling framework; 2) we design causal loop diagrams to analyse social-ecological processes of change in our case studies driven by trade to China and 3) we link these processes of change to the SDG framework. We find that sustainability progress in China from reforestation is cancelled out by the deforestation and cross-sectoral impacts supporting this reforestation abroad. Narratives of economic development support commodity production abroad through unrealised aims of benefit distribution and assumptions of substitutability of socio-ecological forest systems. Across cases, we find the analysed trade supports unambiguous progress on few SDGs only, and we find many mixed effects – where processes that support the achievement of SDGs exist, but are overshadowed by counterproductive processes. Our study represents a useful approach for tracking global-level impacts of national sustainability initiatives and provides cross-scale and cross-sectoral lenses through which to identify drivers of unsustainability that can be addressed in the design of effective sustainability policies.

1. Introduction

With nine years left to meet the sustainable development goals (SDGs) of the United Nation's 2030 Agenda (UN, 2015), research and policy still lack means for an integrated design, implementation and monitoring of development programs across sectors, actors and borders. Failing to consider the complexity of links across social, economic and environmental goals, in time and in space, may lead to unintended (and undesired) social and environmental consequences (Griggs et al., 2013; Leach, 2015; Stafford-Smith et al., 2017; Zeng et al., 2020).

There have been many efforts to understand SDG complexities using different methods, such as expert-consultation (e.g., McCollum et al., 2018; Nilsson et al., 2016) and correlation analyses of target indicators (e.g., Pradhan et al., 2017). These approaches explore interconnections, trade-offs and synergies across goals. Scenario methods map pathways to achieving multiple sustainable goals - even at the global scale – focusing on specific groups or aspects of SDGs, including energy and food related issues (Humpenöder et al., 2018; McCollum et al., 2013;

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https://doi.org/10.1016/j.gloenvcha.2021.102306
Received 1 October 2020; Received in revised form 17 May 2021; Accepted 25 May 2021
Available online 21 June 2021

Muller et al., 2017; Obersteiner et al., 2016; van Vuuren et al., 2012). At national scales, work towards modelling pathways to SDGs is underway (Allen et al., 2016; Gao and Bryan, 2017).

However, understanding how a national initiative contributes to global sustainable development is still not resolved, implying that progress towards achieving the 2030 Agenda can only be monitored post-hoc, and can only inform the design of new initiatives in terms of *gaps*, i.e. by indicating which indicators still need to be improved. In this sense, a more systemic approach to the design and implementation of initiatives that effectively matches the integrated nature of the 2030 Agenda is still lacking.

The telecoupling framework is an analytical approach to examine linkages between regions or places (Liu et al., 2013). Telecouplings have mostly been applied to trade flows and conservation efforts but increasingly include financial flows, migration, invasive species, energy and others (Galaz et al., 2018; Hulina et al., 2017; Liu et al., 2018). Telecouplings focus on people and their environmental contexts and include 'spillovers' (Liu et al., 2018), which represent unintended impacts across seemingly unconnected places or societies.

We here apply the telecoupling framework to track cross-border effects of a national sustainability initiative. Specifically, we analyse the influence of China's reforestation programs on the achievement of SDGs outside the country's borders.

Since the late 1990s, China has implemented reforestation programs that have shown progress from net forest loss to net forest recovery (Feng et al., 2013; Liu, 2013; Liu et al., 2013), and made measurable progress on forest cover targets under SDG 15 – Life on Land. The progress is a result both of a total ban on commercial logging of natural forests and of afforestation programs for different purposes: halting soil erosion and desertification, reducing flood risks and for the conversion of almost 15 million hectares of cropland to forests (Liu, 2013).

Nonetheless, studies suggest that reforestation programs have contributed to increased imports of food and forest products to China, affecting forest cover elsewhere (Lambin and Meyfroidt, 2011; Liu, 2013). As the world's largest trading nation and population, China plays an important role in global sustainability (Liu, 2013), particularly as trade redistributes environmental impacts of policies (Lambin and Meyfroidt, 2011; Lenzen et al., 2012).

The objective of this paper is to illustrate the diversity of cross-scale and context-specific impacts of global change and their relevance to global sustainability, so as to inform the design of effective sustainability practices and their monitoring. To do so, we pull apart aggregated global trade data, which often masks in-country impacts, to identify how reforestation in China influences its forest-products trading partners. We 1) identify forest and agricultural products exported to China that have disproportionate economic importance to countries exporting them; 2) investigate cascading causal effects of increased Chinese demand for these commodities in exporting countries and 3) reframe these effects in terms of their influence on SDG targets.

Our work extends the telecoupling framework to include SDGs and in-depth assessments of impacts on local socio-ecological case study systems. We contribute to filling three identified research gaps: a) better inclusion of how global processes impact on local socio-institutional-ecological dynamics (Friis and Nielsen, 2016, 2017); b) an understanding of immaterial flows – such as discourses and information – in influencing socio-politics and governance (Persson and Mertz, 2019); and c) understanding equity implications of telecouplings (Corbera et al., 2019). This paper takes a step in addressing these gaps by assessing how distant processes impact local human development as mediated by changes in land use, and how these impacts are socially differentiated.

2. Methods

2.1. Tracing trade routes to China

To understand global sustainability impacts of forest policies in China, we trace imports of forest and agricultural commodities that supply China's consumption and production. We use the telecoupling framework (Liu et al., 2013), which has three main components (Fig. 1): (a) sending systems from which a commodity or information comes – here countries that export forestry and agricultural products to China, (b) receiving systems of the commodity or information – here China, and (c) spillover systems which receive unintended impacts of the exchanges between (a) and (b). Within each of these systems one accounts for causes, effects and agents triggering or affected by the impacts. While sending and receiving systems are intuitive and clear to understand, spillovers take various forms; they are akin to externalities as used in economics, leakages, off-site impacts, and indirect impacts (Liu et al., 2018; Pascual et al., 2017).

To identify sending and spillover systems, we centred on China as a receiving system, and assumed that need for land to grow agricultural and forestry commodities drives telecouplings. This follows from forestry policies in China which place restrictions on land use, with demand met in part by imports from other countries (Liu, 2013; Torres et al., 2017). We reflect on this assumption in the discussion.

We systematically selected countries for whom the trade of forest and agricultural commodities to China is economically significant, and can be correlated to reforestation and forest conservation policies in China, i.e., that have changed since the 1990s.

Using the Observatory of Economic Complexity (OEC) (https://atlas.media.mit.edu/) (Simoes and Hidalgo, 2011) – which presents visualisations of traded commodities (in US dollars) from the BACI trade dataset (Gaulier and Zignago, 2010) – we identified seven natural resource categories and for each category, we selected the dominant agriculture or forestry commodity. For each commodity, we identified main exporting countries and selected countries that exported agricultural and forestry commodities primarily to China, and significantly so after the 1990s.

To uncover sending system land use impacts of exporting agriculture and forestry commodities to China, we used data from the Food and Agriculture Organisation of the United Nations (FAO) (http://www.fao.org/faostat). FAO data provide multiple units for commodities, allowing us to relate price variability to fluctuations in volumes traded produced and to land use. The resulting agriculture and forestry commodities used to uncover ecological, social and economic impacts of trade are 1) rubber from Indonesia, Malaysia and Thailand; 2) palm oil from Indonesia 3) soya beans from Brazil and 4) timber from Solomon Islands and Papua New Guinea (Fig. 2 and see Appendix 1 and 2).

2.2. Data analysis: Exploring causes, agents and effects across systems and contexts

For each case study, we examined interactions and feedbacks between flows of investments and trade, exchange of ideas and policy responses, and diversity of local responses – including discourse and equity analyses. To do so we 1) conducted a literature review to understand diverse and nuanced system-wide effects of trade to China in sending systems, 2) built causal loop diagrams to understand the connections between these effects, and what mechanisms determine cascading effects of trade across sending systems 3) related the effects to targets of the SDGs.

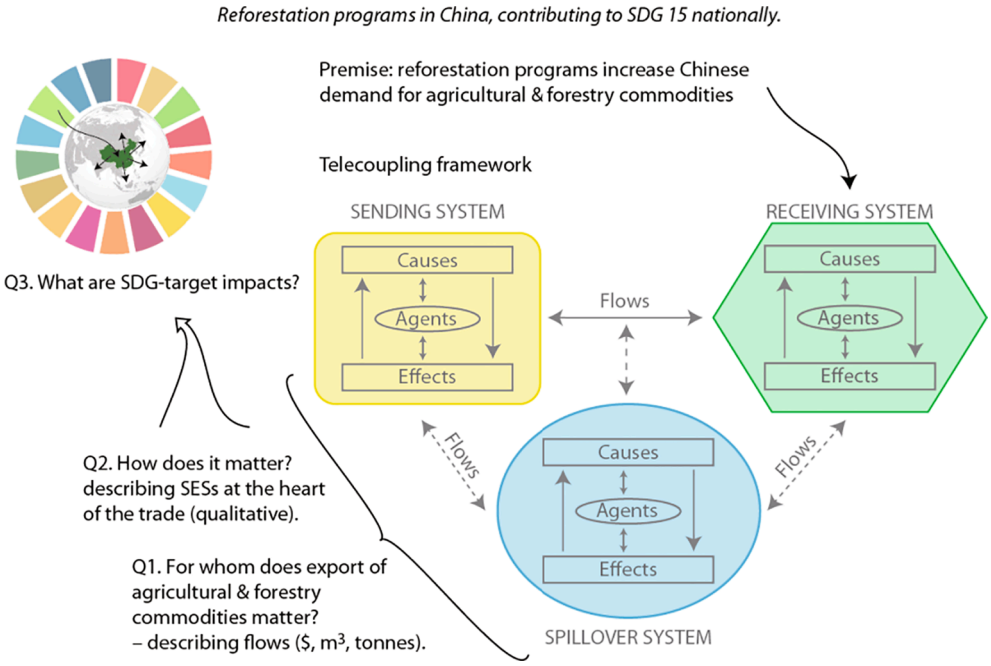

Fig. 1. Methodological approach. Telecoupling framework redrawn from Liu et al., (2013). We frame the analysis around the premise that China's reforestation programs are driving increased imports of agricultural and forestry commodities – making China the main receiving system, pulling trade flows.

2.3. Literature review and case study descriptions

The literature review and previous research experiences of the authors in the case study countries enabled a nuanced understanding of cross-system effects on sustainable development (e.g. Aguiar et al., 2007, 2016; Dyer, 2018; Lapola et al., 2014; Maharani et al., 2019; Wong et al., 2020). The aim was not to be comprehensive. Rather, we sought to illustrate multiple and diverse ways in which social-ecological systems adapt, adjust or transform to changes driven by other social-ecological systems, and in this way, understand processes that connect different dimensions of sustainable development across scales. To do so, we centred case studies on trade and production of selected commodities, and searched literature to understand historical and political context of their production. The case studies were baselines for the design of causal loop diagrams (CLDs, see below), and where questions and gaps appeared from the CLD design, we returned iteratively to the literature search.

2.4. Causal loop diagrams

We built CLDs – based on case study descriptions – to represent cascading impacts at multiple scales of interconnections between the different countries and China. CLDs represent systems with three types of variables: (1) key elements of the system, (2) connections between interacting key elements, and (3) the sign of these interactions. If an increase in the value (volume, demand or economic value) of an element causes an increase in a connected element, the sign is positive (+). If an increase in one causes a decrease in the other, the sign is negative (−).

We identified key elements from the case study descriptions, and using the literature on which these descriptions were built, identified interactions that connect them and their signs (Appendix 2). There are multiple ways of designing systems and their interactions and of framing causal relations. To allow comparability of the case studies' CLDs without losing key traits of each case through over-standardising or generalising, we used a two-level iterative approach. A key challenge we addressed in the iterative approach is difference in availability of research and data across social and environmental disciplines and across cases. Including detailed processes in one CLD for which there is no research in another case, could lead to mis-representations of differences between cases, or of the importance of certain processes relative to others, based only on the availability of research on these areas. To address this challenge, without arbitrarily selecting out available data, for each case study, we first mapped out as many elements and components as we could and identified causal relations based on our literature review. We then used an iterative approach to simplify each system – removing and renaming components to capture the nuance and an even level of detail across case studies. No literature was omitted in the process of simplifying CLDs, as it serves as reference to support the interactions, and inform the SDG-level impacts (see Appendix 3). For example, all CLDs represent 'environmental degradation'. The details of the type of environmental degradation are captured in the data table, and represented in the SDG wheels, where for instance water quality effects are evidenced in the soy case, but not in the timber one – certainly for lack of data, but maybe not for lack of effect (absence of evidence is not equal to evidence of absence). In this way, the CLDs draw out the overarching mechanisms that create the dynamics listed in the case study descriptions without putting added weight on detailed mechanisms.

We then analysed feedback loops in the system; i.e., chains of interactions that go from any element and back to it, through other elements in the defined system. By multiplying the signs of each interaction in a feedback loop, we distinguish reinforcing feedback loops (product of signs is positive), from stabilising feedback loops (product of signs is negative). In these CLDs we highlight which interactions are built on narratives of development, and how these can shape social-ecological dynamics.

2.5. SDG framework implications

We used the SDG framework to evaluate effects of commodity extraction, production and trade in the sending systems. The SDG framework has 169 targets that describe the processes needed to meet each of the 17 Goals. Despite this structure, each target can relate to a number of goals, for example, target 15.6 ('Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally

agreed') is designed to meet SDG 15 (life on land) – and includes aspects of fairness and equality that relate to other goals, including SDG 10 (equality). We systematically linked literature supporting each CLD connection to its matching SDG targets (see Appendix 3). In this way, a CLD connection and the processes described in literature that it describes, can relate to a number of targets under different goals. CLD interactions represent increasing or decreasing effects of one element on the other (+or – sign in the CLD), this effect is not the same as the normative goals expressed in each target, for this reason, we assessed whether the CLD process contributed to meeting the SDG targets (aligned) or not (misaligned). To avoid case-specific biases in the translation of the literature underlying each case to SDG targets, we used an iterative approach whereby from the second case we coded, if a different target was linked to a process, that hadn't been addressed in the previous cases, we returned to the previous cases to ensure a consistent interpretation. For instance, the timber case study reflects gender inequality quite strongly, and prompted us to re-evaluate other cases to ensure differences were based not on our different perspectives of the cases, but on the research available for the different cases. We analysed SDG impacts by aggregating the CLD interaction-target relations to a) the goal level and b) the case level. In this aggregation process, we found that different CLD interactions contributed sometimes in opposing ways to meeting same targets, we identified these instances as 'mixed effects'. Our aim was to connect the multiple impacts represented in the CLDs to the common language of the SDGs, illustrating how interlinked processes may potentially promote or undermine a country's capacity to meet the SDGs. Through this analysis we highlight how a systems approach is essential to the effective implementation of the SDGs.

3. Results

3.1. Telecouplings of forest and agricultural commodities to China

Individual forest and agricultural commodity trade connections represent a very small fraction of China's overall trade. However, these connections can have disproportionately large impacts on trade partners.

Quality and clarity of data differ according to the commodity, where rubber and soybeans data are easily comparable, but different degrees of processing of palm oil are not systematically explicit, and groupings of roundwood differ substantially between datasets (Appendix 1).

The dollar-value of dominant agricultural and forest commodities imported by China varies from up to 18B US$/yr for soybeans to less than 1B$/yr for industrial roundwood. The value of this trade relative to each exporting countries' GDP ranges from less than 1% (soy beans from the USA), to the export of roundwood representing up to 62% of Solomon Islands' GDP.

Wood commodities are challenging to analyse. FAO and OEC categorization of forestry commodities are different, distinctions include the tropical or non-tropical wood, industrial or not, and various degrees of processing. We cannot consistently or coherently compare trade and production trends of these different commodities across sending systems, as FAO data are of poor quality and incomplete. Searching across literature to understand trends also yields different results, illustrating incomplete and flawed data. A consistent result across these datasets is the importance of roundwood, non-coniferous logs for Papua New Guinea and Solomon Islands.

We see a common time-dependent pattern across many sending systems: increased exports to China are first paralleled with increased revenues to the sending systems. Then we see a drop in revenues for each of these commodities over the past 10–15 years, but that coincides with increased production or volumes/weights exported (e.g. rubber from Thailand and Indonesia, palm oil from Indonesia, soybeans from Brazil) or stabilised in others (e.g. palm oil from Malaysia) (See Appendix 1).

3.2. Case studies: causes, agents and effects

3.2.1. Chinese investments in the rubber expansion in Southeast Asia

Malaysia and Indonesia were long-time major exporters of rubber to China, but this pre-dates China's 1990s reforestation policies (Dove, 1993). From the mid-late 1990s, significant areas of rubber plantations in Malaysia and Indonesia were converted to oil palm, primarily for export to China (Cramb and Curry, 2012; McCarthy and Cramb, 2009) and creating a spillover of rubber production in mainland Southeast Asia (Fig. 2).

Thailand is the world's largest producer of natural rubber, with over 1.9 million ha of rubber plantations in 2012 (Fox and Castella, 2013), and nearly 4 million ha in 2016 (Somboonsuke et al., 2019), of which 90% is exported. In Thailand, rubber is mostly produced by smallholdings through the Rubber Integrated Livelihood Systems (RILS), a government programme to support diversified smallholder farming to combine rubber with livestock, fruit, fisheries, rice and other crops. RILS provides higher household incomes than rubber monocrop systems and is argued to better support sustainability and resilience of household livelihoods (Viswanathan, 2008; Viswanathan and Shivakoti, 2008). Thailand's positive experience with the RILS model is an anomaly in the region. Driven in part by the late King Bhumibol's "sufficiency economy philosophy" that focuses on the interests of all stakeholders and long-term profitability, government support – the provision of subsidies, credit and technical extension to smallholders – enables rubber expansion.

As Laos, Cambodia and Myanmar's economies opened up in the late 1990s, entrepreneurs from China, Vietnam, Malaysia and Thailand invested heavily in expanding rubber plantations in these spillover countries (Fox and Castella, 2013; Manivong and Cramb, 2008). By 2011, over 600,000 ha of rubber were planted in Myanmar and more than 280,000 ha in Laos by 2014. In both countries, rubber production is implemented as contract farming systems between farmers and companies, as plantations run by corporations, and as independent smallholder farms; each with different social, environmental and economic impacts (see Kenney-Lazar and Wong, 2016a, 2016b).

China established an Opium Replacement Program (ORP) in 2004 to target opiate production in neighbouring Myanmar and Laos (Lu, 2017). ORP supports Chinese agribusiness investors (primarily rubber companies) to provide opium cultivators with licit livelihood alternatives. Critics dismiss the ORP as a land-grab pretext, because rubber is not an optimal economic or ecological replacement for opium: the crops have contrasting production cycles and market characteristics, and are grown at different altitudes by different types of producers (large corporations and upland ethnic minorities and smallholders, respectively) (Kenney-Lazar et al., 2018; Lu, 2017). Governments of Myanmar and Laos however share similar state discourses of rubber and plantation development as modernising the agriculture sector and have established various land reform policies (e.g. the Turning Land into Capital policy in Laos and the Vacant, Fallow and Virgin Lands Management Law in Myanmar) to facilitate further conversion of perceived low productive smallholdings to modern commercial plantation development (Cohen, 2009; Dwyer and Vongvisouk, 2017; Lu, 2017; Woods, 2011)

In Cambodia, rubber plantations cover 1.2 million ha and make up 80% of total land concessions. Protests against rapid rises in land concessions in Cambodia are increasingly common and violent (Baird, 2017). Investors appear to have deliberately targeted protected areas, with over 70% of the concessions given out in 2012 in Cambodia situated inside national parks, wildlife sanctuaries and protected forests (Warren-Thomas et al., 2015) (https://data.opendevelopmentcambodia.net/map-explorer).

Across these three spillover countries, rubber plantations have had more mixed implications than in Thailand, with strong evidence of dispossession of rural communities from their agricultural and forest lands, increased food insecurity in the conversion of subsistence crop lands to rubber production, and exploitative relations of production

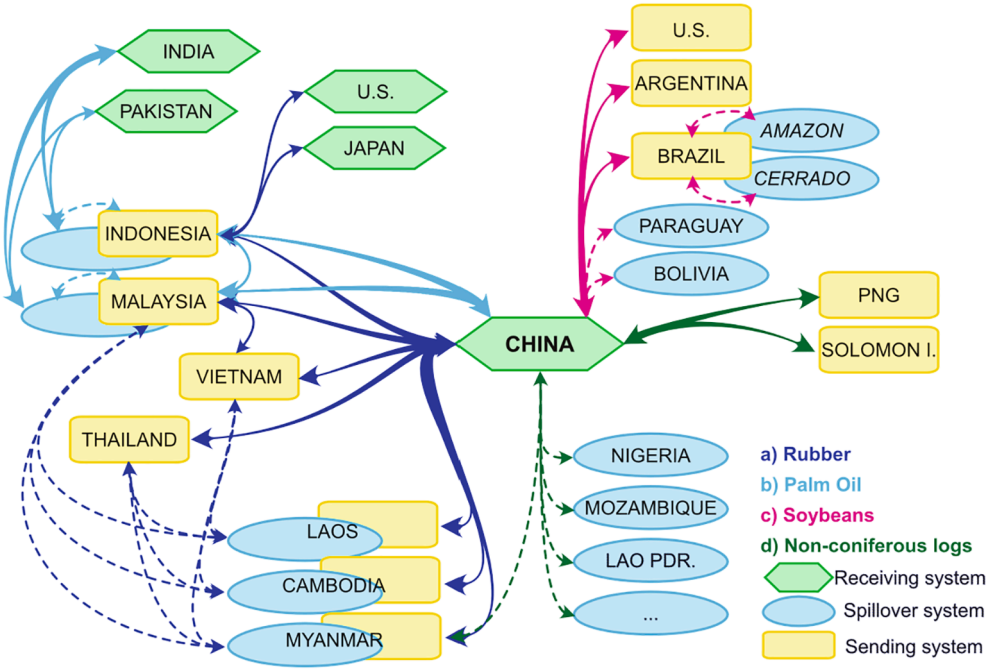

Fig. 2. The telecoupling system(s) of forestry and agricultural commodity trade to China (Appendix 1). Decreasing thickness of arrows indicate a large-to-small cross-scale influences described, e.g. demand from China influences global prices on national supplies, expanding economies investments in spillover countries influence subnational-level planning and land-use. Dashed lines represent spillover flows. For details of the telecoupling system of these four commodities, see Appendix 2. Brazil, Indonesia and Malaysia are represented with spillover systems that represent within country spillovers to new agricultural frontiers. The rubber system of Laos, Cambodia and Myanmar is in ways a spillover of the palm-oil system of Malaysia, as palm oil displaced rubber from these regions to mainland Southeast Asia, and it is a sending system to China.

between farmers and agribusiness companies (Baird, 2009; Fox and Castella, 2013). Demand-driven rubber expansion into marginal upland environments creates exposure to climate hazards, soil erosion and more economic and ecological risks (Ahrends et al., 2015; Ziegler et al., 2009).

3.2.2. Complex dynamics of agrarian differentiation and dispossession around oil palm in Indonesia

China is a key export destination for processed Indonesian palm oil (Rifin, 2013, 2010, see Appendix 1) and Indonesia's processing capacity for crude palm oil more than doubled in two years, to 40 Mt in 2014.

Indonesian oil palm is cultivated mainly in Sumatra and Kalimantan. Production modes vary from independent smallholders to large-scale private estates, with a range of state-managed or brokered arrangements in between (Cramb and Curry, 2012). Oil palm in Indonesia rose from about 5.4 million ha in 2005 to almost 11 million ha in 2014, of which commercial corporations owned 52%, state owned enterprises 7%, and smallholders 41% (Directorate General of Plantation of the Ministry of Agriculture, 2016). An additional 6–7 million ha was reportedly held by corporations but not yet developed (USDA, 2013) and at least 1.8 million ha in Riau province alone was found to be unlicensed and unreported (Anon 2016 in (Li, 2017)). Official figures show that up to mid-2015, more than 5 million ha of forest land have been converted into oil palm plantations (Ministry of Environment and Forestry 2016, cited in (Prabowo et al., 2017)), equal to about half the total plantation area.

Oil palm plantations are contentious in Indonesia. Advocates highlight its contribution to poverty reduction (Edwards, 2016) and jobs generated: oil palm requires on average five times more labour than rubber (World Bank and International Finance Corporation, 2011). However, these jobs may not offer longer term benefits to significantly lift local communities out of poverty (Elmhirst et al., 2017; Li, 2017; Obidzinski et al., 2014). While some residents of plantations have increased opportunities with infrastructure, healthcare and schooling (Obidzinski et al., 2012), many suffer negative effects including the co-optation of customary institutions, loss of forests, polluted water, gender inequalities and lost access to diverse and flexible farming futures (De Vos, 2016; Elmhirst et al., 2017; Li, 2017; Semedi and Bakker, 2014).

Social impacts vary between types of landholder and modes of incorporation into oil palm systems (Obidzinski et al., 2012). Incorporation can involve both large-scale corporate land acquisition and forging smallholder leasing/contract schemes, coupled with the arrival of migrant contract workers. Smallholders may readily convert their fields to oil palm (Feintrenie et al., 2010b): the crop has enabled the emergence of a class of small-scale independent investors (Cramb and McCarthy, 2016). Incremental land acquisitions for oil palm investment signal entrepreneurialism and rural dynamism, but also bring complex patterns of agrarian differentiation and dispossession. These structural variations make it possible to identify both cases of dispossession, accompanied by conflict and resistance (De Vos, 2016; Li, 2011; McCarthy, 2010), and cases of smallholder 'enthusiasm' for oil palm, attracting policy responses aimed at facilitating production and access to value chains (Rist et al., 2010). In parts of Sumatra where villagers are organized and oil palm companies are eager for access to land, deals may be favourable to smallholders (Feintrenie et al., 2010a). In Kalimantan, typical deals are more coercive, requiring customary landholders to give up 10 ha of land to the company, in return for which the company plants two ha with oil palm for the landholder but charges the landholder for the costs of developing the plot (Cramb and McCarthy, 2016; Semedi and Bakker, 2014). This leads to increased indebtedness, loss of social relations and creation of village enclaves within corporate plantations (Li, 2018).

3.3. Social-ecological systems of soy in Brazil

China sources high-protein fodder soy primarily from Brazil, the US and Argentina. Brazil contributes to more than 50% of China's total imports and this trade is increasingly important for Brazil's trade balance. In 2014 total exports of soy products represented 13% of total annual export revenues (Martinelli et al., 2017).

At the end of the 1990s, soybean production started expanding in the northern region of the Amazon, prompting environmental concerns and international reactions which, by the mid-2000s, stabilized expansion into the Amazon. The Cerrado is the modern industrial agricultural frontier since the 1980s (i.e. high productivity, high input, large-scale farming), where soybean development is now centred in the Cerrado area known as MATOPIBA, between the Central-West and Northeast of Brazil. Expansion has occurred on natural vegetation areas or substituting other land uses, such as cattle ranching, leading to indirect

deforestation processes (Lapola et al., 2014, 2010). Brazil's soybean planted area was 32.2 million ha in 2015, 3.8% of the country's territory.

Beyond deforestation, there are multiple and sometimes contrasting perspectives on current and future impacts of the China-Brazil soybean system. From an economic and political perspective, soy trade with China has boosted Brazil's agribusiness sector, which as a whole is responsible for 25% of Brazil's GDP (Lapola et al., 2014). However, this creates a dependence on a single country, where positive outcomes are highly dependent on currency exchange rates (Meyfroidt et al., 2014; Richards et al., 2015; Richards, 2012). Furthermore, soy economy's importance creates political reinforcing feedbacks, where governments promote and redirect investments to monoculture agriculture through credit and infrastructure (to which China contributes). This consolidates monoculture systems, potentially locking-out other actors and agriculture models – small-scale farming, less harmful practices, local market food production (Hunke et al., 2015; Muller et al., 2017; Sparovek et al., 2015). The agribusiness sector has become a powerful and influential political block around pervasive social and environmental issues (Lapola et al., 2014; Oliveira and Hecht, 2016; Rochedo et al., 2018; Wolford and White, 2013). Land reform has stopped and violent crimes in rural areas are on the rise, relating in part to land and resource-use disputes (Souza et al., 2015; Waiselfisz, 2015). Agricultural lobbies are pushing to relax environmental regulations on pesticides and for a revision of the Forest Code to allow agricultural expansion (Oliveira, 2016; Soares-Filho et al., 2014; Sparovek et al., 2012). Though the Cerrado is a biodiversity hotspot it now has less than 10% of protected area and presents deforestation rates higher than those in the Amazon (Lahsen et al., 2016).

The soy agribusiness has complex social impacts. With few exceptions (Choi and Kim, 2016), soy municipalities present better social indicator values than non-soy ones (Garrett and Rausch, 2016; VanWey et al., 2013; Weinhold et al., 2013), but soy municipalities also show higher inequity than non-soy municipalities (Garrett and Rausch, 2016; Martinelli et al., 2017; Weinhold et al., 2013). Medium-sized soy municipalities – especially in the MATOPIBA – have high urbanization rates, attracting people from other states to work in off-farm specialized jobs (Garrett and Rausch, 2016; Richards and VanWey, 2015). Trends of land concentration and income inequality in soybean expansion areas are of concern. In combination with a lack of support to small-scale farmers (Baletti, 2014), inequity contributes to the already chaotic urbanization process in different areas (Brelsford et al., 2017; Kanai, 2014; Mansur et al., 2018), where over 11 million Brazilians live in slums without proper sanitation (Lapola et al., 2014; Martinelli et al., 2010).

3.4. *Logging deals for ownership and profit in Papua New Guinea and Solomon Islands.*

Solomon Islands and Papua New Guinea (PNG) have among the highest forest cover proportionate to land area in the world. PNG also has the world's third largest rainforest after the Amazon and Congo. Both countries are listed as biodiversity hotspots (Myers et al., 2000), and PNG hosts more than 5% of the world's biodiversity (Faith et al., 2000).

70% of PNG's land area is covered by forest. Local and indigenous groups own 97% of this forest under a customary land tenure system whereby lands are inalienable - i.e., they cannot be sold and are held in intergenerational trust (Armitage, 2002). Though protected in the constitution, customary land tenure has been undermined by 99-year Special Agricultural Business Leases (SABLs) to companies. As of 2011, SABLs had been granted over 5 million ha of customary land – 11% of PNGs total land area (Filer, 2011a). Though SABLs were established to free land for agricultural development, limited oil palm plantations have been developed, and research indicates that SABLs constitute a land grab for logging while bypassing PNGs logging legislation (Nelson et al., 2014).

SABL deals have ostensibly been brokered by representatives of customary land holding groups. However, it is well-documented that SABLs facilitate and reproduce elite capture by politicians and others – exclusively men – involved in these business dealings (Cammack, 2011; Filer, 2014, 2011b). In violent clashes between customary land-owners and company lease holders, government military forces have protected the "rights" of companies over land owners (Lattas, 2011). Women have been disenfranchised through their exclusion from business dealings and from positions of representation from local to national levels (World Bank, 2012). Women's loss of autonomy over their livelihoods, high and persistent levels of violence generally and against women in particular have caused decreased influence of women in decision making (Independent State of Papua New Guinea, 2015; Pryke and Barker, 2017). Local logging consequences include forest degradation; loss of natural resources; of access to timber and non-timber forest products; and loss of income as foreign logging companies use loopholes in tax and royalty accounting (Forest Trends, 2006).

Logging in Solomon Islands also represents forest degradation, with minimal land conversion to plantations or other agricultural uses. Although Environmental Impact Assessment (EIA) are necessary for obtaining logging licences, up to 2009, no EIA had been produced for any of the logging licences granted (Gay, 2009). There are more recent cases of legal challenges against granted logging licences due to lack of EIA (Dyer, 2017). Satellite imagery and on-the-ground reporting indicate widespread illegal logging by foreign companies that have sidestepped environmental best practice (Gay, 2009; Wairiu, 2007). Additionally, estimates of sustainable yields for Solomon Island forests have been consistently and increasingly overshot (Katovai et al., 2015).

While logging has been vital to national export earnings, there has been elite-capture of the majority of economic benefits of logging and a lack of wider infrastructural or other improvements for the nation as a whole (Dyer, 2017; Kabutaulaka, 2000; World Bank Group, 2017) (Fig. 3). Foreign logging companies have avoided payment of taxes through routine underreporting and complex financial trickery such as transfer pricing (Kabutaulaka, 2006, 2000). Timber export values and quantities are unreliable – suggesting huge losses in income and timber resources.

The tight co-evolution of modern Solomon Islands politics with logging by large-scale foreign companies has led to dispossession for village dwelling landowners and to their decreased ability to make important decisions over land. This narrows and rigidifies the flexible nature of the customary land tenure system and in some cases, it leads to privatisation of customary land to individuals (Bennett, 2000; Monson, 2011). Decision making is often limited to a small group of influential men, and women have mostly been excluded from business and land negotiations (Dyer, 2018; World Bank Group, 2017). Because of logging's importance to Solomon Island politics, gendered dimensions of governance run from local to national levels (Prowse et al., 2008).

3.4.1. *Causal loop diagrams*

The starting point of all CLDs was the impact of demand for the commodity from China, and the iterative process converged towards

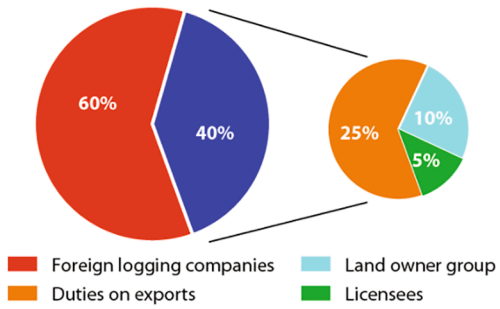

Fig. 3. The division of profit on a logging operation (Gay, 2009; Wairiu, 2007).

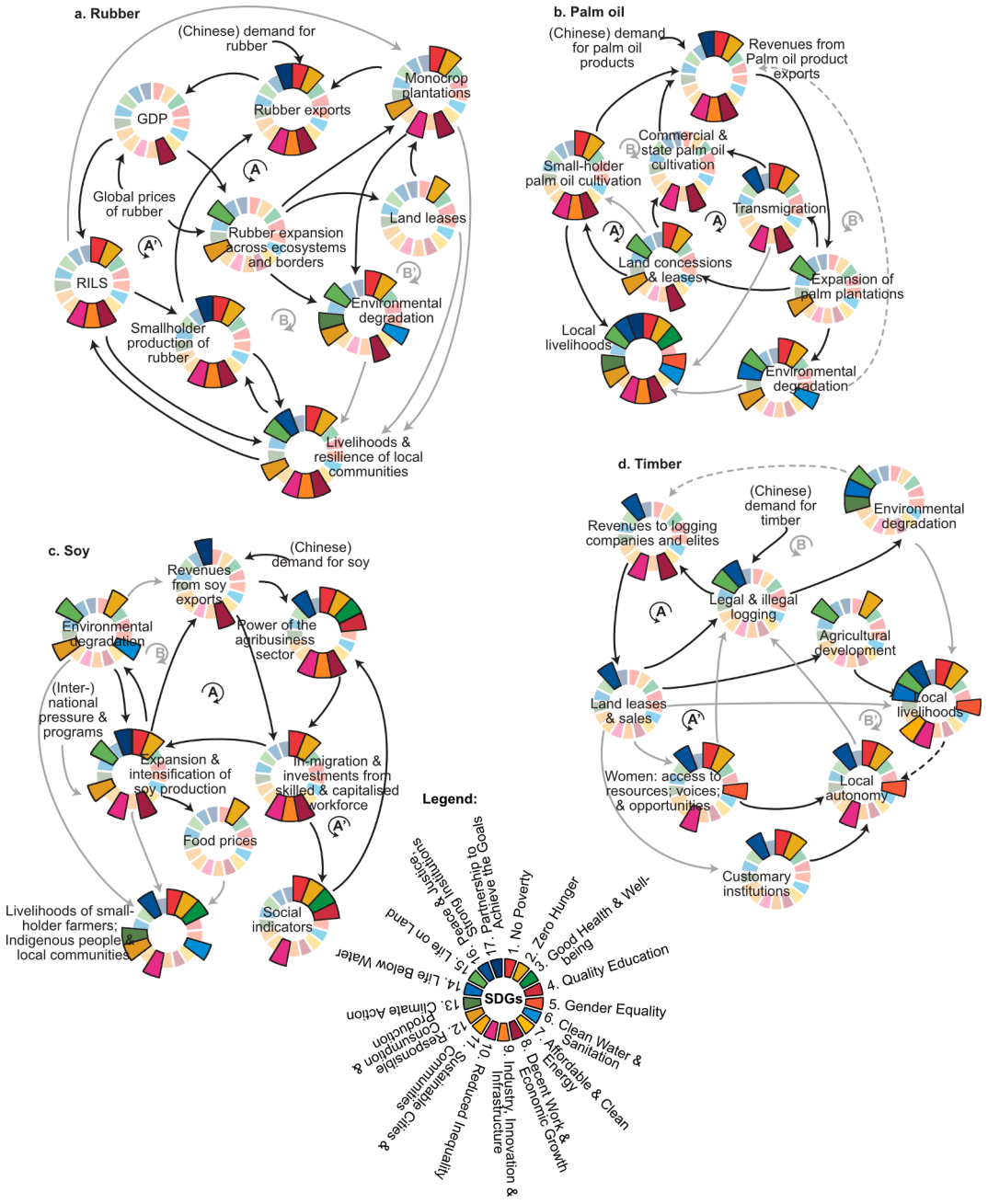

Fig. 4. Causal Loop Diagrams representing the processes (arrows), variables (text) and SDGs (coloured wheels) influenced by Chinese demand for these commodities. Black arrows represent an increasing effect on the variables; grey arrows represent a decreasing effect. The emphasized goals on each wheel represent those influenced by the interactions to that variable. (e.g. when increased GDP promotes the expansion of rubber production, it influences targets under SDGs 13 and 15). The influence on SDGs around any single variable can be both aligned with or against the goals of the 2030 Agenda. Not all variables exist in all exporting countries, (e.g. RILS is exclusive to Thailand). Loops A and A' represent continued demand, production and exports (reinforcing feedbacks). Loops B and B' represent the stabilising feedbacks in which environmental or social processes decrease production (CLD details are in Appendix 3).

loops with 9–11 key elements, and between 15 and 22 interactions, depending on the case study (see Appendix 3).

In the case of rubber (Fig. 4a), we outline two mechanisms that support Chinese demand: the first is monocrop plantations that prevail in Indonesia, Malaysia and frontier countries, and the second is Thailand's RILS. Both mechanisms are part of reinforcing feedbacks, and with continued increase in demand for rubber, both lead to the expansion of rubber production (Table 1, Table 3.1 in Appendix 3). However, should demand for or price of rubber fall, only the RILS system offers alternatives that can buffer economic and livelihood impacts of such falls.

Palm oil presents a complex system, where repercussions of expansion differ according to localised contexts. We illustrate this with both a positive and a negative effect of land concessions and leases on small-holder farmers, specific situations determine which interaction prevails. We found no literature that explored the role of livelihood quality on further expansion and production of palm oil (no feedback identified). Instead, different authors cite situations where palm oil production improves livelihoods through access to infrastructure, employment and education, and others where palm oil contributes to dispossession, health impacts through environmental degradation and inequities between ethnic, social and gender groups (Fig. 4b, Table 1 and Table 3.2 in Appendix 3).

Continued expansion of soy production rests in tight links between

Table 1
Examples reinforcing (A, A') and stabilising (B, B') loops from the causal loop diagrams in Fig. 4, the narratives that justify the expansion, and the flaw in the assumptions that support the narrative. Loops are reinforcing when the product of the signs of the arrows along a full loop is positive, and stabilizing when the product is negative (here shifts in sign are indicated in a shift to/ from italics).

	a. Rubber	b. Palm oils	c. Soy	d. Timber
A loop	GDP -> Expansion across ecosystems & borders -> Monocrop plantations -> Exports -> GDP	Revenues from exports -> Expansion of plantations -> Land concessions & leases ->Commercial & state cultivation -> Revenues from exports	Revenues from exports-> In-migration & investments from skilled & capitalised workforce -> Expansion & intensification of exports -> Revenues from exports	Revenues to logging companies & elites -> Land leases & sales -> Legal & illegal logging -> Revenues to logging companies and elites
A' loop	GDP-> RILS -> Livelihood and resilience of local communities -> Smallholder rubber production -> Rubber exports -> GDP	Revenues from exports -> Expansion of plantations -> Land concessions & leases -> Small-holder cultivation -> Revenues from palm oil product exports	Revenues from exports-> In-migration and investments from skilled & capitalised workforce -> Social indicators -> Power of agribusiness sector -> In-migration and investments from skilled & capitalised workforce -> Expansion & intensification of production -> Revenues from exports	Revenues to logging companies & elites -> Land leases & sales -< *Women: access to resources, voice, opportunities* -< Legal & illegal logging -> Revenues to logging companies & elites
B loop	GDP -> Expansion across ecosystems & borders -> Environmental degradation -< *Livelihoods & resilience of local communities -> Smallholder production -> Exports -> GDP*	Revenues from exports -> Expansion of plantations -> Land concessions & leases -< *Small-holder palm cultivation -> Revenues from palm oil product exports*	Revenues from exports-> In-migration & investments from skilled & capitalised workforce -> Expansion & intensification of production -> Environmental degradation -< *Revenues from exports*	Revenues to logging companies & elites -> Land leases & sales -> Legal & illegal logging -> Environmental degradation (?) -< *Revenues to logging companies & elites*
B' loop	GDP -> Expansion across ecosystems & borders -> Land leases -< *Livelihoods & resilience of local communities -> Smallholder production -> Exports -> GDP*	Revenues from exports -> Expansion of plantations -> Environmental degradation -< *Revenues from exports*		Revenues to logging companies & elites -> Land leases & sales -> Agricultural development -> local livelihoods ->(?)local autonomy -< *Legal & illegal logging -> Revenues to logging companies & elites*
Narratives underlying expansion of production	Unproductive and waste lands can be converted into capital for productivity, economic growth and support trade and market linkages	Palm oil provides employment and revenues to local communities - and is largely operated by smallholders	Soy production results in improved social indicators	The cleared forests make way for palm agriculture that benefit local communities and lifts out of poverty
Falsifiable assumption supporting narrative	Modern agriculture as win–win–win for production, investments and economic growth, and rural development for poor farmers	Oil palm plantations support economic growth that will lead to increased revenues to local farmers and improved infrastructure, more jobs and reduced poverty in the planting regions.	The social indicators reflect improvements in social conditions for local communities, rather than a change in the sampled communities through in migration of skilled and capitalised workforce and displacement of disenfranchised local people	1. Agricultural development is actually taking place at a pace that matches the dispossession through deforestation2. Palm plantations are better development support than native hardwood forests

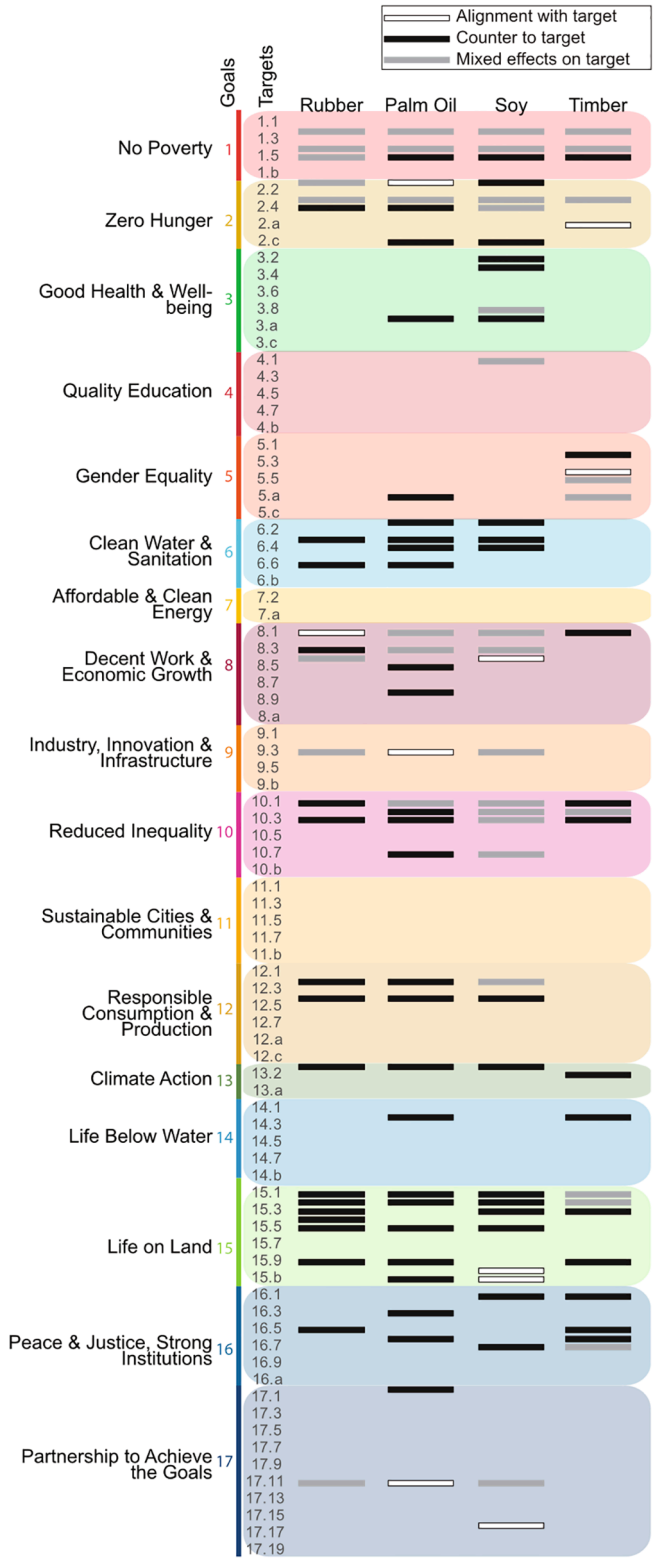

Fig. 5. Targets and goals addressed in each case study, and combined effects of interactions on each target. All 169 targets are represented, though we present only labels for alternate targets.

agribusinesses and governance. Literature and current political events suggest that these links outcompete stabilising roles of environmental regulations. Until recently, (inter-) national pressure to protect the Amazon contributed to limiting expansion of soy in the Amazon, though such pressures didn't expand to the Cerrado. Today's political regime seems to outpower effects of international pressure, and coincides with trade tensions between the US - another important soy sending system - and China. The discourse of soy plantations contributing to positive development relates to measures taken within soy areas. Here, in-migration of skilled and capitalised workers and dispossession of local and indigenous groups creates positive changes in social indicators, but may represent changes in communities being analysed rather than improvements of conditions for given communities over time. We found no literature describing how changes in the livelihoods of smallholder farmers or indigenous people and local communities influence these statistics. For this reason, the soy CLD has no feedback representing the role of local people and communities in stabilising expansion and production of soy (Table 1).

In the timber case study, elite capture of resources is the main mechanism driving further logging. We here put together legal and illegal logging, which co-exist when there is underreporting of exports and/or failure to complete required environmental assessments. Women are both excluded from negotiations on logging deals – *because they are women,* and are an important part of local resistance movements to logging companies. We therefore highlight the gendered impacts of logging in the two pacific islands. The relationships between gender equality and customary institutions are not clear. We represent the importance of both for local autonomy in the CLD (Fig. 4.d), but it is very likely that both contribute differently to increasing autonomy, and might not support each other (i.e., increased gender equality could be at odds with customary institutions, and customary institutions might not support gender equality). Indeed, before logging and exports to China were established, Solomon Islands had been first under British rule and then suffered years of civil unrest and conflict. Gender inequalities in Solomon Islands and PNG range across connected issues of domestic violence against women; limited education and absence of women in decision-making positions (Asian Development Bank (ADB) (2015)).

3.4.2. SDG framework implications

We analysed the CLDs through the SDG framework lens, identifying which targets the different interactions relate to, and how these interactions lead to meeting (alignment) or diverging from (counter to) the targets (Fig. 5, and Appendix 3).

Alignment or mixed effects with regards to SDG targets imply that mechanisms to achieve these particular targets exist. Where the combined impacts of interactions are counter to the target, only processes that go against achieving the SDG targets are in place (Fig. 5). Across case studies, in the 60 interactions described and documented (Fig. 4), we found 377 influences to individual targets (as each interaction could influence multiple targets: Appendix 3), combining to 119 target impacts, of which 59% were misaligned with SDG targets, 8% were aligned, and 33% were mixed. Impacts generated by the case studies always presented misalignment with SDGs 6 (clean water and sanitation), 13 (climate action) and 14 (life below water), and frequently presented misalignments with SDGs 12 (responsible consumption and production), 15 (life on land) and 16 (peace, justice and strong institutions). The palm oil case has the highest fraction of negative SDG-target level effects (75% are misalignments), whereas the soy case study represents the case with fewest (46% are misalignments).

We see that SDGs with an environmental focus (e.g., 6, 13, 14) are generally negatively impacted by the cascading effects of reforestation programs in sending systems, whereas goals that focus on society have more mixed effects. The presence of mixed effects indicates that processes supporting the achievement of SDGs exist, but that they are overshadowed by processes that go against these goals. The presence of mixed effects on societal goals is also perhaps a reflection of social inequities and the unequal effects of development, either when only a subsection of societies are able to improve their livelihoods (for instance when benefits are only distributed to those in direct connection to plantations, without any effective mechanism for the distribution of benefits at a national level) (and/) or when benefits to some depends on

others bearing costs of that 'development' (for instance when women are prevented from carrying out their own livelihood activities).

Our analysis illustrates this through the mostly mixed effects that increased exports to China have on poverty and hunger eradication, on economic growth and equity for instance (SDGs 1, 2, 8 and 10), and predominantly conflicting effects of trade on targets of the environment and natural resources goals (SDGs 6, 13, 14, and 15). Instances where the processes only show alignment with SDG targets are few. Interestingly, two such instances concern targets of SDG 15 in the Brazilian soy case study. This relates to the role of national and international institutions and policies can play in limiting expansion and intensification. The reason such processes have an unmitigated effect on targets 15.a and 15.b however, is because no other interaction in our diagrams addressed these particular targets. In this way, the policy and institutional processes have here a 'niche' effect, which can be a strength, but can also be diluted at the overall goal level, when multiple conflicting processes influence other targets of the same goal.

4. Discussion

4.1. Achieving sustainable development goals beyond national borders

Even if only considering forest cover and land use (or SDG 15, life on land) – we find that national-level benefits of reforestation programs in China are vastly cancelled out by deforestation and environmental degradation driven by these programs in sending systems. A root cause of this *status quo* is clear: continued (increased) consumption and processing of agricultural and forestry commodities that are not being supplied nationally require their production and supply abroad. The forests gained and those lost through these cross-border compensation processes are not equal nor interchangeable: each forest area is part of unique assemblages of evolving social, cultural and biogeophysical processes and each such assemblage contributes to the evolution and development of global social-ecological processes. Removing such assemblages or their autonomy or ability to govern towards their own goals compromises global sustainable development.

We started with the assumption that reforestation programs in China were the cause of cascading effects across telecoupled systems. This framing is useful for our analysis, but does not imply that halting the reforestation programs would 'restore' sustainable development to the case-studies here narrated, or even globally. Palm oil for instance is not readily grown in China – and reforestation can therefore not be a cause of palm oil expansion, but palm oil is not independent from the telecoupling system either – as it drives spillovers of rubber production in mainland Southeast Asia. Though the reforestation programs are related to China's increased demand of agricultural and forestry commodities (Environmental Investigation Agency, 2018), the causes are more complex, multiple and interdependent (Liu, 2013). The assumption that reforestation only displaces forestry and agricultural production is also a simplification, as mining and other types of extraction and land use are also carried out internationally for Chinese (and other) markets – and are likely to shape the achievement of sustainable development goals. Demand growth of agricultural commodities and international trade are long-time processes around the world – and are easily exemplified by such a big country and economy as China's. Furthermore, China is not only a consumer of these commodities, but an important processor of them into goods that are further traded. Though our starting assumption is bold, it allows us to identify nuanced effects of trade and global value chains, and to identify processes and mechanisms that hinder or halt the achievement of sustainability goals, and though the assumption shaped the design of our study, the conclusions we draw do not depend on the assumption's accuracy.

We show here how trade is as a back-door through which environmental and social consequences of national sustainability initiatives are displaced and masked. Indeed, although each trade route described plays an important role in shaping social-environmental dynamics and (sustainable) development of sending and spillover systems, these trade routes represent only a small drop in the ocean of trade on which the Chinese economy is built.

With this displacement of impacts comes a blurring of discursive power, land and resource politics and economic interests that rush into the space of production and extraction. The variety of actors within this space (e.g., customary land owners, individual farmers, governments, businesses, migrants, underlying financial actors or consumers) have different capabilities, agency, responsibilities and power leading to varying insecurities. One cannot account for impact or responsibility displacement in the quotas of goals and targets of the 2030 Agenda. According to the latest Sustainable Development index report (SDSN, 2019), which assesses where each country stands with regard to achieving the SDGs, China currently ranks 39th (out of 162). This report ranks China's spillover score as 96.1 (where 0 is bad and 100 is good). In light of our study, we suggest a more appropriate spillover scoring system would assess how much national progress is made at international cost.

This limited accounting of out-of-country impacts points to significant blindspots in how monitoring for sustainability is currently designed. The problem becomes even more pronounced as more spillover type indicators – such as virtual resources, trade, human displacements and others – are considered (Galaz et al., 2017; Lenzen et al., 2012; Wilting et al., 2017). Here, through the lense of trade, we highlight how such monitoring blindspots render the implementation of national sustainability initiatives globally ineffective - and enable business as usual in terms of unsustainable development. The sustainable development 2019 report states that spillovers must be '*understood, measured and carefully managed since countries cannot achieve the SDGs if others do not do their part*' (SDSN, 2019, p. 14). The results of our analysis lead us to more critical conclusions: we conclude that the sustainable development of some nations – here highlighted in the example of China – is taking place at the cost of sustainable development in other nations. This goes against the UN's 2030 Agenda central mantra of 'leaving no one behind'.

4.2. Developing the telecoupling framework

In this study, we aimed not only to trace cross-border and cross-system impacts of Chinese reforestation programs but also to develop the telecoupling framework, specifically to fill three gaps: 1) understanding the local socio-institutional-ecological dynamic impacts of global changes (Friis and Nielsen, 2016, 2017); 2) understanding immaterial flows of discourse and information that affect socio-politics and governance (Persson and Mertz, 2019) and 3) understanding equity implications of telecouplings (Corbera et al., 2019).

We propose that investigating three crucial questions can fill these gaps: 1) *How* are trade deals done? Who are included, who are excluded? 2) *Why* do sending systems pursue specific models of production and extraction – i.e. What narratives do they use to justify the implications and 3) *For whom* are the trade deals done?

Across cases, State narratives of economic development (#2: *why?*) support the exploitation, expansion and exports of agricultural and forestry commodities in sending systems. This form of economic development has often generated fewer benefits to a much smaller segment of society than expected (#3: *for whom?*) and policies have enabled large scale homogenous landscapes of cash crops to replace multifunctional protected areas (c.f. oil palm in Indonesia), complex and unique forest systems (c.f. Pacific Islands and the Amazon) or multi-cropping systems (e.g., rubber in spillover countries). These narratives are based on the assumption that economic benefits of exploitation, expansion and exports will be distributed where they are needed and contribute to achieving the minimum wellbeing of those most in need. However, this assumption has not materialized where development needs have been transferred to corporations and market-led processes, or when capacity and social safeguards for inclusive engagement of local

smallholders are not prioritized within State policies (#1: *how?*). These narratives further and falsely assume that economic benefits compensate for well-being impacts of lost food crops, of lost access to resources and of environmental degradation.

4.3. Implementation for global sustainable development

We find that existing social and environmental *regulations, policies or laws* are insufficient to mitigating increased demand and exploitation in our case studies. Such measures are effective in managing rubber production within Thailand, but – with continued increases in demand – expansion is pushed beyond Thailand's borders. In the absence of measures to maintain sustainable rates of production and demand, these stabilising processes might take effect through potentially catastrophic *consequences*, such as environmental degradation that prevents further cultivation of crops or support of livelihoods through access to basic ecosystem services (e.g. water access) and through deterioration of human conditions that lead to conflict and breakdown of social and governance structures. In the cases described, social and environmental impacts are being felt by many. To ensure that sustainability initiatives don't solely benefit some at the expense of others, regulations need to be implemented regarding traded products, monitoring needs to account for impacts displaced through trade, and accountability needs to match power. In short, issues of distribution and of transnational equality need to be addressed (Piketty, 2020).

From sub-global levels we see sustainability as through a kaleidoscope: the image changes as we turn the questions and perspectives. For instance, palm oil is a tradeable commodity with a global pricing; oil palm also represents land – that has variable qualities; and livelihoods – with different ranges of opportunities. How, for whom and where palm oil production can contribute to sustainable development is dependent on the land and people it involves, and the alternatives it takes away from or creates for future generations.

Mixed method approaches are a useful means to turn the kaleidoscope of sustainable development. In this study we emphasize qualifying the quantitative aspects of sustainability monitoring, to reveal the unknown unknowns of sustainable development, i.e. those emergent properties, unexpected cascading events or shadow networks (Westley et al., 2011) operating around sustainability interventions. We also find value in quantifying qualitative approaches. Indeed, SDG 12 – on sustainable consumption and production – can and often is interpreted as a qualitative goal: 'to consume and produce better' – but quantification is necessary to understand, monitor and achieve sustainable consumption and production on our finite planet (Almond et al., 2020; Downing et al., 2020; Resare Sahlin et al., 2020), that needs emphasis for impact. Here, China accounts for nearly 20% of the gap in achieving SDG12 and together with just the United States and India, they account for 40% of the gap (SDSN, 2018).

Aristotle and complex systems science tell us that the 'whole is greater than the sum of its parts'. We find that the whole picture of the global impact of reforestation programs in China is less than the sum of its parts – the contribution of these forestry programs to global sustainable development is, at best, insufficient. We need a complex system's perspective - relying on cross-scale and cross-system interactions, to effectively monitor and design those transformative sustainability initiatives that can lead to sustainable development.

5. Conclusions

What happens if sustainability monitoring remains based on aggregated values for broadly standardised variables (such as SDG indicators)? And what happens if this method is confined to national borders? This approach to sustainability monitoring assumes that aggregated outcomes are better outcomes – for example when one country meeting its forest cover targets is understood as progress, irrespective of the underlying processes and differentiated outcomes. In fact, such aggregated outcomes can be achieved at the cost of others – creating inequality and displacement, and thus leading to achieving SDGs without achieving the overarching goal of sustainable development (Lim et al., 2018). Current monitoring and implementation approaches mask the real, nuanced and multifaceted impacts of changes across-scales and systems, and in this way also hide the opportunities for transformative changes to sustainable development.

We here present an approach that accounts for nuanced and multifaceted impacts of change across systems. Our contributions to the telecoupling framework are a critical tool in the design and implementation of sustainable development interventions that explicitly include assessments of cross-scale impacts. The Causal Loop and SDG analysis can be used to specifically identify and align processes so that they combine to meet development goals.

CRediT authorship contribution statement

Andrea S. Downing: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing - original draft, Writing - review & editing. **Grace Y. Wong:** Conceptualization, Investigation, Methodology, Writing - original draft, Writing - review & editing. **Michelle Dyer:** Conceptualization, Investigation, Writing - original draft. **Ana Paula Aguiar:** Conceptualization, Methodology, Writing - original draft. **Odirilwe Selomane:** Conceptualization, Data curation, Investigation, Formal analysis, Writing - original draft. **Amanda Jiménez Aceituno:** Conceptualization, Formal analysis, Investigation, Methodology, Visualization, Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The work of ASD, GYW, MD, OS, APA and AJA were supported by the GRAID programme at Stockholm Resilience Centre. The input of Andrea Downing was also made possible by funding from the Erling-Persson Family Foundation through Global Economic Dynamics and the Biosphere, the Royal Swedish Academy of Sciences. We thank Patrick Flege for his research contributions in the early stages of the project.

Appendices 1–3. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gloenvcha.2021.102306.

References

Aguiar, Ana Paula Dutra, Câmara, Gilberto, Escada, Maria Isabel Sobral, 2007. Spatial statistical analysis of land-use determinants in the Brazilian Amazonia: Exploring intra-regional heterogeneity. Ecol. Model. 209, 169–188. https://doi.org/10.1016/j.ecolmodel.2007.06.019.

Aguiar, Ana Paula Dutra, Vieira, Ima Célia Guimarães, Assis, Talita Oliveira, Toledo, Peter Mann, Santos-Junior, Roberto Araújo Oliveira, Batistella, Mateus, Coelho, Andrea Santos, Savaget, Elza Kawakami, Aragão, Luiz Eduardo Oliveira Cruz, Nobre, Carlos Afonso, Ometto, Jean Pierre H., 2016. Land use change emission scenarios: anticipating a forest transition process in the Brazilian Amazon. Glob. Change Biol. 22, 1821–1840. https://doi.org/10.1111/gcb.13134 Land.

Ahrends, A., Hollingsworth, P.M., Ziegler, A.D., Fox, J.M., Chen, H., Su, Y., Xu, J., 2015. Current trends of rubber plantation expansion may threaten biodiversity and livelihoods. Glob. Environ. Chang. 34, 48–58. https://doi.org/10.1016/j.gloenvcha.2015.06.002.

Allen, C., Metternicht, G., Wiedmann, T., 2016. National pathways to the Sustainable Development Goals (SDGs): a comparative review of scenario modelling tools. Environ. Sci. Policy 66, 199–207. https://doi.org/10.1016/j.envsci.2016.09.008.

Almond, R.E.A., Grooten, M., Petersen, T., 2020. Living Planet Report 2020 - Bending the curve of biodiversity loss. WWF, Gland, Switzerland.

Armitage, L., 2002. Indigenous Property Rights: Custom and Commerce at the Interface - A Case Study of the Ahi People's Land, Morobe Province. PNG, Brisbane Australia.
Asian Development Bank (ADB), 2015. Solomon Islands: Country Gender Assessment. Mandaluyong City, Philippines.
Baird, I., 2017. Resistance and Contingent Contestations to Large-Scale Land Concessions in Southern Laos and Northeastern Cambodia. Land 6, 16. https://doi.org/10.3390/land6010016.
Baird, I.G., 2009. Land, rubber and people: rapid agrarian changes and responses in Southern Laos. J. Lao Stud. 1, 1–53.
Baletti, B., 2014. Saving the Amazon? Sustainable soy and the new extractivism. Environ. Plan. A 46 (1), 5–25. https://doi.org/10.1068/a45241.
Bennett, J.A., 2000. Pacific forest: a history of resource control and contest in Solomon Islands. University of Michigan Library, Ann Arbor, Michigan.
Brelsford, C., Lobo, J., Hand, J., Bettencourt, L.M.A., 2017. Heterogeneity and scale of sustainable development in cities. Proc. Natl. Acad. Sci. 114 (34), 8963–8968. https://doi.org/10.1073/pnas.1606033114.
Cammack, D., 2011. Chronic poverty in papua new guinea. Ssrn. https://doi.org/10.2139/ssrn.1755079.
Choi, S., Kim, H., 2016. The impact of conglomerate farming on the poor: Empirical evidence from the Brazil soy sector. Int. Area Stud. Rev. 19 (2), 147–164. https://doi.org/10.1177/2233865915611571.
Cohen, P.T., 2009. The post-opium scenario and rubber in northern Laos: Alternative Western and Chinese models of development. Int. J. Drug Policy 20 (5), 424–430. https://doi.org/10.1016/j.drugpo.2008.12.005.
Corbera, E., Busck-Lumholt, L.M., Mempel, F., Rodríguez-Labajos, B., 2019. In: Telecoupling: Exploring Land-Use Change in a Globalised World. Springer International Publishing, Cham, pp. 213–232. https://doi.org/10.1007/978-3-030-11105-2_11.
Cramb, R., Curry, G.N., 2012. Oil palm and rural livelihoods in the Asia-Pacific region: An overview. Asia Pac. Viewp. 53 (3), 223–239. https://doi.org/10.1111/apv.2012.53.issue-310.1111/j.1467-8373.2012.01495.x.
Cramb, R., McCarthy, J., 2016. Characterising oil palm production in Indonesia and Malaysia. In: Cramb, R., McCarthy, J. (Eds.), The Oil Palm Complex: Smallholders. NUS Press, Agribusiness and the State in Indonesia and Malaysia, p. 27.
De Vos, R.E., 2016. Multi-functional lands facing oil palm monocultures: a case study of a land conflict in West Kalimantan, Indonesia Multi-functional lands facing oil palm monocultures: a case study of a land conflict in West. ASEAS – Austrian. J. South-East Asian Stud. 9, 11–32. https://doi.org/10.14764/10.ASEAS-2016.1-2.
Directorate General of Plantation of the Ministry of Agriculture, 2016. Statistik Perkebunan Indonesia: Tree Crop Estate Statistics of Indonesia 2014-2016. Stat. Perkeb. Indones. 79. doi:http://ditjenbun.pertanian.go.id/tinymcpuk/gambar/file/statistik/2016/SAWIT 2014-2016.pdf.
Dove, M.R., 1993. Smallholder rubber and Swidden agriculture in Borneo: a sustainable adaptation to the ecology and economy of the tropical forestkaret rakyat dan sistem perladangan di kalimantan: Suatu Adaptasi Yang Baik Terhadap Ekologi dan Ekonomi Hutan Tropika. Econ. Bot. 47 (2), 136–147.
Downing, A.S., Chang, M., Kuiper, J.J., Campenni, M., Häyhä, T., Cornell, S.E., Svedin, U., Mooij, W.M., 2020. Learning from generations of sustainability concepts. Environ. Res. Lett. 15, 083002 https://doi.org/10.1088/1748-9326/ab7766.
Dwyer, M., Vongvisouk, T., 2019. The long land grab: market-assisted enclosure on the China-Lao rubber frontier. Territ. Polit. Gov. 7 (1), 96–114. https://doi.org/10.1080/21622671.2017.1371635.
Dyer, M., 2018. Ungrounded cosmopolitanism: Intersections of moral responsibility and gender in environmental activism in rural Solomon Islands. Womens. Stud. Int. Forum 67, 128–135. https://doi.org/10.1016/j.wsif.2017.04.006.
Dyer, M., 2017. Eating money: Narratives of equality on customary land in the context of natural resource extraction in the Solomon Islands. Aust. J. Anthropol. 28 (1), 88–103. https://doi.org/10.1111/taja.2017.28.issue-110.1111/taja.12213.
Edwards, R.B., 2016. Natural Resource Sectors and Human Development: International and Indonesian Evidence. Australian National University.
Elmhirst, R., Siscawati, M., Basnett, B.S., Ekowati, D., 2017. Gender and generation in engagements with oil palm in East Kalimantan, Indonesia: insights from feminist political ecology. J. Peasant Stud. 44 (6), 1135–1157. https://doi.org/10.1080/03066150.2017.1337002.
Environmental Investigation Agency, 2018. African Log Bans Matter: Reforming Chinese Investment and Trade in Africa's Forest Sector.
Faith, D.P., Nix, H.A., Margules, C.R., Hutchinson, M.F., Walker, P.A., West, J., Stein, J. L., Kesteven, J.L., Allison, A., Natera, G., 2000. The BioRap biodiversity assessment and planning study for Papua new guinea. Pacific Conserv. Biol. 6 (4), 279. https://doi.org/10.1071/PC010279.
Feintrenie, L., Chong, W.K., Levang, P., 2010a. Why do farmers prefer oil palm? Lessons learnt from Bungo district. Indonesia. Small Scale For. 9 (3), 379–396.
Feintrenie, L., Schwarze, S., Levang, P., 2010b. Are local people conservationists? Analysis of transition dynamics from agroforests to monoculture plantations in indonesia. Ecol. Soc. 15, 37.
Feng, X., Fu, B., Lu, N., Zeng, Y., Wu, B., 2013. How ecological restoration alters ecosystem services: an analysis of carbon sequestration in China's Loess Plateau. Sci. Rep. 3, 3–7. https://doi.org/10.1038/srep02846.
Filer, C., 2014. The double movement of immovable property rights in Papua New Guinea. J. Pac. Hist. 49 (1), 76–94. https://doi.org/10.1080/00223344.2013.876158.
FILER, COLIN, 2011a. Interdisciplinary perspectives on historical ecology and environmental policy in Papua New Guinea. Environ. Conserv. 38 (2), 256–269. https://doi.org/10.1017/S0376892910000913.
Filer, C., 2011b. New land grab in Papua New Guinea. Pac. Stud. 34, 269–294.
Forest Trends, 2006. Logging, Legality, and Livelihoods in Papua New Guinea: Synthesis of Official Assessments of the Large-Scale Logging Industry, Volume II. Jakarta.
Fox, J., Castella, J.-C., 2013. Expansion of rubber (Hevea brasiliensis) in Mainland Southeast Asia: What are the prospects for smallholders? J. Peasant Stud. 40 (1), 155–170. https://doi.org/10.1080/03066150.2012.750605.
Friis, C., Nielsen, J.Ö., 2016. Small-scale land acquisitions, large-scale implications: Exploring 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.
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. Ecol. Soc. 22, 30.
Galaz, V., Crona, B., Dauriach, A., Scholtens, B., Steffen, W., 2018. Finance and the Earth system – Exploring the links between financial actors and non-linear changes in the climate system. Glob. Environ. Chang. 53, 296–302. https://doi.org/10.1016/j.gloenvcha.2018.09.008.
Galaz, V., Tallberg, J., Boin, A., Ituarte-lima, C., Hey, E., Olsson, P., Westley, F., 2017. Global Governance Dimensions of Globally Networked Risks : The State of the Art in Social Science Research. Risks. Hazards Cris. Public Policy 8, 4–27.
Gao, L., Bryan, B.A., 2017. Finding pathways to national-scale land-sector sustainability. Nature 544 (7649), 217–222. https://doi.org/10.1038/nature21694.
Garrett, R.D., Rausch, L.L., 2016. Green for gold: social and ecological tradeoffs influencing the sustainability of the Brazilian soy industry. J. Peasant Stud. 43 (2), 461–493. https://doi.org/10.1080/03066150.2015.1010077.
Gaulier, G., Zignago, S., n.d. BACI: International Trade Database at the Product-Level (the 1994-2007 Version), CEPII Working Paper, N°2010-23, Octobre 2010. doi: 10.2139/ssrn.1994500.
Gay, D. (Ed.), 2009. Solomon Islands Diagnostic Trade Integration Study 2009 Report, Foreign Affairs. Honiara, Solomon Islands.
Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M.C., Shyamsundar, P., Steffen, W., Glaser, G., Kanie, N., Noble, I., 2013. Policy: Sustainable development goals for people and planet. Nature 495 (7441), 305–307. https://doi.org/10.1038/495305a.
Hulina, J., Bocetti, C., Campa, H., Hull, V., Yang, W., Liu, J., 2017. Telecoupling framework for research on migratory species in the Anthropocene. Elementa 5. doi: 10.1525/elementa.184.
Humpenöder, F., Popp, A., Bodirsky, B.L., Weindl, I., Biewald, A., Lotze-Campen, H., Dietrich, J.P., Klein, D., Kreidenweis, U., Müller, C., Rolinski, S., Stevanovic, M., 2018. Large-scale bioenergy production : how to resolve sustainability trade-offs? Environ. Res. Lett. 13, 024011.
Hunke, P., Mueller, E.N., Schröder, B., Zeilhofer, P., 2015. The Brazilian Cerrado: Assessment of water and soil degradation in catchments under intensive agricultural use. Ecohydrology 8 (6), 1154–1180. https://doi.org/10.1002/eco.v8.610.1002/eco.1573.
Independent State of Papua New Guinea, 2015. Papua New Guinea National Strategy to Prevent and Respond to Gender Based Violence 2016-2025.
Kabutaulaka, T., 2006. Global Capital and Local Ownership in Solomon Islands' Forestry Industry. In: Firth, S. (Ed.), Globalisation and Governance in The Pacific Islands. ANU E Press The Australian National University, Canberra, pp. 239–258.
Kabutaulaka, T.T., 2000. Rumble in the jungle: land, culture and (un)sustainable logging in Solomon Islands. In: Hooper, A. (Ed.), Culture and Sustainable Development in the Pacific, Pacific Policy Papers. Australian National University, Canberra, pp. 88–97.
Kanai, J.M., 2014. On the peripheries of planetary urbanization: Globalizing manaus and its expanding impact. Environ. Plan. D Soc. Sp. 32 (6), 1071–1087. https://doi.org/10.1068/d13128p.
Katovai, E., Edwards, W., Laurance, W.F., 2015. Dynamics of logging in Solomon Islands: The need for restoration and conservation alternatives. Trop. Conserv. Sci. 8 (3), 718–731. https://doi.org/10.1177/194008291500800309.
M., K.-L., G., W. (Eds.), 2016a. Challenges and opportunities for sustainable rubber in the Lao People's Democratic Republic. Center for International Forestry Research (CIFOR).
Kenney-Lazar, M., Wong, G., 2016b. Challenges and opportunities for sustainable rubber in Myanmar. https://doi.org/10.17528/cifor/006244.
Kenney-Lazar, M., Wong, G., Baral, H., Russell, A.J.M., 2018. Greening rubber? Political ecologies of plantation sustainability in Laos and Myanmar. Geoforum 92, 96–105. https://doi.org/10.1016/j.geoforum.2018.03.008.
Lahsen, M., Bustamante, M.M.C., Dalla-Nora, E.L., 2016. Undervaluing and overexploiting the Brazilian Cerrado at our peril. Environment 58 (6), 4–15. https://doi.org/10.1080/00139157.2016.1229537.
Lambin, E.F., Meyfroidt, P., 2011. Global land use change, economic globalization, and the looming land scarcity. Proc. Natl. Acad. Sci. 108 (9), 3465–3472. https://doi.org/10.1073/pnas.1100480108.
Lapola, D.M., Martinelli, L.A., Peres, C.A., Ometto, J.P.H.B., Ferreira, M.E., Nobre, C.A., Aguiar, A.P.D., Bustamante, M.M.C., Cardoso, M.F., Costa, M.H., Joly, C.A., Leite, C. C., Moutinho, P., Sampaio, G., Strassburg, B.B.N., Vieira, I.C.G., 2014. Pervasive transition of the Brazilian land-use system. Nat. Clim. Chang. 4 (1), 27–35. https://doi.org/10.1038/nclimate2056.
Lapola, D.M., Schaldach, R., Alcamo, J., Bondeau, A., Koch, J., Koelking, C., Priess, J.A., 2010. Indirect land-use changes can overcome carbon savings from biofuels in Brazil. Proc. Natl. Acad. Sci. 107 (8), 3388–3393. https://doi.org/10.1073/pnas.0907318107.
Lattas, A., 2011. Logging, violence and pleasure: Neoliberalism, civil society and corporate governance in West New Britain. Oceania 81, 88–107. doi:10.1002/j.1834-4461.2011.tb00095.x.
Leach, M., 2015. Gender equality and sustainable development. Routledge.

Lenzen, M., Moran, D., Kanemoto, K., Foran, B., Lobefaro, L., Geschke, A., 2012. International trade drives biodiversity threats in developing nations. Nature 486 (7401), 109–112. https://doi.org/10.1038/nature11145.
Li, T.M., 2018. After the land grab: Infrastructural violence and the "Mafia System" in Indonesia's oil palm plantation zones. Geoforum 96, 328–337. https://doi.org/10.1016/j.geoforum.2017.10.012.
Li, T.M., 2017. Intergenerational displacement in Indonesia's oil palm plantation zone. J. Peasant Stud. 44 (6), 1158–1176. https://doi.org/10.1080/03066150.2017.1308353.
Li, T.M., 2011. Centering labor in the land grab debate. J. Peasant Stud. 38 (2), 281–298. https://doi.org/10.1080/03066150.2011.559009.
Lim, M.M.L., Jørgensen, P.S., Wyborn, C.A., 2018. Reframing the sustainable development goals to achieve sustainable development in the Anthropocene-a systems approach. doi:10.5751/ES-10182-230322.
Liu, J., 2013. Forest sustainability in China and implications for a Telecoupled World. Asia Pacific Policy Stud. 1 (1), 230–250. https://doi.org/10.1002/app5.v1-110.1002/app5.17.
Liu, J., Hull, V., Batistella, M., DeFries, R., Dietz, T., Fu, F., Hertel, T.W., Izaurralde, R.C., Lambin, E.F., Li, S., Martinelli, L.A., McConnell, W.J., Moran, E.F., Naylor, R., Ouyang, Z., Polenske, K.R., Reenberg, A., de Miranda Rocha, G., Simmons, C.S., Verburg, P.H., Vitousek, P.M., Zhang, F., Zhu, C., 2013. Framing sustainability in a telecoupled world. Ecol. Soc. 18 (2) https://doi.org/10.5751/ES-05873-180226.
Liu, J., Hull, V., Godfray, H.C.J., Tilman, D., Gleick, P., Hoff, H., Pahl-Wostl, C., Xu, Z., Chung, M.G., Sun, J., Li, S., 2018. Nexus approaches to global sustainable development. Nat. Sustain. 1 (9), 466–476. https://doi.org/10.1038/s41893-018-0135-8.
Lu, J.N., 2017. Tapping into rubber: China's opium replacement program and rubber production in Laos. J. Peasant Stud. 44 (4), 726–747. https://doi.org/10.1080/03066150.2017.1314268.
Maharani, Cynthia D., Moeliono, Moira, Wong, Grace Yee, Brockhaus, Maria, Carmenta, Rachel, Kallio, Maarit, 2019. Development and equity: A gendered inquiry in a swidden landscape Cynthia. For. Policy Econ. 101, 120–128. https://doi.org/10.1016/j.forpol.2018.11.002.
Manivong, V., Cramb, R.A., 2008. Economics of smallholder rubber expansion in Northern Laos. Agrofor. Syst. 74 (2), 113–125. https://doi.org/10.1007/s10457-008-9136-3.
Mansur, A.V., Brondizio, E.S., Roy, S., de Miranda Araújo Soares, P.P., Newton, A., 2018. Adapting to urban challenges in the Amazon: flood risk and infrastructure deficiencies in Belém. Brazil. Reg. Environ. Chang. 18 (5), 1411–1426. https://doi.org/10.1007/s10113-017-1269-3.
Martinelli, L., Batistella, M., Silva, R., Moran, E., 2017. Soy expansion and socioeconomic development in municipalities of Brazil. Land 6, 62. https://doi.org/10.3390/land6030062.
Martinelli, L.A., Naylor, R., Vitousek, P.M., Moutinho, P., 2010. Agriculture in Brazil: Impacts, costs, and opportunities for a sustainable future. Curr. Opin. Environ. Sustain. 2 (5-6), 431–438. https://doi.org/10.1016/j.cosust.2010.09.008.
McCarthy, J.F., 2010. Processes of inclusion and adverse incorporation: oil palm and agrarian change in Sumatra. Indonesia. J. Peasant Stud. 37 (4), 821–850. https://doi.org/10.1080/03066150.2010.512460.
McCarthy, J.F., Cramb, R.A., 2009. Policy narratives, landholder engagement, and oil palm expansion on the Malaysian and Indonesian frontiers. Geogr. J. 175, 112–123. https://doi.org/10.1111/j.1475-4959.2009.00322.x.
McCollum, D.L., Echeverri, L.G., Busch, S., Pachauri, S., Parkinson, S., Rogelj, J., Krey, V., Minx, J.C., Nilsson, M., Stevance, A.-S., Riahi, K., 2018. Connecting the sustainable development goals by their energy inter-linkages. Environ. Res. Lett. 13 (3), 033006. https://doi.org/10.1088/1748-9326/aaafe3.
McCollum, D.L., Krey, V., Riahi, K., Kolp, P., Grubler, A., Makowski, M., Nakicenovic, N., 2013. Climate policies can help resolve energy security and air pollution challenges. Clim. Change 119 (2), 479–494. https://doi.org/10.1007/s10584-013-0710-y.
Meyfroidt, P., Carlson, K.M., Fagan, M.E., Gutiérrez-Vélez, V.H., Macedo, M.N., Curran, L.M., DeFries, R.S., Dyer, G.A., Gibbs, H.K., Lambin, E.F., Morton, D.C., Robiglio, V., 2014. Multiple pathways of commodity crop expansion in tropical forest landscapes. Environ. Res. Lett. 9 (7), 074012. https://doi.org/10.1088/1748-9326/9/7/074012.
Monson, R., 2011. Negotiating Land Tenure: Women, Men and the Transformation of Land Tenure in Solomon Islands, in: Ubink, J. (Ed.), Customary Justice: Perspectives on Legal Empowerment. International Development Law Organization in conjuction with Van Vollenhoven Institute, University of Leiden, Rome, pp. 169–185.
Muller, A., Schader, C., El-Hage Scialabba, N., Brüggemann, J., Isensee, A., Erb, K.H., Smith, P., Klocke, P., Leiber, F., Stolze, M., Niggli, U., 2017. Strategies for feeding the world more sustainably with organic agriculture. Nat. Commun. 8, 1–13. https://doi.org/10.1038/s41467-017-01410-w.
Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B., Kent, J., 2000. Biodiversity hotspots for conservation priorities. Nature 403 (6772), 853–858.
Nelson, P.N., Gabriel, J., Filer, C., Banabas, M., Sayer, J.A., Curry, G.N., Koczberski, G., Venter, O., 2014. Oil palm and deforestation in papua new Guinea. Conserv. Lett. 7 (3), 188–195. https://doi.org/10.1111/conl.2014.7.issue-310.1111/conl.12058.
Nilsson, M., Griggs, D., Visbeck, M., 2016. Map the interactions between Sustainable Development Goals. Nature 534, 320–322. https://doi.org/10.1038/534320a.
Obersteiner, M., Walsh, B., Frank, S., Havlík, P., Cantele, M., Liu, J., Palazzo, A., Herrero, M., Lu, Y., Mosnier, A., Valin, H., Riahi, K., Kraxner, F., Fritz, S., van Vuuren, D., 2016. Assessing the land resource–food price nexus of the sustainable development goals. Sci. Adv. 2 (9), e1501499. https://doi.org/10.1126/sciadv.1501499.
Obidzinski, K., Andriani, R., Komarudi, H., Andrianto, 2012. Environmental and social impacts of oil palm plantations and their implications for biofuel production in Indonesia. Ecol. Soc. 17, 25. https://doi.org/10.5751/ES-04775-170125.
Obidzinski, K., Dermawan, A., Hadianto, A., 2014. Oil palm plantation investments in Indonesia's forest frontiers: limited economic multipliers and uncertain benefits for local communities. Environ. Dev. Sustain. 16 (6), 1177–1196. https://doi.org/10.1007/s10668-014-9519-8.
Oliveira, G.de L.T., 2016. The geopolitics of Brazilian soybeans. J. Peasant Stud. 43, 348–372. https://doi.org/10.1080/03066150.2014.992337.
Oliveira, G., Hecht, S., 2016. Sacred groves, sacrifice zones and soy production: globalization, intensification and neo-nature in South America. J. Peasant Stud. 43 (2), 251–285. https://doi.org/10.1080/03066150.2016.1146705.
Pascual, U., Palomo, I., Adams, W.M., Chan, K.M.A., Daw, T.M., Gómez-baggethun, E., Groot, R.S. De, Mace, G.M., 2017. Off-stage ecosystem service burdens: A blind spot for global sustainability. Environ. Res. Lett. 12.
Persson, Joel, Mertz, Ole, 2019. In: Telecoupling: Exploring Land-Use Change in a Globalised World. Springer International Publishing, Cham, pp. 313–336. https://doi.org/10.1007/978-3-030-11105-2_17.
Piketty, T., 2020. Capital and Ideology, 1st ed. Harvard University Press, Cambridge, Massachusetts, London, England.
Prabowo, D., Maryudi, A., Senawi, Imron, M.A., 2017. Conversion of forests into oil palm plantations in West Kalimantan, Indonesia: insights from actors' power and its dynamics. For. Policy Econ. 78, 32–39. https://doi.org/10.1016/j.forpol.2017.01.004.
Pradhan, P., Costa, L., Rybski, D., Lucht, W., Kropp, J.P., 2017. A systematic study of sustainable development Goal (SDG) interactions Earth's future. Earth's Futur. 1169–1179 https://doi.org/10.1002/eft2.266.
Prowse, M., Shepherd, A., Braunholtz-speight, T., Evans, A.A., Hickey, S., Hulme, D., Moore, K., Anderson, E., Baulch, B., Clarke, M., Dercon, S., Evans, A.A., Farrington, J., Fawkner-, K., German, T., Green, D., Hamlin, A., Highton, N., Holmes, R., Hossain, N., Mehta, A.K., Lwanga-ntale, C., Mckay, A., Moser, C., Rahman, A., Randel, J., Standing, H., Steiner, S., Sumner, A., Toit, A., Bategeka, L., Bebbington, A., Bhide, S., Bird, K., Bridges, S., Cabral, L., Cammack, D., Chimhowu, A., Rose, P., Sanders, D., Santibanez, C., 2008. The Chronic Poverty Report 2008–09 Escaping Poverty Traps Grateful thanks go to the many other contributors. Development.
Pryke, J., Barker, P., 2017. A Bumpy Road: Societal Trends in Papua New Guinea. PNG Ctry. Assess. August 2017 23–42.
Resare Sahlin, Kajsa, Röös, Elin, Gordon, Line J., 2020. 'Less but better' meat is a sustainability message in need of clarity. Nat. Food 1 (9), 520–522. https://doi.org/10.1038/s43016-020-00140-5.
Richards, P., Pellegrina, H., VanWey, L., Spera, S., Lightfoot, D.A., 2015. Soybean development the impact of a decade of agricultural change on urban and economic growth in Mato Grosso, Brazil. PLoS One 10 (4), e0122510. https://doi.org/10.1371/journal.pone.0122510.
Richards, P.D., 2012. Exchange Rates, Soybean Supply Response, and Deforestation in South America. Michigan State University.
Richards, P.D., VanWey, L., 2015. Where deforestation leads to urbanization: how resource extraction is leading to urban growth in the Brazilian Amazon. Ann. Assoc. Am. Geogr. 105, 806–823. https://doi.org/10.3109/02656736.2015.1007538. Histotripsy.
Rifin, A., 2013. Analysis of Indonesia's Market Position in Palm Oil Market in China and India. J. Food Prod. Mark. 19 (4), 299–310. https://doi.org/10.1080/10454446.2013.726950.
Rifin, A., 2010. Export competitiveness of indonesia's palm oil product. Trends Agric. Econ. 3 (1), 1–18.
Rist, L., Feintrenie, L., Levang, P., 2010. The livelihood impacts of oil palm: Smallholders in Indonesia. Biodivers. Conserv. 19 (4), 1009–1024. https://doi.org/10.1007/s10531-010-9815-z.
Rochedo, P.R.R., Soares-Filho, B., Schaeffer, R., Viola, E., Szklo, A., Lucena, A.F.P., Koberle, A., Davis, J.L., Rajão, R., Rathmann, R., 2018. The threat of political bargaining to climate mitigation in Brazil. Nat. Clim. Chang. 8 (8), 695–698. https://doi.org/10.1038/s41558-018-0213-y.
SDSN, 2019. Sustainable Development Report 2019: Transformations to achieve the Sustainable Development Goals.
SDSN, 2018. SDGs Index and Dashboard Report 2018: Global Responsibilites. Implementing the Goals.
Semedi, P., Bakker, L., 2014. Between land grabbing and farmers' benefits: land transfers in West Kalimantan. Indonesia. Asia Pacific J. Anthropol. 15 (4), 376–390. https://doi.org/10.1080/14442213.2014.928741.
Simoes, A.J.C., Hidalgo, C.A., 2011. The economic complexity observatory: an analytical tool for understanding the dynamics of economic development. Scalable Integr. Anal. Vis. Pap. 39–42 from 2011 AAAI Work.
Soares-Filho, B., Rajão, R., Macedo, M., Carneiro, A., Costa, W., Coe, M., Rodrigues, H., Alencar, A., 2014. Cracking Brazil' s Forest code. Science (80-.) 344, 363–364. https://doi.org/10.1126/science.124663.
Somboonsuke, B., Yincharoen, A., Kongmanee, C., Phitthayaphinant, P., 2019. Rubber production system and livelihood of smallholding rubber farming system (SRFS) in southern Thailand: a case study in provinces of Nakhon Si Thammarat, Phatthalung and Trang. Int. J. Agric. Technol. 15, 645–664.
Souza, P.F., Xavier, D.R., Rican, S., de Matos, V.P., Barcellos, C., 2015. The expansion of the economic frontier and the diffusion of violence in the Amazon. Int. J. Environ. Res. Public Health 12, 5862–5885. https://doi.org/10.3390/ijerph120605862.
Sparovek, G., Barretto, A.G.d.O.P., Matsumoto, M., Berndes, G., 2015. Effects of governance on availability of land for agriculture and conservation in Brazil.

Environ. Sci. Technol. 49 (17), 10285–10293. https://doi.org/10.1021/acs.est.5b01300.
Sparovek, G., Berndes, G., de Barretto, A.G., O.P., Klug, I.L.F., 2012. The revision of the brazilian forest act: Increased deforestation or a historic step towards balancing agricultural development and nature conservation? Environ. Sci. Policy 16, 65–72. https://doi.org/10.1016/j.envsci.2011.10.008.
Stafford-Smith, M., Griggs, D., Gaffney, O., Ullah, F., Reyers, B., Kanie, N., Stigson, B., Shrivastava, P., Leach, M., O'Connell, D., 2017. Integration: the key to implementing the sustainable development goals. Sustain. Sci. 12 (6), 911–919. https://doi.org/10.1007/s11625-016-0383-310.21203/rs.2.15057/v1.
Torres, S., Moran, E., Silva, R., 2017. Property rights and the soybean revolution: Shaping how China and Brazil Are Telecoupled. Sustain. 9 (6), 954. https://doi.org/10.3390/su9060954.
UN, 2015. Transforming our world: The 2030 agenda for sustainable development, A/RES/70/1. doi:10.1007/s13398-014-0173-7.2.
USDA, 2013. Indonesia Oilseeds and Products Annual 2013.
van Vuuren, D.P., Batlle Bayer, L., Chuwah, C., Ganzeveld, L., Hazeleger, W., van den Hurk, B., van Noije, T., O'Neill, B., Strengers, B.J., 2012. A comprehensive view on climate change: coupling of earth system and integrated assessment models. Environ. Res. Lett. 7 (2), 024012. https://doi.org/10.1088/1748-9326/7/2/024012.
VanWey, L.K., Spera, S., de Sa, R., Mahr, D., Mustard, J.F., 2013. Socioeconomic development and agricultural intensification in Mato Grosso. Philos. Trans. R. Soc. B Biol. Sci. 368, 20120168–20120168. doi:10.1098/rstb.2012.0168.
Viswanathan, P.K., 2008. Emerging smallholder rubber farming systems in India and Thailand: a comparative economic analysis. Asian J. Agric. Dev. 5, 1–20.
Viswanathan, P.K., Shivakoti, G.P., 2008. Adoption of rubber-integrated farm-livelihood systems: Contrasting empirical evidence from the Indian context. J. For. Res. 13 (1), 1–14. https://doi.org/10.1007/s10310-007-0047-3.
Wairiu, Morgan, 2007. History of the forestry industry in Solomon Islands: the case of guadalcanal. J. Pac. Hist. 42 (2), 233–246. https://doi.org/10.1080/00223340701461684.
Waiselfisz, J.J., 2015. Mortes Matados por Armas de Fogo.
Warren-Thomas, E., Dolman, P.M., Edwards, D.P., 2015. Increasing demand for natural rubber necessitates a robust sustainability initiative to mitigate impacts on tropical biodiversity. Conserv. Lett. 8 (4), 230–241. https://doi.org/10.1111/conl.2015.8.issue-410.1111/conl.12170.
Weinhold, D., Killick, E., Reis, E.J., 2013. Soybeans, poverty and inequality in the Brazilian Amazon. World Dev. 52, 132–143. https://doi.org/10.1016/j.worlddev.2012.11.016.
Westley, F., Olsson, P., Folke, C., Homer-Dixon, T., Vredenburg, H., Loorbach, D., Thompson, J., Nilsson, M., Lambin, E., Sendzimir, J., Banerjee, B., Galaz, V., van der Leeuw, S., 2011. Tipping toward sustainability: emerging pathways of transformation. Ambio 40 (7), 762–780. https://doi.org/10.1007/s13280-011-0186-9.
Wilting, H.C., Schipper, A.M., Bakkenes, M., Meijer, J.R., Huijbregts, M.A.J., 2017. Quantifying biodiversity losses due to human consumption: a global-scale footprint analysis. Environ. Sci. Technol. 51 (6), 3298–3306. https://doi.org/10.1021/acs.est.6b0529610.1021/acs.est.6b05296.s001.
Wolford, W., White, B., 2013. Governing Global Land Deals : The Role of the State in the Rush for Land . Special Issue, Development and Change, 44 (2): 189-210 . Wendy Wolford , Saturnino M . Borras Jr ., Ruth Hall , Ian Scoones and Ben White (editors) (also forthcoming Blackwe 2, 189–210. doi:10.1111/dech.12017/full.
Wong, Grace Y., Moeliono, Moira, Bong, Indah W., Pham, Thuy Thu, Sahide, Muhammad A.K., Naito, Daisuke, Brockhaus, Maria, 2020. Social forestry in Southeast Asia: Evolving interests, discourses and the many notions of equity. Geoforum 117, 246–258. https://doi.org/10.1016/j.geoforum.2020.10.010.
Woods, Kevin, 2011. Ceasefire capitalism: Military-private partnerships, resource concessions and military-state building in the Burma-China borderlands. J. Peasant Stud. 38 (4), 747–770. https://doi.org/10.1080/03066150.2011.607699.
World Bank, 2012. Papua New Guinea - Country gender assessment for the period 2011-2012.
World Bank Group, 2017. Solomon Islands: Systematic Country Diagnostic. Reduction & Promoting Shared Prosperity, Priorities for Supporting Poverty.
World Bank, International Finance Corporation, 2011. The World Bank Group Framework and IFC Strategy for Engagement in the Palm Oil Sector.
Zeng, Y., Maxwell, S., Runting, R.K., Venter, O., Watson, J.E.M., Carrasco, L.R., 2020. Environmental destruction not avoided with the Sustainable Development Goals. Nat. Sustain. doi:10.1038/s41893-020-0555-0.
Ziegler, A.D., Fox, J.M., Xu, J., 2009. The rubber juggernaut. Science (80-.) 324 (5930), 1024–1025. https://doi.org/10.1126/science:1173833.