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Introduction

Agrarian change in tropical landscapes

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Agricultural expansion has transformed forest habitats at alarming rates across the globe, but especially so in tropical landscapes (Laurance et al. 2014; Shackelford et al. 2014) due to increasing global demands for food, fiber and biofuels (Tilman and Clark, 2014). This has resulted in mosaic landscapes encompassing varying levels of tree cover, human settlement and agricultural production units. The expansion of agriculture has resulted in large-scale habitat loss, fragmentation of forests and simplification of natural ecosystems, causing increases in the probability of extinction in small and isolated populations of both flora and fauna (Tilman et al. 1994), significant losses in biological diversity (Fahrig 2003; Ewers and Didham 2006; Krauss et al. 2010) and negative impacts on many ecosystem services (Hooper et al. 2005; Tscharntke et al. 2008).

Between 1700 and 1980, the total area of cultivated land in the world increased by 466% (Meyer and Turner 1992); croplands and pastures have now become one of the largest terrestrial biomes on the planet, exceeding the amounts of forest cover and occupying ~40% of the land surface (Foley et al. 2005; Ellis et al. 2010). Between 1980 and 2000, more than half of new agricultural land across the tropics was established at the expense of intact forests, while a further 28% was opened up to the detriment of disturbed or secondary forests (Gibbs et al. 2010). This habitat loss is further compounded by land degradation and competition from other land uses such as urbanization (Ellis et al. 2010).

Although the rate of expansion of agricultural land has slowed considerably over the last three decades (and even decreased in some areas), the focus on food production has ensured a rapid rate of increase in yield per unit area and has overtaken the rate of global human population growth (Naylor 1996; Matson et al. 1997). Technological and scientific advancements have provided access to cheaper chemical fertilizers and pesticides, high-yielding crop varieties, advanced irrigation technologies and more efficient mechanization (Matson et al. 1997), which have all contributed to elevated crop yields. Unsurprisingly, given the dependency of this model on fossil fuels, concerns have been raised over the long-term sustainability of the intensification of agriculture, particularly as food demands are expected to more than double by 2050 (Tilman et al. 2001; Green et al. 2005; Fischer et al. 2008; Godfray et al. 2010). Pressures on biodiversity and ecosystem services are also increasing due to the growing impacts of human activities across many landscapes (Tylianakis et al. 2008; Defries and Rosenzweig 2010; Tscharntke et al. 2012). Consequently, hard choices need to be made about how tropical landscapes should be managed to optimize multiple outcomes.

The competing global demands for agricultural commodities and vital environmental services provided by forests are now attracting significant attention and investment, for example through calls for "sustainable intensification" of farming and a second Green Revolution (Nature 2010). Meanwhile multiple objectives are increasingly sought from mosaic landscapes such as biodiversity conservation, maintenance of ecosystem services, food production, sustainable livelihood provision and climate change mitigation (Sayer et al. 2013; Reed et al. 2015). However, land scarcity results in trade-offs and synergies between many of these components, particularly between the provision of food and conserving biodiversity (Law and Wilson 2015). As such, global food security is increasingly trading off food for nature (Lambin 2012).

Despite significant progress toward meeting the Millennium Development Goal of halving the prevalence of hunger worldwide by 2015, levels of global food insecurity are still unacceptably high. Approximately 842 million people worldwide do not have sufficient quantities of food to eat and undernutrition is linked to one-third of child deaths in developing countries (UNICEF 2011; Black et al. 2013; FAO et al. 2013). This situation is exacerbated by global population growth and changing dietary patterns resulting in a predicated 50% increase in the demand for agricultural products by 2030 (Bruinsma 2003). Historically, the trade-off between food security and the environment led to a perception that biodiversity conservation and food security were considered mutually exclusive (Tscharntke et al. 2005; Brussaard et al. 2010). This perspective may be misplaced as it fails to account for biodiversity within agricultural landscapes and the multiple contributions to food security that biodiversity already provide to food production systems (Perrings et al. 2006; Bharucha and Pretty 2010; Sunderland 2011).

Managing and negotiating trade-offs between conservation and agricultural production involves maximizing food security benefits while minimizing damage to the wider environment. Two contrasting approaches: 'land sparing' and 'land sharing' have been proposed to minimize the negative consequences of agriculture on biodiversity; they aim to consider land-use change in such a way that competing demands for food, commodities and forest services can be reconciled (Phalan et al. 2011a, 2014)

'Land sparing' aims at intensifying production and maximizing agricultural yields by trading-off its negative consequences on the environment by 'sparing' areas of natural capital (often in the form of protected areas) and therefore reducing the need for agricultural expansion into forest areas (Pirard and Treyer 2010).[1] 'Land sharing' is based on a land-use model that integrates production and conservation within the same land units. It proposes to minimize the use of external inputs and to retain patches of natural habitat within farmlands in a form of extensive agriculture. Under this land management regime, landscapes consisting of low-intensity productive areas are combined with areas of natural biodiversity (Wright et al. 2012). Such strategies include agroforestry systems and traditional swidden farming practices (Ziegler et al. 2009; Clough et al. 2011).

Recent studies suggest that efforts to emulate land sparing through the application of incentives, regulations and land-use planning could lead to the best outcomes for food production, climate change mitigation and biodiversity conservation (Balmford et al. 2005; Green et al. 2005; Phalan et al. 2011b). This perspective has had considerable influence on policy makers and donors and provides some of the underpinning logic for a range of high-profile interventions underway around the world (e.g. Alliance for the Green Revolution in Africa,[2] USAID's Africa Rising Initiative[3] and the Commission on Sustainable Agriculture and Climate Change[4]). In recent studies, land sparing was regarded as a more promising strategy than land sharing for securing crop production with minimum negative impact on the abundance and diversity of birds and trees in southwest Ghana, northern India and southern Uganda (Phalan et al. 2011a, 2011b; Hulme et al. 2013). Consequently, the notion of securing forest conservation and food security through land sparing offers a convincing narrative for achieving desirable agrarian change, particularly in the developing world. However, the approach has also attracted sharp criticism as it has been shown that this strategy rarely occurs 'naturally,' because increased productivity can also increase incentives to further clear forests.

Land sharing is supported by the fact that many species are dependent on farmland and other habitats maintained by humans (Wright et al. 2012) and that farmlands that are structurally similar to the original native vegetation, such as tropical agroforests, often support biodiversity as effectively as native vegetation (Clough et al. 2011). This land sparing versus land sharing debate has consequently become somewhat polarized in the scientific literature (Law and Wilson 2015) and there is increasing opinion that a "black and white" dichotomy has been formed that oversimplifies issues that in practice are highly complex (Gutiérrez-Vélez et al. 2011; Adams 2012; Sunderland 2012; Fischer et al. 2014).

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1 Agricultural intensification does not always mean increases in inputs such as fertilizer and capital (e.g. through mechanization), but it can also include changes to the use of labor and environmental services. See discussion in Pirard and Treyer (2010, 6). More often however, intensification is understood as additional inputs to increase productivity.

2 http://www.agra.org/

3 http://africa-rising.net/

4 See recent article by Commission on Sustainable Agriculture and Climate Change (CSACC) member Mohammed Asaduzzaman: http://climate-l.iisd.org/guest-articles/now-is-the-time-to-make-agriculture-part-of-the-climate-change-solution/

Baudron and Giller (2014) suggest that both options are equally important and can be complementary strategies under different circumstances. Land sparing and land sharing land management regimes are not necessarily mutually exclusive and some landscapes may exhibit elements of both strategies (Scariot 2013). Smallholder farmers for example, who form the backbone of global food security, provide up to 40% of the world's food; most of them fall somewhere on the continuum between land sharing and land sparing (Tscharntke et al. 2012). Baudron and Giller (2014) also identify a number of general principles that should be considered, beyond the land sparing/land sharing debate, for example: managing spillover effects from intensive production systems; maintaining resilience and ecosystem services; accounting for landscape structure and configuration of land units, reducing losses and wastes; improving access to agricultural products in developing countries; changing consumption patterns in developed countries; and developing supportive markets and policies.

It has also recently been recognized that land-use strategies aimed at balancing agriculture and biodiversity conservation must also consider socioeconomic outcomes and trade-offs (Grau et al. 2013; Fischer et al. 2014; Loos et al. 2014). Landscapes should be viewed as complex socioecological systems that consist of mosaics of natural and/or human-modified ecosystems (Bennett et al. 2006). While the physical configuration of topography, soils, vegetation and geology greatly influences land use, forests and settlements, these components are also subject to ecological, historical, economic and cultural processes of an area (Sayer et al. 2013). However, there is a distinct lack of information on the human impacts of agrarian change in forested areas, particularly on the socioeconomic effects of agricultural intensification, long-term dietary diversity and market integration processes. Previous research within the land-sharing versus land sparing debate has focused on the trade-offs between food security and biodiversity at a macro level (Balmford et al. 2005; Clough et al. 2011; Ben Phalan et al. 2011a), while local-scale effects upon livelihoods, poverty, food security and nutrition have been overlooked. More food production does not automatically lead to better local food security and better livelihoods for rural communities (Powell et al. 2015).

The consequences of land-use strategies can only be fully understood within the wider context of local histories, culture, politics and market dynamics. For example, land-use decisions at the household level often influence what happens at the landscape scale, yet in the majority of cases, such decisions are driven by strong externalities such as government policies, labor, extension and markets. A myriad of land uses will fragment and parcel out the landscape, meaning that some landscape configurations may not even lend themselves to a contrasting land sparing or land sharing land-use regime. Therefore, we need to advance our understanding of agricultural landscapes as integral socioecological systems and to move the land sharing/land sparing debate forward from solely examining trade-offs between food production and biodiversity.

The CIFOR-led Agrarian Change Project aims to address this research gap by working directly with communities within multifunctional tropical landscapes to understand the social, economic and ecological consequences of land use and agrarian change processes.

The Agrarian Change Project

Overview

The Agrarian Change Project is a multidisciplinary research project led by CIFOR. It examines socioeconomic outcomes and conservation, livelihood and food security implications of land-use change and agrarian change processes in multifunctional landscapes. The research focuses on landscapes in a number of tropical countries around the world, each exhibiting various combinations of agricultural modification, productivity, changing forest cover and integration with global commodity markets. The relationships between agricultural production and trade-offs/synergies with landscape components (such as local food security, dietary diversity and nutrition levels, market access, tenure, local poverty, as well as biodiversity conservation) are currently being investigated. A common set of qualitative and quantitative research methods have been applied in each landscape to enable a global comparative analysis. The effects of landscape configuration (including forest fragmentation and levels of patchiness), land sharing/sparing scenarios and synergies and trade-offs between different land uses (e.g. agroforestry, crops, livestock rearing, swidden agriculture) with forests and tree-based systems are being examined.

The focal landscapes chosen for the Agrarian Change Project were selected based on extensive background information obtained by conducting scoping studies in the field, primarily by a team of graduate students and their academic supervisors. The case study chapters in this book document the findings of these scoping surveys for seven different landscapes in seven different countries: Bangladesh, Burkina Faso, Cameroon, Ethiopia, Indonesia, Nicaragua and Zambia (Figure 1.1). The purpose of the scoping surveys was to ensure that the landscape selected in each country fulfilled the experimental design criteria devised for the project and to provide detailed background information on land management practices, both historically and more contemporarily for the regions selected.

The first section of this introductory chapter provides contextual background information to the Agrarian Change Project. In the following section, we give a brief overview of the project objectives and experimental design to provide further context for the following case study chapters.

Research objectives

1. How is land use changing over time and what are the underlying drivers behind these changes? Are there consistencies/differences between the different landscapes/countries?
2. What are local people's perceptions of the outcomes of land-use change in each landscape in terms of their livelihoods, access to natural resources, land tenure and food security?
3. What is the relationship between land use and local livelihoods and food security (i.e. food production, food access, market integration, nutrition, wealth) under different land-use scenarios along an agricultural modification gradient?
4. What is the relationship between local food production and local food security along an agricultural modification gradient and does this differ between different countries?

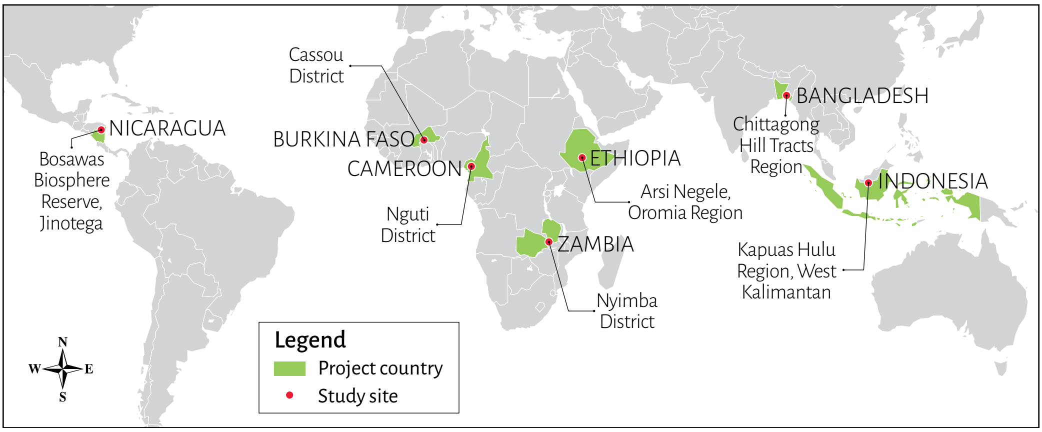

Figure 1.1 Map showing the location of the seven landscapes used as case studies for the Agrarian Change Project.

Research design

Using a landscape-level approach, a nested hierarchical experimental design was devised incorporating three levels (Figure 1.2):

- a **landscape** in each focal country that exhibits changing land-use practices (agricultural modification and forest loss)
- three **land-use 'zones'** in each landscape, collectively representing a gradient/continuum of agricultural modification and decreasing tree cover
- **village/s or settlement/s** within or in close proximity to the dominant zone of land use.

Selection of landscapes, zones and villages

The selection of landscapes in the project was based on prior knowledge by field teams in the focal countries, followed by scoping surveys to ensure that the chosen landscapes met project criteria. Attempts were also made to collate these landscapes where there were already research initiatives in place, such as the Sentinel Landscapes framework of the CGIAR's Forests Trees and Agroforestry Research Program.[5] A continuum of changing land-use practices needed to be present within each landscape; often these mimic historical land-use trajectories. Three land-use 'zones' were clearly identified based on dominant[6] land-use practices representative of the landscape, collectively representing a gradient of agrarian change across the tree cover transition. An agricultural modification gradient often mirrors the forest transition curve (Figure 1.3), where it is anticipated that as agricultural modification increases, forest cover and dependency on forest resources decreases.

5 http://www1.cifor.org/sentinel-landscapes/home.html

6 We acknowledge that multiple land uses will occur in each zone but each zone was identified based on the presence of a most prevalent land use.

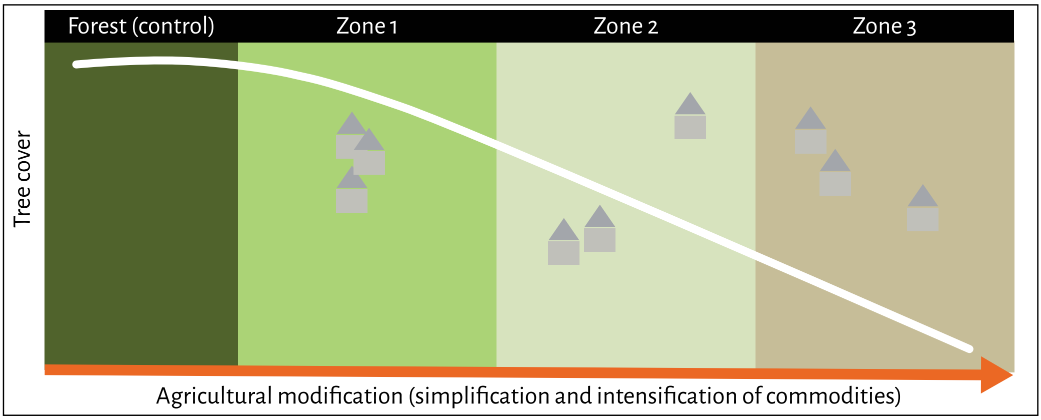

Figure 1.2 The project's landscape-level hierarchical research design.

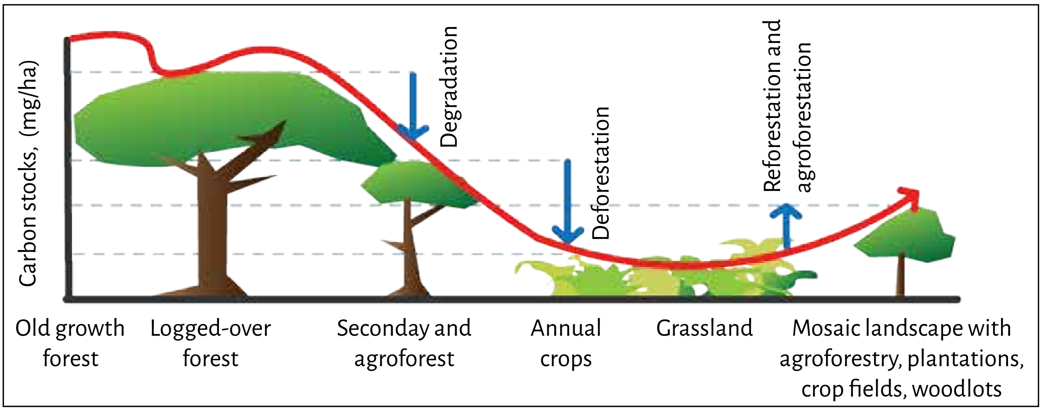

Figure 1.3 Forest transition curve.

Source: CGIAR Research Program on Forests, Trees and Agroforestry, CIFOR

For example:

- Zone 1: an area with 'best' available forest cover and high dependency on forest products, coupled with subsistence agriculture
- Zone 2: an agroforestry system (a mix of forest cover and crops)
- Zone 3: a monoculture/intensive cash crop system (e.g. wheat, maize or palm oil).

There were no constraints to the size of the landscapes or zones within a landscape. However, for each landscape, we ensured that there was limited variability in terms of rainfall/climatic characteristics and elevation and zones within a landscape were of the same biome or agro-ecological zone. Within each zone, there was at least one village (with a minimum number of 100 households, as this was the minimum number of households needed to conduct household surveys later on); ideally each zone should contain several villages, with a minimum number of 100 households combined.

Table 1.1 Example criteria used to help distinguish characteristics of different zones within a focal landscape.

	Criteria	Zone 1	Zone 2	Zone 3
1	Population density	Sparse	Medium	Dense
2	Land tenure	State/customary	Customary	Customary/title deeds
3	Proximity to major towns	Distant	Far	Near
4	Level of dependence on forest resources	High	High–medium	Medium–low
5	Proximity to protected areas (forest reserves, game management areas, national parks)	Near	Far	Distant
6	Level of in-migration	High–medium	Medium–low	Low
7	Level of agricultural inputs (fertilizers)	None–low	Medium	High
8	Market oriented crop production/ presence of cash crops: tobacco, maize, groundnuts and cotton	Rare	Occasional	Common
9	Presence of subsistence farming	High	Medium	Low
10	Level of infrastructural development	Low	Moderate	High

We aimed to capture as much variation along a modification gradient in each focal landscape with regard to the following characteristics:

- agricultural modification (from low inputs – diversified, extensive, subsistence orientated practices through to high input – market orientated, intensive, simplified practices)
- forest/tree cover
- community dependency on forest products
- market access and infrastructure.

To help with the process of distinguishing three zones, a list of criteria was developed for each focal landscape to help discriminate the different practices and relative differences between the key characteristics of each zone (Table 1.1). This was modified for each landscape; it helped to clarify whether the landscapes selected exhibited a gradient of agrarian change/agricultural modification. The type of criteria/variables and number of criteria/variables differed between focal landscapes.

Structure and content of this book

This book uses insights and preliminary data from scoping studies undertaken in seven focal landscapes identified to conduct further data collection for the project. The purpose of this introductory chapter is to provide the background information to help contextualize the research aims and objectives of the project and provide a brief overview of the experimental design and criteria required of the focal landscapes. The case study chapters of this book provide detailed background information on the seven landscapes (in seven different countries) that were chosen to conduct the in-depth global comparative study: Bangladesh, Burkina Faso, Cameroon, Ethiopia, Indonesia, Nicaragua and Zambia. The focal landscapes exhibit various scenarios of changing forest cover and transition, agricultural modification and integration with local and global commodity markets.

Each of the seven case study chapters gives a comprehensive description of the physical and socioeconomic context of each focal landscape and a structured account of the historical and political drivers of land-use change occurring in the area; it draws on information obtained from key informant interviews, FGDs and preliminary data collection about key topics of interest such as changes in forest cover and dependency on forest products, farming practices, tenure institutions, conservation projects and major economic activities. The case studies give first-hand insights into how and why land use has occurred in the focal regions; they give a preliminary insight into the social, economic and environmental effects of these changes and provide comprehensive background information to the study areas that can be drawn upon if further research is conducted in these regions in the future.

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