# 6

# LAND USE INTENSIFICATION

## The promise of sustainability and the reality of trade-offs

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### Introduction

There are seemingly compelling reasons to intensify land-based production systems (Godfray et al., 2010), and yet the benefits of higher productivity have too often been accompanied by substantial, detrimental contributions to environmental change at local to global scales (Foley et al., 2005; Laurance et al., 2014; Poppy et al., 2014; Rockström et al., 2009). By 2050 there will be an estimated 9 billion people on the planet which, along with changing dietary preferences such as increasing meat consumption, could require a doubling of demand for food crop production between 2005 and 2050 (Tilman et al., 2011). This global estimate hides greater regional pressures with increased demand for cereal crops of 150% or more in sub-Saharan African countries such as Ethiopia, Ghana and Tanzania (Franks et al., 2017). Achieving food security will be made more difficult by the increasing competition for land arising from other urgent and important local and global challenges, including demand for land for biodiversity conservation (e.g. protected areas) and for energy security (e.g. biofuels). Given the increasing competition for land, large-scale expansion of agriculture is no longer the preferred option in many places, leaving four alternative and potentially complementary strategies for future food security: (1) increasing yields through intensification; (2) reducing demand by eliminating overconsumption and reducing meat consumption; (3) reducing wastage, estimated at 1.3 billion tonnes of food lost annually post-harvest (Gustavsson et al., 2011); and (4) improving distribution. While priorities vary from country to country, the land use intensification option has generally been pursued most vigorously to date and continues to feature prominently

in global environment and development strategies (DeClerck et al., 2016; Rockström et al., 2017). Land-use intensification, including the target to double the productivity of smallholders by 2030, is seen as fundamental to achieve the UN Sustainable Development Goals of ending hunger (SDG2) and achieving sustainable use of terrestrial ecosystems (SDG15).

Land use intensification has been central for human development throughout history and will play a role in addressing future challenges. However, while some strongly advocate intensification as a way to deliver gains for both human welfare and the environment (e.g. Cohn et al., 2014; Stevenson et al., 2013), this has become hotly debated. In the case of agriculture, some forms of intensification are found not to spare land from agricultural expansion and to lead to a range of negative environmental impacts (Hertel et al., 2014; Phelps et al., 2013). For these reasons, the call now is for 'sustainable intensification', a concept that is generally understood to mean increasing the productivity of land while reducing or eliminating adverse environmental impacts (Godfray and Garnett, 2014; Pretty and Bharucha, 2014; Rockström et al., 2017). Just as there is a debate about the effectiveness of land-use intensification for achieving environmental goals, so too there is a debate about its relationship with poverty. While evidence has accrued that economic growth from agricultural intensification is effective for poverty elimination (de Janvry and Sadoulet, 2009; Thirtle et al., 2003), recent studies have questioned this, both in terms of the short-term effects on the poor (Dawson et al., 2016) and the vulnerability of poorer groups to longer-term environmental degradation (Dearing et al., 2014).

This chapter reviews recent published research that investigates the combined effects of intensification on both ecosystem services and human wellbeing in low- and middle-income countries. Our analysis combines a more descriptive summary of findings across a sample of 60 cases, reported in 53 publications (1997–2017), with a more detailed study of a small number of exemplary cases.

## Conceptualising land use intensification

Land use intensification is broadly defined as activities undertaken with the intention of enhancing the productivity or profitability per unit area of rural land use, including intensification of particular land uses as well as changes between land uses. Most research concerns cases of agricultural intensification, but there were a few cases of terrestrial aquaculture and agroforestry. Based on our sample, we identify four broad types of land use intensification.

1 *Land use conversion*. Predominantly conversion from fallow systems to permanent cropland, but also other changes, e.g. conversion from rain-fed to irrigated and from annual crops to plantations.
2 *Increased inputs*. Primarily physical inputs, including irrigation, chemicals, machinery and labour, but also new knowledge and skills, thus potentially including conservation agriculture as a form of intensification.

3 *Crop or product change*. Involving new types and often higher-yielding varieties of crops, and normally involving specialisation or monocropping and a shift from subsistence to cash-cropping.
4 *Mixed intensification*. More complex combinations of the previous three types.

These land use intensification *activities* produce outcome pathways that incorporate inter-connected social and ecological impacts (Figure 6.1). Local and global *drivers* initiate intensification activities that play out in particular places. Indirect local drivers include markets, governance and population while indirect global drivers include economic globalisation and climate change. While *outcome pathways* are complex, dynamic and context-dependent, we employ the language of social-ecological trade-offs and synergies to summarise these as win-win, lose-lose and win-lose pathways. This simplification should not lose sight of the underlying complexity, but is useful for identifying and describing emerging patterns in the scientific literature.

*Outcomes* from land use intensification – including trade-offs – are given meaning by social *values* and may thus be perceived and experienced in diverse ways by different social groups. Ultimately, the values and meanings attached to outcomes are determinants of *policy responses* in the context of key societal objectives such as food security. For example, growing evidence that the use of neonicotinoid pesticides contributes to declines in flying insect populations has coincided with

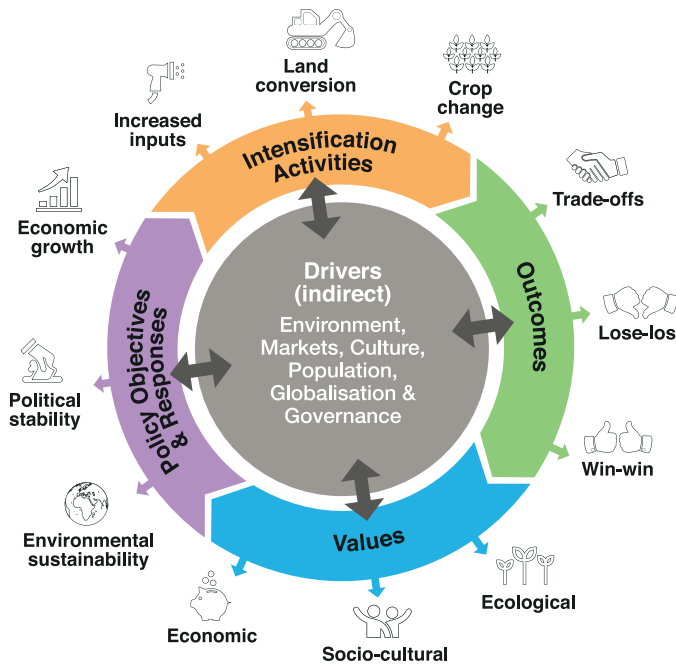


**FIGURE 6.1** Land use intensification process.

wider appreciation of the value of pollinators. This is leading to policy responses that ban or limit the use of such pesticides, thus changing options for future intensification. This example refers mainly to economic preferences, but values involve many types of preferences, including social and cultural ones. Poverty elimination is a primary value in the context of ecosystem services and leads to a consideration of whether, and in what circumstances, land use intensification can produce pathways out of poverty. These elements (drivers, activities, outcomes, values and responses) are not envisaged to be connected in simple linear relationships, but rather involve complex, dynamic and multi-dimensional system changes that cannot be well accounted for through simple causal links (Erb et al., 2013).

## Land use intensification outcomes

We identify and discuss three main themes relating to ecosystem services and wellbeing. First, we consider a central feature of the ecosystem services literature: the use of typologies of multiple ecosystem and human wellbeing outcomes, following the conceptual framework of the Millennium Ecosystem Assessment (MA, 2005). Second, we discuss multiple ecosystem service trade-offs (Howe et al., 2014). Third, we consider an important (but less common) trend towards disaggregation of human wellbeing outcomes to identify winners and losers (Daw et al., 2011). Finally, we try to draw together findings across these three themes to identify the contribution of ESPA research into land use intensification to an understanding of the connections between changes to ecosystem services and to human wellbeing.

### *Measuring multiple outcomes*

Land use intensification studies tend to focus on singular outcomes, such as responses of crop yields to changing inputs, and mainly focus on either ecological or social outcomes in isolation (Rasmussen et al., 2017a). Figure 6.2 summarises the outcome variables adopted in the smaller (but growing) body of work that reports on both social and ecological outcomes. It reveals both the limitations and strengths of the research. In terms of limitations, a small number of more traditional measures continue to dominate (van Vliet et al., 2012). 85% of the 60 studies we reviewed reported on food production, generally classified as a provisioning ecosystem service; 92% of studies reported on income as a poverty variable, which we classify here as a human wellbeing outcome, with the reservation that income is only an intermediate means to achieve desired ways of being. Given our selection of the ecosystem services literature, it is surprising to find that relatively few studies describe any other provisioning or regulating ecosystem services, and fewer still describe cultural ecosystem services (Figure 6.2). Biodiversity and supporting services (notably soil formation) are more frequently included.

This bias in what is measured has strong implications for judgements about the sustainability of intensification. On the one hand, the outcome indicators that

the research community most often measure (food production and income) are the variables that appear most likely to respond positively to land use intensification – this is intuitively what one would expect and is confirmed by our review findings (Figure 6.3). On the other hand, certain indicators of sustainability that are widely recognised as important outcomes of land use (e.g. water purification, water regulation) are infrequently described but, when they are, record negative outcomes

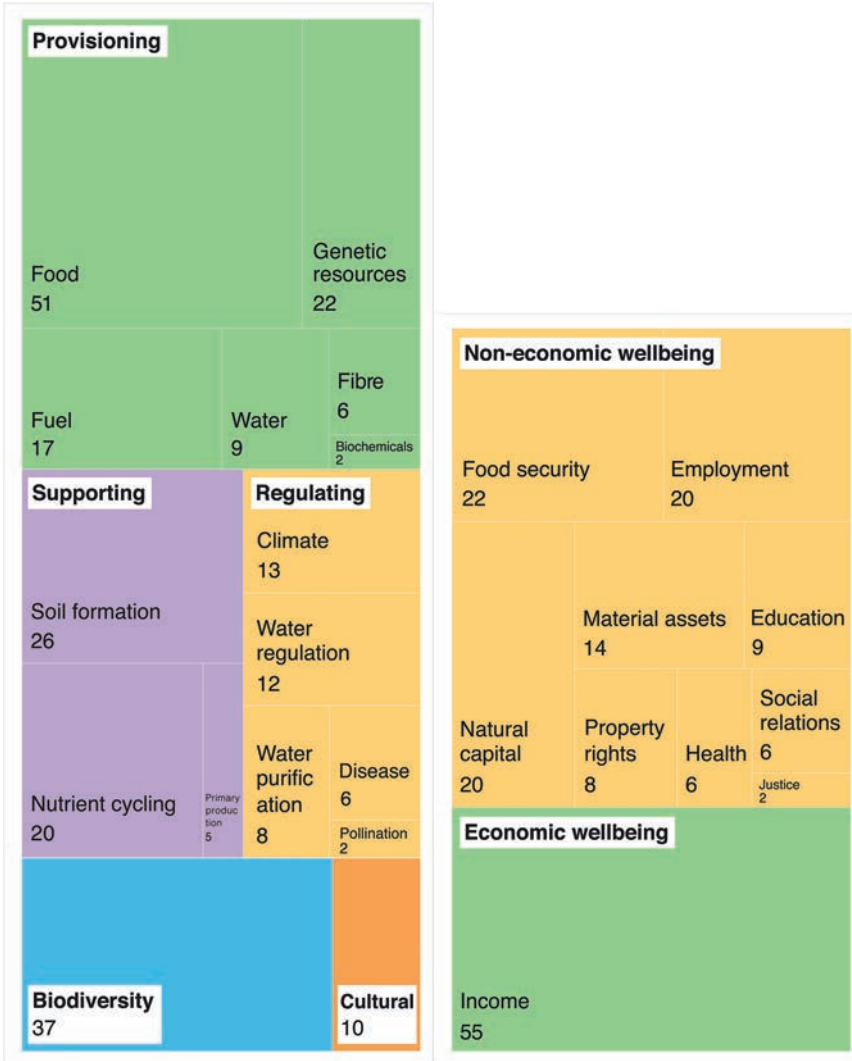


**FIGURE 6.2** Number of cases reporting different measures of ecosystem services and human wellbeing. Note: cultural ecosystem services amalgamate categories of cultural heritage, spiritual and religious, recreation and ecotourism, aesthetic and educational, and sense of place.

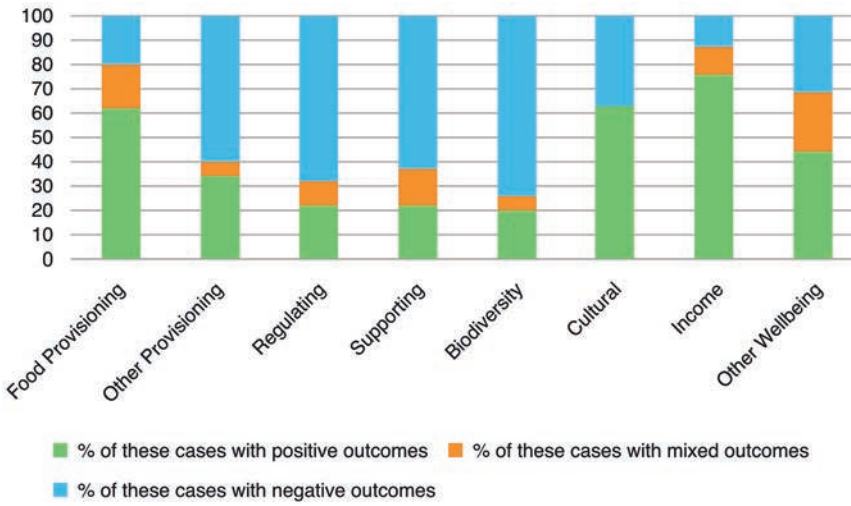


**FIGURE 6.3** Proportion of studies reporting positive and negative outcomes for different categories of ecosystem services and human wellbeing.

in the majority of cases. Connecting these limitations suggests a reporting bias towards measures that one would expect to gain from intensification (e.g. production yields) and against measures that are more likely to show losses (such as water regulation). Studies reporting on cultural ecosystem services remain rare and the positive outcomes in Figure 6.3 may well reflect the very small number of observations. Our finding is that the logic and discourse that supports mainstream land use intensification policies is not currently subject to adequate scientific scrutiny (Figure 6.2).

This limitation in the evidence is not surprising, given that it would be impractical to study multiple ecosystem services and human wellbeing outcomes in most research projects. Regardless of this, the literature we reviewed provides a more complete picture of the outcomes of land use intensification, including the observation that, when measured, impacts on biodiversity, supporting ecosystem services and regulating ecosystem services are more often negative than positive. By contrast, impacts on both economic and non-economic measures of human wellbeing are often reported as positive – the so-called environmentalist's paradox (Raudsepp-Hearne et al., 2010). However, this finding is largely limited to economic measures of wellbeing and only a few cases attempt to show the distribution of benefits among different groups. A case from Mozambique (Box 6.1) shows that the use of multi-dimensional measures of wellbeing provides a more nuanced understanding of outcome pathways, demonstrating, for example, that only some aspects of wellbeing are directly responsive to land use intensification.

## BOX 6.1 IMPACTS OF LAND USE INTENSIFICATION ON MULTI-DIMENSIONAL WELLBEING, MOZAMBIQUE

The ESPA-ACES project explored three case studies in Mozambique and examined how multi-dimensional wellbeing and inequality changed with three common land use intensification activities: intensification of smallholder commercial agriculture, small-scale charcoal production and subsistence cultivation.

The study used the conceptual framework of Erb et al. (2013) to analyse differences across multi-dimensional land-use intensity gradients, including three dimensions of land use intensification: (1) inputs to the production system (e.g. land, technology); (2) outputs from the production system (e.g. product yields); and (3) modifications to system properties and functions (e.g. soil quality and biodiversity). Site-specific measurements of inputs, outputs and system-level modifications were used to create three multi-dimensional gradients, and villages were classified *post hoc* along the gradients. The project also applied the Multi-dimensional Poverty Index (Alkire and Seth, 2016), measuring 15 indicators of wellbeing to reflect the multiple deprivations the poor face in terms of health, living standards and education.

Multi-dimensional wellbeing improved with intensification of both commercial and subsistence agriculture, suggesting that socioeconomic benefits from agricultural intensification and expansion may overcome localised environmental trade-offs, at least in the short term. However, some regulating services may be being undermined by intensification, as smallholders reported more climate shocks in the most deforested areas and a loss of bird predators of crop pests. In contrast, a boom–bust pattern of wellbeing was observed following charcoal intensification, whereby multi-dimensional wellbeing initially increased but subsequently declined. There were limited productive investment opportunities for charcoal-derived income, due to unconducive national policies, and hence resource extraction and related income were unsustainable.

In all sites, intensification only improved endogenous aspects of a household's wellbeing where beneficial outcomes are mediated by a household's agency (e.g. housing material, affordability of healthcare). Exogenous benefits that are beyond the agency of a single household, such as the construction of a village borehole, require additional structural support, irrespective of land use intensification.

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Source: case contributed by ESPA-ACES project team (http://bit.ly/ESPA-ACES)

## *Trade-offs*

We consider three types of trade-off: first, ecological trade-offs between the flow of different ecosystem services; second, trade-offs between different measures of human wellbeing; and third, social-ecological trade-offs between human wellbeing outcomes and ecosystem services outcomes. These primary forms of trade-off all involve social trade-offs, because different groups of people prefer different sets of outcomes and all types of trade-offs therefore produce winners and losers (Rodríguez et al., 2006; Sikor, 2013).

*Ecological trade-offs* between the production of different ecosystem services are dominated by cases in which land use intensification leads to increased food production at the expense of regulating and supporting ecosystem services and biodiversity. Our sample of literature contained 31 cases reporting gains in food provisioning. Of these, 26 report on at least one other ecosystem service, as summarised in Table 6.1.

Such trade-offs between provisioning and other ecosystem services are examined in a case study from China (Box 6.2). A key finding here is that losses to regulating ecosystem services often play out slowly but then appear to reach a critical stage at which feedback systems operate and regime shift occurs. This is also a key finding in a case study of shrimp farming in Bangladesh (Hossain et al., 2016, 2017; Islam et al., 2015; Szabo et al., 2016), in which ecosystem degradation accelerates due to feedbacks. In this case, land use changes that caused salination led to even more land being converted to shrimp production, leading to further salinity and soil degradation. This represents a significant threat to the poor, because the shift away from land-based farming is capital-intensive, attracting wealthier farmers and externalising environmental impacts on poorer rice farmers. Understanding trade-off dynamics requires research that captures change over extended time periods (Dearing, this volume).

*Trade-offs between different human wellbeing outcomes* have been less well studied to date, and this may be reflected in our review. Table 6.2 reports on the 41 cases that found land use intensification to have a positive effect on local agricultural incomes. Broadly speaking it suggests that, where other indicators of (non-economic)

**TABLE 6.1** How increased food production trades off with ecosystem services. This table reports only outcomes for different ecosystem services for the cases that identified positive benefits for food

| | *Positive outcomes* | *Mixed outcomes* | *Negative outcomes* |
|---|---|---|---|
| Non-food provisioning | 6 | 1 | 4 |
| Regulating | 2 | 1 | 10 |
| Cultural | 3 | 0 | 2 |
| Supporting or biodiversity | 7 | 6 | 11 |

### BOX 6.2 AGRICULTURAL INTENSIFICATION IN CHINA: TRADE-OFFS BETWEEN PROVISIONING AND REGULATING ECOSYSTEM SERVICES

During the second half of the twentieth century, China achieved food self-sufficiency but this involved costs to the environment that highlight trade-offs between provisioning and regulating ecosystem services. Dearing et al. (2014) and Zhang et al. (2015) find that degradation of regulating ecosystem services follows non-linear transition pathways, with notable tipping points or regime shifts. The risk of rapid reduction in regulating services appears to be linked to high levels of system connectedness arising from reduced landscape diversity. Centrally planned land use intensification increased system connectedness up until the mid-1980s. There was then a period of diversification (reduced connectedness) due to the shift from top-down planning to household responsibility for farm planning. However, this trend has now been overshadowed by economic globalisation and a renewed trend towards greater connectedness as farmers respond to the same market signals.

The effects of these trade-offs often involve time lags, with collapses in regulating services coming much later than initial gains in provisioning services. Such lags provide important insight into the 'environmentalist's paradox' – wellbeing gains may be achieved despite losses of ecosystem services if the real effects of environmental degradation have not yet occurred. Finally, there is evidence of negative feedback systems – past losses of ecosystem services are becoming evident, and in turn this leads to accelerated ecological degradation. For example, farmers suffering from reduced yields due to soil acidification respond by increasing their use of fertilisers.

wellbeing are also measured, these are often positive too. As an example, the two cases that reported on gender outcomes found that positive effects on income were linked to positive effects on social relations (specifically gender equality in these cases) because land use intensification led to greater income earning opportunities for women, which improved their autonomy and social standing (Agoramoorthy et al., 2012; Dahal et al., 2009).

However, this does not mean that income is a reliable proxy measure for multi-dimensional wellbeing outcomes. In Mozambique (Box 6.1), land use intensification mainly led to improvements in those aspects of wellbeing that involved household control over income. We also find cases where rising income from land use intensification actually led to reduced food security, for example in upland Laos, where intensification of crop production has been found to lead to poorer nutritional outcomes (Box 6.3). Such cases challenge simple notions of synergy between income growth and other measures of human wellbeing.

**TABLE 6.2** How increased income is associated with changes in non-economic human wellbeing outcomes. This table reports only on cases that find land use intensification to have a positive effect on local incomes

| | *Positive outcomes* | *Mixed outcomes* | *Negative outcomes* |
|---|---|---|---|
| Education | 6 | 2 | 0 |
| Food security | 9 | 0 | 3 |
| Natural capital (e.g. land, livestock) | 10 | 1 | 2 |
| Material assets | 4 | 4 | 1 |
| Employment | 8 | 7 | 0 |
| Health | 1 | 1 | 1 |
| Social relations | 2 | 1 | 0 |
| Property rights | 1 | 4 | 0 |
| Justice | 1 | 0 | 0 |

In order to further explore *social-ecological trade-offs* we looked at the pair-wise social and ecological outcomes for each of the 61 cases. The most common paired outcome, found in 23% of cases, is for gains in wellbeing (most commonly income) to be accompanied by losses in ecosystem services. These included water quality (Dearing et al., 2014; Hossain et al., 2016, 2017), carbon storage (Börner et al., 2007), trees in the landscape (Rahman et al., 2016; Wood et al., 2016) and biodiversity (Okubo et al., 2010; Renwick et al., 2014). In a further 10% of cases, gains in wellbeing were accompanied by mixed outcomes for ecosystem services. Only in 17% of cases do we find 'win-win' paired outcomes, dominated by measures of food production and income.

These observations of trade-offs are crude, in the sense that they mainly observe co-outcomes rather than establishing causal pathways. Nevertheless, the overall picture is important: considering the relatively small body of research that investigates both ecosystem services and wellbeing outcomes, win-win outcomes remain quite rare, and positive outcomes for income and food production are frequently associated with negative outcomes for other ecosystem services.

## *Disaggregated outcomes*

All trade-offs ultimately have a social outcome, because different groups value different ecosystem services in different ways. This means that the outcomes of land use intensification will typically involve winners and losers, and thus any serious attempt to understand connections between ecosystem services and poverty alleviation needs to disaggregate outcome measures in ways that reveal impacts on

## BOX 6.3 LAND USE INTENSIFICATION AND DISAGGREGATED WELLBEING OUTCOMES IN UPLAND LAOS

This case focuses on three villages around the Nam Et-Phou Louey National Protected Area in north-eastern Laos. Land use intensification has involved adoption of a new cash crop, reduced fallow times and increased inputs, partly driven by the desire to 'spare' land for tiger conservation. Maize was introduced in 2010, under contract farming arrangements, and villages further from the park's core have integrated maize production into their shifting cultivation systems, whereas Phon Song village has adopted continuous maize cultivation due to land constraints.

Using a Multi-dimensional Poverty Index, it was found that poverty rates had fallen rapidly, from 59% in 2004 to 20% in 2014, but this had been accompanied by reductions in food security. In Phon Song, with the most intensified landscape, there were significantly fewer wild foods, including rodents – 77% of villagers never replace this lost protein source through market-bought meat. Thus, the most intensified landscapes in this region may be the least well nourished. Disaggregated analysis found that inequalities in income were increasing and were closely linked to access to land. When park boundaries were demarcated in 2000, customary land rights became formalised and this favoured households with the most farm labour and those with social connections. This initial condition of inequality is now being amplified – for example, wealthier households are better able to encroach upon park land.

This case illustrates feedback systems that connect changes to ecosystem services and human wellbeing. Land use change contributes (among other drivers) to the commercialisation of farming households, and this is entwined with cultural change that includes a decline in forests as places of spiritual significance – even animist ethnic groups now present domestic rather than forest goods as gifts to their ancestors. Economic and cultural change is shifting the values attached to ecosystem qualities, such that wild plants and animals that were once viewed as provisioning services are increasingly viewed as pests and weeds. In Phon Song, the use of rodenticides and herbicides is becoming more common as a result and researchers observe a co-evolving relationship between cultural and ecological diversity. In this village, the reduction of fallow periods is already leading to falling yields, causing farmers to take loans to intensify inputs, and also leading to widespread illicit forest clearance in the Total Protection Zone. Therefore, it is questionable whether intensification here is sustainable, either for future food production or sparing land for conservation.

Source: Broegaard et al. (2017), Dawson et al. (2017a,b), Rasmussen et al. (2017b)

economically and socially marginal groups. A study from Rwanda, for example, finds that national data on farm incomes is a poor indicator of the wellbeing outcomes for the poor (Dawson et al., 2016). It is therefore surprising that only 11 of our 61 cases reported disaggregated analysis of wellbeing outcomes. Those that do explicitly consider the impacts on marginalised groups (Dawson et al., 2016, 2017b; Dearing et al., 2014; Hossain et al., 2016; Islam et al., 2015) confirm that poor people are less able to access benefits from land use intensification due to a range of institutional and structural barriers to accessing land, capital and expertise. Furthermore, they show that environmental outcomes of land use intensification can be particularly damaging for small farmers and fishers (Hossain et al., 2016; Islam et al., 2015; Box 6.2). One of the emerging findings from studies of disaggregated outcomes of land use intensification is that where inequity is deepened, this not only undermines poverty alleviation objectives but can also undermine long-term ecological sustainability (Dawson et al., 2017b; Martin, 2017). In the example from Laos (Box 6.3), inequitable access to land is amplified by land use intensification and local perceptions of inequity are eroding the legitimacy of the protected area boundaries.

### *Social-ecological outcome pathways*

While we cannot derive rigorous generalisations, we observe that social-ecological outcomes are associated with the type of land use intensification activity. In particular, case studies that primarily involve increasing inputs to land-based production systems are more often associated with positive social-ecological outcomes compared with cases of crop change and land conversion. Indeed most cases involving 'increased input' intensification activities (11 out of 20) report decisively positive human wellbeing outcomes while only 3 out of these 20 report decisively negative wellbeing outcomes. There is an even split between those reporting positive and negative ecosystem service outcomes (8 out of 20 each). Such summary findings are important to note and to follow up in further research, but many cases are likely to involve hidden impacts of intensification. For example, because outcomes are scale dependent, in terms of the time taken to manifest themselves, and in terms of the spatial distribution of benefits and costs, land use intensification may bring wellbeing benefits in one place while transferring costs to other places (Pascual et al., 2017). Thus, if we want to better understand bundled social-ecological outcomes we need to be careful about what we measure, the length of time we measure it for, and the level of aggregation. If we want to understand how land use intensification can contribute to pathways out of poverty, we need longer-term and cross-scale work to understand how losses to key ecosystem services, particularly regulating services, can be avoided (Dearing, this volume).

Considering 'crop change' and 'land conversion' cases, we find anecdotal evidence of fewer positive outcomes for either wellbeing or ecosystem services, and more 'lose-lose' outcomes with negative impacts for both. More research is needed to confirm such trends, though we can still learn from example cases. The 'lose-lose' cases in our sample demonstrate that the pathways leading to these

outcomes are quite varied. For example, we see pathways in which the negative impact on ecosystem services comes soonest and appears to be the cause of negative impacts on the wellbeing of smallholders, e.g. where soil salinisation ultimately undermines livelihoods of the less wealthy, or where deforestation from charcoal intensification ultimately undermines local income. But we also see cases where negative ecological and social outcomes appear in parallel from early on – for example, research in forest-agriculture mosaic landscapes in Rwanda shows how economically and socially marginalised groups were immediately disadvantaged by the government's Crop Intensification Programme, particularly through economic barriers to compliance, reduced tenure security and prohibition of traditional agriculture (Dawson, 2015; Dawson et al., 2016).

The presence of multiple outcome pathways reflects the importance of particular contexts in determining outcomes of land use intensification. For example, in the Laos case the spatial context was crucial, with different outcomes for villages located in different zones of the protected area. In Mozambique, national policy context was important in terms of which dimensions of human wellbeing outcome were affected by land use intensification. However, we also tentatively discern some regularities across categories of outcome pathways. Considering lose-lose categories, we first observe that these tend to directly or indirectly involve increased crop specialisation, with a shift towards monocultures of cash crops – for example, maize cropping in Laos, shrimp production in Bangladesh and tea crops in Rwanda. These changes have been associated with quite rapid impacts – for example, pests that feed on maize, concentration of land holdings in the Rwanda and Laos cases and acceleration of salinisation in the Bangladesh case. Second, drivers of land use intensification often leave marginal groups with limited choices. In Rwanda, government policy has dictated crop change; in Laos, the reservation of land for conservation has driven the switch to continuous maize cropping. A common factor in these cases is that the smallest landholders lack command of the assets needed to succeed with the induced crop change. Thus, a repeated observation is that negative wellbeing outcomes arise from an inability to make necessary intensification of inputs, including investment in labour, fertilisers and pesticides (Aragona and Orr, 2011; Dawson et al., 2016; Jakovac et al., 2015, 2016; Shaver et al., 2015). Finally, we observe that costs are often transferred to the poorest groups as an indirect result of intensification by other farmers, e.g. through increased risk of pests due to the reduction of genetic diversity.

## Conclusions

We introduced this chapter by highlighting expectations for land use intensification to deliver on poverty alleviation and environmental protection goals. Our review shows that we are still some way from understanding the extent to which such 'sustainable intensification' is being achieved in practice, or indeed how it can be achieved in future. An uncritical and summary review of the evidence as a whole might conclude that land use intensification leads to improvements in human

wellbeing despite losses to biodiversity and ecosystem services. However, a deeper exploration makes it clear that we need more research that considers multiple ecosystem services and human wellbeing dimensions, and the multiple and non-linear timing of impacts, as well as finer-grained social levels where impacts are differentiated.

Despite limitations, our research through this lens of integrated social-ecological enquiry reveals few cases of 'win-win' outcomes from land use intensification, and that some apparent wins hide a more complex picture. Where impacts on biodiversity, regulating and supporting ecosystem services are measured (which in itself is not common), the outcomes are more often seen to be negative. Furthermore, in several cases declining ecosystem services are accompanied by losses in wellbeing for some groups of people. These cases suggest multiple and complex pathways to 'lose-lose' outcomes that will benefit from further research. Losses to ecosystem services can lead to losses in human wellbeing, but the reverse causality also appears possible as well as less linear relationships. Equity is in some cases a mediating factor, showing that particular elements of human wellbeing can feed back on ecosystem governance.

While the evidence is limited, the literature suggests that many negative outcomes from intensification are partially predictable. For example, that the poorest will have least access to land, credit and other necessary factors of commercialised agricultural production; and that a progressive shift to landscape level monoculture will increase the demand for soil nutrients and the threat posed by pests and diseases. It is likely predictable that removing or reducing fallow periods will increase the resources needed to deal with weeds; and that heavy irrigation in arid areas will produce salinisation, or that changing large areas of land to saline aquaculture will lead to salinisation problems for adjacent paddy fields; and it is predictable that rolling back or abandoning some forms of intensification when they turn out to be disappointing can be difficult. What is less clear is the pace at which such effects will play out, the kinds of feedback systems that may lead to rapid and irreversible change, and the social and political response to these.

The research and practice communities can contribute to achievement of land use-related SDGs in two main ways. First, we can better use the available knowledge – for example, incorporating new findings related to the differentiated impacts on marginalised groups. But second, to further advance our understanding of sustainable intensification, there has to be a paradigm shift in how we approach and evaluate the outcomes of intensification efforts. Judging purely on production and income increases is inadequate.

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