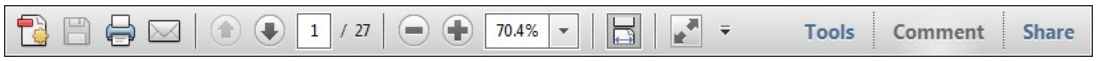
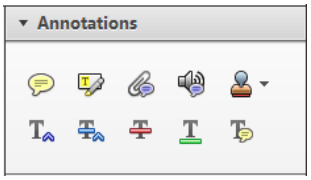
USING e-ANNOTATION TOOLS FOR ELECTRONIC PROOF CORRECTION

WILEY

Once you have Acrobat Reader open on your computer, click on the Comment tab at the right of the toolbar:



This will open up a panel down the right side of the document. The majority of tools you will use for annotating your proof will be in the Annotations section, pictured opposite. We've picked out some of these tools below:

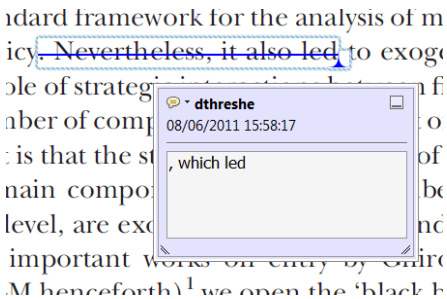


1. Replace (Ins) Tool – for replacing text.

Strikes a line through text and opens up a text box where replacement text can be entered.

How to use it

- Highlight a word or sentence.
- Click on the Replace (Ins) icon in the Annotations section.
- Type the replacement text into the blue box that appears.

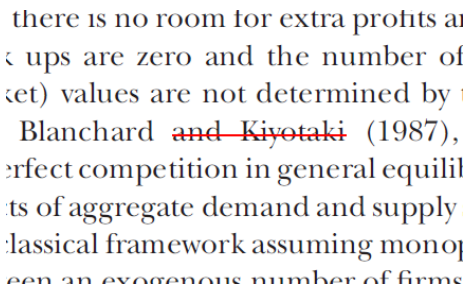


2. Strikethrough (Del) Tool – for deleting text.

Strikes a red line through text that is to be deleted.

How to use it

- Highlight a word or sentence.
- Click on the Strikethrough (Del) icon in the Annotations section.

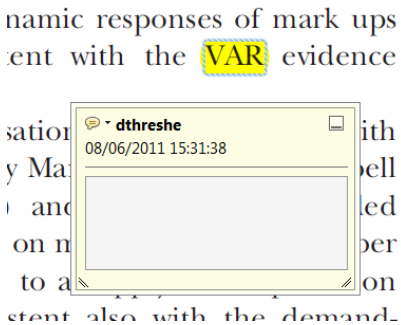


3. Add note to text Tool – for highlighting a section to be changed to bold or italic.

Highlights text in yellow and opens up a text box where comments can be entered.

How to use it

- Highlight the relevant section of text.
- Click on the Add note to text icon in the Annotations section.
- Type instruction on what should be changed regarding the text into the yellow box that appears.

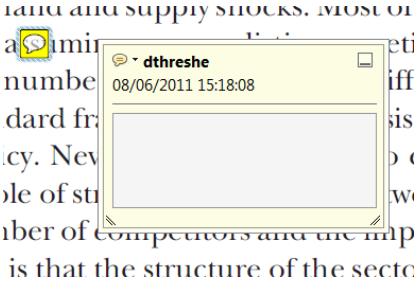


4. Add sticky note Tool – for making notes at specific points in the text.

Marks a point in the proof where a comment needs to be highlighted.

How to use it

- Click on the Add sticky note icon in the Annotations section.
- Click at the point in the proof where the comment should be inserted.
- Type the comment into the yellow box that appears.

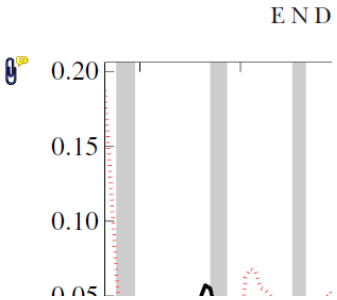


5. Attach File Tool – for inserting large amounts of text or replacement figures.

Inserts an icon linking to the attached file in the appropriate place in the text.

How to use it

- Click on the Attach File icon in the Annotations section.
- Click on the proof to where you'd like the attached file to be linked.
- Select the file to be attached from your computer or network.
- Select the colour and type of icon that will appear in the proof. Click OK.



6. Drawing Markups Tools – for drawing shapes, lines and freeform annotations on proofs and commenting on these marks.

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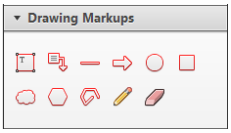
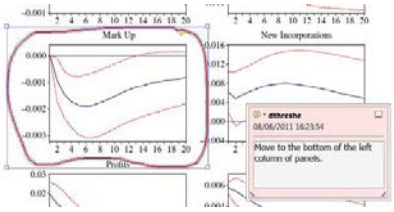


How to use it

- Click on one of the shapes in the Drawing Markups section.
- Click on the proof at the relevant point and draw the selected shape with the cursor.
- To add a comment to the drawn shape, move the cursor over the shape until an arrowhead appears.
- Double click on the shape and type any text in the red box that appears.



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REVIEW

Impacts of large-scale forest restoration on socioeconomic status and local livelihoods: what we know and do not know

Cristina Adams[1,2,5], Sidney T. Rodrigues[3], Miguel Calmon[4], and Chetan Kumar[4]

[1] School of Arts Sciences and Humanities (EACH) and Institute of Energy and Environment (IEE), University of São Paulo (USP), Av. Arlindo Bétio, 1.000, 03828-000 São Paulo, SP, Brazil

[2] Department of Anthropology and The Ostrom Workshop, University of Indiana, Bloomington, IN, USA

[3] STR Consultancy, Rua Prof. Pirajá da Silva, 183, ap. 151, 05451-090 São Paulo, SP, Brazil

[4] Landscape Restoration Science and Knowledge, Global Forest and Climate Change Programme, International Union for Conservation of Nature (IUCN), 1630 Connecticut Avenue, NW, Suite 300, Washington, DC 20009, USA

ABSTRACT

Forests are sources of wood, non-timber forest products and ecosystems services and goods that benefit society as a whole, and are especially important to rural livelihoods. Forest landscape restoration (FLR) has been proposed as a way to counteract deforestation and reconcile the production of ecosystem services and goods with conservation and development goals. But limited evidence indicates how large-scale forest restoration could contribute to improving local livelihoods. Here, we present a conceptual framework to analyze the effects of large-scale restoration on local livelihoods, and use it to review the scientific literature and reduce this knowledge gap. Most of the literature referred to case studies (89%), largely concentrated in China (49%). The main theme explored was income, followed by livelihoods diversification, off-farm employment opportunities, poverty reduction, equity and the provision of timber and energy as ecosystem services. Nearly 60 percent of the papers discussed the importance of governance systems to socioeconomic outcomes. The reforestation/restoration programs and policies investigated in the studies had mixed socioeconomic effects on local livelihoods depending on other variables, such as availability of off-farm jobs, household characteristics, land productivity, land tenure, and markets for forest products and ecosystem services. We conclude that the effects of large-scale restoration initiatives on local livelihoods may vary due to several factors and is still not clear for many situations; therefore, monitoring over time with clear indicators is needed.

Abstract in Portuguese is available with online material.

Key words: forest governance; forest landscape restoration; reforestation.

FORESTS SERVE AS SAFETY NETS AND HELP RURAL PEOPLE TO AVOID, MITIGATE, AND BE LIFTED OUT OF POVERTY (Hobley 2005). They are a source of timber and fuel wood, non-timber forest products, and ecosystem services that can be consumed to improve food security and nutrition and used to generate income (Nagendra 2007, Haglund *et al.* 2011, Lamb 2011, Le *et al.* 2012, Meyfroidt 2013, FAO 2014). The World Bank estimates that forest resources directly contribute to the well-being of approximately one billion people living in extreme poverty in developing countries (Bhargava 2006). In rural areas, five hundred million people depend on a mixture of forest resources and agriculture to meet their needs. Access to these options also helps increase resilience and adaptability of existing agricultural and forest-based systems (Maginnis & Jackson 2005).

Forest restoration is a pressing issue, driven by the need to rehabilitate watersheds and degraded agricultural land, control desertification, restore biodiversity and ecosystem services, and mitigate climate change (van Oosten 2013, Locatelli *et al.* 2015). At the landscape level, forest restoration can contribute both to local livelihoods and to society at large, through the production of ecosystem goods and services (Stanturf *et al.* 2012, IUCN & WRI 2014, Mansourian & Vallauri 2014, Chazdon & Uriarte 2016, Chazdon *et al.* 2016a).

The concept of forest landscape restoration (FLR) expresses a relatively new approach to forest restoration, and can be defined as a planned process that aims to regain ecological integrity and enhance human well-being in deforested or degraded forest landscapes (Maginnis & Jackson 2005, Mansourian *et al.* 2005, Newton & Tejedor 2011, Chazdon *et al.* 2016a). Forest landscape restoration's role in reconciling conservation and development goals has been recognized and incorporated into important international commitments such as the Aichi Target 15 of the Convention of Biological Diversity, the Reducing Emissions from Deforestation and Forest Degradation (REDD) arrangements, and the Bonn Challenge to restore 150 million hectares by 2020

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[5]Corresponding author; e-mail: cadams@usp.br

and 350 million hectares by 2030 (van Oosten *et al.* 2014, Chazdon *et al.* 2016a). Forest landscape restoration is also expected to contribute to several of the United Nations Sustainable Development Goals (United Nations 2015).

However, despite the fact that FLR initiatives are being implemented in several countries, with an expected increase in the coming years, there is still little information on the links between FLR and socioeconomic impacts at the local level (Chazdon 2008, Coomes *et al.* 2008, Sayer 2009, Blignaut *et al.* 2013, Lazos *et al.* 2016). Most of the literature on forest-based livelihoods discusses the benefits of existing forests (FAO 2014) or avoided deforestation and protected areas (Singh *et al.* 2011), but little information is available on the impacts of FLR (Aronson *et al.* 2010, IUCN 2012, Le *et al.* 2012, Weston *et al.* 2015). For this reason, it is still not certain to what extent FLR can improve human well-being (Newton *et al.* 2012).

Two previous reviews attempted to bridge this gap (Aronson *et al.* 2010, Le *et al.* 2012), showing that some of the benefits that can be expected from reforestation projects at the local level are increases in income, availability of food and fiber supplies, employment and other livelihood opportunities, and empowerment and capacity building. However, Barr and Sayer (2012) have shown that some reforestation initiatives in Asia have exacerbated existing inequities between powerful political and economic actors and forest-dependent communities, and the resulting effects of China's large-scale reforestation programs are mixed (He & Sikor 2015).

These different trends highlight the need for a better understanding of the socioeconomic outcomes of large-scale forest restoration initiatives (Aronson *et al.* 2010, Barr & Sayer 2012). Therefore, our goal was to consolidate and analyze existing knowledge on the socioeconomic benefits and eventual drawbacks from forest landscape restoration (FLR) initiatives on local livelihoods, based on a review of scientific literature. We did not intend to provide an exhaustive coverage of the literature, but to investigate patterns and identify socioeconomic aspects that can contribute to future FLR initiatives.

Socioeconomic effects of FLR at the local level are mediated by governance systems (organizations and rules that govern resource use; Ostrom 2009) and contextual variables (economic, environmental, political, and technological), that operate at different levels of organization and are connected by cross-level interactions and feedback processes (Crowder *et al.* 2006, McGinnis 2011, Ostrom 2011, McGinnis & Ostrom 2014, Chazdon *et al.* 2016b). Therefore, in order to contextualize and organize the literature review, we developed a conceptual framework for data analysis, which is presented in the remainder of this section. In section two we define our methods, followed by our main findings organized according to the proposed conceptual framework in section three. In section four the main findings are discussed, and in section five we conclude the paper and offer some recommendations.

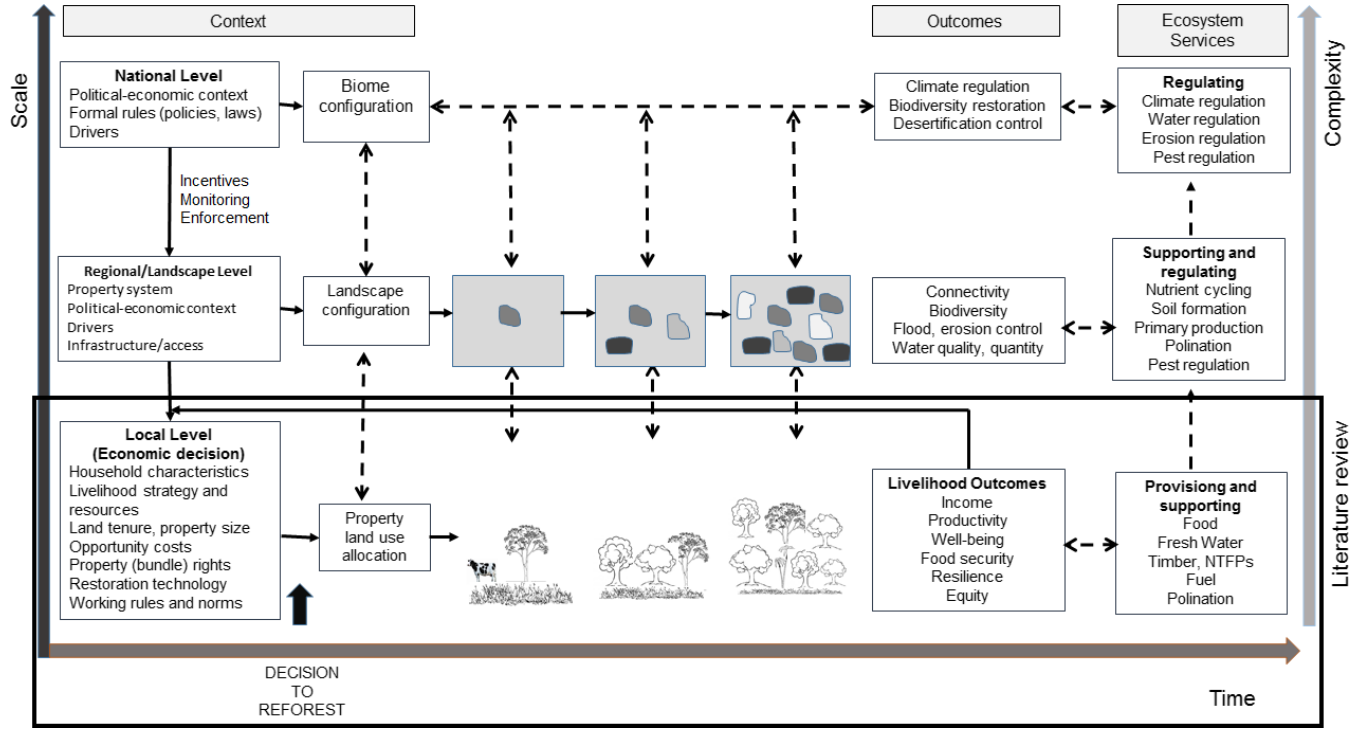
Conceptual Framework.—Landscapes are multidimensional physical entities where nature and culture interact, and have both temporal and spatial characteristics (Balee & Erickson 2006). As such, landscapes are complex adaptive systems that result from the coupling of social and ecological systems (Liu *et al.* 2007, Binder *et al.* 2013, Filotas *et al.* 2014, Bennett *et al.* 2015, Chazdon *et al.* 2016a) and interact across multiple spatial and temporal scales (Young 2006, Schlüter *et al.* 2012, Scholes *et al.* 2013). Additionally, landscapes are composed of different land uses (agriculture, cattle ranching, protected areas) and property rights (state, private and common property), meaning that FLR will have to be accomplished under different governance systems (Chazdon *et al.* 2016a, b).

Even though several interdisciplinary frameworks have already been proposed to understand social-ecological systems (SES) and the connections between the production of ecosystem services and human well-being (Bodin & Tengö 2012, Binder *et al.* 2013, Bennett *et al.* 2015), none of them address FLR. The conceptual framework that we propose (Fig. 1) was designed using elements of the Institutional Analysis and Development Framework (IAD), the Socio-Ecological Systems framework (SES) (McGinnis 2011, Ostrom 2011, McGinnis & Ostrom 2014), the Millenium Ecosystem Assessment (Millenium Ecosystem Assessment 2005), and the sustainable rural livelihoods framework (Scoones 1998, 2009). All four frameworks have been widely used to investigate common pool resources governance and institutions, linkages between ecosystem services and human wellbeing, and factors influencing sustainable rural livelihoods. Livelihoods are defined as "the capabilities, assets (including both material and social resources) and activities required for a means of living" (Chambers & Conway 1991, Scoones 1998: 5).

In our conceptual framework (Fig. 1), decision to reforest at the local (household, property) level takes into consideration household characteristics (*e.g.*, demography, domestic life cycle); livelihood strategies (agricultural intensification/extensification, livelihood diversification, migration) and resources (natural capital, economic/financial capital, human capital, social capital) (Scoones 1998, 2009); opportunity costs of land uses and collective action; the knowledge, costs and availability of restoration technology; and property rights (Schlager & Ostrom 1992, Cole & Ostrom 2011).

Property rights affect incentives to collective action and the use of resource systems, and are conventionally classified as state/public, private, common, and non-property/open access (Cole & Ostrom 2011). However, property rights to natural resources are not always straightforward and can involve different bundles of rights (access, withdraw, management, exclusion and alienation), depending on the institutions in place (*e.g.,* forestry policies) (Schlager & Ostrom 1992). Institutions are "the prescriptions that humans use to organize all forms of repetitive and structured interactions" (Ostrom 2005:3) or, in other words, institutions refer to the 'rules of the game', and encompass both legal documents and informal rules agreed upon by a certain group of people and/or organizations.

Once the decision to reforest is made (large arrow), the forest successional process (assisted or not) initiates and unfolds over time. Outcomes of the reforestation process will vary



13 FIGURE 1. Forest landscape restoration conceptual framework.

temporally, but expected socioeconomic benefits at the local level may include increases in income, land productivity, household resilience, equity, food security, and in the access to ecosystem services (Scoones 1998, 2009, Millenium Ecosystem Assessment 2005, Le *et al.* 2012, FAO 2014). Ecosystem services are the benefits people obtain from ecosystems, and can be divided into provisioning, supporting and regulating services (Millenium Ecosystem Assessment 2005). In our FLR framework, at the local level they encompass food, water, timber, fuel wood, non-timber forest products (NFTPs), and pollination. The outcomes will feed back into the system and influence future economic decisions at the local level. Contextual factors and drivers at the landscape, regional, and national levels, including rules (*e.g.,* policies, laws), incentives (*e.g.* markets), and monitoring and enforcement, will also affect land use decisions at the local level.

Over time, decisions taken collectively by different landowners will affect the land use mosaic at the landscape level, and determine connectivity and biodiversity of reforested fragments, flood and erosion control, and water quality and availability in the watershed (supporting ecosystem services). The aggregated landscape outcomes will both feedback into the local level (soil formation, nutrient cycling) and influence the national or biome level emergent effects (climate regulation, biodiversity restoration, desertification control). However, the increasing complexity of the SES from the local to the national levels, connected by inter-scalar, non-linear interactions and feedbacks, will make it increasingly difficult to devise predictions about outcomes at higher levels and suggests that FLR should be carried out as a flexible and adaptive process (Yin *et al.* 2013). We focused our review on the local level (large box).

METHODS

Forest landscape restoration (FLR) is a recently defined concept (Newton & Tejedor 2011) that incorporates multiple forest functions providing livelihoods and ecosystem services for local people (Chazdon *et al.* 2016a). In this review, we included 'reforests' (Chazdon *et al.* 2016a) originating from reforestation (re-establishment of forest through planting trees or deliberate seeding on land already classified as forest), restoration (assisted recovery of an ecosystem that has been damaged or destroyed), and spontaneous natural regrowth (Society for Ecological Restoration International Science & Policy Working Group 2004, Chazdon 2013, Chazdon *et al.* 2016a). 'Reforests' mixing native and non-native species and agroforestry systems were included, but commercial tree plantations and mangroves were excluded. The literature review was performed using the Thomson-Reuter Web of Science database from year 2000–2015, using the following key words as topics: reforestation* livelihoods, reforestation* governance, forest restoration* livelihoods, forest restoration* governance. Additionally, reports and other types of documents were accessed (grey literature), but not checked systematically. References cited on the reviewed literature were also checked and new papers were included if relevant.

Our initial search on Web of Science yielded 263 articles that were checked and filtered according to the availability of

information on socioeconomic impacts (positive, negative) of forest restoration/reforestation initiatives, independent of the scale of the study (local, landscape, national, global), resulting in 67 articles. Papers not related to the topics under review were eliminated, as well as local case studies with no information on livelihoods impacts. Papers discussing reforestation governance were selected for further analysis. References searched using the other sources discussed above were added, resulting in a database with 123 references. All the papers were read and reclassified according to availability of explicit information on livelihoods, resulting in a final database of 46 articles (see Table S1).

Most of the articles selected were published from 2011 (Fig. 2), and the vast majority were case studies investigating reforestation impacts at the local scale, on specific countries (89%). Only five percent discussed the problem on a global scale, four percent in Latin America and two percent in Asia. Among the countries, China was the one with more entries (49%), followed by Ghana, Niger, Ethiopia (9%), Mozambique, and Vietnam (4%). All other countries had only one paper each (2%).

Based on the sustainable rural livelihoods frameworks (Scoones 1998, 2009) and the indicators of socio-economic success of reforestation reviewed by (Le *et al.* 2012), we unraveled the outcomes in the local level box (Fig. 1) using the variables listed in Table 1 to organize the database and analyze the data. Each article was read and all the information on the variables on Table 1 were organized in a spreadsheet used for the analysis. The literature analysis focused on the local level (Fig. 1), but connections with other levels and the contextual factors were considered, including the governance systems where each case study was embedded.

RESULTS

Although large-scale forestry plantations are not new to tropical countries, FLR initiatives are trying to overcome some of the problems posed by traditional approaches. Aimed at generating financial and economic benefits, traditional approaches typically relied heavily on tree planting of a limited number of non-native species, failing to address the root causes of forest loss and degradation and improve human wellbeing (Dudley *et al.* 2005, Kalame *et al.* 2011). Conversely, new governance frameworks are being designed by FLR initiatives, and examples include comparative experiments led by international NGOs such as IUCN, WRI and WWF (Mansourian & Rambeloarisoa 2005, Newton & Tejedor 2011, IUCN 2012), as well as multi-stakeholder initiatives such as the Atlantic Forest Restoration Pact (Pinto *et al.* 2014), in Brazil.

The literature analysis using the local level outcome variables (Table 1) showed that the main aspect of socioeconomic impacts of FLR assessed was income (Fig. 3), followed by livelihoods

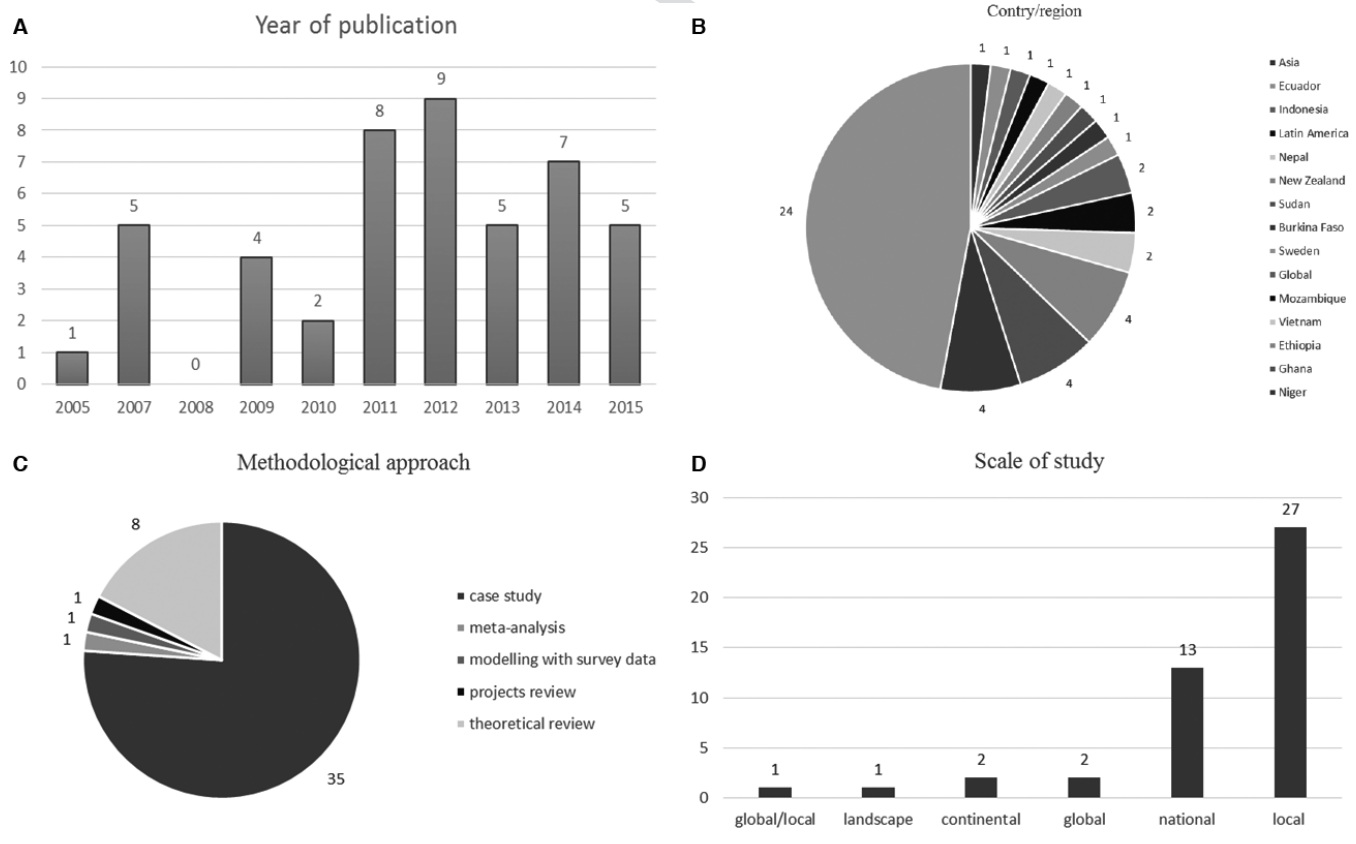


FIGURE 2. Bibliometric information for the reviewed literature as indicated by (A) year of publication, (B) country/region, (C) methodological approach, (D) scale of study.

TABLE 1. *Local level socioeconomic outcome variables used to analyze the literature.*

Socioeconomic outcome variables at the local level	
Income	
Local employment opportunities	On-farm
	Off-farm
Ecosystem provision services (non-cash income)	Food
	Timber, energy
	Non-timber forest products (NFTPs)
Productivity	
Well-being	Food security/sovereignty
	Resilience
	Equity
	Health
	Poverty reduction/increase
	Empowerment/disempowerment
	Intangible benefits/losses
Livelihood opportunities/ resources	Agricultural Intensification/extensification
	Diversification
	Migration Capital (natural, economic, financial, social, human)
Land tenure	
Opportunity Costs to reforest	
Conflicts	
Property rights	
Governance	

diversification, off-farm employment opportunities, poverty reduction, equity and the provision of timber and energy as ecosystem services. It is worthwhile noting that no article explicitly covered impacts of FLR on health, and only two papers discussed the empowerment of local people. Meanwhile, nearly 60 percent of the papers discussed the importance of governance systems to the socioeconomic outcomes. In the remainder of this section, the outcomes variables will be discussed in more detail after an overview of the main large-scale restoration initiatives identified in the literature.

Large-scale Restoration Initiatives.—Since FLR is a relatively new approach, no paper was found regarding the evaluation of the socioeconomic outcomes of this perspective. Most papers (60%) analyzed large-scale national initiatives, such as the Five Million Hectare Reforestation Program (5MHRP) in Vietnam (2%); the National Adaptation Program of Action (NAPA) in Sudan (2%); China's Priority Forest Programs (PFP's) (15%); and the Sloping Land Conversion Program (SLCP) (35%). Six percent of the papers compared national level initiatives. Community-based projects with a bottom-up approach were investigated by 29 percent of the papers, and included the Modified Taungya System (MTS) (6%) and the Farmer Managed Natural Regeneration (FMNR) (10%) in Africa. Although MTS and FMNR are implemented at the local level, at the landscape or biome level (Fig. 1) they have contributed to re-greening of the African Sahel (Sendzimir *et al.* 2011, Weston *et al.* 2015, Reij & Garrity 2016).

The Asian national large-scale reforestation initiatives are based mainly on the payment for ecosystem services (PES) model, such as soil erosion reduction and water production. China's Priority Forest Programs (PFPs) are being implemented since the 1990s and are the world's largest programs in terms of scale, duration, and payments (Xi *et al.* 2014). The SCLP is the largest among them, using payments to convert marginal croplands (low productivity) into forests, "involving millions of mountain-dwelling households as core agents of its implementation" (He 2014: 30). The effects of PFPs have been enhanced through a combination with other rural and urban policies (Bullock & King 2011, Wang *et al.* 2011, He & Lang 2015, He & Sikor 2015).

Although Chinese forest policy has been shifting from command-and-control to decentralized-marketization-based forest governance (Chhatre & Agrawal 2008, Arts & Visseren-Hamakers 2012, Arts *et al.* 2014) to improve local volunteerism and autonomy in policy implementation (He 2014), the PFPs have been criticized for being top-down, using inflexible solutions and simplifying social diversity (He & Lang 2015). Additionally, differences in local-central government interactions caused households involved in PFPs in the different regions to be subjected to different policies, payment removals and reductions (Komarek *et al.* 2014). Recommendations have been made to ensure meaningful local decision-making; increase the flexibility of government policies at the regional level, differentiating payments standards and schemes across regions; and, at the national level, allow sufficient time for local interaction and implementation of a pro-poor approach (He & Lang 2015).

The African case studies showed a greater emphasis on participatory forest-management initiatives and agroforestry systems, considered as an 'effective, efficient, and fair pathway' to achieve sustainable development goals (Mbow *et al.* 2014a). As far as the case studies were concerned, the socioeconomic impacts of reforestation initiatives were apparently less mixed in Africa than in Asia (China), and generally showed results that were more positive. The Modified Taungya System (MTS) is a combination of tree planting and maintenance, with the cultivation of food crops occurring under the tree canopy (until its closure, three years on average), and it has been employed by the Ghanaian Government to restore forest cover. Farmers receive a 40 percent share of timber revenues as a payment for tree planting and maintenance (Ros-Tonen *et al.* 2013).

The Farmer Managed Natural Regeneration (FMNR) is an approach to land restoration and reforestation that aims to reconcile food production, soil conservation, and protection of biodiversity. Farmers select and protect the most vigorous stems that regrow from felled trees or live stumps, pollarding them to grow into straight trunks (Weston *et al.* 2015). It originated in Niger in the 1980s, spreading rapidly from farmer to farmer due to its ease of adoption, reliance on household resources, cultural acceptance, and institutional change in tree tenure from state ownership to households (Reij & Garrity 2016). The establishment of

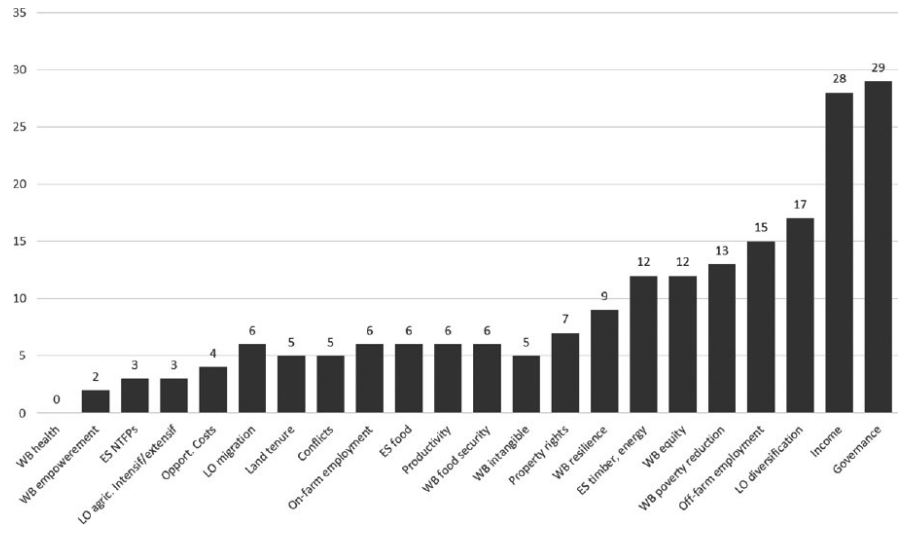


FIGURE 3. Number of articles with explicit information on the investigated socioeconomic outcome variables (Table 1).

cooperatives and user rights under FMNR has empowered local communities to manage their communal lands in a more sustainable way (Brown *et al.* 2011).

The livelihood impacts of FMNR and the MTS were investigated in Niger (Haglund *et al.* 2011, Sendzimir *et al.* 2011) and Ghana (Ros-Tonen *et al.* 2013, Weston *et al.* 2015) and are discussed by Reij and Garrity (2016). The most dramatic economic impacts of FMNR came from the possibility of receiving payments through the creation of carbon emissions offset markets. The Humbo Community-based Natural Regeneration Project in Ethiopia, *e.g.*, is expected to generate an increase in annual income of US $250 per ha per year (Brown *et al.* 2011:329, Weston *et al.* 2015). In Mozambique, agroforestry systems were used for carbon sequestration (Groom & Palmer 2012), and in Sudan reforestation was proposed to help vulnerable poor communities to adapt to the impacts of climate change under National Adaptation Programs of Action (NAPA) of the Climate Convention (UNFCCC) (Kalame *et al.* 2011). However, lessons from past major tree-planting projects in Sudan and the perspective of local farmers were not being incorporated (Kalame *et al.* 2011, Groom & Palmer 2012).

Cash Income and Employment.—Income was the most evaluated outcome of large-scale restoration initiatives (58% of the papers). Overall, the data shows that impacts on income have been mixed, depending on other variables such as availability of off-farm jobs, household characteristics, land productivity, land tenure, and markets for forest products and ecosystem services. The main driver of change in household income was the substitution of farmland by forest. In many cases, but particularly in China, this substitution freed household labor to seek, jobs. When available, off-farm jobs usually became the main income source (Bullock & King 2011, Groom & Palmer 2012, Huang *et al.* 2012, Wang & Maclaren 2012, Komarek *et al.* 2014, He & Sikor 2015).

Availability of off-farm jobs, for example, determined some of the effects of China's SLCP on farmers' livelihoods in the provinces of Guizhou, Ningxia (Groom & Palmer 2012), Sichuan, Saanxi (Bullock & King 2011), Yunnan (He & Lang 2015), and Fujian (Wang *et al.* 2011). He and Lang (2015) found a four-fold increase in income over a period of nine years attributed to off-farm income, but also to SLCP payments. Wang *et al.* (2011) observed an increase of 41 percent in net income by farmer from 2000 to 2007, with income from off-farm employment gradually becoming a crucial source for rural households. When large-scale reforestation programs were complemented with other rural policies in China, off-farm income showed a net income increase of 11.2 percent due to the development of green enterprises (such as pig farms and fish ponds), and the replacement of fuel wood by methane generation and purchased coal (Cao *et al.* 2009). Another source of off-farm cash income that contributed to household's total income were payments and subsidies from the government under the reforestation programs (Liang *et al.* 2012, Liu *et al.* 2013). In Yunnan Province, payments delivered under SLCP were considered to provide critical insurance in the first years of the implementation of the program, allowing households to diversify into off-farm activities, including starting non-farm businesses (He & Sikor 2015).

Although there were concerns about the sustainability of large-scale restoration programs after government payments are removed, Zhou *et al.* (2007) believe that tree plantations will generate sufficient economic return if market prices for forest products remain stable in the future. Groom and Palmer (2012), on the other hand, believe that carbon payments played a minor role in improving household incomes in China, but created a range of off-farm employment opportunities. In Mozambique, cash income from payments for carbon mitigation services increased household income in "29 percent for non-participants, 48 percent for households with agroforestry contracts, and 260 percent for

households with both agroforestry contracts and jobs" (Jindal *et al.* 2012, : 2131), between 2001 and 2008. Furthermore, the regular source of cash income had a special importance for poorer households (Jindal *et al.* 2012).

Increases in household's incomes were also attributed to the revenues of cash crops produced on land that was not converted, and forest products (timber and NFTPs) from reforested areas. Wang and Maclaren (2012) observed a change in the proportions of agricultural income after the implementation of SLCP in Jilin province (Northeast China), with an increase from economic crops (such as tobacco and flax), and a marked decrease from general crops such as maize and soybean. In Niger, Haglund *et al.* (2011) showed that FMNR increased household incomes around 30 percent, non-timber forest products excluded. The income gains appeared to be associated with increases in the value of crops (farmer's diversification into higher value crops) and wood production; livestock production was also likely to have benefited from the greater availability of fodder. In the same region, Cunningham and Abasse (2005) showed that wood sale income was almost nine times higher for farmers intensively applying FMNR to their land, when compared to non-adopting farmers. In Ghana, the MTS brought short-term benefits that included a contribution of crops to male cash (29–50%) and non-cash (28–50%) incomes (Ros-Tonen *et al.* 2013). In Ethiopia, income from wood sales contributed on average up to 25 percent of household total annual cash income (Lemenih & Kassa 2014).

Notwithstanding the substantial evidence of a positive impact of reforestation programs on household's incomes, this was not always the case. Some of the reviewed articles reported declines in net income. In China, three of the eight townships investigated by Wang and Maclaren (2012) had an average net income decline, which was reported by 58 percent of the families involved in SLCP. In the same program, Bennett (2008) showed that compensation standards were significantly below (8–33%) pre-program household net incomes for enrolled participants. Xu *et al.* (2007) observed that peasant households experienced a temporary income loss after land conversion and before receiving compensation payments from the government, while Liang *et al.* (2012) warned that household demographic heterogeneity and differences in time allocation of labor should be taken into account when considering livelihood outcomes.

In a comparison of forest restoration programs in China, Vietnam, Sweden and Ethiopia Sandewall *et al.* (2015) found that, as a general trend, increasing forest plantation at the expense of unsustainable agriculture increased incomes for some households, but did not automatically bring farmers out of poverty. The authors identified two main groups regarding farmer's preferences for engaging in reforestation programs. The first group was composed of poor households that ran low-investment forestry as an option to low productivity agriculture on declining soils, seeking cash for immediate short-term needs. The second one covered more resourceful households, who made long-term investments for future needs (house building, children, and pensions).

Provision of Ecosystem Services and Goods.—In the reviewed literature, few articles had information on the production of provision ecosystem services by reforestation and restoration programs and initiatives: 6 percent on NFTPs, 12.5 percent on food, and 25 percent on timber and fuelwood. Studying the region of Maradi, in Niger, Haglund *et al.* (2011) showed that 98 percent of the households involved in FMNR reported an increase in wood supply. In the same region, Sendzimir *et al.* (2011) observed increases in yields from trees and crops, and an increased availability of firewood and timber that lowered the time collecting these items and/or the money spent buying them, contributed to an increase in household income. The same was observed by Weston *et al.* (2015) and Place and Binam (2013) in West Africa: wood sales were almost nine times higher in households intensively applying FMNR to their land.

The new agroforestry systems for feeding livestock that have emerged in East Africa have had a positive impact on smallholder's production and income from cattle and small ruminants (Franzel *et al.* 2014). Other benefits of fodder tree planting, such as the provision of ecosystem services (fencing, soil fertility improvement, soil erosion control, improvement in animal health, and reproduction) and products (firewood, stakes, bee forage, and seeds) were also reported. The *'Y Ikatu Xingu* Campaign, in Brazil, significantly increased household income with seed production for reforestation (Sanches 2015). In total, 71 tons of native species seeds were produced, generating USD 380,000 (Durigan *et al.* 2013).

Besides timber and NTFPs, reforestation and restoration also benefited food production. Reij *et al.* (2009) showed that agricultural innovations introduced agroforestry projects and FMNR led to a significant increase in cereal yields (100–400 kg/ha) and food security (also see Reij & Garrity 2016). The aggregated soil restoration effect of FMNR in Niger resulted in at least 500,000 additional tons of grain produced per year, which equates to the consumption needs of 2.5 million people (Reij *et al.* 2009). In Ethiopia, households were allowed by the government to harvest honey from bee hives placed within the areas undergoing natural regeneration, although other uses were prohibited (Lemenih & Kassa 2014). In West Africa, FMNR caused an increase in consumable wild resources, especially wild plants and animals (Weston *et al.* 2015). Place and Binam (2013) found crop yields of FMNR adopters to be 15–30 percent higher than non-adopters. In Ghana, MTS plots included cultivated food crops, vegetables and NFTPs that were sold in the nearby market (Ros-Tonen *et al.* 2013).

Livelihood Opportunities: Diversification.—The main reported impact of large-scale forest restoration on local livelihoods was diversification (35%) (*e.g.*, Cao *et al.* 2009, Liang *et al.* 2012, Wang & Maclaren 2012, He & Lang 2015), followed by migration (10%) (Xu *et al.* 2007, Bullock & King 2011, Haglund *et al.* 2011, Sendzimir *et al.* 2011, Wang *et al.* 2011), and agricultural intensification/ extensification (6%) (Clement *et al.* 2008, Reij *et al.* 2009, Opoku-Boamah & Sato 2010). At the household level, the case studies showed that the livelihood impacts have

been mixed, depending on regional landscape and agro-ecological characteristics (soils, rainfall, slopes), the productivity of converted land, household characteristics (resources, demographics), and the availability of off-farm jobs (Bullock & King 2011, Komarek *et al.* 2014, Song *et al.* 2014, He & Lang 2015, He & Sikor 2015).

Diversification of on-farm activities or of income sources was caused by the freeing of labor from agricultural activities due to land use change, and increases in cash income from off-farm jobs (when available), governmental payments, and selling of household surplus produce. In China, the availability of off-farm jobs was attributed to economic growth, globalization, urbanization, favorable road access, long-term trend toward greater reliance on off-farm work, and risk-coping effects (Ahearn *et al.* 2006, Key *et al.* 2006, Liang *et al.* 2012, He & Lang 2015, He & Sikor 2015). For some authors, changes brought by SLCP added to broader livelihood dynamics that were already in place (Yunnan province, He & Sikor 2015), including the abandonment of marginal sloping land in favor of off-farm jobs (Sichuan Province, Li *et al.* 2013). In fact, Wang *et al.* (2011, 2012) believe that temporal and permanent migration for off-farm jobs was caused by contextual factors, and that reduction in rural labor force would be the main factor promoting ecological restoration.

In other cases, households preferred to diversify on-farm activities as a result of restoration programs and policies. In New Zealand, the benefits from carbon farming were used to expand forests (Funk & Kerr 2007), and in Southern China the abandonment of cultivation on marginal lands allowed for the adoption of fruit orchards, fishponds, and livestock production (Xu *et al.* 2007, Huang *et al.* 2012). Increase in livestock production in the Sahel boosted manure produce, improving soil fertility in restoring lands and leading to the emergence of a market for manure and paid work for its transportation (Reij *et al.* 2009). In West Kalimantan, local community members that worked on a reforestation initiative to restore degraded areas in a national park later found employment in other programs, local NGOs, or oil palm plantation seedling nurseries (Pohnan *et al.* 2015). In Ghana, MTS was combined with other income generating activities such as cocoa cultivation and petty trading (Ros-Tonen *et al.* 2013).

Livelihood Opportunities: Agricultural Intensification.—The main observed change in agricultural strategies was system's intensification (Clement *et al.* 2008, Reij *et al.* 2009, Opoku-Boamah & Sato 2010). In Ghana and Vietnam, forestry and settlement policies are causing the abandonment of shifting cultivation, either by allocating plots to farmers in degraded lands being restored (Opoku-Boamah & Sato 2010), or by changing property rights from collective to private property, and granting small plots that do not enable crop fallowing (Clement *et al.* 2008). In the Sahel, agriculture has intensified with positive impacts on local economy, in spite of population growth (Reij *et al.* 2009). However, in Vietnam intensification has caused innumerous unintended consequences, including "nutrient depletion, the disruption of collective land-use systems, conflicts over non-timber forest products (NTFPs) and grazing land" (Clement *et al.* 2008: 466).

Livelihood Opportunities: Migration.—Reforestation policies and initiatives were also responsible for mixed results in migration trends. In places where local production systems were intensified or diversified and on-farm work opportunities increased, outmigration trends were reduced. Most cases that reported reduction in outmigration were situated in Africa (*e.g.,* Sendzimir *et al.* 2011). However, in Niger migration rates increased and Haglund *et al.* (2011) raised the possibility that income gains associated with FMNR are financing household members to travel in search of jobs in urban areas. Clearer trends in outmigration were observed in the case studies conducted in China. In the Guizhou Province, outmigration increased after reforestation and logging ban policies were put in place, especially among families with higher incomes (Xu *et al.* 2007). Wang *et al.* (2011, 2012) observed that younger members with more schooling were the ones migrating, and that households with high rates of outmigration tended to transfer farmlands to other families. In Burkina Faso, farmers developed complex livelihood strategies in which migration remained as a major force, despite reductions in migration incentives due to the sales of tree products by young men (fuel, poles) and women (leaves, fruits) in local markets (Reij *et al.* 2009).

Well-being: Food Security.—The different human wellbeing dimensions used here to evaluate the socioeconomic impacts of restoration initiatives were reported by several articles: food security/sovereignty (12.5%), resilience (19%), equity (25%), health (2%), poverty reduction/increase (27%), empowerment/disempowerment (4%), and intangible benefits/losses (12.5%). The impact of restoration and restoration on food security was mixed. Reporting on the impacts of two different initiatives in Africa, Reij *et al.* (2009) show a positive impact in Burkina Faso and Niger. Before the adoption of the FMNR practices, more than 50 percent of the farm households had a structural food deficit of 6 months or more; after, although not all families became food secure, most of them reduce their deficits to 2 or 3 months, which was considered an important gain. Additionally, there was an increase in fodder, stover and water in the villages, allowing for an expansion of the herds; firewood trees replaced manure as a source of cooking fuel. Similar effects were observed in Niger, where FMNR contributed to an additional 500,000 tons of cereals, affecting the lives of 2.5 million people (17% of the total population in 2009) (Reij *et al.* 2009, Reij & Garrity 2016).

However, in some cases restoration initiatives had the opposite effect on food security. In Ghana the MTS program banned cassava cultivation on restoring lands based on the perception that it would overshadow trees, impacting the production of a staple food and reducing farmers expectations for the future (Ros-Tonen *et al.* 2013). The regulations put in place by two restoration programs in Southwest China prevented people from harvesting wood and killing wild pigs that caused uncompensated crop damage, thus affecting livelihoods (Wandersee *et al.* 2012).

In other places in China, households that converted all of their croplands to forests had their food security adversely affected (Wang & Maclaren 2012), and the implementation of the SCLP project resulted in a decline in food sufficiency (Zhou *et al.* 2007).

Well-being: Resilience.—Reductions in food security directly affect household resilience. Households left with no farming land due to conversion to forest remain subsidy-dependent (Bullock & King 2011), as well as households where older people have preferred to receive the subsidies and abandon labor-intensive farming (Wang & Maclaren 2012). In Vietnam, the change in property rights caused a disruption of collective land-use systems that was considered difficult to reverse (Clement & Amezaga 2009).

Nonetheless, in many cases restoration programs had a positive effect on household's assets, augmenting their ability to cope with and recover from shocks and stresses, or to adapt to long term shifts in livelihood changes (Scoones 1998). In the Fujian Province, farmers built infrastructure that could be used to provide income after government subsidies end (Cao *et al.* 2009). In Africa, the FMNR increased the value of tree stocks, livestock, and consumable wild resources (plants, animals and construction materials) that were used for household consumption (Weston *et al.* 2015), contributing to household's resilience (Reij & Garrity 2016). Ros-Tonen *et al.* (2013: 65) observed the same outcomes under the MTS, with at least 42 percent of the program's revenues being invested in asset building such as "human capital (children's education), financial capital (savings), physical capital (houses), and natural capital (purchase of farmland)". Increases in assets, availability of wild resources, and improved soil fertility and crop yields suggest evidence of declining vulnerability and increasing resilience against periodic shocks (Sendzimir *et al.* 2011, Weston *et al.* 2015).

Wellbeing: Equity.—In Africa, the MTS and the FMNR had positive effects on the daily foraging of women for wood, which declined from 3 h to 30 min a day (Sendzimir *et al.* 2011). Woodfuel is a key resource, benefiting not only women, but also the poorer households (Iiyama *et al.* 2014). Time saved from collecting wood was used to participate in educational activities, preparing food, and for health and children care, empowering women and enhancing their leadership (Reij *et al.* 2009, Sendzimir *et al.* 2011, Weston *et al.* 2015). Gendered differences were also observed in revenue expenditure, with women spending more on secondary and tertiary education for their children. In China, reduction in labor requirement after land conversion led to an increase in childcare and domestic work (Wang & Maclaren 2012).

On the other hand, reforestation projects were also responsible, in some cases, for causing or enhancing existing livelihoods inequalities among households, communities, or villages (Jindal *et al.* 2012, Liang *et al.* 2012, Song *et al.* 2014). The use of broad uniform subsidies in China's programs raised questions about their efficiency in equity, due to the differences in opportunity costs of converting cropland with distinct productivity (Yin *et al.* 2013). The use of land declivity thresholds to determine household participation in restoration programs resulted in some being left with no farming area (usually the poorer ones), creating inequalities among neighbors (Bennett 2008, Bullock & King 2011). Overall, the implementation of Chinese PFPs has contributed to a reduction in rural households' income inequality, but short-term income mobility has been affected with mixed results, depending on the program, the province, the period analyzed, and the size of the area enrolled by the household (Liu *et al.* 2013).

Well-being: Poverty Reduction.—As for poverty reduction, forest restoration programs have had contradictory impacts. The main factor for maintaining poverty rates in China was the reduction or lack of access to jobs in forest-dependent communities (Cao *et al.* 2009, Yin *et al.* 2013, Robbins & Harrell 2014); although many families were above the official poverty line, their livelihoods were still considered precarious (Yin *et al.* 2013). The national afforestation program in Vietnam was considered largely unsuccessful in delivering poverty reduction and economic development (Clement & Amezaga 2009). Yet, the Mountain-River-Lake Program (MRL), in China, was responsible for lifting nearly 10 million people out of poverty over 20 yr, and increasing forested area in approximately 30 percent (Huang *et al.* 2012). Other authors considered that reforestation programs had a higher impact on poorer households and regions (Zhou *et al.* 2007, (Groom & Palmer 2012)Song *et al.* 2014), that benefited from regular sources of cash income (Jindal *et al.* 2012).

Well-being: Empowerment, Intangible Benefits, and Conflicts.—Very few articles reported empowerment and capacity building as a positive impact of restoration initiatives. Besides Pohnan *et al.* (2015) that reported an 'empowerment path' in Indonesia, only Jindal *et al.* (2012) observed a similar effect, in Mozambique. Besides the reduction in the number of households with illiterate members, the N'hambita project improved the visibility of the communities among development agencies, which together with the growth in local leadership helped households to articulate their development needs, thus improving health and water management. Empowerment and capacity building are closely related to other intangible benefits such as self-esteem and the perception that living conditions have improved. In Indonesia, Pohnan *et al.* (2015) showed that gaining new skills and experience improved self-esteem of participants in the Gunung Palung National Park restoration project. Weston *et al.* (2015: 1414) highlight "a cluster of psycho-social benefits, consisting of joy and peace-of-mind from the enhanced beauty and comfort of the new greener landscape, enhanced leadership confidence and experience for women and men who took part in FMNR groups" in West Africa.

Notwithstanding the cases of intangible benefits achieved by forest restoration projects, some cases were mentioned in the literature of conflicts that followed their implementation, though the numbers are likely underrepresented. The top-down approach of the SLCP program that ignored local people's knowledge and

experience in agroforestry practices led to an open conflict between villagers and forest officials (He & Sikor 2015). In Vietnam, the national afforestation program caused conflicts over the use of NFTPs and grazing land (Clement & Amezaga 2009). Barr and Sayer (2012) showed that conflicts arose between villagers, forestry agencies and commercial plantation companies in REDD+ initiatives, which resulted in the displacement of local communities and inequitable agreements with the enterprises.

Land Tenure and Property Rights.—Land tenure and property rights are closely connected to natural resource governance systems (Lazos *et al.* 2016, Fig. 1). The major changes in property rights in rural areas reported in the papers occurred in countries such as China and Vietnam, where state lands where transferred to individual households or communities, under different legal arrangements (Clement & Amezaga 2008, Liang *et al.* 2012, Sandewall *et al.* 2015). Land tenure reforms in China were recognized as a crucial driver of forestry development and re-greening (Liang *et al.* 2012). The Rural Land Contract (2004) allows the transfer of rights from the state to individual plot owners, including rights to transfer, inheritance, and mortgaging for 70 yr. Implementation varies among the different provinces that can promote household based or more collective tenure arrangements (Sandewall *et al.* 2015). In Ghana, under a different governance system, farmers received plots of demarcated land in degraded forest reserves and seedlings, addressing to some extent local land scarcity (Opoku-Boamah & Sato 2011). However, cases of ignoring customary land tenure systems and curtailing traditional land use practices were also reported (Barr & Sayer 2012).

In other places, even though land officially remained with previous landholders, changes in the rights of access, withdraw, management, exclusion, and alienation occurred (Urgenson *et al.* 2014). Traditional access rights were significantly restricted not only for agricultural practices, but also for firewood and NTFPs collection, and livestock grazing (Robbins & Harrell 2014). In one case (Urgenson *et al.* 2014), reforestation programs caused the loss of mountain meadows in Jiuzhaigou National Park, China, impairing its conservation aims. The meadows are a human-modified landscape, maintained by the Amdo Tibetan people for more than 2000 yr through land clearing, burning, and grazing. The cessation of human land-use and intentional planting of trees imposed by the restoration programs "may result in changes in ecological systems, with lower diversity, fewer ecosystem services, and loss of cultural meaning and traditional knowledge over time" (Urgenson *et al.* 2014: 489).

DISCUSSION

Although it is clear that reforestation/restoration initiatives can bring an array of positive socioeconomic effects to households and communities, it is also true that negative impacts have been reported in some places and are an important piece of information for planning and evaluating future FLR initiatives. The reforestation and restoration programs and policies investigated by the scientific literature we reviewed had mixed socioeconomic effects on local livelihoods, but the bottom-up participatory initiatives in Africa seemed to have more positive impacts than the initiatives put in place by centralized governments, especially on ecosystem services and food security.

Tschakert *et al.* (2007), Jindal *et al.* (2012), and Bullock and King (2011) discussed the critical importance of taking into consideration household heterogeneity in reforestation/forest management initiatives. Households differ in their assets, access to productive farmland, labor availability, land tenure, livelihood diversification strategies, risk perceptions, domestic life cycles, knowledge bases, availability of savings to meet investment and maintenance costs, urgent food needs, and benefits they may potentially derive from secondary forests (Lazos *et al.* 2016). These differences not only determine which households are willing to participate, but also how the costs and benefits will be distributed among them, raising ethical questions concerning who will win and who will lose as a result of reforestation projects (Tschakert *et al.* 2007). Household heterogeneity can help to explain why many of the case studies analyzed here showed mixed results with regards to their socioeconomic benefits, and why the debate over the capacity of payments for ecosystem services (PES) to alleviate poverty is still far from settled (Bullock & King 2011, Jindal *et al.* 2012). Additionally, after the payments from the programs are discontinued, livelihoods can be affected by a lack of short or long-term economic opportunities (Boni 2006, Ros-Tonen *et al.* 2013, Robbins & Harrell 2014).

One of the reported positive effects of reforestation/restoration initiatives was the increase in the availability of off-farm jobs and opportunities such as petty trade for rural households (Lazos *et al.* 2016). However, the positive relationship between off-farm and farm income is not straightforward (Chikwama 2010). Off-farm jobs may be available nearby or in distant urban areas, increasing migration rates. Although remittances could be added to the household's diversification strategy, migration involves a number of uncertainties and might increase households' vulnerability (Bezabih *et al.* 2010).

Some of the case studies reviewed highlight the important role of agroforestry systems in addressing climate change adaptation and mitigation, maintaining carbon stocks, securing food security for poor farmers and families, and producing livelihoods benefits, particularly in Africa (Mbow *et al.* 2014a,b, Rahn *et al.* 2014, De Souza *et al.* 2016). However, the learning of advanced cultivation methods to add trees to cropping and animal production systems will have to be addressed in order to increase scale, meaning that investments will have to be made in research and extension services, and new policies will need to be put in place (Langford 2014, Mbow *et al.* 2014a). Yet, in many places in the tropics, smallholders already manage the landscape in multiple ways, such as in shifting cultivation or swidden systems (Erdmann 2005, Padoch & Pinedo-Vasquez 2010, Marquardt *et al.* 2013). Although these systems have often been considered to be destructive (Padoch & Pinedo-Vasquez 2010) and are being intensified by forestry regulations in Ghana and Vietnam, incorporating fallow systems into FLR could help to improve forest-based livelihoods and avoid deforestation if other uses introduced

by landscape governance have a higher opportunity cost (Mukul *et al.* 2016). The ecological knowledge of shifting cultivators on forest dynamics and management has been underestimated in reforestation planning (Chazdon *et al.* 2016a).

Finally, land tenure was identified in the literature as one of the most important drivers of reforestation, and institutional changes were designed in various countries to address insecure tenure (Opoku-Boamah & Sato 2011, Liang *et al.* 2012). However, few papers evaluated the impacts of restoration on the bundle of property rights (Schlager & Ostrom 1992) frequently associated with traditional systems (Ros-Tonen *et al.* 2013, Robbins & Harrell 2014, Urgenson *et al.* 2014). Similarly, evaluations of the impacts of restoration initiatives on women and other vulnerable groups were underrepresented in the literature reviewed. Accordingly, in an investigation of decision-making in adoption of agroforestry in Africa, Villamor *et al.* (2014) verified the existence of gaps in gendered knowledge, preferences, risk taking and access to innovation in land-use.

CONCLUSIONS

Although many are optimistic about the outcomes from FLR approach and its effects on local livelihoods, only recently have large-scale reforestation and restoration initiatives began to be evaluated (Chazdon 2008, Coomes *et al.* 2008, Barr & Sayer 2012, Blignaut *et al.* 2013). In this article, we analyzed the literature on large-scale reforestation/restoration initiatives, focusing on their socioeconomic impacts on local livelihoods. Forest landscape restoration is a long-term commitment of land and resources, and participatory collective decisions are more likely to be implemented, monitored, enforced, and made to endure than centralized ruling (Society for Ecological Restoration International Science & Policy Working Group 2004, Chazdon *et al.* 2016b). Furthermore, the sustainability of complex social-ecological landscapes will depend initially on the rules and incentives put in place to implement reforestation but, over the longer term, they may not be sufficient and will have to be adapted as contextual variables and interactions across scales change (Ostrom 2009). At the same time, socioeconomic and ecological outcomes of FLR will need long-term evaluations (Liu *et al.* 2013) and need to be fed back into the system. Long-term economic implications of forest restoration initiatives are not clear (Bullock & King 2011), and the effects on livelihoods will have to be monitored beyond the provision of environmental payments (Jindal *et al.* 2012).

In sum, forest landscape restoration should be carried out not only as a path to minimize environmental impacts or to create new economic opportunities, but as a form of investment where the financial, environmental, and social benefits are obtained simultaneously, attempting to meet the different demands from a variety of stakeholders. This challenging task has to be addressed by the development of new institutional and governance systems that not only empower stakeholders, but also bring socioeconomic benefits to local livelihoods and improve their well-being.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article:

~~Table~~ S1. *Literature database.*

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