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Global forces of change: Implications for forest-poverty dynamics

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ABSTRACT

This article examines global trends likely to influence forests and tree-based systems and considers the poverty implications of these interactions. The trends, identified through a series of expert discussions and review of the literature, include: (i) climatic impacts mediated through changes in forests, (ii) growth in commodity markets, (iii) shifts in private and public forest sector financing, (iv) technological advances and rising interconnectivity, (v) global socio-political movements, and (vi) emerging infectious diseases. These trends bring opportunities and risks to the forest-reliant poor. A review of available evidence suggests that in a business-as-usual scenario, the cumulative risks posed by these global forces, in conjunction with limited rights, resources, and skills required to prosper from global changes, are likely to place poor and transient poor households under additional stress. The article concludes with an assessment of how interventions for enhancing forest management, combined with supportive policy and institutional conditions, can contribute to a different and more prosperous future for forests and people.

1. Introduction

Global economic, political, and environmental forces shape the forms poverty takes and the pathways that lead to it. Global changes, which can be opaque at local or regional scales, create enormous shocks that limit efforts to alleviate poverty and alter human-forest relationships (Oldekop et al., 2020). These changes create uncertainty regarding the efficacy of existing policy interventions to alleviate poverty, especially for those dependent on forest resources (Hajjar et al., 2021b, this issue). On the other hand, such changes may also generate socio-economic opportunities that help move people out of poverty (Shyamsundar et al., 2020). Thus, it is useful to consider global forces of change to anticipate or forecast likely scenarios in forest-poverty dynamics.

Forest fragmentation and the increase in zoonotic diseases, such as COVID-19, demonstrate the need to attend to the linkages among forest cover change, health, and sustainable development (Di Marco et al., 2020; Dobson et al., 2020). These connected changes also exemplify how transnational processes can directly and indirectly affect communities living in, near or otherwise relying on forests. Forest-reliant households move in and out of poverty through multiple conduits (Jagger et al., 2020). In this paper, we seek to understand and develop an analytical framework for examining how global forces affect these pathways. While global changes have impacts on forests and people across scales, our focus is on local poverty dynamics.

Global changes affect poverty through their direct impacts on tree cover and by altering the magnitude and distribution of forest and tree use. Transnational mechanisms can help move forest- and tree-reliant people and households out of poverty by creating new economic opportunities; they may enable households to preserve their current economic status and well-being by maintaining the flow of forest and tree-related goods and services; they may affect transient poverty by changing risk exposure, thereby temporarily pushing households above or below national poverty lines; and /or, people may be driven deeper into poverty through increased uncertainty and exposure to hazards or because access to trees and other forest resources becomes more costly as a result of global changes. Differing socio-economic conditions across

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geographies and nation-states will dictate how these pathways unfold for any community, household or individual (Oldekop et al., 2021, this issue; Razafindratsima et al., 2021, this issue).

Acknowledging the need to understand global to local influences, this article discusses the implications for forest-poverty dynamics of six major global forces. These are: (i) climatic impacts, (ii) growth in commodity markets, (iii) trends in private and public forest sector financing, (iv) technological advances and interconnectivity, (v) global socio-political movements, and (vi) emerging infectious diseases (EIDs). These forces act on communities by modifying the role of forest and tree-based goods and services in their lives and livelihoods.

In the sections that follow, we first discuss research methods and conceptual considerations, followed by a description of each global change and its implications for forest-poverty dynamics. We conclude with a critical evaluation of conditions and strategies needed to sustain forests and alleviate poverty considering global changes, and potential limitations of our analyses.

2. Methods and key concepts

This article builds on a series of discussions by the Global Forest Expert Panel on Forests and Poverty organized by the International Union of Forestry Research Organizations (IUFRO) in 2019–2020 (Miller et al., 2020). These deliberations identified key outstanding questions on poverty-forest relations and critically evaluated different sub-themes, including the role of global changes. Following the resulting global report (Miller et al., 2020), in this paper, forests are broadly defined to cover multiple tree-based systems, ranging from intact old growth forests to planted forests, to agroforestry systems, and single species tree crop production.

The global changes discussed in this article were identified through: a) discussions by experts in three workshops (Chapter 6 in Miller et al., 2020; and b) a review of the literature on global changes and forest interlinkages (Eakin et al., 2014; Liu et al., 2015; Oldekop et al., 2020; Watts et al., 2019; World Economic Forum, 2020). Expert assessments were supplemented through traditional literature reviews on each global change, relying on academic search engines such as Google Scholar and institutional reports to identify implications for forest-poverty dynamics. An independent review by six reviewers provided additional feedback both on the relevant literature and structure of this paper.

Each of the discussed global changes meet three criteria: they are driven by actions and actors beyond any one nation-state, but influence forests and tree-based systems in multiple regions; they are dynamic, reflecting shifting geo-political conditions; and they are likely to influence forest-poverty dynamics. Other trends such as urbanization (Jiang and O'Neill, 2017), wide-ranging economic globalization (Lambin and Meyfroidt, 2011), and demographic changes (Foley et al., 2005), while not comprehensively addressed given the rural focus of our analysis, are examined in discussing commodity markets and migration as a response to climate change (Cattaneo et al., 2019). Deforestation, an important global trend, is integrated into all six global changes. Because the majority of the world's forests-proximate people (living within 5 km of forests) live in the tropics (1.03 billion rural people) and low- and middle-income countries (1.14 billion rural people), our review largely focuses on this population (Newton et al., 2020).

Global changes affect local poverty dynamics through their impacts on forest and tree-based systems. As Fig. 1 shows, there are four dynamic ways in which poverty is affected by changes in the quantity and quality of forest and tree-based goods and services (Jagger et al., 2020). Globally driven increases in forest-based economic opportunities or public investments may enable households to diversify and/or grow their income, which can potentially move people out of poverty. Technological and global socio-political transformations that facilitate continued access to the economic, dietary, and cultural assets that forests provide, and stem negative effects from deforestation, can help multitudes of Indigenous Peoples and local communities maintain their status quo. On the other hand, livelihood and health shocks driven by global climate, pandemics, technological advances, or markets, can push communities either temporarily or permanently into poverty. How forest use and access changes, and its implications for poor households, including sub-groups of the poor, will depend on a host of socio-economic and political conditions (Oldekop et al., 2021, this issue). Razafindratsima et al. (2021, this issue) provide evidence on the diverse uses of forests by poor households, noting, in particular, the gendered dimensions of poverty. The forest-poverty dynamics illustrated in Fig. 1 are discussed in detail in Jagger et al. (2020).

In the sections below, we use available literature and publicly accessible data on specific global changes to identify how they affect forests and tree-based systems, and how this, in turn, affects poverty dynamics. Local poverty dynamics can also affect forest quality and quantity; however, these complicated feedback loops are largely beyond the scope of this paper and the special issue.

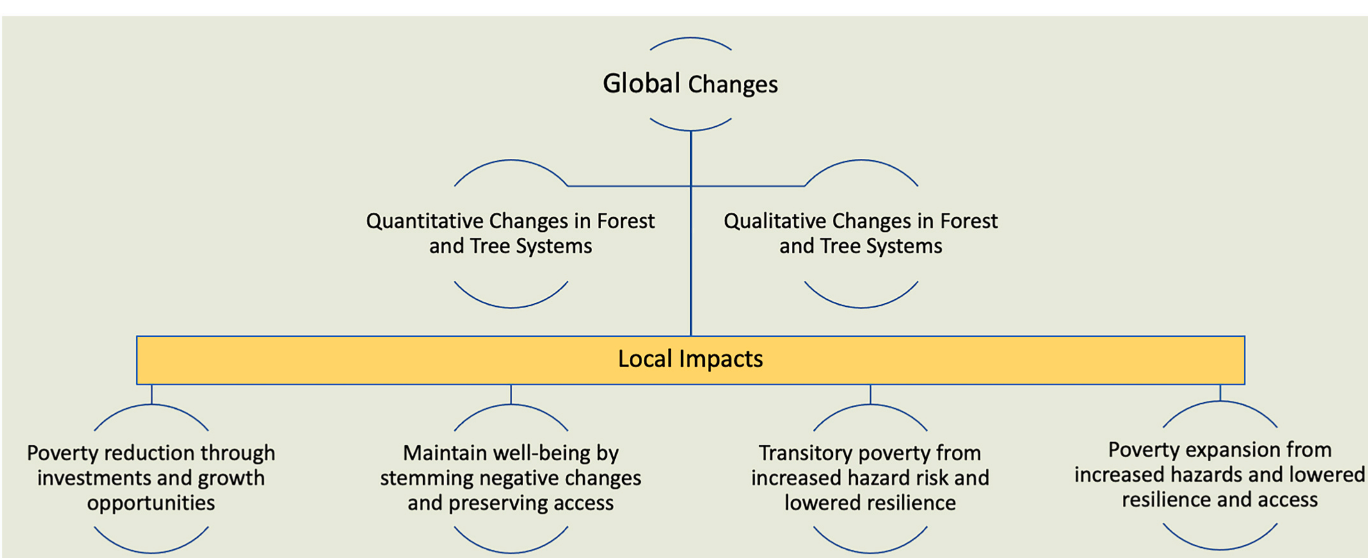

Fig. 1. Global changes and their effects on local poverty dynamics mediated through changes in access to and availability of quality goods and services from forests and trees.

3. Climate change, forests and positive feedback loop

Climate change increases risks to the lives and livelihoods of the forest-reliant poor by affecting the forest ecosystem services on which they depend. These changes will worsen with deforestation, itself a major contributor to climate change (Gibbs et al., 2018; Lawrence and Vandecar, 2015), creating a positive feedback loop that accelerates climate change (Staal et al., 2020).

Climate induced changes have varied effects on forests. Changes in temperature, carbon dioxide and precipitation can increase the length of tree growing seasons (Walther et al., 2002); alter the distribution of terrestrial vegetation (Bertin, 2008); shift species' geographic ranges (Hansen et al., 2001; Ortega et al., 2019); influence productivity (Vitasse et al., 2009); increase the risk and intensity of natural disasters such as drought, fires, flooding, and insect outbreaks (Seppälä et al., 2009; Staal et al., 2020); and affect biodiversity and ecosystem services (Seymour and Busch, 2016), among others.

The release of sequestered forest carbon resulting from deforestation, degradation, and forest fires also produces a significant amount of greenhouse gases. Conversely, improved forest management can offset carbon losses (Griscom et al., 2017). For instance, reductions in deforestation and increasing reforestation in the tropics can cost-effectively provide some 10–20.9% of the reductions needed between 2020 and 2030 to meet the 2° C warming goal outlined in the Paris agreement (Busch et al., 2019).

3.1. Increasing climate risks faced by the poor

Climate change directly threatens the forest-reliant poor by destroying assets, impeding livelihoods, and reducing ecosystem services (Hallegatte et al., 2015; IPCC, 2018). As forests degrade, those that depend on forests and trees for income and subsistence may have to travel further or migrate to maintain their livelihoods. Air pollution, water contamination, psycho-social harm and visibility impairment from wildfires can seriously harm human health (Fowler, 2003). Even though the exact regional impacts of climate change are unclear, drier and hotter areas will most likely see negative impacts on livelihoods (Olsson et al., 2019; Seymour and Busch, 2016).

Two key climate effects – increased frequency, intensity, and/or amount of hydrologic and heat events and stressors (Coffel et al., 2018; Mora et al., 2017; Olsson et al., 2019; Prevedello et al., 2019) are likely to have direct and forest-induced poverty effects. Increased flooding (Neumann et al., 2015; Zhu et al., 2010), intensified cyclones (Bacmeister et al., 2018; Walsh et al., 2016) and increased coastal erosion (Alongi, 2015; Harley et al., 2017; Johnson et al., 2015) threaten existing forests and tree-based goods and services. Floods, tropical storms, degraded landscapes, and landslides in forest landscapes can also lead to loss of human life, livestock, and dwellings (Das and Vincent, 2009; Samir, 2013).

Increased drought and loss of evapotranspiration from forests pose threats to agriculture (Aryal et al., 2020; Lawrence and Vandecar, 2015) and to non-timber forest product (NTFP) availability (Gurung et al., 2021; Kunwar, 2011), making rain-dependent, small-scale farmers and NTFP harvesters more vulnerable to income losses and food insecurity (Cooper et al., 2009; Damania et al., 2017; Wani et al., 2009). Deforestation can exacerbate microclimates, making them drier and hotter (Lawrence and Vandecar, 2015), potentially driving people to deforest more land (Desbureaux and Damania, 2018). For instance, cocoa farmers in Cote d'Ivoire have replaced forests with farmland from the drier east to the wetter southwest of the country, which has further contributed to drier conditions in a positive feedback cycle (Ruf et al., 2015). Increasing temperatures, exacerbated by forest loss (Cohn et al., 2019), can make outdoor labor more hazardous (Suter et al., 2019) and increase mortality (Mora et al., 2017). In many locations, extreme droughts are also predicted to increase the number, intensity, length, and severity of forest fires (Abatzoglou and Williams, 2016; Jolly et al., 2015; Knorr et al., 2016; Taufik et al., 2017).

Migration will likely be an important adaptation response to climate-induced events (Cattaneo et al., 2019). While difficult to estimate, there has been a steady climb in international migrants, from 85 million people in 1970 to 272 million people in 2019 (International Organization for Migration, 2019). Although climate change-induced migration is expected to increase in the future (Marchiori et al., 2012; Missirian and Schlenker, 2017), peoples' movements will vary depending on the speed of climatic events (slow or rapid onset), available adaptation opportunities, and household access to resources (Cattaneo et al., 2019). Notably, Rigaud et al. (2018), considering demographic, socio-economic and climate scenarios, estimate that there will likely be 143 million 'within-country' climate migrants by 2050. There are, however, many uncertainties in projecting future migration (Cattaneo et al., 2019).

Improved forest and tree management can play an important role in climate change adaptation (Keenan, 2015), providing new income opportunities for forest-reliant communities (Hajjar et al., 2021b, this issue; Ota et al., 2020). For example, tree planting has increased milk production and dairy income in East Africa (Wambugu et al., 2011), reduced human-wildlife conflict in South Africa (Chakeredza et al., 2007), and improved farm productivity during a drought period in Malawi (Amadu et al., 2020), making agroforestry an important climate smart agricultural adaptation strategy. Domesticating and commercializing indigenous fruit trees increases food security and incomes across Sub-Saharan Africa, with potential for increasing income from commercializing fruit trees (Omotayo and Aremu, 2020). Although tree planting projects can have negative impacts on livelihoods if they compete for land used by the poor (Seppälä et al., 2009; Smith et al., 2019), they can also help secure land tenure (Guillerme et al., 2011; Ota et al., 2020), reduce soil erosion (Korkanç, 2014) and associated flooding (Yin and Li, 2001), and landslides (Pradhan et al., 2012), and potentially reduce risks and increase farm yields (Brown et al., 2018; Maas et al., 2013). The local (Prevedello et al., 2019) and regional (Cohn et al., 2019) heat-reducing effects of increased tree cover will be particularly important in tropical areas (Coffel et al., 2018; Mora et al., 2017). The choice of tree species, local contexts, and instruments used to encourage tree planting will influence how poor households are affected (Erbaugh et al., 2020; Fleischman et al., 2020; Hajjar et al., 2021b, this issue; Razafindratsima et al., 2021, this issue).

4. Growth in commodity markets

Commodities produced in the tropics at the forest-agriculture frontier play an important role in deforestation and degradation (Curtis et al., 2018; Seymour and Harris, 2019). Demand for four commodities – beef, soybean, palm oil, and timber – have significantly contributed to landscape change (Curtis et al., 2018; Henders et al., 2018; Newton et al., 2013; Persson et al., 2014). Other commodities, such as coffee (Philpott et al., 2008; Tadesse et al., 2014), cocoa, cassava (Gockowski and Sonwa, 2011) and illicit coca production (Armenteras et al., 2013) also impact forests (Onder et al., 2021).

Beef production has had the biggest impact on deforestation to date (Henders et al., 2015; World Economic Forum, 2020). Brazil, China, the European Union, and the United States are major beef producers (Brack et al., 2016), with Brazilian cattle production having the largest forest footprint (Henders et al., 2015; Pendrill et al., 2019). Brazil and the United States are also major producers and exporters of soybean (le Polain de Waroux et al., 2019), which is mainly used for animal feed (Brack et al., 2016), with China being a major importer.

Indonesia and Malaysia produce about 80–90% of all palm oil (Brack et al., 2016; Henders et al., 2015). Deforestation from oil plant cultivation shows a downward trend, with its contribution to deforestation declining from an estimated 23% (2001–16) to less than 15% (2014–16) (Austin et al., 2019). Tropical timber is mainly produced in Brazil, Indonesia, Malaysia, and Papua New Guinea (Persson et al., 2014). During 2000–16, timber plantations contributed to 14% of deforestation in Indonesia, with the rate peaking in 2010–12 (Austin et al., 2019). Arguably, timber plantations play multiple roles – they can also reduce pressure on natural forests (Ainembabazi and Angelsen, 2014; Bowyer et al., 2005), contribute to restoring degraded lands (Bowyer et al., 2005), and improve smallholders' livelihoods (Khamzina et al., 2012; Roshetko et al., 2013). In general, however, evidence on plantation-led improvements in livelihoods and poverty is both limited and mixed (Malkamäki et al., 2018; Santika et al., 2019).

Available projections on beef, soybean, oil palm, and timber suggest that commodity production is likely to see double-digit growth over the next decade (see Table 1). This reinforces the urgency of understanding the connections among commodity demand, production, deforestation, and poverty.

4.1. Can decoupling commodity production and deforestation contribute to poverty reduction?

As demand for tropical forest commodities increases, there is pressure to decouple the growth of commodity production from deforestation. Ten strategies (see Table A1) offer opportunities to achieve net zero deforestation while maintaining or increasing production of forest-impacting commodities (World Economic Forum, 2020). These strategies build on core principles of sustainable intensification (certification, pilot scaling); increased funding for sustainability (influencing demand and financing); and improved governance (property rights, jurisdictional approaches, enforcement). The potential poverty outcomes from decoupling deforestation and commodity growth, however, are likely to vary based on local conditions, as discussed below. The poverty reduction benefits of tenure reform, for instance, are dependent on complementary conditions such as law enforcement, access to justice, technical assistance, access to finance etc. (Hajjar et al., 2021a, this issue), which differ significantly across countries.

Changing land use from forests to commodity agriculture offers opportunities to smallholders if they can take advantage of global markets. Evidence from Paraguay, for instance, suggests that farmers and Indigenous communities have improved incomes and livelihoods through soybean cultivation (Cardozo et al., 2016). Likewise, there is evidence that oil palm cultivation has increased smallholder incomes and rural employment in Asia, reducing poverty rates (Qaim et al., 2020) and benefiting non-farm employment and income (Bou Dib et al., 2018). In Brazil, soybean cultivation supports an estimated 2.5 formal sector jobs outside of agriculture per square kilometer of production (Richards et al., 2015). Contract production, a type of partnership between buyers and smallholder commodity sellers that is well established in countries such as India, Thailand and South Africa (Boulay and Tacconi, 2012; Sartorius and Kirsten, 2002), shows poverty mitigation potential (Hajjar et al., 2021a, this issue).

Commodity markets also bring risks. In Brazil and Indonesia, lack of legal clarity on rights has made households vulnerable to land grabbing (Friends of the Earth et al., 2008; Gabay and Alam, 2017), with land speculation contributing to rural conflicts (Nepstad et al., 2006; Nepstad and Stickler, 2008; Rist et al., 2010). In Malaysia, expansion of oil palm cultivation has brought in foreign workers and contributed to wage suppression (Abdullah et al., 2011). The Brazilian state has sought to counter smallholder displacement by resettling landless farmers from poor regions and connecting them directly to soybean companies. However, rugged geography, small-scale operations, and high production costs have limited smallholder partnerships with companies (Lima et al., 2011).

Institutional and policy reforms can contribute to better social and environmental outcomes associated with commodity market growth (Climate Focus, 2017). Security over land rights can reduce land grabbing, and jurisdictional approaches may be able to increase access to information through more transparent decision-making (Hajjar et al., 2021b, this issue; Razafindratsima et al., 2021, this issue). About 35–40% of palm oil is produced by small landholders (Climate Focus, 2017). Thus, improving credit, training and technology access to such smallholders can increase productivity (Climate Focus, 2017; World Economic Forum, 2020). Vietnam is illustrative of how smallholder forestry and incomes can grow with policy reforms that strengthen land security and improve the access to credit (Nguyen et al., 2010; Sikor, 2011; World Bank, 2019). Institutional innovations and cooperatives that enable smallholders to pool resources and increase market shares are also important (Poole and de Frece, 2010). Studies of cacao producers in Côte d'Ivoire and Ghana (Calkins and Ngo, 2010) and small-scale timber producers in Turkey (World Bank, 2017) point to members in cooperatives having higher incomes relative to non-members; however, causality is difficult to explicitly show in many such examples (Hajjar et al., 2021a, this issue).

In general, the implications of supply chain reforms on heterogenous poor communities need additional careful research and analyses (Hajjar et al., 2021a, this issue; Newton and Benzeev, 2018). In their meta-analysis of 24 cases, DeFries et al. (2017), for instance, found that certification was associated with economic and environmental outcomes that were overwhelmingly positive or neutral, while social outcomes were more variable. Gender and indigeneity are two axes along which the social impacts of certification and other schemes are likely to vary, requiring special attention in scaling up these strategies (Loconto, 2015; Lyon et al., 2010). Furthermore, data on reforms, such as how zero-deforestation commitments (ZDC) affect social dimensions, lag well behind evidence on the impacts of such commitments on forest cover change (Newton and Benzeev, 2018). Additional evidence on the social dimensions of different supply chain reform initiatives would help identify whether companies are adopting voluntary practices (Thorlakson et al., 2018), how these align with national policies (Carodenuto, 2019) and whether they mitigate poverty (Newton and Benzeev, 2018).

Table 1
Projected Increase in commodity production at the forest-agriculture frontier.

Commodity	Projected Increase (%)	Source
Beef production, developing countries (2016–18 to 2028)	17.0	OECD/FAO (2019)
Soybean Exports (2016–17 to 2028)	49.0	Gale et al. (2019)
Soybean production (2005–07 to 2050)	79.7	Alexandratos and Bruinsma (2012)
Oil Palm (2016–18 to 2028)	18.0	OECD/FAO (2019)
Volumetric demand for wood (2010–2050)	284.7	WWF (2012)

5. Public and private forest sector financing

The forest sector is generally financed through budgetary allocations from domestic governments, international aid, and, increasingly, private sources. Support for forestry covers efforts to reduce deforestation as well as for private and public tree planting and restoration. The overall and relative amounts from different funding sources is changing, with implications for poverty reduction.

5.1. Overseas development forest aid

Overseas development assistance (ODA) for forestry often supports forest protection and improvement, rural economic development, and forest-related climate mitigation and adaptation (Environmental Defense Fund and Forest Trends, 2018). Building on previous work (Agrawal et al., 2013), we reviewed multilateral international forestry aid. Data for this analysis came from the Organization for Economic Cooperation and Development (OECD), World Bank, Global Environment Facility, Asian Development Bank, African Development Bank, and Inter-American Development Bank databases. Forest-related aid projects in these databases were identified using the following keywords in titles or descriptions: "forest," "agroforestry," "deforestation," or "tree."

While broad-based “Restoration” was not included, forest restoration projects were otherwise included. Data include forest-related climate financing (e.g., REDD+) to the extent that this was identified through the search terms. To eliminate duplicates, we removed projects with the same name, country and/or committed amount.

Forest sector aid over the last 5 years represents 1% of ODA across all sectors (USD 177.18 billion) (OECD, 2021). During 2014–2017, nearly USD 7 billion in international and bilateral aid was allocated to forest projects (Fig. 2). This suggests that average annual forest aid was ~ USD 1.7 billion, a reduction from USD 3.5 billion per year between 2000 and 2013. Not all data were available for 2018 and 2019, but trends at the World Bank and Inter-American Development Bank indicate that forest-related funding decreased during these years relative to 2017 by 77% and 53% respectively. Overall, these figures suggest that international forest aid may be showing a stagnant or declining trend.

The geographic allocation of international forest aid was unequal during the study period. Asian nations received the greatest amount of funding (USD 3.1 billion), followed by countries in the Americas (USD 1.4 billion), and Africa (USD 1 billion). Projects that received forest aid cover a range of approaches, including afforestation/reforestation, payments for ecosystem services, alternative livelihood provision for forest-proximate people, forestry agency reforms to reduce deforestation, consolidation of national parks, and sustainable forest management and agroforestry, among others.

5.2. Growth in private investments and markets

Although systematic data on private financing of the forestry sector is limited, some evidence suggests the value of carbon forest offset markets is increasing, as is the value of private forestry impact investments with the goal of generating both public and private returns (Bass et al., 2019; Ginn, 2020).

The Global Impact Investing Network (GIIN) estimates that over 1,720 organizations managed USD 715 billion in impact investment assets globally in 2019 (Hand et al., 2020), with 37 funds managing at least USD 9.4 billion directly in forests and related assets (Bass et al., 2019). These funds represent investments that aim to provide returns from forest products while also achieving environmental and social co-benefits. Most of the funds focus on investments in Australia, Canada, and the United States, though six of the 37 funds invest in projects in sub-Saharan Africa, Latin America, and Southeast Asia (Bass et al., 2019). Accurately identifying how much of the investment is directed toward forests is, however, difficult because these investments have dual- or triple-bottom lines and may be categorized within larger, less specific categories like conservation projects (Hand et al., 2020), and because reliable data on foreign and domestic private investments in forestry are limited (Castrén et al., 2014).

Fig. 2. Forest-related international aid, 2014–2017.
Source: Authors’ assessment based on data from OECD, World Bank, GEF, Asian Development Bank, African Development Bank, and Inter-American Development Bank.

Voluntary forest carbon offsets represent a specific area of private sector growth. The market typically brings private sector funding to Forest and other Land Use (FLU) projects related to afforestation/reforestation, avoided deforestation, degradation and sustainable forest management (e.g., REDD+), landscape management, and agroforestry. To identify the growth in the forest carbon offset market, we draw from Forest Trends’ State of the Voluntary Carbon Market reports (2006 through -2020) (Forest Trends’ Ecosystem Marketplace, 2021). Market value and total transacted volume of offsets were identified from total values from the 2019 report (Forest Trends’ Ecosystem Marketplace, 2019), for all years from 2006 through 2018.

Fig. 3 shows that the voluntary forest carbon market is still small (~ USD 300 million in 2018). Though there is significant fluctuation in both the total market and the proportion of FLU projects from year to year, FLU offsets show a slight upward trend over the 2006-18 period. Because of the reporting methodology, the percentage of total offsets in each year from FLU is likely underestimated.

5.3. Financing poverty reduction through forestry investments

Identifying the poverty impacts from overseas forestry investments, either through aid, impact investment, or voluntary carbon offset programs, is challenging. Inconsistent monitoring and evaluation, lack of publicly available data, long gestation periods between project investment and benefit accrual (from tree-planting, for instance), and the presence of multiple “bottom lines” make estimating causality difficult.

An appraisal of the forestry portfolio of the largest donor in the sector, the World Bank, sheds some light on the poverty implications of forestry aid. Shyamsundar et al. (2020) show that the World Bank’s forestry investments (worth over USD 1 billion and completed between 2002 and 2015) are mainly in middle-income countries, with low-income countries accounting for only 10% of projects. A majority of projects in the World Bank’s forestry portfolio included poverty-related components such as technical support and training to improve community forestry and/or smallholder plantations, support for nurseries and small-scale forest businesses, and strengthening forest rights (Shyamsundar et al., 2020). While there is generally limited evidence on poverty outcomes from forestry aid, pointing to the need for careful evaluations, many assessments of REDD+ projects (which are largely publicly financed (Well and Carrapatoso, 2017)), are available (Duchelle et al., 2018; Lawlor et al., 2013). Hajjar et al. (2021a, this issue), discussing in detail the implications of REDD+ on poverty, suggest that available evidence points to mixed results.

Private sector financing in the form of impact investments usually complements public or private non-profit financing (Ginn, 2020). Financing of nascent forestry enterprises and locally owned small and medium forest enterprises can generate employment and spread prosperity to local forest-reliant communities (Hajjar et al., 2021a, this issue; Kozak, 2007; Macqueen et al., 2020; Macqueen, 2008; Sanchez Badini et al., 2018). Financing in the agroforestry space has seen some investors (e.g., TechnoServe, 2021) combining business advice with capital investments, and others, such as the One Acre Fund non-profit, providing technical assistance and financing for tree planting to some one million African farmers (One Acre Fund, 2021). Agroforestry benefits can differ along gender lines, with positive benefits to women ranging from reduced burden from collecting wood to cash income from tree product sales to improved nutrition (Razafindratsima et al., 2021, this issue). Also, as previously noted, certification of sustainable products, often financed through impact investments, appears more likely to contribute to positive economic outcomes relative to social and distributive outcomes (DeFries et al., 2017).

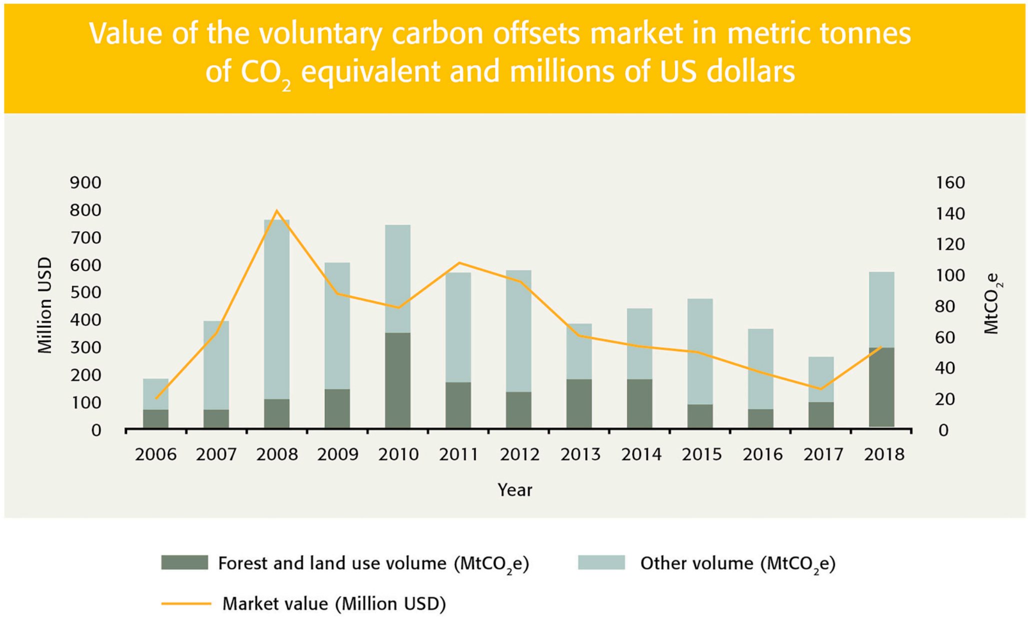

Fig. 3. Value of the voluntary carbon offsets market in metric tons of CO_2 equivalent and millions of US dollars.
Source: Data drawn from multiple reports, Forest Trends State of Voluntary Carbon Market reports (2007–2019) (Forest Trends' Ecosystem Marketplace, 2021).

Consideration of co-benefits, including poverty reduction, by the voluntary carbon offsets market may be increasing. From 2016 to 2018, the number of forestry and land use projects certified using a combination of Voluntary Carbon Standard (VCS) and Climate, Community and Biodiversity (CCB) standards, the latter of which pays attention to social outcomes, increased by 325%, while total carbon offsets only increased 53%, indicating market preference for projects with social and environmental co-benefits (Forest Trends' Ecosystem Marketplace, 2019). Of the 166 forestry and land use projects currently under some stage of verification or validation for CCB, 38 are in Africa, 50 in Asia, and 70 in Latin America, with China, Brazil and Colombia leading the use of this approach in their respective regions ("Verra Registry Database,", 2021). Documented evidence on the poverty reduction benefits of the voluntary carbon offsets market is relatively lean. Available information from Mozambique suggests that forest restoration with CCB verified emission reductions may have had mixed results (Jindal et al., 2012; Mathur et al., 2014). The authors found that communities had limited power and ability to advocate for themselves (Mathur et al., 2014), but gains may have accrued from broader project-related economic development activities (Jindal et al., 2012).

Even though private sector forestry funding is steadily increasing, both public and private investments remain small relative to, for example, the financing required for large-scale forest restoration (Castrén et al., 2014). To prevent worst case scenarios of land grabbing and corporate 'greenwashing,' and to ensure that the voluntary carbon offsets market meets social objectives, standards need to pay greater attention to issues such as income predictability, transaction costs, and meaningful local participation, especially for and among smallholders (DeFries et al., 2017; Franco and Borras, 2019; Fuente and Hajjar, 2013; Melo et al., 2014). Understanding how women participate in and benefit from forest carbon financed projects is a particularly important social consideration. Evidence from REDD+ programs in Nepal (Khadka et al., 2014) and the Congo Basin (Brown, 2011), for instance, suggests that more equitable outcomes can be achieved when women are involved in the planning and execution of these programs.

6. Technological change and rising interconnectivity

Pathways that link forests and livelihoods are moderated and mediated by material technology. Changes in bio-geophysical data availability, remote sensors, and computational speed have improved the ability to monitor and study forest-livelihood relationships. Rapid advances over the past thirty years in computing and internet technology have contributed to publicly available, high-resolution earth observation data, enabling reliable and replicable assessments of global land cover change (Loveland and Dwyer, 2012).

Increases in interconnectivity – including via social media – have shifted the dissemination of forest-livelihoods knowledge and emerged as new means for organizing by forest-proximate peoples, including providing new pathways for their participation in broader decision-making processes (Castells, 2007; Loader and Mercea, 2011; Stevens et al., 2016). Together, these technologies potentially affect forest-livelihood relationships by improving information available on forest resources, providing more accurate and scalable methods for forest monitoring, and connecting forest proximate peoples.

6.1. *Improved monitoring and evaluation of forests*

Over the last decade, a variety of spatial products and new remote sensors have enhanced forest monitoring and evaluation, with widespread uptake of high-resolution tree-cover maps from Landsat data beginning in 2000 (Hansen et al., 2013). Public and private satellites that provide higher-resolution imagery, LIDAR technology piloted on unmanned aerial vehicles (UAVs), and the use of artificial intelligence (AI) to analyze data compose the technological frontier of spatial data and analysis. Satellite imagery at resolutions greater than 30 m per pixel help identify fine spatial patterns and changes in forest structure (Kayitakire et al., 2006; Steven et al., 2003). LIDAR imagery enables three-dimensional analyses of canopy height and density, facilitating assessments of forest structure (Ferraz et al., 2016; Ganivet and Bloomberg, 2019). New monitoring technologies, such as acoustic sensors and UAVs, have also enhanced the ability to monitor and regulate products provisioned by forest systems (Marvin et al., 2016).

The variety of new data types, sources and methodologies result in improvements for real-time tracking of forest changes as well as forest fires and generate novel ways to monitor forest ecosystem services (Davies et al., 2009; Hansen et al., 2016; Wheeler et al., 2014). For example, combining data from different sensors, which enables the estimation of above-ground forest carbon (Asner et al., 2010; Le Toan et al., 2011), with spatial data on the extent of forest cover, can help identify a suite of carbon sequestration and other ecosystem services (Martínez-Harms et al., 2016). Bioacoustics and spatial data can help identify the connections between forest conservation, regeneration, and biodiversity (Burivalova et al., 2019). These technologies spot and count wildlife, map land cover, and promote real-time monitoring of protected areas (Iacona et al., 2019; Wich and Koh, 2018), including the detection of poachers and poaching in real-time (Kamminga et al., 2018). Forensic science uses visual, chemical, and genetic techniques to determine the origin of a wood samples (Dormontt et al., 2015), which can potentially reduce illegal logging and strengthen legally sourced supply chains (Sasaki et al., 2016; Tnah et al., 2010).

6.2. Social media and the rise in user-group connectivity

Mobile phones and associated social media access enable knowledge exchange, network building, and political claims-making for forest-reliant communities. Indigenous and forest community groups increasingly connect through applications such as Facebook and Twitter in order to develop alliances in favor of community forest rights, pursue 'boomerang effects' that galvanize international attention to pressure national governments to respect or support local management of forests, and to share news about specific phenomena (Keck and Sikkink, 1998; Sauls, 2020). Mobile phones and more accessible photovideo technology also enable forest communities to capture and share their own narratives (e.g., "If Not Us Then Who?,", 2021) (Mitchell-Walthour, 2020). Groups that engage in international training or exchanges use social media to maintain networks, which serve to disseminate best practices around sustainable forestry and effective advocacy (Duncombe, 2016; Sauls, 2020). Even as mobile phone accessibility can enhance access to market information, facilitate peer-to-peer learning, and ease logistics planning for smallholders, the impact of these innovations on the income of forest-reliant communities is, as yet, unclear (Baird and Hartter, 2017; Duncombe, 2016; Sife et al., 2010).

6.3. Technology, knowledge, and changes in power relationships

Remotely sensed spatial data, advances in acoustic sensors, data from UAVs, and forensic timber science provide replicable, reliable, and low-cost methods to monitor forest resources. In addition, these technological advances are helpful in designing governance mechanisms, such as payments for ecosystem services (Curtis et al., 2018; Mitchell et al., 2017), and community-based forest management (Blackman et al., 2017; Santika et al., 2019). These advances may also aid in curtailing human-wildlife conflict, a major cause of crop raiding, injury, and even death in many tropical forests (Nyhus, 2016) and in facilitating the mapping and monitoring of Indigenous territories (Paneque-Gálvez et al., 2017; Radjawali et al., 2017). Such technologies also provide employment opportunities for technologically literate forest-proximate people, advance opportunities for research on forest areas, strengthen sustainable supply chains, and contribute to community-based forest management or co-management (Bellfield et al., 2015; Iacona et al., 2019; Marvin et al., 2016).

In general, however, enhanced availability of material technologies improves the detection of forest cover change but does not provide immediate solutions to address the complexities of forest-related policies, land tenure, monitoring, and enforcement challenges (Erbaugh and Nurrochmat, 2019; Gaveau et al., 2017). Improved technologies for forest monitoring often reinforce pre-existing regulations (Musinsky et al., 2018). This can limit the informal or extra-legal access communities have to forestlands. For example, by harmonizing formal tenure and maps of tree-cover through the One Map initiative, the Government of Indonesia has prioritized sequestering carbon and clarifying formal tenure. This process has led to the identification of informal forest use by forest proximate people and has enabled exclusion of forest use among some communities that live near or within government forests (Astuti and McGregor, 2017). In Tanzania, REDD+ readiness projects combined remotely sensed forest imagery with a focus on formal tenure to become harbingers of "conservation-related exclusion" (Lund et al., 2017). The benefits from technology-enhanced monitoring are not necessarily equitable.

Advanced forest monitoring technology remains largely the purview of experts (e.g., states, researchers, and NGOs). Unless capacity building is included when rolling out new technologies, the ability of rural communities to leverage these tools to enhance their own livelihoods may be limited. However, counterexamples are emerging. New smartphone applications such as TIMBY (*This Is My Backyard*) and ForestLink offer communities in Liberia and Cameroon, respectively, the capacity to monitor illegal logging, and recent reports from Peru suggest these types of programs can be effective (Eilu, 2020; Slough et al., 2021). The Association of Forest Communities of Petén (ACOFOP) in Guatemala has made concrete livelihoods gains by leveraging geospatial data and smart phones to improve forest management and responsiveness to threats, which has also helped ACOFOP gain political support (Millner, 2020). In general, democratizing the use of material technology and interpretation of associated data is a critical next step in empowering communities to manage forest resources and directly alleviate poverty.

7. Global socio-political movements

Climate change and biodiversity loss have transitioned from topics discussed primarily by biophysical scientists to issues of widespread public concern informed by international efforts to synthesize scientific evidence (Díaz et al., 2018; IPBES, 2019; IPCC, 2018). A range of global social movements shape contemporary politics around forests and the forest-reliant poor. Such social movements include protests on inequality and racism and in support of Indigenous peoples' rights and climate change action, as well as countervailing forces, such as anti-environmental populism. These global movements are shaping contemporary politics around forests and the forest-reliant poor.

7.1. Shifting political and civic landscapes

Recent changes in global discourses and political priorities have shifted political and civic landscapes related to forests and the environment. In several countries, governments have rejected climate mitigation and other environmental policies: the re-positioning of several governments, including the United States' multi-year withdrawal from the 2015 Paris climate agreement and Brazil regarding protections in the Amazon, exemplifies this trend (Fearnside, 2018; McCarthy, 2019). The changing political landscape portends potential conflicts between priorities at local, national, and international scales, particularly real and perceived trade-offs between conservation and forest-based economic development. In some cases, national growth strategies are in fact deepening commitment to extractivism as the basis of development (Bebbington et al., 2018a, 2018b; Humphreys Bebbington et al., 2018), with a reduction in environmental and social protections for forest peoples and ecosystems (de la Vega-Leinert and Schönenberg, 2020).

The contemporary moment also features a major counter-current to national, anti-environmental political shifts. Public awareness of the threat that environmental change poses to human well-being has coincided with renewed resistance to social injustice, inspiring new socio-political movements across the globe (Fagan and Huang, 2019; Lee et al., 2015). The climate youth movement, for example, has become increasingly popular and inspired a suite of new, often young, activists. In September of 2019 alone, there were over 2,500 events scheduled in over 150 countries to sound the alarm about the climate crisis (Tollefson and Monastersky, 2019). Other movements such as Extinction Rebellion call for nonviolent, civil disobedience to compel governments to act before biodiversity loss and rising temperatures reach a tipping point. Forests—and other 'natural climate solutions' (e.g., Griscom et al., 2017)—are central to the demands made by these movements, which are occurring simultaneously with other mass movements demanding political accountability (e.g., Brazil, Chile, France, Hong Kong and the US) and the fusing of environmental and social justice concerns (e.g., Green New Deal in the US or the European Green Deal) (Wright, 2019).

7.2. Indigenous rights and social justice movements

Indigenous Peoples and local communities are estimated to have legal rights to over 15.3% of forestland in the 58 most forested countries in the world (Rights and Resources Initiative, 2018), although the actual figure is likely to be much higher. The growing recognition of Indigenous and community rights over forests since the 1980s reflects shifts in development and environmental conservation theory, as well as self-identified and well-organized forest-reliant communities staking their ancestral claims to land and resources. When faced with local protest while implementing forest governance reforms, major development donors, such as the World Bank, increasingly supported formalized, collective land rights arrangements (Anthias and Radcliffe, 2015; Bryan, 2012; Jackson and Warren, 2005). Since the 1990s, the failure of exclusionary models to consistently achieve biodiversity and forest conservation without negatively affecting human rights has also led to the inclusion of Indigenous and local communities in forest management via extractive reserves, Indigenous and Afro-descendant territories, and co-management arrangements (Brockington, 2004; Hutton et al., 2005).

The COVID-19 pandemic has also precipitated a worldwide recognition of systemic injustice, especially anti-Black racism, and other forms of discrimination related to racial, ethnic, and religious identities. Building from previous protest waves in the UK, South Africa, Brazil, and the United States in particular, this emerging international movement has raised awareness of institutionalized racism across many countries and sectors, including the environment (Finney, 2014; Knudsen and Andersen, 2019; Miles, 2019). While these protests have, on the one hand, highlighted how marginalized groups are harmed by policies of the state, they have also underscored how excluding diverse voices in professionalized forestry, conservation, and development organizations may lead to an undervaluation of the lived experiences of minority groups and their experiences in nature (Finney, 2014; Hays, 2019; Kloek et al., 2017). The current movement is already spurring reflection amongst conservation and forestry groups on how they might become more inclusive, including by directly grappling with legacies of colonialism and dispossession that have disproportionately affected Indigenous peoples and people of color (Mollett and Kepe, 2018).

7.3. Implications for forest-poverty dynamics

New environmental movements, often rallying around visible threats like forest fires, are pushing governments toward action on climate change and forest loss. These efforts, reinforced by global dissatisfaction with increasing inequality (Hickel, 2017), and layered onto on-going Indigenous rights' movements, often view social and environmental justice as paired goals. This combined set of priorities could substantively address poverty in forested areas; however, whether attention translates into action – and whether actions to address climate change and forest loss are inclusive of the needs of forest-proximate and -reliant communities – depends on broader political conditions.

The rise of populist governments provides a direct challenge to environmental movements. The anti-environmental perspectives often held by these governments may sacrifice forests and the environment for national economic growth, with limited benefit to the poorest people. Populism often layers onto underlying political conditions, including extractivism, the roll back of social protections, endemic corruption, and in some cases even illicit activities (such as illegal mining, poaching, and narco-trafficking) across scales (Devine, 2014; McSweeney et al., 2014; Tollefson, 2016; Yagoub, 2017), which can threaten the well-being of forest-reliant peoples.

Given many Indigenous and local communities' dependence on forests for their livelihoods, land rights and secure access to forests is a priority for these groups (Rights and Resources Initiative, 2018). Although the causal link between forest rights and poverty alleviation is mixed, case study evidence suggests that income and community-provided social services increase with greater control of forest resources (Bocci et al., 2018; Hajjar et al., 2021b, this issue). The implications of forest rights for ecological and social well-being depends on many contextual factors, including how local institutions and practices interact with dominant economic forces and external institutions (Bebbington et al., 2018a; Robinson et al., 2014), and the degree to which governments respect the rights of forest groups or use force to suppress pro-pro-social and environmental civic action (Middeldorp and Le Billon, 2019; Scheidel et al., 2020).

8. Infectious disease and forest cover change

Infectious diseases are an important cause of global morbidity and mortality, responsible for some 10 million deaths or 1/5th of all deaths worldwide in 2016 (Hay et al., 2017). The past two decades has seen a rise in emerging infectious diseases (EIDs), such as Ebola, SARS, MERS, the novel Coronavirus (COVID-19) and others, a trend that is likely to continue (Allen et al., 2017; CDC, 2020a). Some 70% of EIDs originate from interactions among wild and/or domestic animals and humans (Morse et al., 2012).

Research over the past several decades has documented the importance of forest loss and increasing forest edge for established vector-borne diseases, such as dengue and malaria (Chaves et al., 2020; Husnina et al., 2019; MacDonald and Mordecai, 2019). However, zoonoses (diseases that spread from vertebrate animals to humans) received less widespread global attention until COVID-19 (Di Marco et al., 2020). Anthropogenic changes, including deforestation and expansion of agricultural land that increases contact between humans and wildlife, intensification of livestock production near wildlife areas, and increases in hunting and trading of wildlife all contribute to zoonoses (Allen et al., 2017; Dobson et al., 2020). Deforestation and biodiversity disruption can create new breeding habitats for disease vectors by changing the ecological conditions that regulate predator-prey relationships and make wildlife more vulnerable to disease (Keesing et al., 2010; Pongsiri et al., 2009). Climatic changes, such as increases in temperature and changes in precipitation patterns in forested areas, can also change the geographic range and population density of zoonotic pathogens and the pathogen load in individual hosts and vectors (Mills et al., 2010). Trade in wildlife and wet markets contribute to zoonoses by increasing contact between animals and humans (Dobson et al., 2020; Wolfe et al., 2005), though the emergence and spread of zoonoses can take different complex pathways (Altizer et al., 2011; Epstein et al., 2006).

8.1. Pandemics and the rural poor

Pandemics affect rural communities, including the forest-reliant poor, through health-related and economic pathways. The Ebola outbreak in West Africa killed more than 11,000 people by 2016 (CDC, 2020a), contributed to a 12% reduction in the combined GDP of Guinea, Liberia and Sierra Leone relative to pre-Ebola expectations, and changed economic transactions across several other countries in Africa (World Bank, 2015). COVID -19, as of 23rd July 2021, had infected over 192 million people, resulting in over 4 million deaths worldwide (John Hopkins University and Medicine, 2021). Varying estimates suggest that the global economy may contract by 3–5% in 2020 (International Monetary Fund, 2020; World Bank, 2020a). Assuming a 5% contraction of the global economy, rural populations in extreme poverty are expected to increase by 15% globally (Laborde Debucquet et al., 2020). Notably, in many parts of the world, COVID-19 is occurring where the background rate of malaria, dengue, and other infectious diseases already take a huge health toll (Lorenz et al., 2020; Saavedra-Velasco et al., 2020).

Fig. 4 illustrates the many pathways through which COVID-19 continues to affect rural households. In addition to health losses, for many forest-reliant poor, economic disruptions have led to changes in labor and non-labor income, especially where work is tied to forest-related tourism or disrupted forestry supply chains (FAO, 2020; Spenceley et al., 2021). The implications of the complete stoppage of ecotourism, identified as a critical lever for poverty reduction (Hajjar et al., 2021a, this issue), is particularly dire. Household consumption can decline as urban members return, public services decline, or if laws against bushmeat hunting are strengthened, reducing access to subsistence (Nasi and Fa, 2020; Shyamsundar, 2020; World Bank, 2020b). In remote Indigenous territories, EIDs can pose a serious existential threat because of limited access to immediate health care and ability to reduce spread, once exposed, as evidenced in the Brazilian Amazon in 2020 (Conde, 2020; Taylor, 2020).

There are potential positive feedback loops between health shocks and rural poverty (Rohr et al., 2019). Forests tend to act as a safety net when rural communities face covariate shocks (Wunder et al., 2014). Thus, pandemic-related economic shocks can lead rural communities to increase their extraction from forests, contributing to deforestation and degradation, with additional indirect negative effects on household welfare (Shyamsundar, 2020). Initial findings from Madagascar, for instance, note an increase in fires and forest clearing near protected areas as people who normally relied on tourism income prepare to invest more in agriculture (Eklund et al., 2020). In addition, macro-policy responses to the economic contractions resulting from COVID-19 may lead to a reduction in overseas development aid, including funding for forests, and incentivize governments to loosen regulations around forest protection, potentially increasing forest encroachment by outside actors and undermining subsistence and forest-based income and forest rights (Bebbington et al., 2018a; Gonzales, 2020; Vila Benites and Bebbington, 2020).

Previous policy responses to risks associated with zoonoses have been largely reactive, focusing on disease investigation and vaccine development. However, given the enormous costs and welfare implications of the COVID-19 pandemic, there is increasing interest in cost-effective 'preventive' policies (Dobson et al., 2020), such as the One-Health approach, which seeks to integrate ecological and human health considerations (CDC, 2020b; Di Marco et al., 2020). These may include a range of strategies: reduction in forest fragmentation and livestock and agricultural production in proximity to wildlife; increase in forest buffer areas; investment in rural health clinics; wildlife trade restrictions; and/or improved wildlife and livestock disease surveillance (Bloomfield et al., 2020; Di Marco et al., 2020; Dobson et al., 2020). To the extent that the forest-reliant poor may be involved in the pathways leading to zoonotic epidemics, public investments that strengthen food supply chains, provide alternatives to illegal wildlife use and trade, and reduce unmanaged encroachment of natural areas may offer triple-win opportunities.

9. Discussion

Forests play a varied role in poverty dynamics (Jagger et al., 2020). They help maintain peoples' well-being by supporting subsistence needs, act as a safety net by helping to reduce risk by smoothing consumption, and can be a source of prosperity; noting, however, that benefits are not necessarily shared equitably across people of different gender, ethnicity, or race groupings. Forest-reliance can also have negative impacts on local well-being, such as through wildlife conflicts or pest infestation that push people further into poverty. The impact of global changes on forest-poverty dynamics may be magnified by the

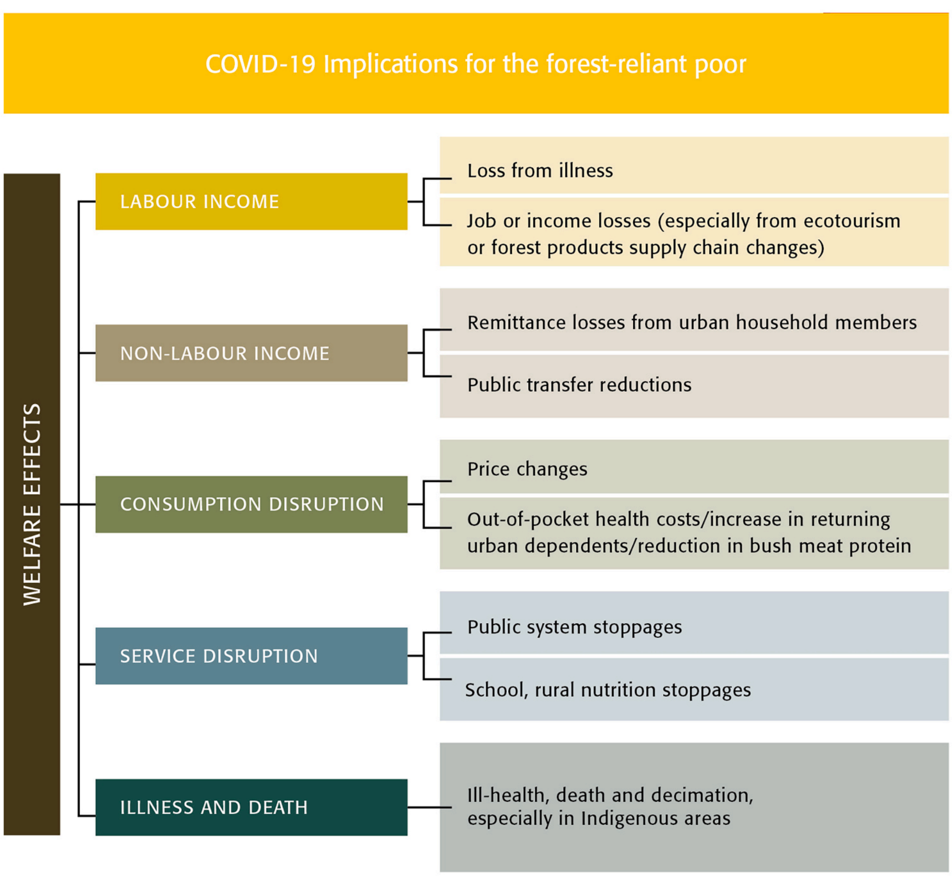

Fig. 4. COVID 19 implications for the forest-reliant poor (adapted from Fig 1. in World Bank, 2020b).

multidimensional vulnerabilities that forest-reliant communities experience and local to global adaptive responses.

Fig. 5 illustrates how the intersection of multiple global forces deepens the impact on forest-poverty dynamics (see also Table A2). For example, climate change and EIDs pose health and economic risks to the forest-reliant poor that may together push larger numbers of households into transient or chronic poverty. At the same time, some of these global forces may act as powerful countermeasures. Public finance can help people move out of poverty (e.g., through capacity building or access to credit) and support well-being by strengthening ecosystem services (e.g., restoring watersheds to improve water quality and reduce flooding). Targeted private financing can increase cash income flows (through payments for carbon, for example), enabling smallholders to build assets to move out of poverty and better adapt to climate change. Advanced technology, wielded well, can clarify rights, reduce land conflicts, and help poor communities access markets. Interconnectivity is also a powerful tool for social networking, helping Indigenous communities, for instance, to advance forest rights movements. However, rapidly emerging technologies can also increase poverty in cases where technical forest monitoring reduces subsistence forest uses.

Global changes offer both opportunities and risks to the forest-reliant poor. In a 'Business as usual' scenario (Fig. 6), multiple risks posed by global changes to the forest-reliant poor may overshadow any opportunities for poverty alleviation. This is largely because poor households have limited capacity or resources to take advantage of new opportunities. Nevertheless, policy, market and institutional reforms that reduce risks and improve access to new opportunities could enable movements out of poverty. Cross-sectoral strategies, such as OneHealth, that transcend the silos of health, biodiversity conservation, and poverty alleviation, can also mitigate risks and lead to alternative models of development for forest landscapes (Di Marco et al., 2020).

Fig. 6 identifies a potential improved future scenario for the forest-reliant poor with measures undertaken to reduce global risks and strengthen capacity to manage vulnerability and embrace opportunities. Specific measures may include: a) financing commodity supply chain reforms (strengthening transparency, training, networking and resources for smallholders to access global value chains); b) deploying technologies that work for the poor (including those that enable monitoring of investments and commodity flows); c) strengthening land rights, particularly of Indigenous Peoples; d) integrating sectoral interventions, e.g., OneHealth actions (buffer areas between agriculture and livestock production and forests, wildstock and human disease surveillance, alternatives to wildlife trade); e) investing in climate adaptations that reduce exposure to natural disasters and stabilize ecosystem services; and, f) encouraging global social movements that boost the voice of forest-reliant peoples while countering trends toward criminalization.

These strategies can build the enabling environment for promising levers of change that contribute to poverty reduction, including community forest management, ecotourism, agroforestry, and small and medium forest enterprises (Hajjar et al., 2021a, this issue).

10. Conclusions

This article has identified a set of cumulative threats and opportunities that global changes pose to forest-reliant poor households. Many of the global changes discussed in this paper act as shocks to households – they manifest as negative health impacts, land losses, land-use conflicts, loss of resource access and political support, among others. However, they may also open new opportunities that contribute to income and employment of forest-reliant people, enhance their connection to broader networks, and empower them with strengthened self-

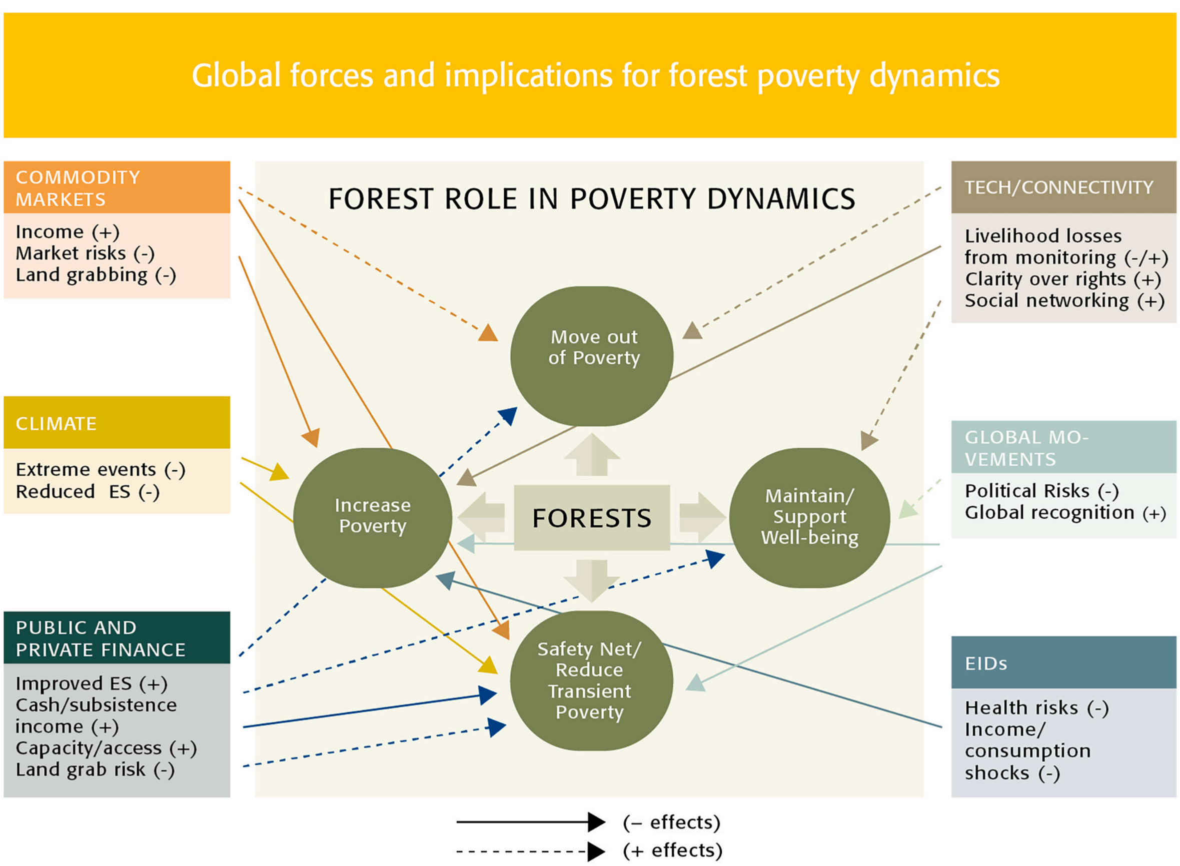

Fig. 5. Global forces and implications for forest poverty dynamics.
Note: ES = Ecosystem services, EIDs = Emerging infectious diseases.

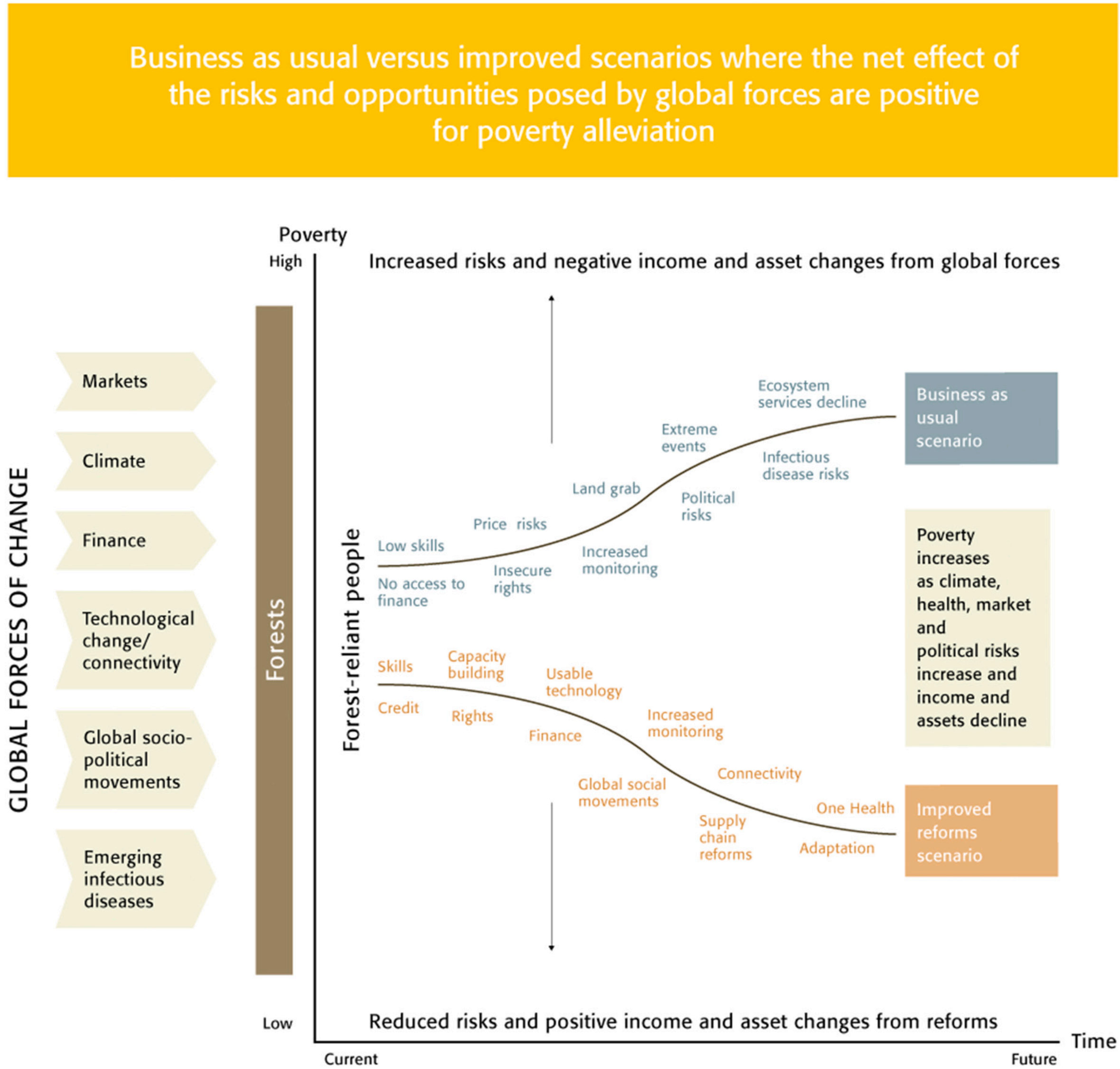

Fig. 6. Business as usual versus improved scenarios where the net effect of the risks and opportunities posed by global forces are positive for poverty alleviation

governance and technical skills. Democratizing the use of technology and building capacity for data interpretation will further help to empower forest communities. Private and public financing in improved forest management can build resilience and, when aligned with social and environmental outcomes, can enhance the position of forest-reliant peoples.

There are large gaps in knowledge related to both global trends and forest-poverty dynamics (Hajjar et al., 2021b, this issue). The published literature on varying effects of climate change on the forest proximate poor and of market supply chains on human welfare, for instance, is limited. Thus, our analyses related to global changes depend, in part, on historical evidence or conceptual theories of change. Furthermore, the analysis in this chapter does not address meta-trends such as urbanization or broad-based economic globalization that have indirect, uncertain, but potentially large effects on the forest-reliant poor. It is also unable to do justice to the uncertainties related to available projections on future global changes.

The poor are not a homogenous class of people and are differentiated by gender, access to assets, social status, and so on. Thus, global changes will likely have distinct effects on different sub-groups (women, landless labor, Indigenous communities) based on pre-existing inequities and socio-economic and political realities (Hajjar et al., 2021a, this issue; Oldekop et al., 2021, this issue; Razafindratsima et al., 2021, this issue). Few studies that examine the poverty impacts of forest-related policy, institutional, and market reforms provide evidence of differentiated impacts (Hajjar et al., 2021a, this issue). Thus, understanding how global changes land on different sub-groups among poor households, and the role of policy reforms in reducing poverty among these sub-groups considering global changes, is an important area for additional research.

Figs. 5 and 6 in this paper provide an analytical framework that can be tested and further explored in specific contexts. For instance, the potential poverty implications identified in these figures (and Table A1) could be verified at national, regional, or local scales depending on data availability. Knowledge of socio-political conditions may also help clarify the differentiated effects of global changes on different demographic groups. There are also potential feedback loops in regions where global changes degrade forest and increase poverty, which may, in turn, lead to further degradation of forest and tree-based systems, resulting in a vicious cycle of poverty and forest loss. These complex feedback loops could be empirically traced in national contexts where global and local actions collude to damage forests and increase poverty.

This article provides opportunities to consider where poverty alleviation and forest management can coalesce to serve ecological, social, and economic goals. Given that global forces of change on forest-poverty dynamics will vary across local contexts (Oldekop et al., 2021, this issue), it will be necessary to continue broad-scale and case study research to better understand the implications of global changes on specific forest management and use mechanisms (Hajjar et al., 2021b, this issue). Research into measures across sectors that account for the combined strength of these (and other) global forces may serve to improve outcomes on forest-poverty dynamics and lead to alternative models of development for forest landscapes.

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Appendix A. Supplementary data

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References

Abatzoglou, J.T., Williams, A.P., 2016. Impact of anthropogenic climate change on wildfire across western US forests. Proc. Natl. Acad. Sci. 113, 11770–11775. https://doi.org/10.1073/pnas.1607171113.

Abdullah, R., Ismail, A., Rahman, A., 2011. Labour requirements in the malaysian oil palm industry in 2010. Oil Palm Ind. Econ. J. 11, 12.

Agrawal, A., Cashore, B., Hardin, R., Shepherd, G., Benson, C., Miller, D., 2013. Economic Contributions of Forests (Background Paper No. 1). United Nations Forum on Forests, Istanbul.

Ainembabazi, J.H., Angelsen, A., 2014. Do commercial forest plantations reduce pressure on natural forests? Evidence from forest policy reforms in Uganda. Forest Policy Econ. 40, 48–56. https://doi.org/10.1016/j.forpol.2013.12.003.

Alexandratos, N., Bruinsma, J., 2012. World Agriculture Towards 2030/2050: The 2012 Revision (ESA Working Paper No. 12– 03). FAO, Rome.

Allen, T., Murray, K.A., Zambrana-Torrelio, C., Morse, S.S., Rondinini, C., Di Marco, M., Breit, N., Olival, K.J., Daszak, P., 2017. Global hotspots and correlates of emerging zoonotic diseases. Nat. Commun. 8, 1124. https://doi.org/10.1038/s41467-017-00923-8.

Alongi, D.M., 2015. The impact of climate change on mangrove forests. Curr. Clim. Chang. Rep. 1, 30–39. https://doi.org/10.1007/s40641-015-0002-x.

Altizer, S., Bartel, R., Han, B.A., 2011. Animal migration and infectious disease risk. Science 331, 296–302. https://doi.org/10.1126/science.1194694.

Amadu, F.O., Miller, D.C., McNamara, P.E., 2020. Agroforestry as a pathway to agricultural yield impacts in climate-smart agriculture investments: evidence from southern Malawi. Ecol. Econ. 167, 106443. https://doi.org/10.1016/j.ecolecon.2019.106443.

Anthias, P., Radcliffe, S.A., 2015. The ethno-environmental fix and its limits: indigenous land titling and the production of not-quite-neoliberal natures in Bolivia. Geoforum 64, 257–269. https://doi.org/10.1016/j.geoforum.2013.06.007.

Armenteras, D., Rodríguez, N., Retana, J., 2013. Landscape dynamics in Northwestern Amazonia: an assessment of pastures, fire and illicit crops as drivers of tropical deforestation. PLoS One 8, e54310. https://doi.org/10.1371/journal.pone.0054310.

Aryal, J.P., Sapkota, T.B., Khurana, R., Khatri-Chhetri, A., Rahut, D.B., Jat, M.L., 2020. Climate change and agriculture in South Asia: adaptation options in smallholder production systems. Environ. Dev. Sustain. 22, 5045–5075. https://doi.org/10.1007/s10668-019-00414-4.

Asner, G.P., Powell, G.V.N., Mascaro, J., Knapp, D.E., Clark, J.K., Jacobson, J., Kennedy-Bowdoin, T., Balaji, A., Paez-Acosta, G., Victoria, E., Secada, L., Valqui, M., Hughes, R.F., 2010. High-resolution forest carbon stocks and emissions in the Amazon. Proc. Natl. Acad. Sci. 107, 16738–16742. https://doi.org/10.1073/pnas.1004875107.

Astuti, R., McGregor, A., 2017. Indigenous land claims or green grabs? Inclusions and exclusions within forest carbon politics in Indonesia. J. Peasant Stud. 44, 445–466. https://doi.org/10.1080/03066150.2016.1197908.

Austin, K.G., Schwantes, A., Gu, Y., Kasibhatla, P.S., 2019. What causes deforestation in Indonesia? Environ. Res. Lett. 14, 024007 https://doi.org/10.1088/1748-9326/aaf6db.

Bacmeister, J.T., Reed, K.A., Hannay, C., Lawrence, P., Bates, S., Truesdale, J.E., Rosenbloom, N., Levy, M., 2018. Projected changes in tropical cyclone activity under future warming scenarios using a high-resolution climate model. Clim. Chang. 146, 547–560. https://doi.org/10.1007/s10584-016-1750-x.

Baird, T.D., Hartter, J., 2017. Livelihood diversification, mobile phones and information diversity in Northern Tanzania. Land Use Policy 67, 460–471. https://doi.org/10.1016/j.landusepol.2017.05.031.

Bass, R., Murphy, P., Dithrich, H., 2019. Scaling Impact Investment in Forestry. Global Impact Investing Network (GIIN), New York.

Bebbington, A.J., Humphreys Bebbington, D., Sauls, L.A., Rogan, J., Agrawal, S., Gamboa, C., Imhof, A., Johnson, K., Rosa, H., Royo, A., Toumbourou, T., Verdum, R., 2018a. Resource extraction and infrastructure threaten forest cover and community rights. Proc. Natl. Acad. Sci. 115, 13164–13173. https://doi.org/10.1073/pnas.1812505115.

Bebbington, A.J., Sauls, L., Rosa, H., Fash, B., Humphreys Bebbington, D., 2018b. Conflicts over extractivist policy and the forest frontier in Central America. Eur. Rev. Latin Ame. Caribb. Stud. 106, 103–132. https://doi.org/10.32992/erlacs.10400.

Bellfield, H., Sabogal, D., Goodman, L., Leggett, M., 2015. Case study report: community-based monitoring systems for REDD+ in Guyana. Forests 6, 133–156. https://doi.org/10.3390/f6010133.

Bertin, R.I., 2008. Plant phenology and distribution in relation to recent climate change. J. Torrey Bot. Soc. 135, 126–146. https://doi.org/10.3159/07-RP-035R.1.

Blackman, A., Corral, L., Lima, E.S., Asner, G.P., 2017. Titling indigenous communities protects forests in the Peruvian Amazon. Proc. Natl. Acad. Sci. 114, 4123–4128. https://doi.org/10.1073/pnas.1603290114.

Bloomfield, L.S.P., McIntosh, T.L., Lambin, E.F., 2020. Habitat fragmentation, livelihood behaviors, and contact between people and nonhuman primates in Africa. Landsc. Ecol. 35, 985–1000. https://doi.org/10.1007/s10980-020-00995-w.

Bocci, C., Fortmann, L., Sohngen, B., Milian, B., 2018. The impact of community forest concessions on income: an analysis of communities in the Maya Biosphere Reserve. World Dev. 107, 10–21. https://doi.org/10.1016/j.worlddev.2018.02.011.

Bou Dib, J., Krishna, V.V., Alamsyah, Z., Qaim, M., 2018. Land-use change and livelihoods of non-farm households: the role of income from employment in oil palm and rubber in rural Indonesia. Land Use Policy 76, 828–838. https://doi.org/10.1016/j.landusepol.2018.03.020.

Boulay, A., Tacconi, L., 2012. The drivers of contract eucalypt farming in Thailand. Int. For. Rev. 14, 1–12. https://doi.org/10.1505/146554812799973190.

Bowyer, J., Howe, J., Guillery, P., Fernholz, K., 2005. Fast-Growth Tree Plantations for Wood Production – Environmental Threat or a Means of “Saving” Natural Forests? Dovetail Partners, Inc., White Bear Lake, MN.

Brack, D., Glover, A., Wellesley, L., 2016. Agricultural Commodity Supply Chains: Trade, Consumption and Deforestation (Research Paper). Chatham House, the Royal Institute of International Affairs, London.

Brockington, D., 2004. Community conservation, inequality and injustice: myths of power in protected area management. Conserv. Soc. 2, 411–432.

Brown, H.C.P., 2011. Gender, climate change and REDD+ in the Congo Basin forests of Central Africa. Int. For. Rev. 13, 163–176. https://doi.org/10.1505/146554811797406651.

Brown, S.E., Miller, D.C., Ordonez, P.J., Baylis, K., 2018. Evidence for the impacts of agroforestry on agricultural productivity, ecosystem services, and human well-being in high-income countries: a systematic map protocol. Environ. Evid. 7, 24. https://doi.org/10.1186/s13750-018-0136-0.

Bryan, J., 2012. Rethinking territory: social Justice and neoliberalism in Latin America’s territorial turn. Geogr. Compass 6, 215–226. https://doi.org/10.1111/j.1749-8198.2012.00480.x.

Burivalova, Z., Game, E.T., Butler, R.A., 2019. The sound of a tropical forest. Science 363, 28–29. https://doi.org/10.1126/science.aav1902.

Busch, J., Engelmann, J., Cook-Patton, S.C., Griscom, B.W., Kroeger, T., Possingham, H., Shyamsundar, P., 2019. Potential for low-cost carbon dioxide removal through tropical reforestation. Nat. Clim. Chang. 9, 463–466. https://doi.org/10.1038/s41558-019-0485-x.

Calkins, P., Ngo, A.-T., 2010. The Impacts of farmer cooperatives on the well-being of cocoa producing villages in Côte d’Ivoire and Ghana. Can. Jo. Dev. Stud. 30, 535–563. https://doi.org/10.1080/02255189.2010.9669315. Revue canadienne d’études du développement.

Cardozo, M.L., Salas, D., Ferreira, I., Mereles, T., Rodríguez, L., 2016. Soy expansion and the absent state: indigenous and peasant livelihood options in eastern Paraguay. J. Lat. Am. Geogr. 15, 87–104. https://doi.org/10.1353/lag.2016.0032.

Carodenuto, S., 2019. Governance of zero deforestation cocoa in West Africa: new forms of public–private interaction. Environ. Policy Gov. 29, 55–66. https://doi.org/10.1002/eet.1841.

Castells, M., 2007. Communication, power and counter-power in the network society. Int. J. Commun. 1, 29.

Castrén, T., Katila, M., Lindroos, K., Salmi, J., 2014. Private Financing for Sustainable Forest Management and Forest Products in Developing Countries: Trends and Drivers. PROFOR, Washington, DC.
Cattaneo, C., Beine, M., Fröhlich, C.J., Kniveton, D., Martinez-Zarzoso, I., Mastrorillo, M., Millock, K., Piguet, E., Schraven, B., 2019. Human migration in the era of climate change. Rev. Environ. Econ. Policy 13, 189–206. https://doi.org/10.1093/reep/rez008.
CDC, 2020a. 2014-2016 Ebola Outbreak in West Africa | History [WWW Document]. U.S. Centers for Disease Control and Prevention. URL. https://www.cdc.gov/vhf/ebola/history/2014-2016-outbreak/index.html. accessed 7.26.21.
CDC, 2020b. One Health Basics [WWW Document]. U.S. Centers for Disease Control and Prevention. URL. https://www.cdc.gov/onehealth/basics/index.html. accessed 7.26.21.
Chakeredza, S., Hove, L., Akinnifesi, F.K., Franzel, S., Ajayi, O.C., Sileshi, G., 2007. Managing fodder trees as a solution to human–livestock food conflicts and their contribution to income generation for smallholder farmers in southern Africa. Nat. Res. Forum 31, 286–296. https://doi.org/10.1111/j.1477-8947.2007.00160.x.
Chaves, L.S.M., Fry, J., Malik, A., Geschke, A., Sallum, M.A.M., Lenzen, M., 2020. Global consumption and international trade in deforestation-associated commodities could influence malaria risk. Nat. Commun. 11, 1258. https://doi.org/10.1038/s41467-020-14954-1.
Climate Focus, 2017. Commodities and Forests Agenda 2020: Ten Priorities to Remove Tropical Deforestation from Commodity Supply Chains (White Paper). World Economic Forum, Geneva.
Coffel, E.D., Horton, R.M., de Sherbinin, A., 2018. Temperature and humidity based projections of a rapid rise in global heat stress exposure during the 21st century. Environ. Res. Lett. 13, 014001 https://doi.org/10.1088/1748-9326/aaa00e.
Cohn, A.S., Bhattarai, N., Campolo, J., Crompton, O., Dralle, D., Duncan, J., Thompson, S., 2019. Forest loss in Brazil increases maximum temperatures within 50 km. Environ. Res. Lett. 14, 084047 https://doi.org/10.1088/1748-9326/ab31fb.
Conde, M., 2020. Brazil in the time of coronavirus. Geopolítica(s). Rev. Estud. Sobre Espacio Poder 11, 239–249. https://doi.org/10.5209/geop.69349.
Cooper, P., Rao, K.P.C., Singh, P., Dimes, J., Traore, P.S., Rao, K., Dixit, P., Twomlow, S. J., 2009. Farming with current and future climate risk: advancing a "Hypothesis of Hope" for rainfed agriculture in the semi-arid tropics. SAT eJournal 7, 19.
Curtis, P.G., Slay, C.M., Harris, N.L., Tyukavina, A., Hansen, M.C., 2018. Classifying drivers of global forest loss. Science 361, 1108–1111. https://doi.org/10.1126/science.aau3445.
Damania, R., Desbureaux, S., Hyland, M., Islam, A., Rodella, A.-S., Russ, J., Zaveri, E., 2017. Uncharted Waters: The New Economics of Water Scarcity and Variability. World Bank Publications, Washington, DC.
Das, S., Vincent, J.R., 2009. Mangroves protected villages and reduced death toll during Indian super cyclone. Proc. Natl. Acad. Sci. https://doi.org/10.1073/pnas.0810440106.
Davies, D.K., Ilavajhala, S., Wong, M.M., Justice, C.O., 2009. Fire information for resource management system: archiving and distributing MODIS active fire data. IEEE Trans. Geosci. Remote Sens. 47, 72–79. https://doi.org/10.1109/TGRS.2008.2002076.
de la Vega-Leinert, A.C., Schönenberg, R., 2020. Transdisciplinary perspectives on current transformations at extractive and agrarian, frontiers in Latin America. J. Land Use Sci. 15, 99–107. https://doi.org/10.1080/1747423X.2020.1766245.
DeFries, R.S., Fanzo, J., Mondal, P., Remans, R., Wood, S.A., 2017. Is voluntary certification of tropical agricultural commodities achieving sustainability goals for small-scale producers? A review of the evidence. Environ. Res. Lett. 12, 033001 https://doi.org/10.1088/1748-9326/aa625e.
Desbureaux, S., Damania, R., 2018. Rain, forests and farmers: evidence of drought induced deforestation in Madagascar and its consequences for biodiversity conservation. Biol. Conserv. 221, 357–364. https://doi.org/10.1016/j.biocon.2018.03.005.
Devine, J.A., 2014. Counterinsurgency ecotourism in Guatemala's Maya biosphere reserve. Environ. Plann. D Soc. Space 32, 984–1001. https://doi.org/10.1068/d13043p.
Di Marco, M., Baker, M.L., Daszak, P., Barro, P.D., Eskew, E.A., Godde, C.M., Harwood, T. D., Herrero, M., Hoskins, A.J., Johnson, E., Karesh, W.B., Machalaba, C., Garcia, J. N., Paini, D., Pirzl, R., Smith, M.S., Zambrana-Torrelio, C., Ferrier, S., 2020. Opinion: sustainable development must account for pandemic risk. Proc. Natl. Acad. Sci. 117, 3888–3892. https://doi.org/10.1073/pnas.2001655117.
Díaz, S., Pascual, U., Stenseke, M., Martín-López, B., Watson, R.T., Molnár, Z., Hill, R., Chan, K.M.A., Baste, I.A., Brauman, K.A., Polasky, S., Church, A., Lonsdale, M., Larigauderie, A., Leadley, P.W., van Oudenhoven, A.P.E., van der Plaat, F., Schröter, M., Lavorel, S., Aumeeruddy-Thomas, Y., Bukvareva, E., Davies, K., Demissew, S., Erpul, G., Failler, P., Guerra, C.A., Hewitt, C.L., Keune, H., Lindley, S., Shirayama, Y., 2018. Assessing nature's contributions to people. Science 359, 270–272. https://doi.org/10.1126/science.aap8826.
Dobson, A.P., Pimm, S.L., Hannah, L., Kaufman, L., Ahumada, J.A., Ando, A.W., Bernstein, A., Busch, J., Daszak, P., Engelmann, J., Kinnaird, M.F., Li, B.V., Loch-Temzelides, T., Lovejoy, T., Nowak, K., Roehrdanz, P.R., Vale, M.M., 2020. Ecology and economics for pandemic prevention. Science 369, 379–381. https://doi.org/10.1126/science.abc3189.
Dormontt, E.E., Boner, M., Braun, B., Breulmann, G., Degen, B., Espinoza, E., Gardner, S., Guillery, P., Hermanson, J.C., Koch, G., Lee, S.L., Kanashiro, M., Rimbawanto, A., Thomas, D., Wiedenhoeft, A.C., Yin, Y., Zahnen, J., Lowe, A.J., 2015. Forensic timber identification: it's time to integrate disciplines to combat illegal logging. Biol. Conserv. 191, 790–798. https://doi.org/10.1016/j.biocon.2015.06.038.
Duchelle, A.E., Simonet, G., Sunderlin, W.D., Wunder, S., 2018. What is REDD+ achieving on the ground? Current Opinion in Environmental Sustainability. Environ. Chang. Issues 2018 (32), 134–140. https://doi.org/10.1016/j.cosust.2018.07.001.
Duncombe, R., 2016. Mobile phones for agricultural and rural development: a literature review and suggestions for future research. Eur. J. Dev. Res. 28, 213–235. London. https://doi.org.holycross.idm.oclc.org/10.1057/ejdr.2014.60.
Eakin, H., DeFries, R., Kerr, S., Lambin, E.F., Liu, J., Marcotullio, P.J., Messerli, P., Reenberg, A., Rueda, X., Swaffield, S.R., Wicke, B., Zimmerer, K., 2014. Significance of telecoupling for exploration of land-use change. In: Seto, K.C., Reenberg, A. (Eds.), Rethinking Global Land Use in an Urban Era, Strüngmann Forum Reports. The MIT Press, Cambridge, MA, pp. 141–161. https://doi.org/10.7551/mitpress/9780262026901.003.0008.
Eilu, E., 2020. Role of mobile phone technology in combating illegal timber logging in africa: a review. In: Goyal, M.R., Eilu, E. (Eds.), Digital Media and Wireless Communications in Developing Nations: Agriculture, Education, and the Economic Sector. Apple Academic Press, Palm Bay, FL, pp. 91–101.
Eklund, J., Jokinen, A.-P., Toivonen, T., 2020. COVID-19 Causes a Threat to Protected Areas in the Global South – Evidence from Madagascar. Digital Geography Lab Blog. URL. https://blogs.helsinki.fi/digital-geography/2020/06/01/covid-madagascar-protectedareas/. accessed 7.24.21.
Environmental Defense Fund, Forest Trends, 2018. Mapping Forest Finance: A Landscape of Available Sources of Finance for REDD+ and Climate Action in Forests. Environmental Defense Fund, New York.
Epstein, J.H., Field, H.E., Luby, S., Pulliam, J.R.C., Daszak, P., 2006. Nipah virus: impact, origins, and causes of emergence. Curr. Infect. Dis. Rep. 8, 59–65. https://doi.org/10.1007/s11908-006-0036-2.
Erbaugh, J.T., Nurrochmat, D.R., 2019. Paradigm shift and business as usual through policy layering: forest-related policy change in Indonesia (1999-2016). Land Use Policy 86, 136–146. https://doi.org/10.1016/j.landusepol.2019.04.021.
Erbaugh, J.T., Pradhan, N., Adams, J., Oldekop, J.A., Agrawal, A., Brockington, D., Pritchard, R., Chhatre, A., 2020. Global forest restoration and the importance of prioritizing local communities. Nat. Ecol. Evol. 4, 1472–1476. https://doi.org/10.1038/s41559-020-01282-2.
Fagan, M., Huang, C., 2019. A Look at How People Around the World View Climate Change. Pew Research Center. URL. https://www.pewresearch.org/fact-tank/2019/04/18/a-look-at-how-people-around-the-world-view-climate-change/. accessed 7.27.21.
FAO, 2020. Impacts of COVID-19 on Wood Value Chains and Forest Sector Response: Results from a Global Survey 2020. FAO, Rome. https://doi.org/10.4060/cb1987en.
Fearnside, P., 2018. Why Brazil's new president poses an unprecedented threat to the Amazon. Yale Environ. 360. URL. https://e360.yale.edu/features/why-brazils-new-president-poses-an-unprecedented-threat-to-the-amazon. accessed 7.24.21.
Ferraz, A., Saatchi, S., Mallet, C., Meyer, V., 2016. Lidar detection of individual tree size in tropical forests. Remote Sens. Environ. 183, 318–333. https://doi.org/10.1016/j.rse.2016.05.028.
Finney, C., 2014. Black Faces, White Spaces: Reimagining the Relationship of African Americans to the Great Outdoors. UNC Press Books, Chapel Hill, NC.
Fleischman, F., Basant, S., Chhatre, A., Coleman, E.A., Fischer, H.W., Gupta, D., Güneralp, B., Kashwan, P., Khatri, D., Muscarella, R., Powers, J.S., Ramprasad, V., Rana, P., Solorzano, C.R., Veldman, J.W., 2020. Pitfalls of tree planting show why we need people-centered natural climate solutions. BioScience 70, 947–950. https://doi.org/10.1093/biosci/biaa094.
Foley, J.A., DeFries, R., Asner, G.P., Barford, C., Bonan, G., Carpenter, S.R., Chapin, F.S., Coe, M.T., Daily, G.C., Gibbs, H.K., Helkowski, J.H., Holloway, T., Howard, E.A., Kucharik, C.J., Monfreda, C., Patz, J.A., Prentice, I.C., Ramankutty, N., Snyder, P.K., 2005. Global consequences of land use. Science 309, 570–574. https://doi.org/10.1126/science.1111772.
Forest Trends' Ecosystem Marketplace, 2019. Financing Emissions Reductions for the Future: State of the Voluntary Carbon Markets 2019. Forest Trends, Washington, DC.
Forest Trends' Ecosystem Marketplace, 2021. Publications Archive [WWW Document]. Forest Trends, URL. https://www.forest-trends.org/publications/. accessed 7.26.21.
Fowler, C., 2003. Human health impacts of forest fires in the Southern United States: a literature review. J. Ecol. Anthropol. 7, 39–63. https://doi.org/10.5038/2162-4593.7.1.3.
Franco, J.C., Borras, S.M., 2019. Grey areas in green grabbing: subtle and indirect interconnections between climate change politics and land grabs and their implications for research. Land Use Policy 84, 192–199. https://doi.org/10.1016/j.landusepol.2019.03.013.
Friends of the Earth, LifeMosaic, Sawit Watch, 2008. Losing Ground: The Human Rights Impacts of Oil Palm Plantation Expansion in Indonesia. Friends of the Earth, London.
Fuente, T.D.L., Hajjar, R., 2013. Do current forest carbon standards include adequate requirements to ensure indigenous peoples' rights in REDD projects? Int. For. Rev. 15, 427–441. https://doi.org/10.1505/146554813809025676.
Gabay, M., Alam, M., 2017. Community forestry and its mitigation potential in the Anthropocene: the importance of land tenure governance and the threat of privatization. Forest Policy Econ. 79, 26–35. https://doi.org/10.1016/j.forpol.2017.01.011. Forest governance in the Anthropocene: a challenge for theory and practice.
Gale, F., Valdes, C., Ash, M., 2019. Interdependence of China, United States, and Brazil in Soybean Trade (Economic Research Service Outlook No. OCS-19F-01). USDA, Washington, DC.
Ganivet, E., Bloomberg, M., 2019. Towards rapid assessments of tree species diversity and structure in fragmented tropical forests: a review of perspectives offered by remotely-sensed and field-based data. For. Ecol. Manag. 432, 40–53. https://doi.org/10.1016/j.foreco.2018.09.003.

Gaveau, D.L.A., Pirard, R., Salim, M.A., Tonoto, P., Yaen, H., Parks, S.A., Carmenta, R., 2017. Overlapping land claims limit the use of satellites to monitor no-deforestation commitments and no-burning compliance. Conserv. Lett. 10, 257–264. https://doi.org/10.1111/conl.12256.

Gibbs, D., Harris, N., Seymour, F., 2018. By the Numbers: The Value of Tropical Forests in the Climate Change Equation. World Resources Institute, URL. https://www.wri.org/insights/numbers-value-tropical-forests-climate-change-equation. accessed 7.25.21.

Ginn, W., 2020. Valuing Nature: A Handbook for Impact Investing. Island Press, Washington, DC.

Gockowski, J., Sonwa, D., 2011. Cocoa intensification scenarios and their predicted impact on CO2 emissions, biodiversity conservation, and rural livelihoods in the Guinea rain forest of West Africa. Environ. Manag. 48, 307–321. https://doi.org/10.1007/s00267-010-9602-3.

Gonzales, J., 2020. Brazil Minister Advises Using COVID-19 to Distract from Amazon Deregulation. Mongabay Environmental News, URL. https://news.mongabay.com/2020/05/brazil-minister-advises-using-covid-19-to-distract-from-amazon-deregulation/. accessed 7.24.21.

Griscom, B.W., Adams, J., Ellis, P.W., Houghton, R.A., Lomax, G., Miteva, D.A., Schlesinger, W.H., Shoch, D., Siikamäki, J.V., Smith, P., Woodbury, P., Zganjar, C., Blackman, A., Campari, J., Conant, R.T., Delgado, C., Elias, P., Gopalakrishna, T., Hamsik, M.R., Herrero, M., Kiesecker, J., Landis, E., Laestadius, L., Leavitt, S.M., Minnemeyer, S., Polasky, S., Potapov, P., Putz, F.E., Sanderman, J., Silvius, M., Wollenberg, E., Fargione, J., 2017. Natural climate solutions. Proc. Natl. Acad. Sci. 114, 11645–11650. https://doi.org/10.1073/pnas.1710465114.

Guillerme, S., Kumar, B.M., Menon, A., Hinnewinkel, C., Maire, E., Santhoshkumar, A.V., 2011. Impacts of public policies and farmer preferences on agroforestry practices in Kerala, India. Environ. Manag. 48, 351–364. https://doi.org/10.1007/s00267-011-9628-1.

Gurung, L.J., Miller, K.K., Venn, S., Bryan, B.A., 2021. Climate change adaptation for managing non-timber forest products in the Nepalese Himalaya. Sci. Total Environ. 796, 148853. https://doi.org/10.1016/j.scitotenv.2021.148853.

Hajjar, R., Newton, P., Ihalainen, M., Agrawal, A., Alix-Garcia, J., Castle, S.E., Erbaugh, J.T., Gabay, M., Hughes, K., Mawutor, S., Pacheco, P., Schoneveld, G., Timko, J.A., 2021a. Levers for alleviating poverty in forests. Forest Policy Econ. 132, 102589.

Hajjar, R., Zavaleta Cheek, J., Jagger, P., Kamoto, J., Newton, P., Oldekop, J., Razafindratsima, O.H., Shyamsundar, P., Sills, E., 2021b. Research frontiers on forests, trees, and poverty dynamics. Forest Policy Econ. 131, 102554. https://doi.org/10.1016/j.forpol.2021.102554.

Hallegatte, S., Bangalore, M., Bonzanigo, L., Fay, M., Kane, T., Narloch, U., Rozenberg, J., Treguer, D., Vogt-Schilb, A., 2015. Shock Waves: Managing the Impacts of Climate Change on Poverty, Climate Change and Development. The World Bank, Washington, DC. https://doi.org/10.1596/978-1-4648-0673-5.

Hand, D., Dithrich, H., Sunderji, S., Nova, N., 2020. Annual Impact Investor Survey 2020. Global Impact Investing Network (GIIN), Washington, DC.

Hansen, A.J., Neilson, R.P., Dale, V.H., Flather, C.H., Iverson, L.R., Currie, D.J., Shafer, S., Cook, R., Bartlein, P.J., 2001. Global change in forests: responses of species, communities, and biomes: interactions between climate change and land use are projected to cause large shifts in biodiversity. BioScience 51, 765–779. https://doi.org/10.1641/0006-3568(2001)051[0765,GCIFRO]2.0.CO;2.

Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S.V., Goetz, S.J., Loveland, T.R., Kommareddy, A., Egorov, A., Chini, L., Justice, C.O., Townshend, J.R.G., 2013. High-resolution global maps of 21st-century forest cover change. Science 342, 850–853. https://doi.org/10.1126/science.1244693.

Hansen, M.C., Krylov, A., Tyukavina, A., Potapov, P.V., Turubanova, S., Zutta, B., Ifo, S., Margono, B., Stolle, F., Moore, R., 2016. Humid tropical forest disturbance alerts using Landsat data. Environ. Res. Lett. 11, 034008 https://doi.org/10.1088/1748-9326/11/3/034008.

Harley, M.D., Turner, I.L., Kinsela, M.A., Middleton, J.H., Mumford, P.J., Splinter, K.D., Phillips, M.S., Simmons, J.A., Hanslow, D.J., Short, A.D., 2017. Extreme coastal erosion enhanced by anomalous extratropical storm wave direction. Sci. Rep. 7, 6033. https://doi.org/10.1038/s41598-017-05792-1.

Hay, S.I., Abajobir, A.A., Abate, K.H., Abbafati, C., Abbas, K.M., Abd-Allah, F., Abdulkader, R.S., Abdulle, A.M., Abebo, T.A., Abera, S.F., Aboyans, V., Abu-Raddad, L.J., Ackerman, I.N., Adedeji, I.A., Adetokunboh, O., Afshin, A., Aggarwal, R., Agrawal, S., Agrawal, A., Ahmed, M.B., Aichour, M.T.E., Aichour, A.N., Aichour, I., Aiyar, S., Akinyemiju, T.F., Akseer, N., Lami, F.H.A., Alahdab, F., Al-Aly, Z., Alam, K., Alam, N., Alam, T., Alasfoor, D., Alene, K.A., Ali, R., Alizadeh-Navaei, R., Alkaabi, J.M., Alkerwi, A., Alla, F., Allebeck, P., Allen, C., Al-Maskari, F., AlMazroa, M.A., Al-Raddadi, R., Alsharif, U., Alsowaidi, S., Althouse, B.M., Altirkawi, K.A., Alvis-Guzman, N., Amare, A.T., Amini, E., Ammar, W., Amoako, Y.A., Ansha, M.G., Antonio, C.A.T., Anwari, P., Ärnlöv, J., Arora, M., Artaman, A., Aryal, K.K., Asgedom, S.W., Atey, T.M., Atnafu, N.T., Avila-Burgos, L., Avokpaho, E.F.G.A., Awasthi, A., Awasthi, S., Azarpazhooh, M.R., Azzopardi, P., et al., 2017. Global, regional, and national disability-adjusted life-years (DALYs) for 333 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet 390, 1260–1344. https://doi.org/10.1016/S0140-6736(17)32130-X.

Hays, C.M., 2019. The "Park" as racial practice: constructing Whiteness on Safari in Tanzania. Environ. Values 28, 141–170. https://doi.org/10.3197/096327119X15515267418502.

Henders, S., Persson, U.M., Kastner, T., 2015. Trading forests: land-use change and carbon emissions embodied in production and exports of forest-risk commodities. Environ. Res. Lett. 10, 125012. https://doi.org/10.1088/1748-9326/10/12/125012.

Henders, S., Ostwald, M., Verendel, V., Ibisch, P., 2018. Do national strategies under the UN biodiversity and climate conventions address agricultural commodity consumption as deforestation driver? Land Use Policy 70, 580–590. https://doi.org/10.1016/j.landusepol.2017.10.043.

Hickel, J., 2017. Is global inequality getting better or worse? A critique of the World Bank's convergence narrative. Third World Q. 38, 2208–2222. https://doi.org/10.1080/01436597.2017.1333414.

Humphreys Bebbington, D., Verdum, R., Gamboa, C., Bebbington, A., 2018. The infrastructure-extractives-resource governance complex in the Pan-Amazon: roll backs and contestations. Eur. Rev. Lat. Am. Caribb. Stud. 183–208. https://doi.org/10.32992/erlacs.10414.

Husnina, Z., Clements, A.C.A., Wangdi, K., 2019. Forest cover and climate as potential drivers for dengue fever in Sumatra and Kalimantan 2006–2016: a spatiotemporal analysis. Tropical Med. Int. Health 24, 888–898. https://doi.org/10.1111/tmi.13248.

Hutton, J., Adams, W.M., Murombedzi, J.C., 2005. Back to the barriers? Changing narratives in biodiversity conservation. Forum Dev. Stud. 32, 341–370. https://doi.org/10.1080/08039410.2005.9666319.

Iacona, G., Ramachandra, A., McGowan, J., Davies, A., Joppa, L., Koh, L.P., Fegraus, E., Game, E., Guillera-Arroita, G., Harcourt, R., Indraswari, K., Lahoz-Monfort, J.J., Oliver, J.L., Possingham, H.P., Ward, A., Watson, D.W., Watson, J.E., Wintle, B.A., Chadès, I., 2019. Identifying technology solutions to bring conservation into the innovation era. Front. Ecol. Environ. 17, 591–598. https://doi.org/10.1002/fee.2111.

If Not Us Then Who? [WWW Document], 2021. If Not Us Then Who? URL. https://ifnotusthenwho.me/. accessed 7.26.21.

International Monetary Fund (Ed.), 2020. The Great Lockdown, World Economic Outlook. International Monetary Fund, Washington, DC.

International Organization for Migration, 2019. World Migration Report 2020. IOM, Geneva.

IPBES, 2019. Summary for policymakers of the global assessment report on biodiversity and ecosystem services. In: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.3553579.

IPCC, 2018. Summary for policymakers. In: Masson-Delmotte, V., Zhai, P., Pörtner, H.-O., Roberts, D., Skea, J., Shukla, P.R., Pirani, A., Moufouma-Okia, W., Péan, C., Pidcock, R., Connors, S., Matthews, J.B.R., Chen, Y., Zhou, X., Gomis, M.I., Lonnoy, E., Maycock, T., Tignor, M., Waterfield, T. (Eds.), Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty. Intergovernmental Panel on Climate Change (IPCC), Geneva.

Jackson, J.E., Warren, K.B., 2005. Indigenous movements in Latin America, 1992–2004: controversies, ironies, new directions. Annu. Rev. Anthropol. 34, 549–573. https://doi.org/10.1146/annurev.anthro.34.081804.120529.

Jagger, P., Zavaleta Cheek, J., Miller, D.C., Ryan, C., Razafindratsima, O.H., Shyamsundar, P., Sills, E., 2020. Key Concepts for Understanding Forest-Poverty Dynamics. In: Miller, D., Mansourian, S., Wildburger, C. (Eds.), Forests, Trees and the Eradication of Poverty: Potential and Limitations (Global Assessment Report), 39. IUFRO, Vienna, pp. 33–54.

Jiang, L., O'Neill, B.C., 2017. Global urbanization projections for the shared socioeconomic pathways. Glob. Environ. Chang. 42, 193–199. https://doi.org/10.1016/j.gloenvcha.2015.03.008.

Jindal, R., Kerr, J.M., Carter, S., 2012. Reducing poverty through carbon forestry? Impacts of the N'hambita community carbon project in mozambique. World Dev. 40, 2123–2135. https://doi.org/10.1016/j.worlddev.2012.05.003.

John Hopkins University & Medicine, 2021. COVID-19 Dashboard [WWW Document]. Johns Hopkins Coronavirus Resource Center. URL. https://coronavirus.jhu.edu/map.html. accessed 7.26.21.

Johnson, J.M., Moore, L.J., Ells, K., Murray, A.B., Adams, P.N., MacKenzie, R.A., Jaeger, J.M., 2015. Recent shifts in coastline change and shoreline stabilization linked to storm climate change. Earth Surf. Process. Landf. 40, 569–585. https://doi.org/10.1002/esp.3650.

Jolly, W.M., Cochrane, M.A., Freeborn, P.H., Holden, Z.A., Brown, T.J., Williamson, G.J., Bowman, D.M.J.S., 2015. Climate-induced variations in global wildfire danger from 1979 to 2013. Nat. Commun. 6, 7537. https://doi.org/10.1038/ncomms8537.

Kamminga, J., Ayele, E., Meratnia, N., Havinga, P., 2018. Poaching detection technologies—a survey. Sensors 18, 1474. https://doi.org/10.3390/s18051474.

Kayitakire, F., Hamel, C., Defourny, P., 2006. Retrieving forest structure variables based on image texture analysis and IKONOS-2 imagery. Remote Sens. Environ. 102, 390–401. https://doi.org/10.1016/j.rse.2006.02.022.

Keck, M.E., Sikkink, K., 1998. Activists beyond Borders: Advocacy Networks in International Politics. Cornell University Press, Ithaca, NY.

Keenan, R.J., 2015. Climate change impacts and adaptation in forest management: a review. Ann. For. Sci. 72, 145–167. https://doi.org/10.1007/s13595-014-0446-5.

Keesing, F., Belden, L.K., Daszak, P., Dobson, A., Harvell, C.D., Holt, R.D., Hudson, P., Jolles, A., Jones, K.E., Mitchell, C.E., Myers, S.S., Bogich, T., Ostfeld, R.S., 2010. Impacts of biodiversity on the emergence and transmission of infectious diseases. Nature 468, 647–652. https://doi.org/10.1038/nature09575.

Khadka, M., Karki, S., Karky, B.S., Kotru, R., Darjee, K.B., 2014. Gender equality challenges to the REDD Initiative in Nepal. Mt. Res. Dev. 34, 197–207. https://doi.org/10.1659/MRD-JOURNAL-D-13-00081.1.

Khamzina, A., Lamers, J.P.A., Vlek, P.L.G., 2012. Conversion of degraded cropland to tree plantations for ecosystem and livelihood benefits. In: Martius, C., Rudenko, I., Lamers, J.P.A., Vlek, P.L.G. (Eds.), Cotton, Water, Salts and Soums: Economic and Ecological Restructuring in Khorezm. Uzbekistan. Springer, Dordrecht, pp. 235–248. https://doi.org/10.1007/978-94-007-1963-7.

Kloek, M.E., Elands, B.H.M., Schouten, M.G.C., 2017. Race/Ethnicity in visual imagery of dutch nature conservation organizations. Soc. Nat. Resour. 30, 1033–1048. https://doi.org/10.1080/08941920.2017.1295500.

Knorr, W., Jiang, L., Arneth, A., 2016. Climate, CO_2 and human population impacts on global wildfire emissions. Biogeosciences 13, 267–282. https://doi.org/10.5194/bg-13-267-2016.

Knudsen, B.T., Andersen, C., 2019. Affective politics and colonial heritage, Rhodes Must Fall at UCT and Oxford. Int. J. Herit. Stud. 25, 239–258. https://doi.org/10.1080/13527258.2018.1481134.

Korkanç, S.Y., 2014. Effects of afforestation on soil organic carbon and other soil properties. CATENA 123, 62–69. https://doi.org/10.1016/j.catena.2014.07.009.

Kozak, R., 2007. Small and Medium Forest Enterprises: Instruments of Change in the Developing World. Rights and Resources Initiative, Washington, DC.

Kunwar, R.M., 2011. Assessment of Climate Change Impacts on Non Timber Forest Products (NTFPs), Medicinal and Aromatic Plants (MAPs) and Important Tree Species (ITS) in the Sacred Himalayan Landscape, Nepal. WWF Nepal Program, Kathmandu.

Laborde Debucquet, D., Martin, W., Vos, R., 2020. Poverty and Food Insecurity Could Grow Dramatically as COVID-19 Spreads. International Food Policy Research Institute, Washington, DC. https://doi.org/10.2499/p15738coll2.133762_02.

Lambin, E.F., Meyfroidt, P., 2011. Global land use change, economic globalization, and the looming land scarcity. Proc. Natl. Acad. Sci. 108, 3465–3472. https://doi.org/10.1073/pnas.1100480108.

Lawlor, K., Madeira, E.M., Blockhus, J., Ganz, D.J., 2013. Community participation and benefits in REDD+: a review of initial outcomes and lessons. Forests 4, 296–318. https://doi.org/10.3390/f4020296.

Lawrence, D., Vandecar, K., 2015. Effects of tropical deforestation on climate and agriculture. Nat. Clim. Chang. 5, 27–36. https://doi.org/10.1038/nclimate2430.

le Polain de Waroux, Y., Garrett, R.D., Graesser, J., Nolte, C., White, C., Lambin, E.F., 2019. The restructuring of South American soy and beef production and trade under changing environmental regulations. World Dev. 121, 188–202. https://doi.org/10.1016/j.worlddev.2017.05.034.

Le Toan, T., Quegan, S., Davidson, M.W.J., Balzter, H., Paillou, P., Papathanassiou, K., Plummer, S., Rocca, F., Saatchi, S., Shugart, H., Ulander, L., 2011. The BIOMASS mission: mapping global forest biomass to better understand the terrestrial carbon cycle. Remote Sens. Environ. 115, 2850–2860. https://doi.org/10.1016/j.rse.2011.03.020. DESDynI VEG-3D Special Issue.

Lee, T.M., Markowitz, E.M., Howe, P.D., Ko, C.-Y., Leiserowitz, A.A., 2015. Predictors of public climate change awareness and risk perception around the world. Nat. Clim. Chang. 5, 1014–1020. https://doi.org/10.1038/nclimate2728.

Lima, M., Skutsch, M., Costa, G., 2011. Deforestation and the social impacts of soy for biodiesel: perspectives of farmers in the South Brazilian Amazon. Ecol. Soc. 16 https://doi.org/10.5751/ES-04366-160404.

Liu, J., Mooney, H., Hull, V., Davis, S.J., Gaskell, J., Hertel, T., Lubchenco, J., Seto, K.C., Gleick, P., Kremen, C., Li, S., 2015. Systems integration for global sustainability. Science 347. https://doi.org/10.1126/science.1258832.

Loader, B.D., Mercea, D., 2011. Networking democracy? Social media innovations and participatory politics. Inf. Commun. Soc. 14, 757–769. https://doi.org/10.1080/1369118X.2011.592648.

Loconto, A., 2015. Can certified-tea value chains deliver gender equality in Tanzania? Fem. Econ. 21, 191–215. https://doi.org/10.1080/13545701.2014.1001765.

Lorenz, C., Azevedo, T.S., Chiaravalloti-Neto, F., 2020. COVID-19 and dengue fever: A dangerous combination for the health system in Brazil. Travel Med. Infect. Dis. 35, 101659. https://doi.org/10.1016/j.tmaid.2020.101659.

Loveland, T.R., Dwyer, J.L., 2012. Landsat: building a strong future. Remote Sens. Environ. 122, 22–29. https://doi.org/10.1016/j.rse.2011.09.022. Landsat Legacy Special Issue.

Lund, J.F., Sungusia, E., Mabele, M.B., Scheba, A., 2017. Promising change, delivering continuity: REDD+ as conservation fad. World Dev. 89, 124–139. https://doi.org/10.1016/j.worlddev.2016.08.005.

Lyon, S., Bezaury, J.A., Mutersbaugh, T., 2010. Gender equity in fairtrade–organic coffee producer organizations: cases from Mesoamerica. Geoforum 41, 93–103. https://doi.org/10.1016/j.geoforum.2009.04.006. CRITICAL REVIEW FORUM: Behind Enemy Lines: Reflections on the Practice and Production of Oppositional Research.

Maas, B., Clough, Y., Tscharntke, T., 2013. Bats and birds increase crop yield in tropical agroforestry landscapes. Ecol. Lett. 16, 1480–1487. https://doi.org/10.1111/ele.12194.

MacDonald, A.J., Mordecai, E.A., 2019. Amazon deforestation drives malaria transmission, and malaria burden reduces forest clearing. Proc. Natl. Acad. Sci. 116, 22212–22218. https://doi.org/10.1073/pnas.1905315116.

Macqueen, D.J., 2008. Forest connect: reducing poverty and deforestation through support to community forest enterprises. Int. For. Rev. 10, 670–675. https://doi.org/10.1505/ifor.10.4.670.

Macqueen, D., Bolin, A., Greijmans, M., Grouwels, S., Humphries, S., 2020. Innovations towards prosperity emerging in locally controlled forest business models and prospects for scaling up. World Dev. 125, 104382. https://doi.org/10.1016/j.worlddev.2018.08.004.

Malkamäki, A., D'Amato, D., Hogarth, N.J., Kanninen, M., Pirard, R., Toppinen, A., Zhou, W., 2018. A systematic review of the socio-economic impacts of large-scale tree plantations, worldwide. Glob. Environ. Chang. 53, 90–103. https://doi.org/10.1016/j.gloenvcha.2018.09.001.

Marchiori, L., Maystadt, J.-F., Schumacher, I., 2012. The impact of weather anomalies on migration in sub-Saharan Africa. J. Environ. Econ. Manag. 63, 355–374. https://doi.org/10.1016/j.jeem.2012.02.001.

Martínez-Harms, M.J., Quijas, S., Merenlender, A.M., Balvanera, P., 2016. Enhancing ecosystem services maps combining field and environmental data. Ecosyst. Serv. 22, 32–40. https://doi.org/10.1016/j.ecoser.2016.09.007.

Marvin, D.C., Koh, L.P., Lynam, A.J., Wich, S., Davies, A.B., Krishnamurthy, R., Stokes, E., Starkey, R., Asner, G.P., 2016. Integrating technologies for scalable ecology and conservation. Glob. Ecol. Conserv. 7, 262–275. https://doi.org/10.1016/j.gecco.2016.07.002.

Mathur, V.N., Afionis, S., Paavola, J., Dougill, A.J., Stringer, L.C., 2014. Experiences of host communities with carbon market projects: towards multi-level climate justice. Clim. Pol. 14, 42–62. https://doi.org/10.1080/14693062.2013.861728.

McCarthy, J., 2019. Authoritarianism, populism, and the environment: comparative experiences, insights, and perspectives. Ann. Am. Assoc. Geogr. 109, 301–313. https://doi.org/10.1080/24694452.2018.1554393.

McSweeney, K., Nielsen, E.A., Taylor, M.J., Wrathall, D.J., Pearson, Z., Wang, O., Plumb, S.T., 2014. Drug policy as conservation policy: narco-deforestation. Science 343, 489–490. https://doi.org/10.1126/science.1244082.

Melo, I., Turnhout, E., Arts, B., 2014. Integrating multiple benefits in market-based climate mitigation schemes: the case of the climate, community and biodiversity certification scheme. Environ. Sci. Pol. 35, 49–56. https://doi.org/10.1016/j.envsci.2013.02.010. Climate change and deforestation: the evolution of an intersecting policy domain.

Middeldorp, N., Le Billon, P., 2019. Deadly environmental governance: authoritarianism, eco-populism, and the repression of environmental and land defenders. Ann. Am. Assoc. Geogr. 109, 324–337. https://doi.org/10.1080/24694452.2018.1530586.

Miles, T., 2019. The Afro-Brazilian struggle for visibility in Ceará. NACLA Rep. Am. 51, 394–400. https://doi.org/10.1080/10714839.2019.1692995.

Miller, D.C., Mansourian, S., Wildburger, C., 2020. Forests, Trees and the Eradication of Poverty: Potential and Limitations (Global Assessment Report No. 39). IUFRO World Series, IUFRO.

Millner, N., 2020. As the drone flies: configuring a vertical politics of contestation within forest conservation. Polit. Geogr. 80, 102163. https://doi.org/10.1016/j.polgeo.2020.102163.

Mills, J.N., Gage, K.L., Khan, A.S., 2010. Potential influence of climate change on vector-borne and zoonotic diseases: a review and proposed research plan. Environ. Health Perspect. 118, 1507–1514. https://doi.org/10.1289/ehp.0901389.

Missirian, A., Schlenker, W., 2017. Asylum applications respond to temperature fluctuations. Science 358, 1610–1614. https://doi.org/10.1126/science.aao0432.

Mitchell, A.L., Rosenqvist, A., Mora, B., 2017. Current remote sensing approaches to monitoring forest degradation in support of countries measurement, reporting and verification (MRV) systems for REDD+. Carbon Balance Manag. 12, 9. https://doi.org/10.1186/s13021-017-0078-9.

Mitchell-Walthour, G., 2020. Afro-Brazilian women YouTubers' use of African-American media representations to promote social justice in Brazil. J. Afr. Am. Stud. 24, 149–163. https://doi.org/10.1007/s12111-020-09458-7.

Mollett, S., Kepe, T., 2018. Introduction: land rights, biodiversity conservation and justice. In: Land Rights, Biodiversity Conservation and Justice: Rethinking Parks and People, Routledge Studies in Sustainable Development. Routledge, London, p. 13.

Mora, C., Dousset, B., Caldwell, I.R., Powell, F.E., Geronimo, R.C., Bielecki, C.R., Counsell, C.W.W., Dietrich, B.S., Johnston, E.T., Louis, L.V., Lucas, M.P., McKenzie, M.M., Shea, A.G., Tseng, H., Giambelluca, T.W., Leon, L.R., Hawkins, E., Trauernicht, C., 2017. Global risk of deadly heat. Nat. Clim. Chang. 7, 501–506. https://doi.org/10.1038/nclimate3322.

Morse, S.S., Mazet, J.A., Woolhouse, M., Parrish, C.R., Carroll, D., Karesh, W.B., Zambrana-Torrelio, C., Lipkin, W.I., Daszak, P., 2012. Prediction and prevention of the next pandemic zoonosis. Lancet 380, 1956–1965. https://doi.org/10.1016/S0140-6736(12)61684-5.

Musinsky, J., Tabor, K., Cano, C.A., Ledezma, J.C., Mendoza, E., Rasolohery, A., Sajudin, E.R., 2018. Conservation impacts of a near real-time forest monitoring and alert system for the tropics. Remote Sens. Ecol. Conserv. 4, 189–196. https://doi.org/10.1002/rse2.78.

Nasi, R., Fa, J.E., 2020. COVID-19-Led Ban on Wild Meat Could Take Protein off the Table for Millions of Forest Dwellers. CIFOR Forests News. URL. https://forestsnews.cifor.org/64855/covid-19-led-ban-on-wild-meat-could-take-protein-off-the-table-for-millions-of-forest-dwellers?fnl=en. accessed 7.26.21.

Nepstad, D.C., Stickler, C.M., 2008. Managing the tropical agriculture revolution. J. Sustain. For. 27, 43–56. https://doi.org/10.1080/10549810802225226.

Nepstad, D.C., Stickler, C.M., Almeida, O.T., 2006. Globalization of the Amazon soy and beef industries: opportunities for conservation. Conserv. Biol. 20, 1595–1603. https://doi.org/10.1111/j.1523-1739.2006.00510.x.

Neumann, B., Vafeidis, A.T., Zimmermann, J., Nicholls, R.J., 2015. Future coastal population growth and exposure to sea-level rise and coastal flooding - a global assessment. PLoS One 10, e0118571. https://doi.org/10.1371/journal.pone.0118571.

Newton, P., Benzeev, R., 2018. The role of zero-deforestation commitments in protecting and enhancing rural livelihoods. Curr. Opin. Environ. Sustain. 32, 126–133. https://doi.org/10.1016/j.cosust.2018.05.023. Environmental change issues 2018.

Newton, P., Agrawal, A., Wollenberg, L., 2013. Enhancing the sustainability of commodity supply chains in tropical forest and agricultural landscapes. Glob. Environ. Chang. 23, 1761–1772. https://doi.org/10.1016/j.gloenvcha.2013.08.004.

Newton, P., Kinzer, A.T., Miller, D.C., Oldekop, J.A., Agrawal, A., 2020. The number and spatial distribution of forest-proximate people globally. One Earth 3, 363–370. https://doi.org/10.1016/j.oneear.2020.08.016.

Nguyen, T.T., Bauer, S., Uibrig, H., 2010. Land privatization and afforestation incentive of rural farms in the Northern Uplands of Vietnam. Forest Policy Econ. 12, 518–526. https://doi.org/10.1016/j.forpol.2010.05.007.

Nyhus, P.J., 2016. Human–wildlife conflict and coexistence. Annu. Rev. Environ. Resour. 41, 143–171. https://doi.org/10.1146/annurev-environ-110615-085634.

OECD, 2021. Query Wizard for International Development Statistics [WWW Document]. OECD. URL. https://stats.oecd.org/qwids/about.html. accessed 7.26.21.

OECD, Food and Agriculture Organization of the United Nations, 2019. OECD-FAO Agricultural Outlook 2019-2028, OECD-FAO Agricultural Outlook. OECD, Paris. https://doi.org/10.1787/agr_outlook-2019-en.

Oldekop, J.A., Rasmussen, L.V., Agrawal, A., Bebbington, A.J., Meyfroidt, P., Bengston, D.N., Blackman, A., Brooks, S., Davidson-Hunt, I., Davies, P., Dinsi, S.C., Fontana, L.B., Gumucio, T., Kumar, C., Kumar, K., Moran, D., Mwampamba, T.H., Nasi, R., Nilsson, M., Pinedo-Vasquez, M.A., Rhemtulla, J.M., Sutherland, W.J., Watkins, C., Wilson, S.J., 2020. Forest-linked livelihoods in a globalized world. Nat. Plants 6, 1400–1407. https://doi.org/10.1038/s41477-020-00814-9.

Oldekop, J.A., Gabay, M., Humphreys, D., Mutta, D., Song, C., Timko, J.A., Rasmussen, L. V., Stoian, D., 2021. A framework for analysing contextual factors shaping forest-poverty dynamics. Forest Policy Econ. 132, 102591.

Olsson, L., Barbosa, H., Bhadwal, S., Cowie, A., Delusca, K., Flores-Renteria, D., Hermans, K., Jobbagy, E., Kurz, W., Li, D., Sonwa, D.J., Shukla, P.R., Skea, J., 2019. Land degradation. In: Buendia, E. Calvo, Masson-Delmotte, V., Pörtner, H.-O., Roberts, D.C., Zhai, P., Slade, R., Connors, S., van Diemen, R., Ferrat, M., Haughey, E., Luz, S., Neogi, S., Pathak, M., Petzold, J., Pereira, J. Portugal, Vyas, P., Huntley, E., Kissick, K., Belkacemi, M., Malley, J. (Eds.), Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems. Intergovernmental Panel on Climate Change (IPCC), Geneva, pp. 345–436.

Omotayo, A.O., Aremu, A.O., 2020. Underutilized African indigenous fruit trees and food–nutrition security: opportunities, challenges, and prospects. Food Energy Secur. 9, e220 https://doi.org/10.1002/fes3.220.

Onder, S., Erbaugh, J.T., Kosmidou-Bradley, G.C., 2021. Economic issues related to asian deforestation. Oxford Res. Encycl. Environ. Sci. https://doi.org/10.1093/acrefore/9780199389414.013.575.

One Acre Fund, 2021. Trees & Agroforestry [WWW Document]. One Acre Fund, URL. https://oneacrefund.org/impact/trees-agroforestry/. accessed 7.27.21.

Ortega, J.C.G., Machado, N., Diniz-Filho, J.A.F., Rangel, T.F., Araújo, M.B., Loyola, R., Bini, L.M., 2019. Meta-analyzing the likely cross-species responses to climate change. Ecol. Evol. 9, 11136–11144. https://doi.org/10.1002/ece3.5617.

Ota, L., Herbohn, J., Gregorio, N., Harrison, S., 2020. Reforestation and smallholder livelihoods in the humid tropics. Land Use Policy 92, 104455. https://doi.org/10.1016/j.landusepol.2019.104455.

Paneque-Gálvez, J., Vargas-Ramírez, N., Napoletano, B., Cummings, A., 2017. Grassroots innovation using drones for indigenous mapping and monitoring. Land 6, 86. https://doi.org/10.3390/land6040086.

Pendrill, F., Persson, U.M., Godar, J., Kastner, T., Moran, D., Schmidt, S., Wood, R., 2019. Agricultural and forestry trade drives large share of tropical deforestation emissions. Glob. Environ. Chang. 56, 1–10. https://doi.org/10.1016/j.gloenvcha.2019.03.002.

Persson, U.M., Henders, S., Cederberg, C., 2014. A method for calculating a land-use change carbon footprint (LUC-CFP) for agricultural commodities – applications to Brazilian beef and soy, Indonesian palm oil. Glob. Chang. Biol. 20, 3482–3491. https://doi.org/10.1111/gcb.12635.

Philpott, S.M., Arendt, W.J., Armbrecht, I., Bichier, P., Diestch, T.V., Gordon, C., Greenberg, R., Perfecto, I., Reynoso-Santos, R., Soto-Pinto, L., Tejeda-Cruz, C., Williams-Linera, G., Valenzuela, J., Zolotoff, J.M., 2008. Biodiversity loss in Latin American coffee landscapes: review of the evidence on ants, birds, and trees. Conserv. Biol. 22, 1093–1105. https://doi.org/10.1111/j.1523-1739.2008.01029.x.

Pongsiri, M.J., Roman, J., Ezenwa, V.O., Goldberg, T.L., Koren, H.S., Newbold, S.C., Ostfeld, R.S., Pattanayak, S.K., Salkeld, D.J., 2009. Biodiversity loss affects global disease ecology. BioScience 59, 945–954. https://doi.org/10.1525/bio.2009.59.11.6.

Poole, N., de Frece, A., 2010. A Review of Existing Organisational Forms of Smallholder Farmers' Associations and their Contractual Relationships with other Market Participants in the East and Southern African ACP Region (No. 11). In: AAACP Paper Series. All ACP Agricultural Commodities Programme, Rome.

Pradhan, B., Chaudhari, A., Adinarayana, J., Buchroithner, M.F., 2012. Soil erosion assessment and its correlation with landslide events using remote sensing data and GIS: a case study at Penang Island, Malaysia. Environ. Monit. Assess. 184, 715–727. https://doi.org/10.1007/s10661-011-1996-8.

Prevedello, J.A., Winck, G.R., Weber, M.M., Nichols, E., Sinervo, B., 2019. Impacts of forestation and deforestation on local temperature across the globe. PLoS One 14, e0213368. https://doi.org/10.1371/journal.pone.0213368.

Qaim, M., Sibhatu, K.T., Siregar, H., Grass, I., 2020. Environmental, economic, and social consequences of the oil palm boom. Ann. Rev. Resour. Econ. 12, 321–344. https://doi.org/10.1146/annurev-resource-110119-024922.

Radjawali, I., Pye, O., Flitner, M., 2017. Recognition through reconnaissance? Using drones for counter-mapping in Indonesia. J. Peasant Stud. 44, 817–833. https://doi.org/10.1080/03066150.2016.1264937.

Razafindratsima, O.H., Kamoto, J., Sills, Erin, Mutta, D., Song, C., Kabwe, G., Castle, S.E., Kristjanson, P.M., Ryan, Casey, Brockhaus, M., Sunderland, T., 2021. Evidence for the roles of forests and tree-based systems in poverty dynamics. Forest Policy Econ. 131, 102576.

Richards, P., Pellegrina, H., VanWey, L., Spera, S., 2015. Soybean development: the impact of a decade of agricultural change on urban and economic growth in Mato Grosso, Brazil. PLoS One 10, e0122510. https://doi.org/10.1371/journal.pone.0122510.

Rigaud, K.K., De Sherbinin, A.M., Jones, B., Bergmann, J., Clement, V., Ober, K., Schewe, J., Adamo, S.B., McCusker, B., Heuser, S., Midgley, A., 2018. Groundswell: Preparing for Internal Climate Migration. World Bank, Washington, DC.

Rights and Resources Initiative, 2018. At a Crossroads: Consequential Trends in Recognition of Community-based Forest Tenure from 2002-2017. Rights and Resources Initiative, Washington, DC.

Rist, L., Feintrenie, L., Levang, P., 2010. The livelihood impacts of oil palm: smallholders in Indonesia. Biodivers. Conserv. 19, 1009–1024. https://doi.org/10.1007/s10531-010-9815-z.

Robinson, B.E., Holland, M.B., Naughton-Treves, L., 2014. Does secure land tenure save forests? A meta-analysis of the relationship between land tenure and tropical deforestation. Glob. Environ. Chang. 29, 281–293. https://doi.org/10.1016/j.gloenvcha.2013.05.012.

Rohr, J.R., Barrett, C.B., Civitello, D.J., Craft, M.E., Delius, B., DeLeo, G.A., Hudson, P.J., Jouanard, N., Nguyen, K.H., Ostfeld, R.S., Remais, J.V., Riveau, G., Sokolow, S.H., Tilman, D., 2019. Emerging human infectious diseases and the links to global food production. Nat Sustain 2, 445–456. https://doi.org/10.1038/s41893-019-0293-3.

Roshetko, J.M., Rohadi, D., Perdana, A., Sabastian, G., Nuryartono, N., Pramono, A.A., Widyani, N., Manalu, P., Fauzi, M.A., Sumardamto, P., Kusumowardhani, N., 2013. Teak agroforestry systems for livelihood enhancement, industrial timber production, and environmental rehabilitation. For. Trees Livelihoods 22, 241–256. https://doi.org/10.1080/14728028.2013.855150.

Ruf, F., Schroth, G., Doffangui, K., 2015. Climate change, cocoa migrations and deforestation in West Africa: what does the past tell us about the future? Sustain. Sci. 10, 101–111. https://doi.org/10.1007/s11625-014-0282-4.

Saavedra-Velasco, M., Chiara-Chilet, C., Pichardo-Rodriguez, R., Grandez-Urbina, A., Inga-Berrospi, F., 2020. Coinfección entre dengue y COVID-19: necesidad de abordaje en zonas endémicas. Rev. Fac. Cien. Med. Univ. Nac. Cordoba 77, 52–54. https://doi.org/10.31053/1853.0605.v77.n1.28031.

Samir, K.C., 2013. Community vulnerability to floods and landslides in Nepal. Ecol. Soc. 18 https://doi.org/10.5751/ES-05095-180108.

Sanchez Badini, O., Hajjar, R., Kozak, R., 2018. Critical success factors for small and medium forest enterprises: a review. Forest Policy Econ. 94, 35–45. https://doi.org/10.1016/j.forpol.2018.06.005.

Santika, T., Wilson, K.A., Budiharta, S., Law, E.A., Poh, T.M., Ancrenaz, M., Struebig, M. J., Meijaard, E., 2019. Does oil palm agriculture help alleviate poverty? A multidimensional counterfactual assessment of oil palm development in Indonesia. World Dev. 120, 105–117. https://doi.org/10.1016/j.worlddev.2019.04.012.

Sartorius, K., Kirsten, J., 2002. Can small-scale farmers be linked to agribusiness? The timber experience. Agrekon 41, 295–325. https://doi.org/10.1080/03031853.2002.9523600.

Sasaki, N., Asner, G.P., Pan, Y., Knorr, W., Durst, P.B., Ma, H.O., Abe, I., Lowe, A.J., Koh, L.P., Putz, F.E., 2016. Sustainable management of tropical forests can reduce carbon emissions and stabilize timber production. Front. Environ. Sci. https://doi.org/10.3389/fenvs.2016.00050.

Sauls, L.A., 2020. Becoming fundable? Converting climate justice claims into climate finance in Mesoamerica's forests. Clim. Chang. 161, 307–325. https://doi.org/10.1007/s10584-019-02624-1.

Scheidel, A., Del Bene, D., Liu, J., Navas, G., Mingorría, S., Demaria, F., Avila, S., Roy, B., Ertör, I., Temper, L., Martínez-Alier, J., 2020. Environmental conflicts and defenders: a global overview. Glob. Environ. Chang. 63, 102104. https://doi.org/10.1016/j.gloenvcha.2020.102104.

Seppälä, R., Buck, A., Katila, P. (Eds.), 2009. Adaptation of Forests and People to Climate Change: A Global Assessment Report. (No. 22). IUFRO World Series. International Union of Forest Research Organizations (IUFRO), Helsinki.

Seymour, F., Busch, J., 2016. Why Forests? Why Now?: The Science, Economics, and Politics of Tropical Forests and Climate Change. Center for Global Development, Washington DC.

Seymour, F., Harris, N.L., 2019. Reducing tropical deforestation. Science 365, 756–757. https://doi.org/10.1126/science.aax8546.

Shyamsundar, P., 2020. Conservation for the "Last-Mile". The Nature Conservancy. URL. https://www.nature.org/en-us/what-we-do/our-insights/perspectives/rural-communities-pandemic-conservation/. accessed 7.25.21.

Shyamsundar, P., Ahlroth, S., Kristjanson, P., Onder, S., 2020. Supporting pathways to prosperity in forest landscapes – a PRIME framework. World Dev. 125, 104622. https://doi.org/10.1016/j.worlddev.2019.104622.

Sife, A.S., Kiondo, E., Lyimo-Macha, J.G., 2010. Contribution of mobile phones to rural livelihoods and poverty reduction in Morogoro Region, Tanzania. Electron. J. Inf. Syst. Dev. Countries 42, 1–15. https://doi.org/10.1002/j.1681-4835.2010.tb00299.x.

Sikor, T., 2011. Financing Household Tree Plantations in Vietnam: Current Programmes and Future Options (Working Paper No. 69). Center for International Forestry Research, Bogor, Indonesia.

Slough, T., Kopas, J., Urpelainen, J., 2021. Satellite-based deforestation alerts with training and incentives for patrolling facilitate community monitoring in the Peruvian Amazon. Proc. Natl. Acad. Sci. 118. https://doi.org/10.1073/pnas.2015171118.

Smith, P., Adams, J., Beerling, D.J., Beringer, T., Calvin, K.V., Fuss, S., Griscom, B., Hagemann, N., Kammann, C., Kraxner, F., Minx, J.C., Popp, A., Renforth, P., Vicente Vicente, J.L., Keesstra, S., 2019. Land-management options for greenhouse gas removal and their impacts on ecosystem services and the sustainable development goals. Annu. Rev. Environ. Resour. 44, 255–286. https://doi.org/10.1146/annurev-environ-101718-033129.

Spenceley, A., McCool, S., Newsome, D., Báez, A., Barborak, J.R., Blye, C.-J., Bricker, K., Sigit Cahyadi, H., Corrigan, K., Halpenny, E., Hvenegaard, G., Malleret King, D., Leung, Y.-F., Mandić, A., Naidoo, R., Rüede, D., Sano, J., Sarhan, M., Santamaria, V., Beraldo Sousa, T., Zschiegner, A.-K., 2021. Tourism in protected and conserved areas amid the COVID-19 pandemic. PARKS 27, 103–118. https://doi.org/10.2305/IUCN.CH.2021.PARKS-27-SIAS.en.

Staal, A., Flores, B.M., Aguiar, A.P.D., Bosmans, J.H.C., Fetzer, I., Tuinenburg, O.A., 2020. Feedback between drought and deforestation in the Amazon. Environ. Res. Lett. 15, 044024 https://doi.org/10.1088/1748-9326/ab738e.

Steven, M.D., Malthus, T.J., Baret, F., Xu, H., Chopping, M.J., 2003. Intercalibration of vegetation indices from different sensor systems. Remote Sens. Environ. 88, 412–422. https://doi.org/10.1016/j.rse.2003.08.010.

Stevens, T., Aarts, N., Termeer, C., Dewulf, A., 2016. Social media as a new playing field for the governance of agro-food sustainability. Curr. Opin. Environ. Sustain. 18, 99–106. https://doi.org/10.1016/j.cosust.2015.11.010. Sustainability governance and transformation 2016: Informational governance and environmental sustainability.

Suter, M.K., Miller, K.A., Anggraeni, I., Ebi, K.L., Game, E.T., Krenz, J., Masuda, Y.J., Sheppard, L., Wolff, N.H., Spector, J.T., 2019. Association between work in deforested, compared to forested, areas and human heat strain: an experimental study in a rural tropical environment. Environ. Res. Lett. 14, 084012 https://doi.org/10.1088/1748-9326/ab2b53.

Tadesse, G., Zavaleta, E., Shennan, C., 2014. Coffee landscapes as refugia for native woody biodiversity as forest loss continues in southwest Ethiopia. Biol. Conserv. 169, 384–391. https://doi.org/10.1016/j.biocon.2013.11.034.

Taufik, M., Torfs, P.J.J.F., Uijlenhoet, R., Jones, P.D., Murdiyarso, D., Van Lanen, H.A.J., 2017. Amplification of wildfire area burnt by hydrological drought in the humid tropics. Nat. Clim. Chang. 7, 428–431. https://doi.org/10.1038/nclimate3280.

Taylor, L., 2020. Coronavirus in the Amazon. New Sci. 246, 10. https://doi.org/10.1016/S0262-4079(20)31121-0.

TechnoServe, 2021. Our Work: Business Solutions to Poverty for Enterprising People [WWW Document]. TechnoServe. URL. https://www.technoserve.org/our-work/. accessed 7.26.21.

Thorlakson, T., de Zegher, J.F., Lambin, E.F., 2018. Companies' contribution to sustainability through global supply chains. Proc. Natl. Acad. Sci. 115, 2072–2077. https://doi.org/10.1073/pnas.1716695115.

Tnah, L.H., Lee, S.L., Ng, K.K.S., Faridah, Q.-Z., Faridah-Hanum, I., 2010. Forensic DNA profiling of tropical timber species in Peninsular Malaysia. For. Ecol. Manag. 259, 1436–1446. https://doi.org/10.1016/j.foreco.2010.01.017.

Tollefson, J., 2016. Political upheaval threatens Brazil's environmental protections. Nature 539, 147–148. https://doi.org/10.1038/539147a.

Tollefson, J., Monastersky, R., 2019. The hard truths of climate change. Nature 573, 326.

Verra Registry Database [WWW Document], 2021. Verra: Standards for Sustainability. URL. https://registry.verra.org/app/search/CCB. accessed 7.26.21.

Vila Benites, G.V., Bebbington, A., 2020. Political settlements and the Governance of Covid-19: mining, risk, and territorial control in Peru. J. Lat. Am. Geogr. 19, 215–223. https://doi.org/10.1353/lag.2020.0081.

Vitasse, Y., Porté, A.J., Kremer, A., Michalet, R., Delzon, S., 2009. Responses of canopy duration to temperature changes in four temperate tree species: relative contributions of spring and autumn leaf phenology. Oecologia 161, 187–198. https://doi.org/10.1007/s00442-009-1363-4.

Walsh, K.J.E., McBride, J.L., Klotzbach, P.J., Balachandran, S., Camargo, S.J., Holland, G., Knutson, T.R., Kossin, J.P., Lee, T., Sobel, A., Sugi, M., 2016. Tropical cyclones and climate change. WIREs Clim. Chang. 7, 65–89. https://doi.org/10.1002/wcc.371.

Walther, G.-R., Post, E., Convey, P., Menzel, A., Parmesan, C., Beebee, T.J.C., Fromentin, J.-M., Hoegh-Guldberg, O., Bairlein, F., 2002. Ecological responses to recent climate change. Nature 416, 389–395. https://doi.org/10.1038/416389a.

Wambugu, C., Place, F., Franzel, S., 2011. Research, development and scaling-up the adoption of fodder shrub innovations in East Africa. Int. J. Agric. Sustain. 9, 100–109. https://doi.org/10.3763/ijas.2010.0562.

Wani, S.P., Rockström, J., Oweis, T.Y., 2009. Rainfed Agriculture: Unlocking the Potential. CABI, Cambridge, MA.

Watts, N., Amann, M., Arnell, N., Ayeb-Karlsson, S., Belesova, K., Boykoff, M., Byass, P., Cai, W., Campbell-Lendrum, D., Capstick, S., Chambers, J., Dalin, C., Daly, M., Dasandi, N., Davies, M., Drummond, P., Dubrow, R., Ebi, K.L., Eckelman, M., Ekins, P., Escobar, L.E., Montoya, L.F., Georgeson, L., Graham, H., Haggar, P., Hamilton, I., Hartinger, S., Hess, J., Kelman, I., Kiesewetter, G., Kjellstrom, T., Kniveton, D., Lemke, B., Liu, Y., Lott, M., Lowe, R., Sewe, M.O., Martinez-Urtaza, J., Maslin, M., McAllister, L., McGushin, A., Mikhaylov, S.J., Milner, J., Moradi-Lakeh, M., Morrissey, K., Murray, K., Munzert, S., Nilsson, M., Neville, T., Oreszczyn, T., Owfi, F., Pearman, O., Pencheon, D., Phung, D., Pye, S., Quinn, R., Rabbaniha, M., Robinson, E., Rocklöv, J., Semenza, J.C., Sherman, J., Shumake-Guillemot, J., Tabatabaei, M., Taylor, J., Trinanes, J., Wilkinson, P., Costello, A., Gong, P., Montgomery, H., 2019. The 2019 report of The Lancet Countdown on health and climate change: ensuring that the health of a child born today is not defined by a changing climate. Lancet 394, 1836–1878. https://doi.org/10.1016/S0140-6736(19)32596-6.

Well, M., Carrapatoso, A., 2017. REDD+ finance: policy making in the context of fragmented institutions. Clim. Pol. 17, 687–707. https://doi.org/10.1080/14693062.2016.1202096.

Wheeler, D., Hammer, D., Kraft, R., Steele, A., 2014. Satellite-Based Forest Clearing Detection in the Brazilian Amazon. World Resources Institute, Washington, DC.

Wich, S.A., Koh, L.P., 2018. Conservation Drones: Mapping and Monitoring Biodiversity. Oxford University Press, Oxford. https://doi.org/10.1093/oso/9780198787617.001.0001.

Wolfe, N.D., Daszak, P., Kilpatrick, A.M., Burke, D.S., 2005. Bushmeat hunting, deforestation, and prediction of zoonotic disease. Emerg. Infect. Dis. 11, 1822–1827. https://doi.org/10.3201/eid1112.040789.

World Bank, 2015. The Economic Impact of Ebola on Sub-Saharan Africa: Updated Estimates for 2015. World Bank, Washington, DC.

World Bank, 2017. Forest Policy Note: Turkey. World Bank, Washington, DC.

World Bank, 2019. Country Forest Note: Vietnam. World Bank, Washington, DC.

World Bank, 2020a. Global Economic Prospects, June 2020, Global Economic Prospects. The World Bank, Washington, DC. https://doi.org/10.1596/978-1-4648-1553-9.

World Bank, 2020b. Poverty and Distributional Impacts of COVID-19: Potential Channels of Impact and Mitigating Policies. World Bank, Washington, DC.

World Economic Forum, 2020. The Global Risks Report 2020 (No. 15), Insight Report. World Economic Forum, Geneva.

Wright, R., 2019. The story of 2019: protests in every corner of the globe. The New Yorker (December 30). https://www.newyorker.com/news/our-columnists/the-story-of-2019-protests-in-every-corner-of-the-globe.

Wunder, S., Börner, J., Shively, G., Wyman, M., 2014. Safety nets, gap filling and forests: a global-comparative perspective. World Dev. For. Livelihoods Conserv. 64, S29–S42. https://doi.org/10.1016/j.worlddev.2014.03.005.

WWF, 2012. WWF Living Forests Report: Chapter 4, Forests and Wood Products. WWF International, Gland, Switzerland.

Yagoub, M., 2017. Doubling of Mexico Mining Losses Sign of Growing Criminal Involvement. InSight Crime. URL. https://insightcrime.org/news/brief/doubling-of-mexico-mining-losses-sign-of-growing-criminal-involvement/. accessed 7.25.21.

Yin, H., Li, C., 2001. Human impact on floods and flood disasters on the Yangtze River. Geomorphology 41, 105–109. https://doi.org/10.1016/S0169-555X(01)00108-8. The Yangtze River: an Introduction.

Zhu, X., Linham, M.M., Nicholls, R.J., 2010. Technologies for climate change adaptation – coastal erosion and flooding. In: TNA Guidebook. Danmarks Tekniske Universitet, Risø Nationallaboratoriet for Bæredygtig Energi, Roskilde, Denmark.