

Reforestation and smallholder livelihoods in the humid tropics

Liz Ota^{a,*}, John Herbohn^{a,b}, Nestor Gregorio^a, Steve Harrison^b

^a University of the Sunshine Coast, 90 Sippy Downs Dr, Sippy Downs, 4556, QLD, Australia

^b The University of Queensland, St Lucia, 4072, QLD, Australia



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ABSTRACT

Smallholder livelihoods and the restoration of tropical forests are intimately intertwined. To address the question of how reforestation affects livelihoods and how they in turn affect reforestation, a meta-synthesis was undertaken of 339 scientific publications identified from a systematic literature search. This study is focused on smallholders in the humid tropics, and uses the Sustainable Livelihoods Framework, which was developed by the UK Department for International Development as the framework for analysis. The links between reforestation and livelihoods are found to be diverse and highly interconnected. Reforestation is only one of a smallholder's activities and typically forms part of a mosaic of land uses across a landscape. Therefore, reforestation should be designed, managed and evaluated under the perspective of a diverse livelihood portfolio, and not as a single activity isolated from other portfolio components, especially under current landscape approaches. It is important for reforestation to be a complementary rather than a competitive livelihood activity. Reforestation has great potential to address poverty, and to increase smallholder socio-ecological resilience and local social equity. However, reforestation outcomes are often suboptimal. Assessing smallholder capacity and the surrounding environment prior to reforestation, and addressing limiting local capacities and conditions in a timely manner, may enhance the likelihood of optimal benefits.

1. Introduction

There are current ambitious global goals for forest restoration. For example, the Bonn Challenge, recently endorsed by the UN Decade on Ecosystem Restoration (UN Environment, 2019), is a global aspiration to undertake forest restoration on 350 million hectares by 2030 using the Forest and Landscape Restoration (FLR) approach. These restoration initiatives are based on landscape land-use approaches. They also acknowledge that addressing livelihoods of the rural poor is integral to successful restoration of tropical forests, and put people in the centre of the processes to reconcile human uses and conservation (Sayer et al., 2013; Locatelli et al., 2015; Aumeeruddy and Sansonnens, 1994).

There are about 500 million small farms in developing countries, which comprises the majority of world's poor (Wiggins et al., 2010). The degradation of ecosystems affects the wellbeing of about 3.2 billion people and the resulting loss of species and ecosystem services costs about 10% of annual global gross product (UN Environment, 2019). Through the Bonn Challenge, 1.5 billion hectares with the potential for mosaic restoration have been identified (Bonn Challenge, 2017). And there are overlaps of forests needing restoration and smallholder managed plots. In this context, smallholder reforestation will be an important land use for the provision of both environmental and human

benefits in the tropics.

Evidence of the ways in which smallholder livelihoods influence and are influenced by reforestation has been increasingly recognised in the literature since the 1980s (Ota et al., 2017). While scientific evidence is appreciated as a valuable input in decision-making for policy and practice, decisions on conservation management are often based on anecdotal knowledge (e.g. Sutherland et al., 2004). Local ecological knowledge should also be considered in natural resources management through a knowledge integration process (Raymond et al., 2010). The lack of scientific or local knowledge in decision-making processes in natural resources management can lead to poor decision making. Evidence in a particular field of knowledge can be used to assess patterns and provide guidance to practitioners (Sutherland et al., 2004). A rigorous means of compiling and analysing scientific evidence of the impacts and effectiveness of a particular intervention is by undertaking a systematic review (Pullin and Knight, 2009). Meta-synthesis, also referred to as qualitative meta-analysis, provides a secondary qualitative analysis of findings across a general research topic (Timulak, 2009).

A meta-synthesis was conducted to answer the questions: How does reforestation affect livelihoods? And how do livelihood characteristics related to each of the components of the sustainable livelihoods framework affect reforestation? The paper is focused on smallholders in

* Corresponding author.

E-mail address: lota@usc.edu.au (L. Ota).

the humid tropics, and uses the Sustainable Livelihoods Framework (SLF) proposed by the UK Department for International Development, 1999 as the structural basis. The research aimed to provide a conceptual foundation for stakeholders involved in reforestation. This can be used to anticipate smallholders' strengths and challenges when engaging in reforestation and the potential impacts of it on local livelihoods, and thereby attain improved outcomes. The paper commences with a description of the SLF proposed by DFID. Next, the methods used for the systematic literature search, data extraction and analysis are described. Then, the results are organised in sections for each component of the SLF. The following section presents the policy implications of the study and the main conclusions.

2. The DFID sustainable livelihoods framework

The assessment of livelihood impacts, also referred to as *sustainable livelihood approaches*, is often embedded in assistance programs related to poverty alleviation, and is the basis of monitoring and evaluation (Friend and Funge-Smith, 2002). The use of the concept of sustainable livelihoods in the context of development and poverty alleviation was introduced by Chambers and Conway (1992), and has been used broadly since. Sustainable livelihood approaches are people-centered methodological tools to analyse people's dynamic opportunities, risks, choices and livelihoods. They are used to assess the population which was reached by the intervention, the livelihood benefits achieved and the impacts on the various groups within a community (Friend and Funge-Smith, 2002). These approaches are especially useful for local-level assessments of assistance programs (Thulstrup, 2015). Among the frequently applied sustainable livelihood approaches are those developed by the UK Department for International Development (DFID), Oxfam, CARE and the United Nations Development Programme (UNDP) (Carney et al., 2001).

While CARE's sustainable livelihood approach focuses on household livelihood security and local-level interventions, the UNDP approach is centred on assets and shocks (i.e. livelihood disruptions) for adaptive policy interventions (Carney et al., 2001). The DFID SLF approach pays special attention to asset support and access for the poor (DFID, 1999; Rakodi, 2014). The Oxfam sustainable livelihood approach is similar to the SLF, but prioritises the right to sustainable livelihoods (Rakodi, 2014). The SLF provides a straightforward means to simplify and analyse complex livelihood systems. It is well suited to research on natural resource management, it is easy to understand and use, and it has been consequently widely used in this field (e.g. Suich, 2010; Wang et al., 2017; Pandey et al., 2017; Pokharel and Nurse, 2004). Besides sustainable livelihoods approaches, several other frameworks can be applied for the same end, such as the Human Ecosystem Framework (Machlis et al., 1997), and the Capitals and Capabilities Framework (Bebbington, 1999). Other frameworks were considered for this work, but the SLF remained the most suitable for the research.

The SLF was first presented in 1998 by Carney (1998) as a modified version of the Sustainable Rural Livelihoods Framework proposed by Scoones (1998). In 1999, DFID published the Sustainable Livelihoods Guidance Sheets online. Among the criticisms of the SLF are that other capital assets, such as political capital, should have equal status as the five ones already present in the framework. Also, there are criticisms that the capital categories used are oversimplified and that the framework misrepresents the trade-offs between the capital assets (Toner, 2003). Increasing the level of endowment in relation to these five capital assets may not be enough to address poverty. Acknowledging this issue, the framework also includes the institutional arrangements, political organisations and power relations that surround the lives of the poor, as well as the vulnerabilities to which they are exposed. Despite criticisms, the DFID SLF has global acceptance and provides a useful framework for the local-scale assessment of reforestation and livelihoods.

The SLF includes the *vulnerability context*, *capital assets*, *policies*,

institutions and processes (formerly referred to as *transforming structures and processes*), *strategies* and *outcomes*, and the relationships between them. The vulnerability context includes vulnerabilities to *shocks*, *trends* and *seasonality* that are out of people's control (Adato and Meinzen-Dick, 2002). Examples of *shocks* are natural disasters including severe storms and floods, disease outbreaks and social conflicts (e.g. civil unrest). Population and governance changes, along with changes in technology and markets are included in *trends*. Seasonal patterns that can affect the livelihood strategies and outcomes include seasonal environmental conditions, market prices, and employment opportunities in the particular region. *Shocks*, *trends* and *seasonality* usually have negative impacts on livelihoods, but they can also positively affect people's lives. For example, new technologies can increase the local wellbeing of individuals and families.

The assortment of assets held by a household includes human, financial, social, natural and physical capital (Scoones, 1998; DFID, 1999). Financial capital includes savings, income and credit. Group membership and social networks are examples of social capital. Examples of assets classified as natural capital are land, water, forest and marine resources, high quality air and plant genetic diversity. Physical capital includes infrastructure, tools and technologies. The *policies, institutions, and processes* component includes organisations, services, policy environment, incentives, culture, power relations and rules governing peoples' lives (Hobley, 2001; Hamilton-Peach and Townsley, 2004). Livelihood strategies are the arrangement of activities chosen by people to achieve the desired livelihood outcomes.

3. Research method

A systematic search was performed in the Thomson Reuters ISI Web of Science database. Keywords were derived from papers previously selected by the authors for the definition of the search string. Publications in English, Spanish, French and Portuguese, that dealt with reforestation and livelihoods of smallholders in the tropics, excluding the dry tropics, were searched. The search initially yielded 1244 journal articles published from January 1989 to June 2016.

Two members of the review team applied the inclusion criteria judging whether to include or exclude papers (explained in full in Ota et al., 2017) to a sample of the 1244 documents. Using the Kappa statistic (a measure of agreement, in a range from 0 to 1, of two or more observers in regard to a categorical variable), the degree of agreement between the judgements of the reviewers was calculated. There was substantial agreement in the classification of the documents by the two team members (Kappa = 0.71) and the remaining publications were assessed by only one member of the team.

A total of 185 papers met the inclusion criteria, and further three papers were excluded because the full text could not be accessed. Another 141 papers were included through a complementary search of the reference lists of the 182 papers initially included. From an initial list of articles that were expected to be reached by the search but were not, additional 16 papers were included. In total, 339 peer-reviewed scientific publications were assessed. More details on the search and inclusion criteria can be found in Ota et al. (2017).

The selected publications comprise research articles from 44 countries, published in 92 academic journals (listed in the appendix). Agroforestry systems, including homegardens, cocoa and coffee agroforestry systems and improved fallows, were the focus of most papers. Research on non-agroforestry reforestation systems, including timber monocultures, mixed-species timber plantations, and ecological restoration, were also found. The most frequent field of study was 'Anthropology and Social Sciences'. 'Technical Forestry and Silviculture' studies were more frequent in Latin America than Africa and Asia (Ota et al., 2017).

Data on the way in which reforestation and livelihood components affect each other were extracted from the 339 retrieved documents. Data extraction was carried out with the use of a Microsoft Access form.

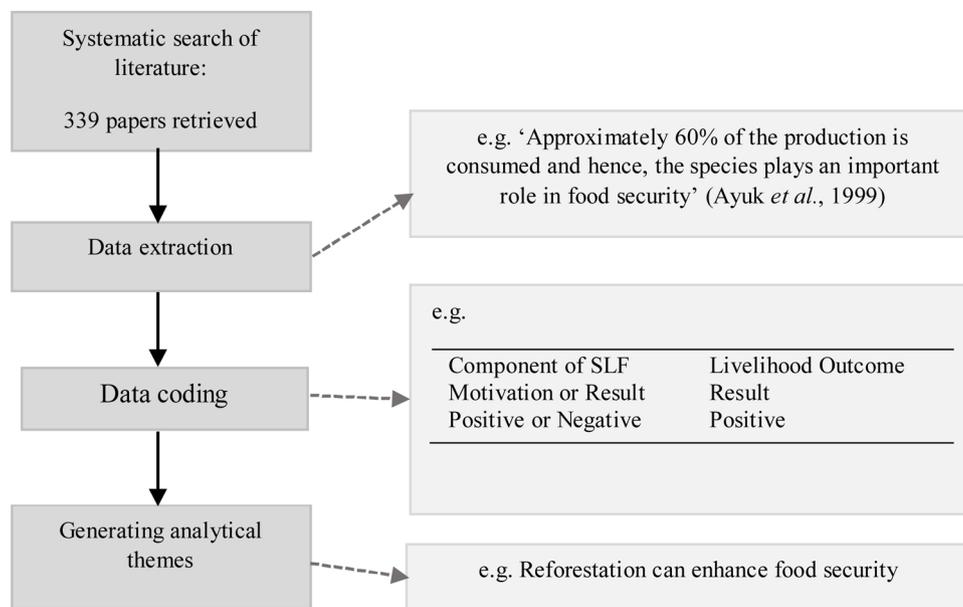


Fig. 1. Steps involved to generate analytical themes from the literature related to smallholder livelihoods and reforestation in the humid tropics.

Data extraction involved collecting information on the links between the SLF components and the reforestation activities. Data were then coded as being a motivation or result of reforestation. The codes were categorised as being a factor affecting or being affected by reforestation, positively or negatively. Each factor was also categorised according to the component of the SLF to which they were related. Coded data were used to generate analytical themes. In Fig. 1 there is an example of an extract from a publication, how it has been coded and the analytical theme generated from it.

4. Relationships between tropical reforestation and smallholder livelihoods based on components of the Sustainable Livelihoods Framework

Numerous and highly interconnected factors link reforestation and smallholder livelihoods. In general, authors argued that reforestation was an ecologically sound smallholder land use. Negative outcomes of reforestation were less frequently discussed. The constraints for smallholder reforestation were focused on both socioeconomic and biophysical factors. The impacts of reforestation on livelihoods, and the converse, are highly context-specific, depending on the particular circumstances of the reforestation activity and the socioeconomic environment. In the subsections below the relationships between reforestation and each of the SLF components are discussed separately. The examples given in the boxes were selected to display a range of positive and negative ways the components of the SLF affect and are affected by reforestation.

4.1. Links between tropical reforestation and smallholder livelihood vulnerabilities

Smallholder vulnerability to shocks, trends and seasonality can either motivate or constrain smallholders engaging in reforestation (see examples in Box 1). For instance, natural shocks such as adverse weather conditions can discourage tree growing due to risk of damage to the plantation or financial loss (Nibbering, 1999; e.g. Ali, 2005; Mercer *et al.*, 2005; Molua, 2005; Baynes *et al.*, 2009; Rahman *et al.*, 2015). Recently, reforestation has been seen as an appropriate strategy for mitigation and adaptation to climate change and severe natural events (Lin, 2007; Guariguata *et al.*, 2008; Schroth *et al.*, 2009; e.g. Locatelli *et al.*, 2011; Lasco *et al.*, 2014; Mbow *et al.*, 2014; Rahn *et al.*,

2014; Jadan *et al.*, 2015; Locatelli *et al.*, 2015; Townsend and Masters, 2015). Similarly, price fluctuations can either constraint or encourage tree growing. Price fluctuations for farming products can make small-scale forestry an uncertain enterprise (Tremblay *et al.*, 2015). But it can also encourage smallholders who have crop monocultures to add tree components to their farming system as a means of diversification of products for financial buffering (e.g. Herzog, 1994; Tchoundjeu *et al.*, 2010; Lehébel-Péron *et al.*, 2011; Toledo and Moguel, 2012; Castro *et al.*, 2013).

Market and technology trends can favour reforestation. Because of the potential for reforestation to provide marketable products and services while promoting biodiversity conservation and social equity, new market niches focused on these values have grown in importance in recent years. For example, green consumerism, an emerging movement for environmental enhancement (Andrews and DeVault, 2009), favours shaded systems over sun-grown monocultures of crops such as coffee and cocoa.

Changes in technologies used by smallholders in developing countries can mean a transition from environmentally-damaging forms of slash-and-burn practices to more ecologically sound farming systems, such as low-intensity slash-and-burn or agroforestry systems. Species domestication and value-adding technologies can enhance the positive impacts of tropical reforestation (Ayuk *et al.*, 1999; Herve and Vidal, 2008; Baynes *et al.*, 2015a; Townsend and Masters, 2015). Nevertheless, the advent of new technologies can also mean the conversion of traditional low-impact slash-and-burn and other diverse systems into more intensified ones with fewer livelihood components, increased livelihood vulnerabilities and higher market dependence (Romero-Alvarado *et al.*, 2002; Steffan-Dewenter *et al.*, 2007; Rice, 2008; Guillerme *et al.*, 2011; Mukul and Herbohn, 2016).

Cultural changes caused by population trends often result in more intense farming systems and demand for cash due to the increased dominance of a consumer culture. Increasing upland population density is another population trend that can lead to land-use intensification. Upland population growth leads to reduced fallow periods and depleted soil fertility (Franzel, 1999; Grist *et al.*, 1999; Thangata *et al.*, 2002; David and Raussen, 2003; Nath *et al.*, 2005; Kiptot *et al.*, 2007). Soil fertility depletion is a risk for household energy and food security, and improved tree fallows are often used to promote soil conservation (e.g. Grist *et al.*, 1999; Kwesiga *et al.*, 1999; Niang *et al.*, 2002; David and Raussen, 2003; Basamba *et al.*, 2007; Joslin *et al.*, 2011; Thangata and

Box 1

Examples of the ways in which smallholder livelihood vulnerabilities and tropical reforestation are linked to each other from literature assessed

- Shocks due to conflicts (displacement and destruction due to war) leading to the temporary abandonment of homegardens
The north and central sites (Nho Quan and Nghia Dan) contain home gardens of an average age of 25 and 21.5, respectively. This was explained by the fact that the home gardens in the Mekong area, especially those at Thuan An, were less affected by the war with the United States than some areas in the north. Displacement and destruction due to war meant that many home gardens were re-established after the American war ended in 1975 (hence an approximate age of 25). (Trinh et al., 2003, p. 323)
- Natural seasonality discouraging tree planting
A substantial risk of losing plantations to dry season fires or other abiotic or biotic threats apparently discouraged small farmers from investing in grafted clones for planting (Schroth et al., 2003, p. 164)

Box 2

Examples of linkages between livelihood assets and smallholder reforestation

- Reforestation increasing the household financial capital
Interviews revealed that the financial contributions from the sale of products from trees planted in homestead farms were greater than household income derived from other sources including timber extraction, wage labour, labour migration, artisanal production, civil service and remittances. The proceeds from the sale of trees (and associated tree products) significantly supplemented household income, normally derived from various sources including both farm and off-farm activities (Ite, 2005, p. 216).
- Reforestation increasing soil fertility (a natural capital)
Soil fertility improvement was the second most frequently mentioned benefit of incorporating trees in cocoa fields, expressed by more than 50% of farmers. (Dumont et al., p. 1060)
- Development and infrastructure (representing physical capital) leading to the conversion of agroforestry systems to more intensified land uses
In traditional villages where agroforests are the only sources of income and represent the dominant cropping system, people seem more concerned and are still willing to keep their agroforests. In contrast, in developed villages, preserving agroforests would be a hindrance to development because they represent the only available land. (Therville et al., 2011, p. 31)
- Social capital leading to wider dissemination of new practices such as reforestation
Technical training and provision of information is less effective than social networks for the diffusion and dissemination of knowledge and the adoption of new practices such as new seeds (Kiptot et al., 2006). Kinship, communities of practice and social networks thus serve to disseminate information from farmer to farmer on complex principles of practice (Kiptot et al., 2006). (Jerneck and Olsson, 2013, p. 121)

Hildebrand, 2012; Mafongoya and Jiri, 2016).

4.2. Links between tropical reforestation and smallholder livelihood assets

All five categories of assets (financial, human, natural, physical and social capital) are related to reforestation, examples in Box 2. Each asset category is discussed below.

4.2.1. Interactions between financial capital and tropical reforestation

Limited access to financial resources, including credit, is a major constraint to reforestation (e.g. Smith et al., 1996; Levasseur and Olivier, 2000; Reyes et al., 2005; Soini, 2005; Kiptot et al., 2007; Pagiola et al., 2007; Clement and Amezaga, 2009; McElwee, 2009; Rahman et al., 2015; Tremblay et al., 2015), especially due to its high initial cost (Pagiola et al., 2007; Hoch et al., 2012), long maturity period and high risk (Montagnini et al., 2003; Hoch et al., 2012). Financial or economic incentives, such as payments for environmental services and advanced payments for timber, are potential means to overcome this constraint (Snapp et al., 1998; Montagnini et al., 2003; Pagiola et al., 2007; Pollini, 2009; Montagnini and Finney, 2011). Making microfinance for land uses with long payback periods available for smallholders enables small-scale reforestation. Financially-constrained smallholders favour systems and technologies with low opportunity cost that require low financial inputs, especially during the early years of plantation growth when cash flows are negative.

Reforestation is expected to increase the financial capital of a household. It can increase land value, and provide products for household consumption and sale (e.g. Levasseur and Olivier, 2000; Simons and Leakey, 2004; Ite, 2005; Molua, 2005; Magcale-Macandog et al., 2006; Kirby and Potvin, 2007; Sonwa et al., 2007; Soto-Pinto et al., 2007; Hoch et al., 2009; Pfund et al., 2011; Toledo and Moguel, 2012; Cosyns et al., 2014; Jagoret et al., 2014b; Nyaga et al., 2015; Oduro et al., 2015; Tremblay et al., 2015). Trees on farms are

frequently seen as savings accounts for the household, which can be harvested to meet casual expenses or one-off substantial expenses such as for a wedding or education, thus acting as a financial buffer (Saintpierre and Bingrong, 1994; Magcale-Macandog et al., 1999; Nissen et al., 2001; Ramirez et al., 2001; Schreckenberger et al., 2002; Rice, 2008; Cole, 2010a; Nath et al., 2011; Ofori et al., 2014). Financial outcomes of diversified reforestation systems are expected to be obtained in a more distributed way throughout the life of a project than in simpler systems (e.g. Padoch et al., 1985; Staver et al., 1994; Ite, 2005; Nath et al., 2005; Montagnini and Finney, 2011; Hoch et al., 2012; Berget et al., 2015; Mbosso et al., 2015). Trees are also used as collateral for loans (Dury et al., 1996; Magcale-Macandog et al., 1999; den Hertog and Wiersum, 2000), increasing capacity of landholders to invest in new livelihood activities.

Despite their great potential to increase financial capital of poor households, expected profits from reforestation are not often realised, due to managerial, marketing, technological and biophysical constraints (e.g. see Magcale-Macandog et al., 1999; Fischer and Vasseur, 2002; Browder et al., 2005; Nath et al., 2005; Hoch et al., 2009; McElwee, 2009; Hoch et al., 2012). Incentives and compensation payments can decrease households' risks of having to rely on reforestation for their livelihoods.

4.2.2. Interactions between human capital and tropical reforestation

Low labour availability most frequently hinders smallholder involvement in reforestation or appropriate site management (e.g. Mercer et al., 2005; Walters et al., 2005; Osborne, 2011; Marquardt et al., 2013). However, it can also favour reforestation when the alternative land use is more labour demanding (e.g. Thacher et al., 1996; Bertomeu, 2006; Bense, 2008; Irawanti et al., 2014; Knoke et al., 2014). Limited knowledge and technical capability constrain not only the tree planting activity itself, but also diversification of agricultural systems, appropriate management for improved tree growth

performance and the realisation of the potential financial returns (Reyes et al., 2005; Walters et al., 2005; Piotta et al., 2010; Hoch et al., 2012; Marquardt et al., 2013; Irawanti et al., 2014; Tremblay et al., 2015). Limited understanding of markets and prices makes smallholders more vulnerable to opportunistic middlemen. Similarly, lack of knowledge on forest policies and regulations results in smallholders selling illegal timber for lower prices than could be achieved with a legal product.

Reforestation can increase human capital. It can improve smallholders' knowledge and capabilities (Tchoundjeu et al., 2010; Baynes and Herbohn, 2011), and generate employment opportunities (Simons and Leakey, 2004; Nath et al., 2005; Mendez et al., 2007; Tchoundjeu et al., 2010; Rahman et al., 2015), directly or indirectly. Due to the low labour requirements once the implementation phase is over, reforestation has the potential to make more labour available to other household activities when compared to alternative land uses that are more continuously labour-demanding. As well, landholders' confidence and entrepreneurial skills are often enhanced from participation in reforestation programs.

4.2.3. Interactions between natural capital and tropical reforestation

Availability of land unsuitable for agriculture (e.g. degraded soil, steep areas or land far from the homestead) motivates reforestation (e.g. Thacher et al., 1996; Gladwin et al., 2002; Piotta et al., 2003; Iqbal et al., 2006; Cole, 2010b; Farley, 2010). Most frequently, land unavailability and inaccessibility limit reforestation (e.g. Aumeeruddy and Sansonnens, 1994; Murniati Garrity and Gintings, 2001; Baynes et al., 2009; McElwee, 2009; Tchoundjeu et al., 2010). When there is a land shortage, smallholders may prioritise growing food over forestry. However, in some cases, land shortage has the potential to motivate reforestation as a means of obtaining a larger variety of products from small plots of land (Aumeeruddy, 1994). The availability of natural capital to invest, including high quality seeds or wildlings from nearby forest fragments can reduce initial costs and dependence on external resources, and enable reforestation, as argued by de Sousa et al., 2016.

Often reforestation is used to address soil fertility depletion and erosion (e.g. Adesina et al., 2000; Adesina and Chianu, 2002; Chowdhury, 2007; Garen et al., 2009; Joslin et al., 2011; Plath et al., 2011), and forest product shortages for farmers (e.g. Leuschner and Khaleque, 1987; Pasicolan et al., 1997; Adesina et al., 2000; Bensen, 2008; Blay et al., 2008). Reforestation sites are frequently seen as a legacy for the following generations (e.g. Simmons et al., 2002; Ahmed and Rahman, 2004; Mercer et al., 2005; Baynes and Herbohn, 2011; Scriven and Malhi, 2012). These sites are also important areas for farm experimentation (including domestication of species), repository of local knowledge (Smith et al., 1996; Coomes and Natalie, 2004; Heckler, 2004; Aguilar-Stoen et al., 2009; Toledo and Moguel, 2012), and recreation and social activities (Boissiere et al., 2009; Neulinger et al., 2013).

Reforestation also has the potential to protect water resources (Thacher et al., 1996; Long and Zhou, 2001; Dumont et al., 2014), regulate microclimate (Albertin and Nair, 2004; Lin, 2007; Herve and Vidal, 2008; Márquez and Schwartz, 2008; de Souza et al., 2012; Jaramillo et al., 2013; Dumont et al., 2014), sequester carbon (Dejong et al., 1995; Sanchez, 2000; Montagnini, 2001; Kirby and Potvin, 2007; Thangata and Hildebrand, 2012), conserve biodiversity and genetic resources (Gajasen and Gajasen, 1999; Coomes and Natalie, 2004; Walters et al., 2005; Dawson et al., 2008; Waldron et al., 2012), and provide amenity and scenic values (Simmons et al., 2002; Heckler, 2004; Gasco, 2008; Márquez and Schwartz, 2008; Irawanti et al., 2014).

Some authors have argued that land-sparing systems can provide more environmental services than land-sharing ones. Roughly defined, land-sharing systems rely on interactions between land-use components (e.g. crops and trees) as a means to meet both productive and conservation objectives from a single system. Land-sparing systems, on the other hand, are based on intensifying productive land uses as a means

to spare land for conservation. Reforestation can either increase or reduce crop yields. Cash crop production can be enhanced as a result of the ecosystem services provided by trees and other system components (Nissen et al., 2001; Briggs and Twomlow, 2002; Niang et al., 2002; Thorlakson and Neufeldt, 2012; Jaramillo et al., 2013), a positive argument for land-sharing systems. However, crop yields can be reduced due to competition and shade from trees (e.g. Lévassieur and Olivier, 2000; Lyngbæk et al., 2001; Bertomeu, 2006; Seeborg-Elverfeldt et al., 2009; Hegde and Bull, 2011). Therefore, often land-sparing and intensified systems are favoured (e.g. Ruf, 2011; Nyaga et al., 2015).

4.2.4. Interactions between physical capital and tropical reforestation

Access to information and technology gives smallholders the choice of reforesting and to use more advantageous land-use practices. Availability of infrastructure is an important physical capital factor necessary for successful reforestation. It enables the action of extension agents, farmer-to-farmer technology diffusion, value-adding of products, access to input materials and access to markets for reforestation outputs. No negative impacts of reforestation on physical capital were identified. Reforestation can lead to higher physical protection of homesteads and farms against extreme weather conditions such as in homestead forests in Africa (as noted by Ofori et al., 2014). Timber and income from reforestation are often used for household infrastructure improvements as observed in agroforestry systems in Bangladesh (Nath and Inoue, 2014). Support programs also frequently provide enhanced infrastructure and technologies to the local communities, including forest nurseries, farming equipment, systems for clean water and agricultural inputs (e.g. Staver et al., 1994; Walters et al., 2005; Asaah et al., 2011).

4.2.5. Interactions between social capital and tropical reforestation

Most frequently, social capital outcomes from reforestation are positive. Enhanced collective action, social networks and trust among stakeholders (Kwesiga et al., 1999; Nkamleu and Manyong, 2005; Vieira et al., 2007; Rice, 2011; Cosyns et al., 2014), social skills (Tchoundjeu et al., 2010), exchange of knowledge and products (Kwesiga et al., 1999; Tchoundjeu et al., 2010; Neulinger et al., 2013; Jagoret et al., 2014a, b), and social esteem and prestige (Das and Das, 2005; Wollenberg and Nawir, 2005; Kiptot et al., 2007; Tchoundjeu et al., 2010; Neulinger et al., 2013) are often related to reforestation.

Negative social capital outcomes from reforestation include the exclusion of social groups, which can increase the gap between the wealthy and the poor. Marginalised members of the society are subject to unfavourable social institutions, especially when it comes to accessing market organisations and extension. For instance, in Nepal, poor people were negatively affected by community forestry (Pokharel and Nurse, 2004). The poor were excluded from assistance, social leadership positions and social groups; their access to resources was reduced and livelihoods harmed as a consequence. To mitigate social inequalities, reforestation extension and support programs have recently been targeting disadvantaged groups, especially women (e.g. Asaah et al., 2011; Lennette et al., 2011; Toledo and Moguel, 2012; Johansson et al., 2013).

Creation and strengthening of, and participation in, community organisations has a positive influence on reforestation (e.g. Adesina et al., 2000; Emtage and Suh, 2004; Ogunlana, 2004; Nkamleu and Manyong, 2005; Sills and Caviglia-Harris, 2015). Social groups are catalysts of ecological restoration (Walters, 1997). Community organisations can enhance extension contact, capacity building, training opportunities, exercise of choice and social links of landholders. Interaction among smallholders enables the exchange of knowledge and experiences. Frequently, landholders are influenced by choices and successes achieved by neighbours and friends. For instance, in Australia, important sources of natural resources management information were trusted friends and relatives and experiences related by respected neighbours and nearby landowners (Meadows et al., 2014). However,

conflicts within social groups are frequent. Leadership dissatisfaction and the difficulty to organise labour and share benefits in communities can impact negatively on reforestation (e.g. Estoria et al., 2004; Schroth and da Mota, 2013; Epule et al., 2014). Problems related to communal work can lead farmers to opt for individual investments (e.g. Dejong et al., 1995; Schroth and da Mota, 2013).

4.3. The links between tropical reforestation and policies, institutions and processes surrounding smallholder livelihoods

The main organisations involved in smallholder reforestation are social groups (e.g. cooperatives and community groups), industry and market organisations, governmental and non-governmental agencies, and research, extension and development organisations. Corruption within governmental agencies and community organisations discourages reforestation. Nevertheless, these groups are extremely important in the promotion of natural resources management practices. Governments have the ability to provide information, financial incentives and political support. Community groups play an important facilitating role for smallholders to access resources and assistance that may not be available to individuals.

Smallholders in community organisations typically have better access to extension and markets than individual farmers. Further, there has been a recent shift of institutional arrangements governing natural resources management towards decentralisation in various countries (Meynen and Doornbos, 2004), and community organisations typically play a central role in these initiatives. Community organisations can benefit from decentralisation by attaining tenure rights on public lands through schemes such as Community-based Forest Management in the Philippines (Cagalanan, 2015). Community forestry projects can also improve forest governance (Charmley and Poe, 2007).

Despite the benefits of community forestry groups, their success is affected by a complex set of factors. It is not a simple matter of aggregating smallholders into a group for the potential benefits to flow automatically. It is a common flaw in the implementation of community-based forestry programs to assume that community groups will be functional units that result automatically in the improvements in the livelihoods of members. Baynes et al. (2015b) found that increasing bonding social capital (i.e. the ability of a community to work together for a common aim) is required to mitigate conflicts within the community groups and increase cohesion and independence of external assistance. These authors also found that one way to increase community forestry group-bridging capital (i.e. the ability of a community to interact with the outside world) is through capacity building that will enable them to deal with legal requirements for harvesting and manage commercial enterprises.

Some elements of the Baynes et al. (2015) model are worth emphasising in context of the links between reforestation and livelihoods of smallholders. The model highlights the importance of communities (and smallholders as members of those communities) receiving benefits from reforestation, including from marketable products. Markets can play an important role in facilitating reforestation (Brancaion et al., 2017). However, market institutions are frequently disadvantageous to smallholders, who lack bargaining power due to limited selling opportunities and limited knowledge on current market practices (e.g. Herzog, 1994; Thorlakson and Neufeldt, 2012; Rahman et al., 2015). Smallholders are often unable to directly reach the final buyer; long and complex supply chains result in loss of profits to middlemen. Becoming organised into producer groups is a way of overcoming the difficulties and disadvantages of the markets to which smallholders are exposed. Producer groups are more able to achieve higher quality, standardised products (Reyes et al., 2005) and better selling arrangements (Dahlquist et al., 2007) than individual small-scale farmers.

Laws and regulations can favour reforestation. For example, in Sumatra, a governmental decree recognising the sustainable local management of agroforests within state forest zones resulted in farmers

feeling secure to make long-term investments in complex agroforestry systems (Kusters et al., 2007). Nevertheless, laws and regulations are often overly complicated or unclear. Poor coordination between government agencies also generates uncertainties (e.g. Primavera, 2000). Further, availability of information on existing policies is limited, and fees charged to obtain timber harvesting and selling permits are beyond the reach of smallholders with limited access to support and credit. In Tanzania, for instance, complex forest laws and procedures added to the limited knowledge of regulations and lack of trust between forest officers and local communities hinders tree growing (Pfund et al., 2011). Further discouragement for smallholder compliance with laws and regulations is the fear that illegal fees will be sought by officers. In the Philippines, for instance, logging checkpoints are cynically referred to as ‘cashpoints’ (Herbohn et al., 2005). The fear of future policy changes affecting the legality of harvesting planted trees adds another level of uncertainty to reforestation.

Informal or uncertain land tenure is frequently found within smallholder systems in the tropics. Tenure is potentially the most complex factor influencing community forestry success (Baynes et al., 2015b). Lack of secure tenure often limits tree planting, access to credit and participation in incentive programs (Kusters et al., 2007). For example, farmers' motivation to plant trees is adversely influenced by uncertainties inherent in PNG's system of customary land tenure (Baynes et al., 2017). Because strengthened tenure claims can be achieved through tree planting, tenure insecurity can in some cases motivate reforestation (Walters et al., 2005; Kusters et al., 2007; Osborne, 2011).

Gender and tenure issues often coincide. Women have limited access to land (e.g. Ogunlana, 2004; Tchoundjeu et al., 2010), especially under patrilineal land inheritance patterns (e.g. Adesina and Chianu, 2002; Mukadasi et al., 2007). Besides land, women often lack access to cash, infrastructure, information and assistance (e.g. Ogunlana, 2004; Tchoundjeu et al., 2010). Policy makers and extension officers frequently overlook women's role in reforestation, since they have traditionally focused on male farmers (Fouladbash and Currie, 2015). In smallholder land use in the tropics, women were frequently included in groups of marginalised members of the social structure along with the youth and the poor, and the above limitations are pronounced for all of them.

4.4. Smallholder livelihood strategies and tropical reforestation

Smallholders manage diverse livelihood portfolios, combining a variety of land-use strategies to meet the households' subsistence and cash needs, either through the use of land-sparing or land-sharing systems. For instance, some farmers hold a swidden-fallow agroforestry portfolio with fields in different stages of the fallow cycle (e.g. Coomes and Burt, 1997), whereas others complement tree cropping with shifting cultivation for shorter-term returns (e.g. Fouladbash and Currie, 2015).

Land-sharing and land-sparing both have their pros and cons (Koen Kusters, 2014). However, the sharing-sparing discussion is a dichotomous simplification of complex land-use systems and dynamics (Koen Kusters, 2014). The landscape approach considers an integration of a range of land uses (McGuire, 2014) in a dynamic socio-ecological system. In terms of the landscape approach, the sharing-sparing perspective seems to lose its importance. Reforestation is only part of the landscape use, along with other systems that complement each other. Both production and conservation objectives can be pursued in the landscape, regardless whether within a single plot or in diverse systems, using a landscape land-use approach. Reforestation is only one component of the livelihood portfolios of smallholders, who pursue multiple and multi-faceted goals to meet their financial, social, human, physical and natural capital needs. In concordance with Suich (2010), it is argued that activities are often evaluated individually and few studies address the outcomes of a range of activities that in combination shape

the livelihood portfolios.

Smallholders often seek both income generation and subsistence benefits from reforestation (Levasseur and Olivier, 2000; Blay et al., 2008; Thorlakson and Neufeldt, 2012). Diversified systems have multiple functions that include cultural uses, food and energy security, social value, market oscillation buffering, and protection against natural hazard. Farmers living close to markets tend to have more market-oriented land-use systems (Gillespie et al., 1993), which defines the systems' species composition. Commercial farmers tend to use more inputs than subsistence-oriented farmers (Alayón-Gamboa and Gurri-García, 2008). Financial returns from commercial forestry can be higher, but subsistence farmers trade income maximisation for the diversification of benefits and decreased vulnerabilities. For subsistence smallholders, uncertainties and risks are more pronounced issues, because a disturbance in their reforestation systems can directly affect household well-being, nutrition and health. Smallholders and communities tend to harvest forest products in a rather opportunistic way, as distinct from silvicultural and market maximisation. Products are often sold to meet immediate household needs including food and education, or casual expenses such as weddings or religious celebrations.

5. Policy implications and conclusions

Even though the SLF diagram may suggest a linear sequential order of facts and consequences, the relationships among the components are highly dynamic and intertwined. Smallholder assets interact with each other and the level of access to (and availability of) resources is affected by processes beyond the control of smallholders. Enabling conditions for reforestation depend on the local context and an infinite combinations of capacities and institutional environment may exist. In some cases the lack of a given resource may be compensated by the high availability of another capital asset. In other cases, a lacking resource may be irreplaceable and addressing this limitation may be the essential first step towards reforestation, if reforestation is to provide optimal outcomes.

Reforestation has the potential to substantially reduce poverty in rural areas, especially in situations where there is degraded and underutilised land. Through reforestation, smallholders can diversify their livelihood portfolios and increase household income as well as the availability of products for subsistence. Such products often include food and firewood. Improved food and energy security leads to greater well-being of people. The provision of products and services from reforested areas can act as buffers to climatic and market conditions adverse to smallholders (e.g. droughts and low market prices for a specific farming product). Hence, the availability of natural resources can increase socio-ecological resilience to the vulnerabilities to which smallholders are frequently exposed.

Increased social equity in respect to access to resources, including gender equality, resulting from socially sound extension activities of reforestation projects, enhances the community's welfare and cohesion. Through reforestation farmers can gain control over resources, and through participation in extension and support programs they enhance their decision-making capability, leading to more effective governance. This higher self-sufficiency, or community empowerment, favours future practices by extension agents and reforestation activities. Adding to all the potential benefits mentioned above, in comparison to ecologically degrading agricultural practices frequently used in densely populated uplands, a more sustainable land use can be achieved with reforestation, enhancing the quality of water, soil, air and climate.

Despite the great range of benefits that reforestation can bring, they are often not achieved. Barriers for full realisation of benefits from reforestation often derive from limited availability and access to resources. Limiting resources include knowledge, social networks, cash, propagules, and water, among many others. Limited understanding of regulations and opportunities, along with environmental and market risks also hinder realisation of the potential benefits of reforestation.

Often, benefits are accrued by a small group of people within a community as a result of a deficient governance system and lack of transparency of resources utilisation. Undesirable impacts can also result from reforestation if the approach is not tailored to the local context. Increased tension over land and resources tenure can be an effect of poor coordination of pre-definition of rights and duties among stakeholders. Adding to that, reforestation can be excluding if there is a requirement for minimum levels of resources for smallholder engagement in the activity. The exclusion of vulnerable groups can increase the gap between the wealthy and the poor.

It is important for reforestation to be a complementary rather than competitive activity within the portfolio of livelihood activities available to smallholders. If labour demand is flexible or can be met by household members that are less involved in other household activities (e.g. women and youth), and land allocated for reforestation would not otherwise be cropped, the opportunity cost of reforestation is low. Despite the fact that multi-use multi-function agricultural systems have commonly been promoted for smallholders, simpler systems in separate blocks per activity might be more favourable in some situations. For instance, small woodlots could be one of these systems combined with mono-culture cropping, rather than complex agroforestry systems which are difficult to manage and design. Separate woodlots and crop areas can be synergic with conservation in a landscape context, and more easily adopted by smallholders.

Reforestation is only one of the livelihood portfolio activities and should not be dealt with in isolation. This is particularly relevant under the FLR approach. The approach seeks to combine land uses across a landscape for a more sustainable management of natural resources and better governance. Reforestation can be used in FLR for environmental benefits, direct human benefits or a combination of both. When using reforestation in FLR for purely environmental benefits might require a complementary land use that will provide livelihoods. When reforestation is focused on direct human benefits, attention is needed on the timeframe of benefits and the suitability of the timeframe to smallholders. For smallholders with the need for more immediate benefits, reforestation focused on livelihoods may comprise crops or other short-term products, or be associated with other land uses that will provide livelihoods to smallholder until the reforestation site itself is able to provide enough returns.

If ambitious forest restoration goals, including desired impacts on human wellbeing, are to be met, it is crucial to be able to foresee potential barriers and negative impacts from reforestation. Different contexts have different opportunities for reforestation, and also different limitations. Interventions will need to be tailored to the local context and different levels and types of support may be needed depending on the local capacities and intended outcomes. An assessment of smallholders' capacity, including their livelihood assets, strategies adopted and vulnerabilities, as well as the institutions surrounding them prior to the beginning of the reforestation activity can assist in the identification of improvements in capacity needed for an optimal outcome of an initiative. Such an assessment would also assist identifying features of the institutional and natural environment that may constrain optimal outcomes, so they can be addressed in a timely manner.

Facilitating resource access for smallholders, and particularly to marginalised groups, has been identified as a means for better reforestation outcomes and as an important objective for intervention from external agents. Often this can be done through indirect measures rather than direct action. For instance, consolidating enabling policies, institutions and processes – as changing the rules of the game by promoting the inclusion of women in reforestation and providing them access to resources including land – might have a stronger and longer-lasting impact in smallholders' livelihoods than the direct one-off provision of limited benefits – as providing free seedlings or cash for women to plant trees. Hence, the entry points for interventions might be an indirect driver of the outcome desired. However, doing this requires a deep understanding of the socioeconomic landscape in order to

identify the underlying causes for the limited availability or accessibility of a particular asset.

This paper presents a comprehensive analysis of the literature connecting tropical reforestation and smallholder livelihoods. Results and discussions from this study can be useful in efforts under the current FLR movement. Reforestation can be an important land-use in a landscape under restoration, and large areas to be restored are under smallholder management. Reforestation has great potential to provide both goods and services, and other livelihood benefits, for smallholders while providing a range of environmental benefits.

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Appendix 1 List of journals included in the study

Table A1

Table A1
Number of articles identified per journal of publication.

Journal Title	Number of articles included
Agroforestry Systems	90
Agriculture, Ecosystems & Environment	25
Small-scale Forestry	20
Forest Ecology and Management	15
Biodiversity and Conservation	13
Forests, Trees and Livelihoods	9
Human Ecology	9
Ecological Economics	7
Journal of Ethnobiology	7
Economic Botany	6
Ecology and Society	6
Environmental Management	6
Agricultural Systems	6
New Forests	5
Journal of Sustainable Agriculture	5
Mitigation and Adaptation Strategies for Global Change	4
Mountain Research and Development	3
Interciencia	3
International Journal of Agricultural Sustainability	3
Plos One	3
Conservation Biology	3
Ecological Applications	3
Land Use Policy	3
Bois et Forets des Tropiques	3
Journal of Sustainable Forestry	3
Agricultural Economics	3
Environmental Science & Policy	2
Sustainability	2
Conservation Letters	2
International Journal of the Commons	2
Ambio	2
Nutrient Cycling in Agroecosystems	2
PNAS	2
International Forestry Review	2
African Studies Quarterly	2
Forest, Trees and Livelihoods	2
Journal of Environmental Planning and Management	1
Environment and Development Economics	1
Environmental Modelling & Software	1
Journal of Applied Ecology	1
Ecological Engineering	1
Open Journal of Forestry	1
Biotropica	1
International Journal of Sustainable Development and World Ecology	1

(continued on next page)

a systems approach and ASEM/2016/103 Enhancing livelihoods through Forest and Landscape Restoration].

CRediT authorship contribution statement

Liz Ota: Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft. **John Herbohn:** Conceptualization, Methodology, Writing - review & editing, Supervision. **Nestor Gregorio:** Conceptualization, Writing - review & editing. **Steve Harrison:** Writing - review & editing.

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Table A1 (continued)

Journal Title	Number of articles included
Environment: Science and Policy for Sustainable Development	1
Journal of Rural Studies	1
Professional Geographer	1
Land Economics	1
Landscape and Urban Planning	1
Carbon management	1
Journal of Latin American Geography	1
Biological Conservation	1
African Journal of Ecology	1
Regional Environmental Change	1
Agriculture & Food Security	1
Environment, Development and Sustainability	1
Society & Natural Resources	1
Ecosphere	1
World Development	1
Procedia - Social and Behavioral Sciences	1
Plant and Soil	1
Renewable Agriculture and Food Systems	1
Journal of Forestry Research	1
Current Science	1
Applied Geography	1
Land Degradation & Development	1
American Journal of Alternative Agriculture	1
Journal of Tropical Forest Science	1
Journal of Forestry	1
Biotechnologie, Agronomie, Société et Environnement	1
Nature Communications	1
Journal of Development Studies	1
Journal of Forest Research	1
Annals of Forest Science	1
Forest Policy and Economics	1
American Journal of Agricultural Economics	1
The Journal of Peasant Studies	1
Agronomy Journal	1
Experimental Agriculture	1
Ethnobotany Research and Applications	1
Agriculture and Human Values	1
Revue d'Ecologie	1
Forests	1
NJAS	1
Agricultural and Forest Meteorology	1
Frontiers in Ecology and the Environment	1
Tropical Ecology	1
Acta Amazonica	1
Global Environmental Change	1
Global Change Biology	1
Geographical Journal	1

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