Finding the Right Balance: Exploring Forest and Agriculture Landscapes

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SNV SMART DEVELOPMENT WORKS

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Foreword

Agricultural expansion is a major driver of deforestation. Given a growing population and projected growth in demand for food, fuel and fibre it will continue to exert the greatest pressure on the remaining forest areas, for the foreseeable future. If we are to tackle deforestation (and its associated greenhouse gas emissions and its impact on biodiversity) then it is at the nexus of agriculture and forests where solutions need to be found. It is critical we clearly understand the relationship between agricultural production systems and their impact on forest landscapes. There continues to be a knowledge gap in our understanding that can, and has, led to the prescription of seemingly intuitive but likely erroneous or partial solutions. As this report highlights, the relationship is complex, often with no simple win-win outcomes. It requires more sophisticated analysis and integrated solutions.

For SNV Netherlands Development Organisation (SNV), an organisation that primarily works on improving agricultural practices to reduce poverty, it is of high interest how we could merge our skills in this area with our expertise in forestry. It was for this reason the REDD+, Energy and Agriculture Program (REAP) was developed. For REAP, the question remains of how we encourage agricultural development in order to increase rural incomes and improve food security without destroying forests. It is critical that we understand this in order to determine our strategy when working in forest-agriculture landscapes.

This discussion paper aims to advance our understanding of the relationship and to propose solutions. To this end the paper develops an assessment framework. It is hoped that the paper will provide guidance to scholars, policy makers and development practitioners to further enrich their understanding and guide them to identify and introduce appropriate interventions that can balance objectives in the forestry and agriculture sectors. In the context of climate change it is no longer a desire but a need to keep the world’s forests standing.

Tom Derksen

Managing Director Agriculture

Executive Summary

The competition for land between agriculture production and forests has resulted in agriculture being the most significant driver of deforestation and degradation globally, accounting for around 80 per cent of the world's deforestation over the last decade (Graham and Vignola 2011). This paper further examines the relationship between forests and agriculture. To do this we first take a historical perspective to understand the evolution of agriculture production systems and interactions with forests. With global food demand expected to double in the next 50 years, alongside increasing demand for agricultural commodities for non-food products such as biofuels, competition for land remains a key challenge in balancing the demand of global consumers with the need to maintain forest health and quality (Graham and Vignola 2011, Rudel 2009). In the context of climate change, there is a need to move out of this long phase of economic development during which forests have been sacrificed.

An examination of the basic incentives which lead to the conversion of forests for agriculture, highlights that the dynamics and causes of deforestation and forest degradation are multiple and highly complex. The evolution towards more integrated and global markets and, at the local level, the political economy dynamics, clearly highlights the considerable challenge in changing current incentive structures. Addressing this challenge will require innovative, integrated solutions, including the development of improved technologies and policies that promote more ecologically efficient food production while optimising land allocation for forest conservation and agriculture. It also requires solutions that tap into the myriad of economic values that forests currently provide. Community-based forest management (CBFM), payments for ecosystems services and REDD+ may not provide the silver bullet, but they are critical ingredients in balancing the agriculture-forest interface.

One commonly cited option to reconcile agricultural development and forest protection, which has garnered much support, is through agricultural intensification; the basic idea is that if we can increase agricultural yields per area in order to meet the growing global food demands this will reduce the need for more land and hence avoid further encroachment into forested areas. Agricultural intensification provides huge benefits and can help increase the income of many poor farmers, but it also poses serious risks, especially to forests, primarily by increasing the returns from agriculture and therefore providing further incentives for expansion of the sector. While this hypothesis likely holds at the global level, at the local level a number of factors will condition what impact agricultural intensification will have on forested areas. As we move towards a more globalised system of production the competition is only likely to increase, with the value from agricultural land increasing and excess supply rapidly absorbed. The need for balance between land for forest and agriculture can also be addressed through stricter regulation and/or enforcement.

Countries such as Brazil have shown how this can be achieved. However, for the foreseeable future in many of the tropical forest countries, this regulatory framework is still either very weak or does not exist.

We do not question the need for technological improvements in agriculture, nor do we believe that forests must take priority in any competition for land. In order to release millions of people from poverty there is the need for such developments and land must be found. What we question is where and how agriculture is cultivated, as well as the types of activities that should be introduced to support solutions that balance the needs of the agriculture and forestry sectors. A siting tool has been developed to help identify the suitability of different agricultural commodities across a landscape, which includes potential risks to forest conversion. This provides the necessary information on the agriculture-forestry relationship across a landscape, enabling trade-offs to be examined, and helps to identify pro-poor and sustainable solutions.

Given the growing commitments from agro-industries and governments to no deforestation in supply chains, it is more important than ever to fully understand this forest-agriculture relationship and to prescribe appropriate solutions. The tool can be applied by development practitioners, governments and agro-industries to help steer efforts towards practices that find the right balance between agricultural development and forest protection.

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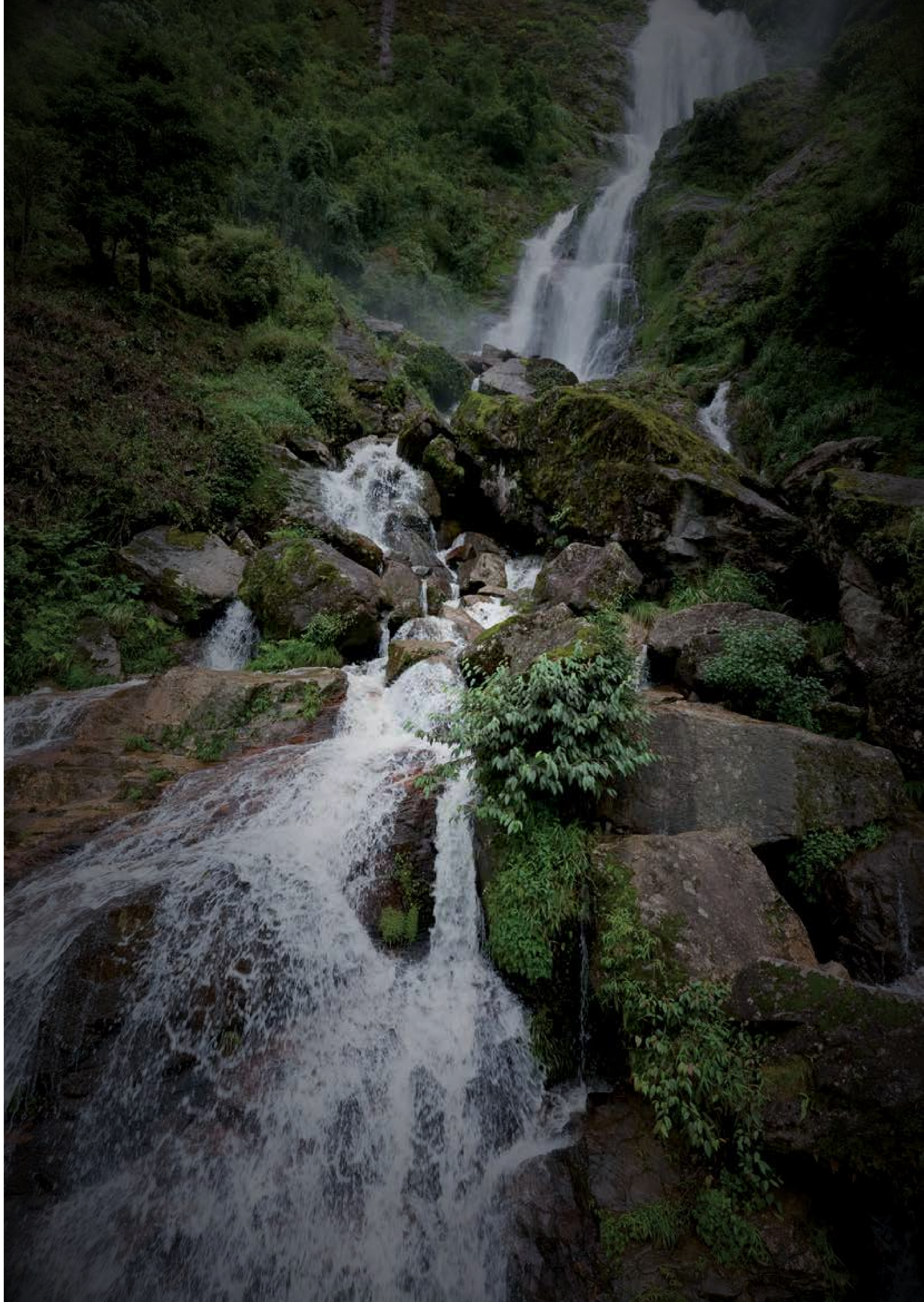
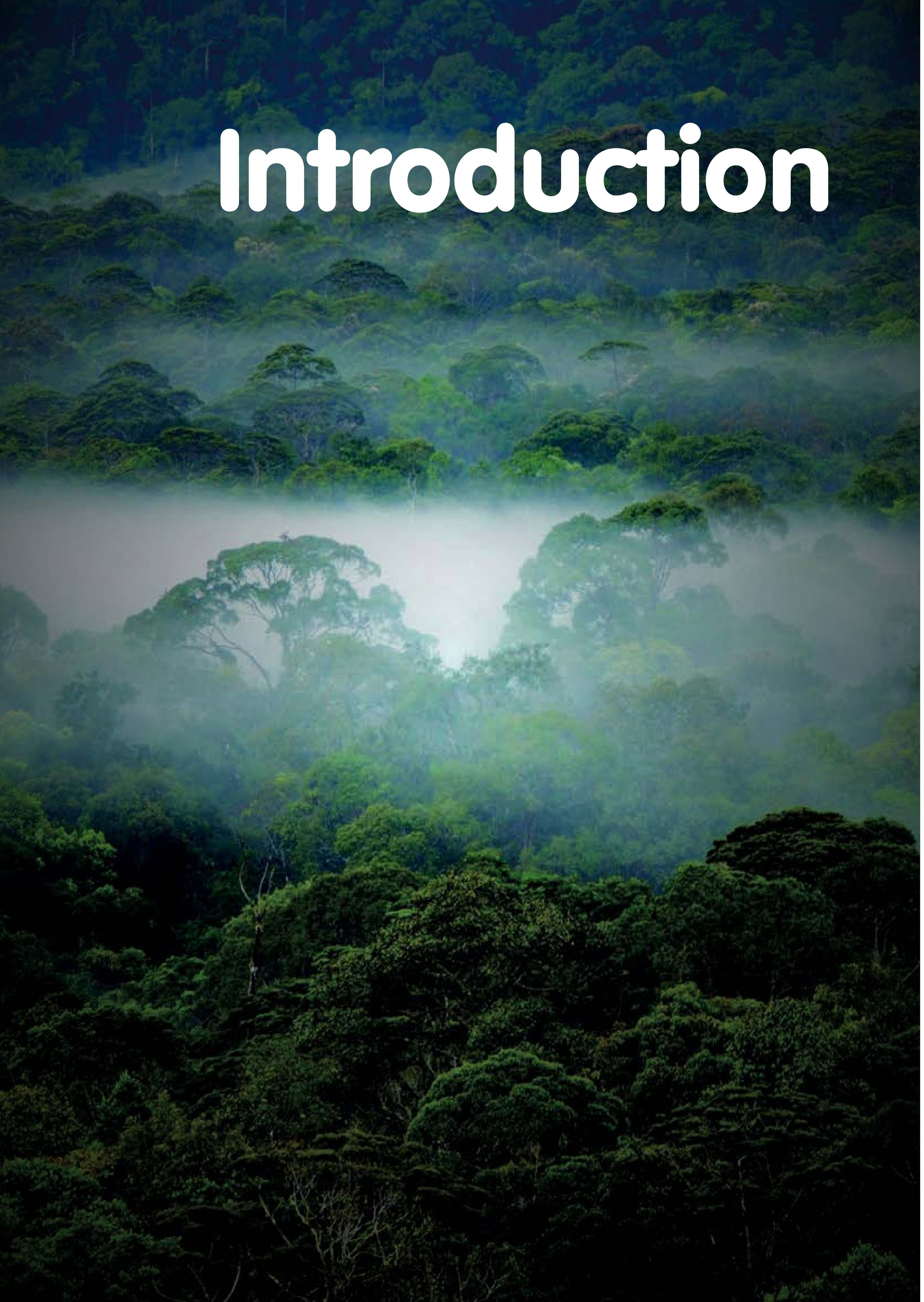
Abbreviations

ASB	Alternatives to Slash and Burn Partnership for the Tropical Forest Margins
CBFM	community-based forest management
CIFOR	Centre for International Forestry Research
EKC	environmental Kuznet curve
FT	forest transition
GHG	greenhouse gas
HCV	high conservation value
ICRAF	The World Agroforestry Centre
NTFPs	non-timber forest products
P&C	principles and criteria
PES	payment for ecosystem services
RCA	responsible cultivation area
REAP	REDD+, Energy and Agriculture Program
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RSPO	Roundtable on Sustainable Palm Oil
SNV	SNV Netherlands Development Organisation





Introduction

For most countries, greater agricultural output and forest conservation are both promoted as part of national plans and policies.

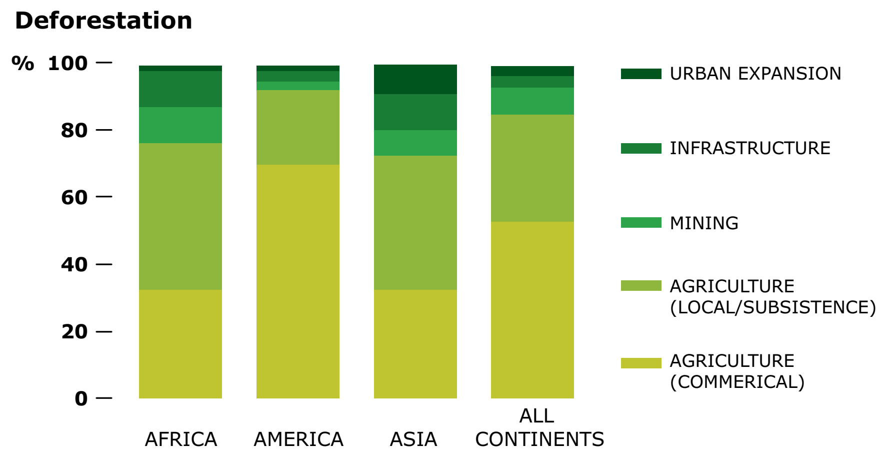
Both goals are viewed as vital in promoting sustainable development. However, agriculture and forests are intrinsically linked, principally through the direct competition for land, which means these goals may often not be compatible. The dynamics and causes of deforestation and forest degradation are multiple and highly complex. Proximate or direct drivers of deforestation are human activities that directly affect the loss of forests and can be grouped into different categories; these are generally recognised as agriculture expansion, infrastructure development and wood extraction (Geist and Lambin 2001). As shown in Figure 1, agriculture is the major driver of deforestation. These direct drivers result from complex interactions of underlying forces in social, political, economic, technological and cultural domains and need to be tackled at multiple levels in order to stop deforestation in the long-term. The relationship between the drivers also needs to be clearly understood, as they are often linked, in particular logging, a major driver of forest degradation, is often closely associated with subsequent agricultural expansion (Souza 2006).

The rapid expansion of agriculture for food, fuel and other products has resulted in significant greenhouse gas (GHG) emissions. An estimated 4 - 14 per cent of global GHG emissions are associated with deforestation and degradation, making agriculture a major component of global climate change mitigation efforts (Vermeulen et al. 2012). It is therefore critical that we fully understand the relationship between the development of the agriculture sector and its impact on forests and propose appropriate integrated solutions. In this paper we aim to clarify these relationships and describe tools we currently use that can provide insight into the trade-offs between deforestation and (agricultural) development.

In the first section a historical perspective is presented in order to understand the evolution of agricultural production systems and the interactions with forests. This section highlights how the relationship has changed over time and the fact that the same trajectory of using forest land for agricultural expansion cannot, and should not, be pursued. In section two we further examine the basic motivations and incentives that lead to the conversion of forest for agriculture land. This further confirms that the dynamics and causes of deforestation and forest degradation are multiple and highly complex. It is therefore critical that there is a thorough understanding of the situation in order to recommend appropriate interventions.

The third section further explores the notion that agricultural intensification is a solution to engaging local farmers in approaches that deliver higher yields alongside forest protection. Here, it is shown that the relationship is far more complex and will often have the opposite affect at the local level. Drawing on the seminal work of Angelsen and Kaimowitz (2001), eight factors that standout as principal determinants of the interrelationship of land intensification with deforestation are examined. This section further demonstrates how government policy can support or counter any efforts.

Figure 1: Major direct drivers of deforestation and forest degradation 2000-2011 in tropical and sub-tropical countries (Rautner et al. 2013)



Building on findings from the previous three sections of this report, a siting tool is outlined in Section 4 to help practitioners determine an approach to balance the twin objectives of agricultural development and forest protection across landscapes. It is expected that the application of this will reduce the risks of deforestation from future interventions and deliver sustainable agricultural development. SNV is currently applying this tool to help determine approaches across different landscapes.

Section 1:

Agriculture, Forests and Deforestation: a Historical Perspective

In this section we summarise some of the basic ideas and theories that serve as a conceptual foundation to understanding how forest and agriculture systems have evolved over time. Building on these we look at how this relationship is likely to evolve given future challenges.

1.1 Evolution of agriculture production systems and the interaction with forests

Over time, agriculture production systems have changed in how they interact with forest systems. A dominant historical trend exists (Sunderlin et al. 2005, Gibbs et al. 2010): early hunter and gatherer populations used the forests as a source of food; with the onset of swidden cultivation, forests served as a source of agricultural lands whose fertility was maintained and restored by forest ecosystems in a system of rotational fallow; this was followed by a move to more permanent agriculture at the forest frontier, where forest lands tend to serve as a source of new agricultural lands (Sunderlin et al. 2005). Moving from hunting and gathering to sedentary agriculture, forests tend to become less dense and forest cover decreases; there are, however, significant exceptions (Sunderlin et al. 2005).

Through the course of this transition, populations in forested areas typically become more integrated with the market economy, with the proportion of overall household income from forest resources tending to decline. This is a result of increased income opportunities in agriculture and other sectors and also due to decreased availability of types of forest resources that might have been abundant in the past (Sunderlin 2005) (see Table 1).

Deforestation and forest degradation has fuelled agricultural expansion and economic development, arguably benefiting billions of people (Sunderlin et al. 2005). However, in the context of climate change, it is no longer just desirable but is necessary to keep forests standing, and there is a need to move out of this long phase during which forests have continued to be a sacrificial biome (Sunderlin and Atmadja 2009). The transition of agriculture for subsistence to local and then global markets to feed a growing population with increased per capita resource consumption has been a major trend fuelling large-scale depletion of the world's forests. This competition for land has resulted in agriculture being the most significant driver of deforestation and degradation globally, accounting for around 80 per cent of the world's deforestation over the last decade (Graham and Vignola 2011).

Table 1: Types of forest-based livelihoods and associated attributes of forest use

	Associated attributes of forest use			
Type of livelihood	**Main type of forest use**	**Density of forests**	**Mode of forest use**	**Forest product income as share of total income**
A. Hunting and gathering	Food: capture and collection of forest fauna and flora	High	Direct use value in household: high Exchange value (income through sale): low	High
B. Swidden cultivation	Source of agricultural land restored by forest fallows Use and marketing of forest products	Medium	Use value: medium Exchange value: medium	Medium
C. Sedentary agriculture at forest frontier	Source of new agricultural land Marketing of forest products	Low	Use value: low Exchange value: high	Low

1.2 The forest transition theory

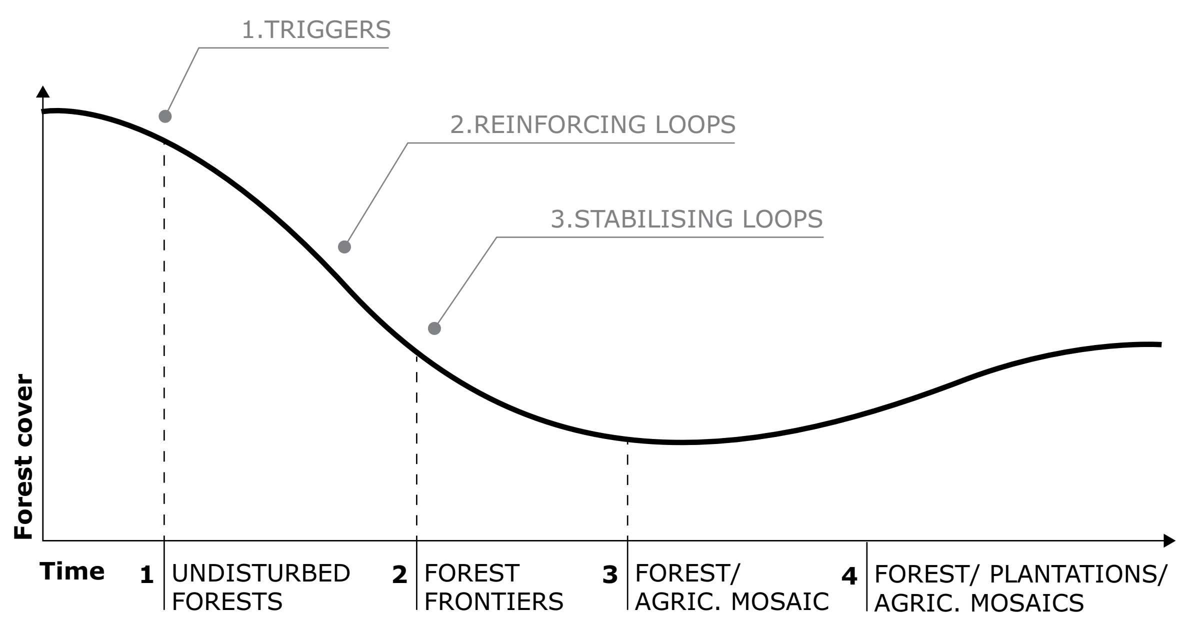
The likely temporal changes in a country's forest cover can be represented by the forest transition (FT) theory. FT is a generalised model and is broad enough to capture the empirical regularity witnessed across most of Europe and America over the last 200 years as well as more recent trends in Africa, Latin America and Asia (Angelsen 2007, Angelsen and Rudel 2013). There has been a gradual transition from deforestation to reforestation in Europe, while agricultural yields have continued to increase (Mather 2001).

The reasons for this have been described by Mather (2001): the move towards more commercially orientated agriculture, facilitated by improved transport networks, has allowed for more specialised production and severed the links between local population growth and agriculture expansion. In combination with the introduction of improved technologies focused on cultivating more productive areas, there has been a gradual shift of agricultural production from marginal to fertile regions, with some of the marginal areas reverting back to forest. At the same time, the onset of industrialisation has seen migration out of rural areas to cities for industrial jobs (Mather 2001). This has been accompanied by a shift in energy supply from wood to coal therefore reducing the need for wood fuel. This period also witnessed major political and cultural changes, with society attributing greater importance to the protection of forests (Mather 2001). These conditions influenced the policy and regulatory framework that enables yield increases in agriculture production and forest conservation.

This forest transition has been summarised by Angelsen (2007) in Figure 2, which shows the four stages and three influencing factors driving the transition. Triggers refer to factors which start the deforestation process, which are later reinforced by other factors such as technological advancements or the construction of roads and ports to facilitate trade (Angelsen 2007). Deforestation stabilises as forest rents (the value assigned to them by society) become higher due to scarcity and socio-economic or political forces (stabilising loops), leading to a period of forest-agriculture mosaic and eventually forest recovery (Angelsen 2007).

This highlights the need to understand where a country or a region lies along the forest transition curve. Countries further along the transition curve are likely to have developed

Figure 2: The forest transition theory



the necessary institutions and regulatory frameworks to deal with abuses of forest conversion.

1.3 The environmental Kuznets curve (EKC)

The FT theory highlights that forest cover stabilises with time. The idea that economic development and the conservation of forest cover are ultimately compatible goals — that environmental degradation displays an inverted-U shaped pattern over time as income rises — has been described by the environmental Kuznets curve (EKC) (Grossman and Krueger 1994). This relationship has been examined specifically for forests (see for example Culas and Dutta 2002, Madhusudan, Hammig and Bhattarai 2001). Based on the environmental Kuznets hypothesis, it can be argued that countries can grow out of deforestation. In which case the best option is to accelerate economic growth in order for countries to reach a point where forest will stabilise and reach a stage of recovery. However, there are fundamental flaws in this hypothesis.

Firstly, in order for rich countries to reach a period of forest cover restoration this has been achieved by high per capita consumption of fossil fuels which has allowed agricultural intensification, the greater import of agricultural goods and a greater reliance on the urban sectors (service, manufacturing, industry), as well as wood fuel substitution. All of these reduce the pressure on a country's forests but considerably increase the level of fossil fuel consumption, which cannot be extended globally due to the threats of global climate change (Sunderlin et al. 2005). The linkage of environmental quality with domestic incomes also ignores the fact that environmental degradation through resource use is often driven by international demand. Therefore, the level of economic activity in such sectors will not bear an automatic relationship to the aggregate incomes or institutional development of the country in which the activity takes place. Environmental problems can be exported to other countries.

It must also be recognised that even if forest cover does increase this will not be the same forest and some of the ecological services, such as biodiversity, may be lost or degraded. Even if the predictions hold true, the estimated EKC turning points occur at GDP per capita levels of around US$4,000–6,000 (Wunder 2003) and therefore most tropical countries are far away from their turning point. It would take many years of accelerated environmental degradation, with potentially large catastrophic, irreversible effects, before they could reach this level — if they ever can. The world is no longer able to sustain such levels of resource use (WWF 2012). The issue then becomes how countries can reach a level of income and related forest conservation without having to go through the many years of destruction; in other words, how can they tunnel through the Kuznet curve?

1.4 Future trends in the interaction between agriculture and forests

It is clear that the general pattern of forest areas competing with the need for land for agriculture will only intensify. With global food demand expected to double in the next 50 years, alongside an increasing demand for agricultural commodities and non-food products — particularly biofuels — the trade-off between forests and agriculture remains a key challenge going forward in balancing the consumptive demands of global consumers with the desire to maintain forest health and quality (Greg-Gran 2010, Graham and Vignola 2011, Rudel 2009).

Laurance et al. (2014) reviewed the trends of agricultural expansion and its impacts on tropical forest ecosystems and biodiversity given a growing human population and consumption patterns and an expected large-scale increase in the demand for food and biofuels. Analysing these trends, the authors expect that this will lead to: 1) large expansion and intensification of agriculture in the tropics, mainly in Sub-Saharan Africa and South-America; 2) on-going land conversion and degradation of tropical mature forests, woodlands and semi-arid land types; 3) a key role for new infrastructure in determining where and how extensive agriculture will take place; and 4) growing conflicts between food production and nature conservation. The question therefore remains: how can these likely trends be countered? One saving grace is that much of the land may not be able to be converted due to its inaccessibility, relatively low quality and vulnerability to erosion, among other reasons (Evans 1998). Nevertheless, in many areas, there will be a continuation of the historical role of forests in wealth creation through predatory forest-product harvesting and forest conversion, even if at a reduced scale compared to the past (Sunderlin 2005).

Over the longer term the human population and its demand for resources may stabilise, but for the foreseeable future this is not the case. It is not the purpose of this paper to put forward solutions to address these underlying factors driving resource use. However, it is the purpose of this paper to understand how, given the likely trends, it is possible to introduce improved integrated forest and agriculture solutions.

Addressing this challenge will require innovative, integrated solutions, including the development of improved technologies and policies that promote more ecologically efficient food production while optimising the land allocation for conservation and agriculture (Laurance et al. 2014). It will also require decision makers (governments, private sector suppliers, international organisations) to learn from decades of experience in attempting to strike a balance between agricultural expansion and forest conservation. Such thinking needs to take into account the complex interplay between global supply and demand for agricultural commodities and the intricate web of stakeholders involved at various levels: international, national and local. The tendency to focus on win-win scenarios should be avoided. It will often be the case, as is shown by history, that such win-win outcomes cannot be found. There is the need to accept trade-offs and to establish processes to better deal with them. There is an inherent difficulty, if not an impossibility, of having various stakeholders agree on optimal trade-offs, but clear information on the choices can help avoid needless conflicts and lay the groundwork for consensual solutions (Sunderlin 2005). In order to be able to put forward viable solutions, it is first important to better understand the basic motivation that drives people to cut down the forest to replace it with agriculture.

Section 2
Agriculture, Forests and Deforestation:
the Incentives to Convert

This section provides a better understanding of the factors that motivate people to replace forests with agricultural production systems. The section begins by presenting the basic hypothesis around land rents, which helps to describe the economic incentives underlying the decision to deplete forests. A number of interventions which increase forest rents are then examined as well as an assessment of options. Finally, we look to better understand the complexity of factors influencing land use decisions, in particular the key role of the state in determining natural resource use.

2.1 The von Thunen hypothesis: land rents

Basic economic principles would dictate that land is allocated to the use which yields the highest rent, or financial return. In this way, a forest will continue to be cleared up until the profit from conversion becomes uneconomical. This is underpinned by the von Thunen hypothesis. In this case, land rent is expressed as a function of the distance of the forest to the marketplace. In this way, forests closer to the market will be more accessible and more vulnerable to being cleared for agriculture. The theory was developed nearly 200 years ago and although the world and it dynamics have become a lot more complex, the basic idea on land rents remains. Numerous factors will influence the spatial relationship and the rental value including commodity prices, labour and capital availability and the cost of inputs (e.g. wages). The factors are also underpinned by the underlying causes of deforestation: notably political and social factors which will be dealt with in the next section.

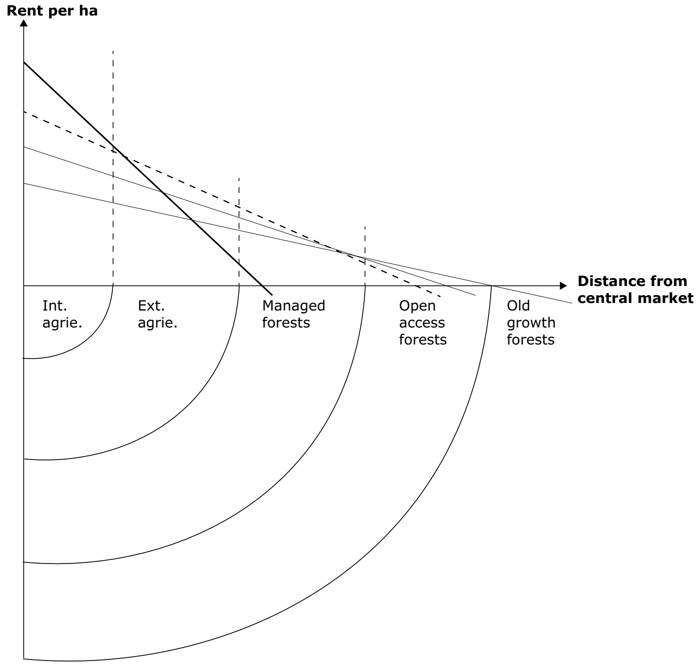
The agriculture-forestry trade-off illustrated through the von Thunen hypothesis is extended by Angelson (2007) by considering how the theory can be represented for five broad land-use types: intensive agriculture, extensive agriculture, managed forests, open access forests and old growth (virgin) forest (Figure 3). In this case, areas within close proximity to the marketplace and where exploitable land rents are high are likely to be under intensive agriculture. This is true for many lowland landscapes in Southeast Asia which have been converted into rice fields, for example. As the distance increases, rents become higher and more costly to exploit which indicates a progressive move from intensive agriculture through to extensive agricultural systems (e.g. expansive grazing areas common in Latin America) and eventually to untouched old-growth forest (Angelsen 2007).

Angelsen (2007) defines the distance between the extensive agriculture and the forest as the extensive margin. This area is particularly important in the context of efforts to limit deforestation through continued agriculture expansion into forested areas.

This model can be linked to the forest transition theory: forests tend to transition through four stages depending on the rents available from either forests or agriculture (Angelsen 2007). High agricultural rents will lead to a period of high deforestation. The rate of deforestation will slow over time as the forest rents become higher (e.g. due to scarcity of forests, stricter enforcement and/or the introduction of payments for ecosystems services) and eventually lead to a period of forest recovery as the rent equation tips in favour of forested land (Angelsen 2007).

Figure 3: The von Thünen model with five alternative land uses (from Angelsen 2007).

Note: The four rent curves are designated by different lines: fat-solid = intensive agriculture; fat-dotted = extensive agriculture; thin-solid = managed forestry; thin-dotted = open access forestry.

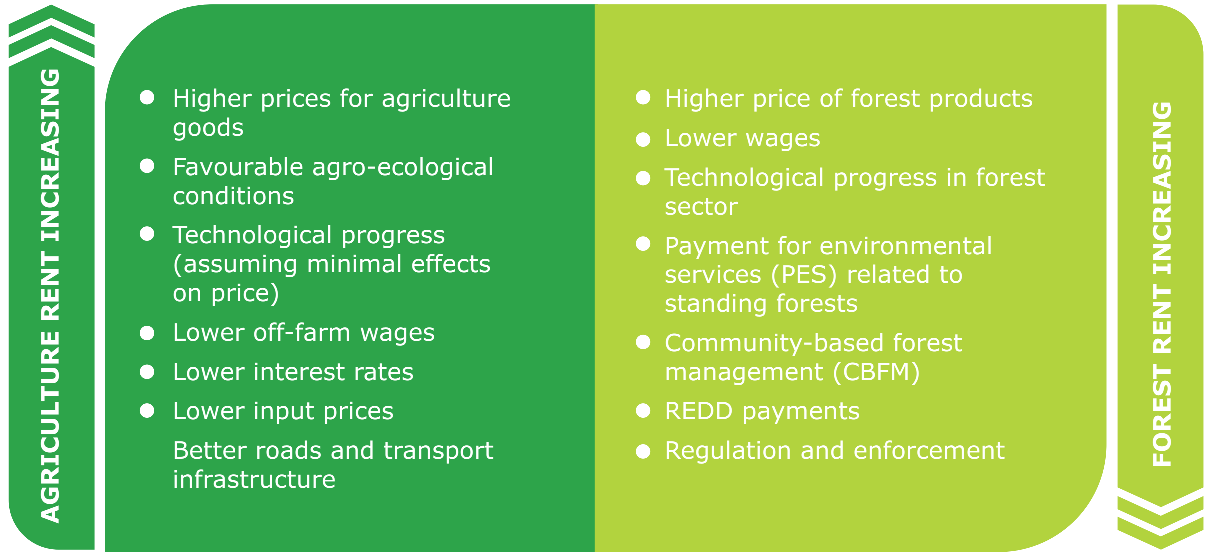


It is important to highlight how changes which may occur in the extensive margin may have indirect consequences for production in the intensive margin and vice versa. For example, if technological advancements result in an increase in production per hectare, this can result in an increased supply of the commodity in intensive land uses and may reduce deforestation pressure in the extensive margin. It could also help increase wages and lead to further migration into the area from the forest frontiers, again reducing pressure. This clearly highlights the need to adopt a broader landscape approach when examining the forest-agriculture relationship.

Figure 4 highlights some of the factors which may influence the decisions to convert or protect forests on these extensive margins. The right-hand column indicates those factors which increase forest land rents and therefore act as an incentive for forest protection. One approach to address the balance of agriculture and forestry objectives would be to introduce activities that push up the rental value of forests.

Clearly this is a simplified model which does not capture the full complexity of the dynamics of land and forest rents. A major cause of deforestation and forest degradation is from illegal and/or unsustainable harvesting which is a result of the high economic values associated with different tree species (Geist and Lambin 2001). High timber prices can lead to increased mining of the forest resource. However, this does not deflect from the fact that introducing ways to increase the value of standing or sustainably used forests will help ensure their survival. Successful efforts to promote more sustainable use of forests, such as agro-forestry (Minang et al. 2014, Minang and van Noordwijk 2013, Albrecht and Kandji 2003), forest certification (for example, Forest Stewardship Council) and community-based forest enterprises (small-scale wood processing industries, promotion of the exploitation of non-timber forest products (NTFPs), apiculture, etc.), (Macqueen 2009, Macqueen 2008) are discussed at length elsewhere so are not discussed in this report. Such approaches are necessary to help redress the agriculture-forest balance in order to promote a more sustainable use of forests. There are also possible interventions to increase the protective rental value of forests; these include tapping into possible payments for ecological services, as well as REDD+ payments. These schemes, and the main ingredients for success of these, are outlined Box 1. An important intervention which has shown to be a critical ingredient in forest protection is introducing CBFM systems.

Figure 4: Factors influencing agricultural and forest land rents[1]



Community-based forest management

Community-based forest management (CBFM) is a term used to describe models of forest management and use in which the rights and obligations are assigned to the neighbouring local communities. CBFM is commonly cited as a solution to bring both conservation and income benefits to local communities and therefore a means to raise the forest rent curve, curbing the pressure to deforest.

Research examining case studies in 16 countries across Latin America, Africa and Asia found that protected areas lost, on average, 1.47 per cent of forest cover per year compared to just 0.24 per cent in community-managed forests (Porter Bollard et al. 2012). Greater rule-making autonomy at the local level was associated with better forest management and livelihood benefits (Porter-Bollard et al. 2012). In general, it would appear that average deforestation rates have been lower in indigenous territories and communities than in other forests outside protected areas, particularly in Latin America. Recent studies from Bolivia, Brazil, Colombia, Honduras, Mexico, Nicaragua, Panama and Peru all support this overall conclusion (Bonilla-Moheno et al. 2013, Armenteras, Rodriguez and Retana 2009, Killeen et al. 2008, Oliveira et al. 2007, Nepstad et al. 2006, Stocks, McMahan and Taber 2007).

Recognition of the importance of CBFM has been met with greater efforts to introduce such systems in many countries. Between 1985 and 2000, the forest areas owned by communities in developing countries more than doubled to over 380 million hectares – representing approximately 22% of the total forest area in those countries (White and Martin 2002) with further large increases until 2008 (Sunderlin 2009).

Indigenous peoples and other local communities formally own or have legal rights to manage more than 270 million hectares of forest in Latin America; almost 40 per cent of the total forest area (Rights and Resources Initiative 2014). Formal government recognition of indigenous ownership of most of these forests is relatively recent; most indigenous territories received their titles in the last forty years, and many in the last decade or so (Rights and Resources Initiative 2014).

1. Adopted from Angelsen (2007)

Commonly cited benefits of establishing CBFM include the following (Angelsen 2007):

- Local communities are better able to manage the forests, with more in depth knowledge of the surrounding forest areas and the resources they provide
- Local communities will often establish their own set of social systems which provide overall structure, management and policing of forested areas
- Goods and services provided by the forest are consumed locally which provide a further incentive to maintain or use them sustainably
- Cash and non-cash incomes increase, primarily through the ability to accrue value from the sustainable use of the forest area (e.g. NTFPs or timber); this also provides an incentive to stop encroachment from outsiders.

The trend which emerges from an examination of CBFM is that its success is mixed and that it delivers better in terms of forest conservation than community livelihood improvements (Angelsen 2007). Where such schemes are building on traditional tenure arrangements, there is a higher likelihood they will succeed.

In an examination of the relationship between CBFM and poverty alleviation it is necessary to differentiate between poverty avoidance and poverty mitigation (Sunderlin et al. 2003). While CBFM is shown to support poverty avoidance, the potential to support poverty mitigation is not so evident (Sunderlin et al. 2003). There are a number of factors which might explain why the evidence on poverty mitigation has so far been less promising. In an assessment of the impact of the policies to transfer large areas of forests back to communities it was found that new statutory rights do not automatically result in rights in practice and a variety of institutional weaknesses and policy distortions have limited the impacts of change (Larson and Dahal 2012). Other explanations include the fact that expectations concerning the ability and incentives of forest communities to solve the basic collective action problems, as well as the potential forest benefits on offer, have been too high in the first instance (Angelsen 2007). Also, the drive towards decentralisation and CBFM by national governments has been driven more by forest conservation than poverty agendas, with the opportunities for use of forest products often restricted to meet domestic needs, removing any opportunities for increasing incomes through commercial trade (Angelsen 2007). In some cases the communities have been restricted access to the more valuable timber resources which continue to be extracted by the state and/or other organisations with vested interests. Add to this the fact that there continue to be minimal payments for ecological services, such as watershed payments and/or carbon payments, and the economic benefits to communities are often small or even negative (Angelsen 2007).

CBFM can be an important strategy to increase overall forest rents and act as a break on deforestation. However, in order to provide a lasting solution which brings both conservation and income improvements it is necessary to identify and introduce interventions which allow the communities to procure the full economic benefits from the forest. A number of options for sustainable forest management are mentioned in the section above. Other options to increase the protective value of the forests are outlined in Box 1.

As with all payments for ecosystem services, in order to be effective they need to have clear resource land tenure arrangements. In the forest frontiers where the highest levels of deforestation are taking place, these resource tenure systems are often lacking. This supports the approach to link such schemes to CBFM efforts. A critical element of success will be introducing appropriate benefit distribution systems (Enright et al. 2013).

Although the preceding text points to the fact that there are clear options which could act as a break on agricultural expansion, such interventions are not always supported. Governments may not support the outright control of such forest lands by communities and may want to control any possible stumpage value from timber extraction.

Against this background, the relationship between/amongst national laws, economics and political institutions and government policies is central to many recent explanations of forest loss. Ultimately, how resources are used will come down to national and local authorities and their desire for forest conservation. For many countries at low levels of per capita GDP, there continues to be a lack of funds to invest in forest conservation and the need for economic growth, at the expense of forests, is deemed paramount. There are also vested interests which can influence

Box 1: Options to increase the protective rental value of forests

Protective value	Description
Payment for ecosystem services	Under payment for ecosystem services (PES) schemes buyers pay forest/land users to change their practices in order that they continue to provide ecosystem services from the forest/land. In this way, PES essentially increases the forest rent by recognising more completely the set of values the forest provides. PES schemes have been designed for conserving watersheds, protection biodiversity, preserving scenic beauty and capturing and storing carbon (Landell-Mills and Porras 2002). There is already some evidence that well designed PES schemes can result in efficient, cost effective and equitable conservation (Wunder et al 2008, Landell-Mills and Porras 2002)). Although the basic idea behind PES schemes is simple, the ability to introduce such schemes can be institutionally challenging (Landell-Mills and Porras 2002) particularly in remote areas, like forest frontiers, where there are underdeveloped institutions and an overall lack of governance (Wunder 2008). In those more remote areas the need for community forest management becomes more evident. The three ecological services -- biodiversity, watersheds and landscape beauty -- are too spatially specific to allow for true competition: the users have to work with the providers who happen to occupy the land that provides their targeted ecosystem services, with most existing PES schemes being transactions with one single buyer, e.g., the state or a hydro-electrical power plant or only few large buyers (Wunder 2008b). Under genuine market preconditions PES schemes would, in fact, never happen because the transaction costs of negotiating PES deals would be too high (Wunder 2008b). Payment schemes for these services are probably best addressed through scaled-up, state-run schemes, which can address both institutional and informational transactional-cost constraints (Wunder 2008b). Given the basic institutional structures required, as well as a commitment from the state to protect these ecological services, it continues to be challenging for such schemes to be introduced in many countries.
Carbon/ REDD+	It has been estimated that 17-18 per cent of GHGs are produced in tropical regions by land that is being cleared for agriculture, logging and activities that degrade the integrity of forests (IPCC 2007). REDD was perceived as a quick and cheap option for taking early action to limit global warming to 2°C. However, it became evident REDD+ required broad institutional and governance reforms, such as tenure, decentralisation and corruption control, and that there was a far greater need to work on policies outside the forest sector, particularly agriculture (Angelsen 2009). The problems of introducing REDD+ do not distract from the basic fact that forests are a critical store of carbon that contributes an important economic value that needs to be captured and distributed to the providers of the this service. Estimate of the economic value falls from around US$34-50 which produces very high estimates for the value of forests as carbon stores (Tol et al. 2000). Although this is far above the price traded on international markets, it provides an indication of the economic importance of the carbon stored in trees. In order to be effective in providing an economic counter weight to agriculture rents it is important that appropriate sites are targeted. These need to be high-threat, low cost, carbon rich areas. Using spatial targeting will be critical to the success of REDD+ schemes. In order to better understand the opportunity costs, various models have been produced. The REDD+ Abacus model (Harja D et al. 2011) can help understand the level of potential payments which may provide sufficient economic incentives to change behaviour. This allows for the identification of feasible areas at the margin where REDD+ finance may tip the balance in favour of forest protection.

political processes on how resources are used. In order to better understand these incentives the role of politics and national governance in defining resource use are further developed in the section below.

2.2 Politics, economic liberalisation and political economy

Policies and the regulatory frameworks are key factors which determine whether or not forest encroachment may occur. Incentives for people to migrate to rural areas to exploit land for agriculture through land grants and access rights defined by policies and regulations, for example, have seen waves of deforestation occur across the world. Subsidies on agricultural inputs have also lowered the production costs, making it more viable in remote areas often associated with high-value conservation areas (OECD 2005). Infrastructure developments have also facilitated the expansion of agriculture into forested areas (Pirard and Belna 2012). Weak enforcement and limited capacity is a persistent issue around many protected areas.

The relationship of national laws, economic and political institutions, and government policies to environmental degradation is central to many recent explanations of forest loss. There are two underlying causes associated with political choices which fundamentally define resource use within a country. Firstly, there is the trend towards a globalised system of economic production facilitated through market liberalisation, and secondly, there are the more localised political economy forces at play which influence resource/forest use. These factors can be re-enforcing. Each is examined below.

Market liberalisation

The 1980s and early 1990s witnessed major changes in policies in many countries, moving towards market liberalisation for goods and capital and cutbacks in government regulations and interventions. The role of national and international goods and financial markets in shaping production and resource use patterns through prices has been considerable (Stedman-Edwards 1997). The actual environmental impact of market liberalisation depends on a myriad of factors, for example: whether the crops promoted are less damaging than domestically produced crops; whether the changes in commodity mix precipitate extensification or intensification; how it changes labour markets, etc. The results tend to be mixed (Reed 1996). Although these adjustments may have helped countries to promote economic growth, they have also been associated with a greater need for forest land for agricultural production of export commodities. Commodity booms have precipitated large scale deforestation across the world (Angelsen and Kaimowitz 2001).

Expanding global markets for key agricultural commodities has stimulated a continuing need for further land areas for agriculture. Huge growth in the international demand for palm oil, for example, has driven 80 per cent of plantation expansions in Asia through the 1990s, mostly in Indonesia and Malaysia (Graham and Vignola 2011). In Brazil, increases in deforestation rates by 28 per cent in 2013 were driven by a combination of price hikes for soy alongside a weakening domestic currency (Nepstad et al. 2013). This has driven up land values, causing the take-over of cattle grazing land for soy production and pushing graziers into forested land (Nepstad et al. 2013). In Vietnam, large tracts of forests in the Central Highlands were removed to fuel the boom for coffee production in the early 2000s (Vietnam RPP 2012).

Governments have often sought to mitigate some of the effects of relations with international markets through macroeconomic policies that alter prices, including controls on trade, capital flows, exchange rates and national markets. It is also recognised that changes in macroeconomic policies, without changes in the underlying political and market structures (the political economy), may worsen resource use patterns (Stedman-Edwards 1997).

A political economy perspective

Political economy is concerned with the distribution of and struggle for power and resources, and analyses the attributes of underlying formal structures to identify and understand interests and incentives (Lutrell et al. 2012). The primary focus of political economy approaches is on actors, networks, institutions and their competing interests. When applying a political economy lens with respect to forest and agriculture, we examine how political structures and decisions determine how forest land is used, and by whom, and the relationship with the interests and actors within the agriculture sector. Its importance in defining the relationship between forests and agriculture has been clearly highlighted for Brazil (Campari 2005) and Indonesia (Lutrell et al. 2012). It attempts to go beyond understanding economics as the only factor which determines how land is used at the forest-agriculture margins, highlighting the role of politics in the struggle for power and resources which shape interests and incentives.

Political economy recognises that there may be a bias in political decision making to support the more politically influential groups and to prioritise their needs. Providing access to land for agriculture (which could be forested areas) provides a relatively low cost option to be used to gain political support from powerful groups. Priority is often given to the politically more powerful groups, such as business and industry. Business and political interests in the land-based natural resources sectors can be highly intertwined (Brockhaus et al. 2011) with authorities dependent on the support from these sectors. In some cases this has led to dispossession of forest land from communities to business interests in the agriculture sector (Colchester, Jiwan and Kleden 2014). Policies both within and outside the forestry sector that support deforestation and forest degradation create path dependencies and entrenched interests that hamper policy change (Brockhaus et al. 2013).

Competition for political power often takes place within a formal legal framework, but winning depends on delivering exclusive patronage benefits (jobs, money, access to services, monopoly privileges) directly to supporters or clients, or appealing to ethnic or other sources of identity. Understanding the impact of these institutional arrangements in a given context is therefore critically important.

Where national governments have taken responsibility for resource management away from local people the communities have few options under national laws to legitimise their tenure claims and they may be more likely to opt for a strategy of forest clearing to strengthen their claims and prevent others from clearing their land first. The breakdown of common property institutions, often induced by government policies or by in-migration, creates new open-access resources (Southgate 1988).

Forest-dependent people who live in or near forests tend to be politically weak or even powerless. There is a history of competition with more powerful outsiders, such as national governments, forest concessionaires, agro-industrialists, commercial farmers and operator of mines, for access to the forest resources they depend on. The political weakness of forest-dependent people is reinforced by their geographic distance from urban centres where political alliances favouring forest conversion tend to be formed and maintained (Sunderlin 2005).

Therefore, to understand resource patterns under a political economy perspective one must look not only at the results of policies and market structures, but also at the reasons why those policies and market structures persist. Understanding the dynamics of the incentive structures between the levels is important in assessing the likelihood of national-level reforms such as REDD+ being implemented successfully (Lutteral 2012). This distribution of political and economic power will shape policies that affect forest use (Stedman-Edwards 1998).

2.3 Summing up

This section highlights that the dynamics and causes of deforestation and forest degradation are highly complex. It is critical that they are well understood in order to prescribe appropriate responses. Local users will often be driven by those options which make most economic sense, which in the case of forest land often means agriculture expansion. In the absence of strict regulations and enforcement, local farmers have an incentive to continue to remove forest to expand agriculture.

In this section we show how we can help balance this relationship through adding value to the forest rents. This may require a suite of interventions, securing community rights as well as helping tap into potential financing sources to provide an economic incentive for forest protection. However, the underlying forces of global integration of markets as well as political economy motivations at the local level clearly highlight the difficulty in changing the incentive structures. The question therefore remains: what can be done or what would be the best strategy to bring about change which meets the twin objectives of increased agricultural production and forest protection.

One option which has been widely promoted is agricultural intensification, so more can be produced from less land. This would seem an intuitive response. However, it would appear to go against the economic rents argument, as efforts to intensify would increase the agricultural rents and potentially increase pressure for conversion of forest land. Given the fact that the land intensification argument is being used as a response to halt deforestation, it is clearly critical that this dynamic is fully understood or policies and actions could be introduced which have the converse affect to their stated aims. Attention is directed in the next section to better understand whether agriculture intensification will support forest protection.

Section 3:

Reconciling Agriculture with Forests:

the Role of Agricultural Intensification

3.1 Agricultural intensification and forest protection

The increasing demand for agricultural commodities for food, fuel and other products, alongside a diminishing area of fertile land, continues to place pressure on forests. Solutions could involve looking at ways in which existing land can be used more effectively through agricultural intensification.

Intensification is typically promoted through changes in production systems which improve the efficiency of the land being used (Baudrion and Giller 2014). By generating more output per unit of land, it is intuitive that less land will be cleared because of the efficiency gains made within the existing agricultural landscapes. This theory is often referred to as the Borlaug hypothesis – named after Norman Borlaug, noted as *"the father of the green revolution"*[2]. The green revolution describes a period from the 1940s to the late 1960s in which significant technological change brought about large increases in agricultural productivity. It is often linked in many countries (especially across Asia) to reduced pressure on forests (Angelsen and Kaimowitz 2001). The introduction of fertilisers, irrigation and pesticides to farming across staple food crops (in particular rice, wheat and maize) brought about a huge global increase in output, without the need for a major expansion into new lands.

Intensification can be stimulated in many ways. Often, intensification is promoted through technology which improves the way crops are grown resulting in an increase of the crop per unit area of land. For example, technology may be introduced to replace labour through the introduction of mechanised labour. Intensification can also come through the introduction of new seed varieties which provide a higher yield or are perhaps more resilient to local conditions. It can also be promoted through simply increasing investments into the existing practices. For example, hiring more labour or applying a larger quantity of fertiliser can promote larger yields in the short term. Such options may not be currently available to low-income farmers who are poor and are therefore capital and credit constrained. Thus, intensification efforts may be supported through financing mechanisms which allow smallholders to invest in production methods they otherwise would not have been able to afford.

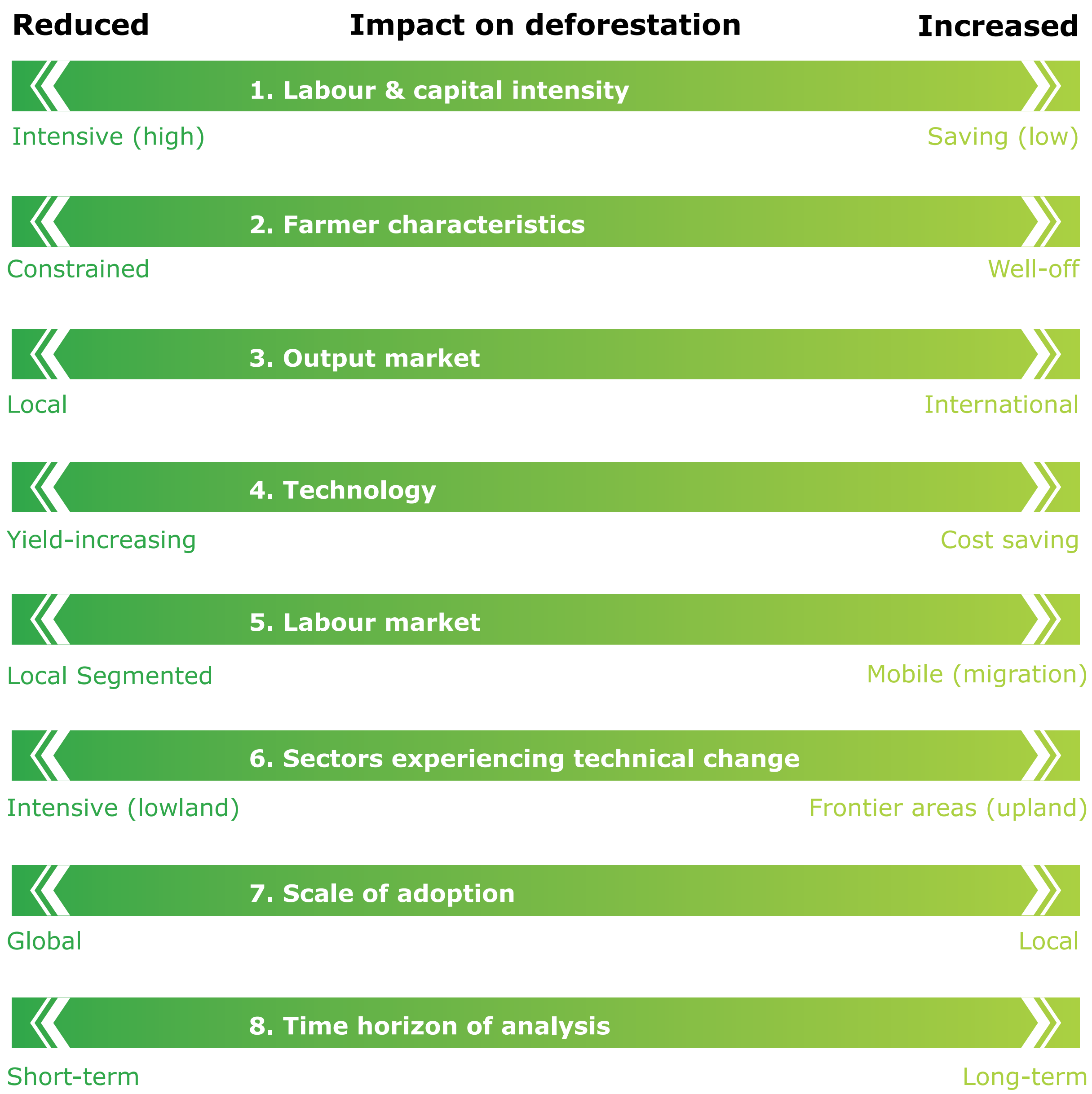
To understand the impact on forests it is critical to consider how farmers will react in response to the introduction of new technologies in agriculture. A generally accepted hypothesis, which has stood the test of time, is that as long as there is unutilised potential farmland (i.e. forest areas), farmers will have an economic motivation to expand their cultivated areas, rather than to intensify (Boserup 1965).

The relationship between technology change in agriculture and forests is complex and will differ on a case by case basis. Angelsen and Kaimowitz (2001) developed a theoretical framework that helped to formulate initial hypotheses on the impact of agricultural technology on forest areas, which were subsequently examined against 16 case studies from around the world. One of the reasons they undertook this research was

2. Scott Kilman and Roger Thurow. "Father of 'Green Revolution' Dies". The Wall Street Journal.

that they felt that the research community and general public knew surprisingly little about this issue and decisions and policy were often based on perceived myths rather than hard facts. This seminal work helped identify eight key factors which condition whether the introduction of technologies for agricultural development will result in deforestation or not. These have been summarised in Figure 5 and are examined in more detail below. The issue of the underlying policy context is also highlighted, given its influence on all the key factors.

Figure 5: Key issues in the technological change–deforestation link (adapted by author from Angelsen and Kaimowitz 2001)



3.2 Key issues in the relationship between agricultural intensification and forests

1. Labour and capital intensity of new technology

Smallholder farmers are typically characterised by constrained access to both capital and labour. At forest frontiers while labour and capital are often scarce, land is often abundant and farmers' preference is for new technologies which help supplant these scarce factors of production (capital and labour) in order to expand production into new forest areas. Any new technology that affects this balance of capital and labour will therefore influence the size of the area of land they can produce on (Angelsen and Kaimowitz 2001). In situations where farmers are not capital or labour-constrained, it is less important how labour- and capital-intensive new technologies are (Angelsen and Kaimowitz 2001).

If the technology is able to free up labour, this would allow the farmer(s) to use this time to expand their agricultural area (and potentially convert more of the forest area). In cases where greater mechanisation leads to less need for labour, it can lead to migration of workers to other (forested) areas. In a study from Sulawesi, Indonesia, Ruf (2001) finds that green revolution technologies were linked with more forest clearing in the uplands for cocoa planting due to the movement of freed up labour to these areas.

In the case of capital this is often highly constrained for poor farmers; any saved capital is likely to be invested back to improve their livelihood. If a technology is introduced which allows for greater saving this would allow farmers to have additional funds which could be used to invest in land expansion. Evidence shows that farmers are more likely to expand their area than intensify the current area (Boserup 1965). In sectors which are capital-intensive, such as soybean production, subsidised credit and access to private credit removed a potential brake on expansion (Kaimowitz and Smith 2001).

Understanding the relative effects of technological changes to the balance of capital and labour will be an important determinant of whether intensification is coupled with forest protection. The end result will, however, also be dependent on other factors discussed below, including the labour market, scale of the technological change and the time horizon.

2. Farmer characteristics

Agriculture intensification is likely to lead to reduced pressure on the forest land where local farmers are motivated by subsistence needs (Angelsen and Kaimowitz 2001, Pirard and Belna 2012, Graham and Vignola 2011). Smallholders in more remote areas are less likely to be motivated to clear additional land under intensification as their primary concern is to produce food for their immediate needs (Graham and Vignola 2011). In the most simplistic case, where communities are 100 per cent subsistence farming, intensification of agriculture would therefore certainly reduce forest pressure. This basic notion is often referred to as the full-belly scenario (Angelsen 2013).

However, in cases where farmers are able to produce surplus to their requirements they may be motivated to sell and use any capital raised to further invest into new areas. In the above example in Sulawesi an additional impact of the introduction of the green revolution technologies was that it led to an increase in the wealth of smallholder farmers who then typically reinvested these profits into clearing land for cocoa (Ruf 2001).

For commercial, profit seeking operators, intensification will likely promote further clearing as operators seek to exploit further opportunities to expand into forested lands (Graham and Vignola 2011). Commercial scale operators are also typically better linked to the market, and can easily sell excess supply. Larger scale operators are also better placed to reinvest higher profits from intensification into capital and further land acquisitions (Angelsen and Kaimowitz 2001). However, this does not rule-out commercial-scale land intensification coupled with forest protection. Additional incentives and/or strong government regulation would need to be put in place to prevent large scale operators from clearing land following productivity increases.

3. Output markets

Agricultural intensification implies that through the expansion of output on existing land the additional supply of agriculture produce can be used to meet existing demand, thereby lessening the pressure on nearby forest areas (Matt 2013, Graham and Vignola 2011, Angelsen and Kaimowitz 2001). However, this assumes that demand for the commodity is fixed and that local farmers are unable to sell excess supply (Graham and Vignola 2011). Such a case may be true for remote farming communities who are isolated from larger markets or live close to a subsistence way of life and are therefore less motivated by larger market incentives (Angelsen and Kaimowitz 2001). However, the move towards global integrated markets implies that there this excess supply is rapidly absorbed. Where the output market is local, the impact on deforestation is reduced, whilst when the output market is global the impact on deforestation tends to increase. The extent will depend on a number of factors.

One key factor is the relative responsiveness of demand to changes in prices (the price elasticity of demand). The more responsive demand is to changes in prices (referred to as elastic demand), the more likely any intensification will promote deforestation, especially for exported crops (Angelsen and Kaimowitz 2001). Basically, as overall prices fall due to more output, demand responds to this fall and increases, triggering a market incentive to produce more (which may require more land). This is referred to as the rebound effect', following a productivity gain of significant size. In this case, intensification promotes an increase in supply from existing land which will likely generate a fall in prices and eventually a spike in demand (Pirard and Belna 2012). Here, the environmental benefits likely to be linked to the productivity gains can be quickly offset by the corresponding fall in price and increased demand (Pirard and Belna 2012). If the price is not responsive to output changes (referred to as inelastic demand) there will be less of a rebound effect and it is therefore less likely that intensification will eventually lead to further deforestation.

Another critical factor is the relative scale at which the production change occurs. The larger the change in output has on the total market share of supply, the larger will be the effect on prices. These two factors can help explain why the green revolution was able to have a significant impact in reducing the expansion of land. Food commodities, such as rice and cereals, are relatively unresponsive to changes in prices – people need these commodities even if prices go up. So demand is unlikely to change significantly and there will not be a major rebound effect. Also, the green revolution led to a considerable increase in supply which depressed the overall price for the food crops. Therefore the technologies were widely introduced, leading to a considerable increase in output, downwards pressure on prices and with demand not being highly responsive to the changes, this resulted in a drop in economic rents from the land and no major incentive for further expansion. Markets for more non-essential goods, such as coffee and cocoa, are more vulnerable to demand swings in line with changes in price. Efforts of intensification in such commodities can therefore be more vulnerable to a rebound effect. Non-food commodities which are highly substitutable are also more likely to be price sensitive. For example, rubber and biofuels tend to be more price sensitive because of the variety of substitute products on the market (Angelsen 2013). These explanations provide further explanation for the commodity booms and deforestation which have occurred globally.

Most agricultural commodities are also traded on multiple export markets meaning that any excess in supply is fast absorbed into other markets (Shively and Martinez 2001). Such is the case for global commodities such as palm oil, for which the raw materials are used in hundreds of different globally traded goods (Pirard and Belna 2012). As such, where farmers are linked into larger, international supply chains, any increase in productivity will likely be absorbed through several market streams, increasing profitability and thus likely to stimulate further deforestation (Angelsen and Kaimowitz 2001).

4. Technology

The relative effect of technology on the production system can also be a critical factor in whether land is spared from further clearing following intensification. This can be best highlighted through the distinction between two types of technology: those that increase yields and those that reduce costs (e.g. mechanised labour).

In the case of technologies which reduce costs they do not directly affect supply and output prices, although they may affect supply indirectly by increasing the profitability of production (Angelsen and Kaimowitz 2001). In doing so, cost-saving technologies can directly increase farmer profits and make it more attractive to reinvest in expanding their activities through clearing land. Alternatively, yield increasing technologies may have a positive effect on forest protection by limiting the necessity of expanding to maintain supply. This effect will, however, depend on a suite of additional factors discussed here, namely the scale, price elasticity and labour effects of the technology change.

In the case of the American South, Rudel (2001) illustrates how the green revolution generated an increase in yield and productivity across most key agricultural commodities, again leading to lower prices and reduced rent on marginal lands. However, many other factors were at play, especially the role of technology types and government policy. The main drivers of yield improvements came through fertiliser use and mechanisation, both of which supported more productive land areas (Rudel 2001). This drove the migration of many people on marginal land into the city to find alternative, non-farm employment, whilst the marginal land was reforested over time (Rudel 2001). Technology advancements as part of the green revolution were best suited to lowland agriculture. This was seen as an important reason for sparing upland forests since the technologies were not appropriate to apply in such areas.

5. Labour market

The effectiveness of intensification will also be dependent on local labour market conditions. Intensifying agriculture can alter the demand for labour and can also influence its supply, depending on labour mobility.

For example, initiatives to improve irrigation systems in agricultural production in Palawan, Philippines promoted an increase in labour demand in lowland farming areas (Shively and Martinez 2001). The resulting migration of workers to lowland areas to meet labour demand resulted in a significant reduction in forest pressure in upland areas (Shively and Martinez 2001). In Asia, the green revolution saw large increases in productivity generated in lowland wet-rice agriculture. The massive scale at which new cropping techniques and technologies were implemented, alongside the huge labour force that was mobilised to work under the intensive production systems, ensured that prices remained low and migration was largely kept to lowland fields that required more labour (Shively and Martinez 2001). However, the reverse effect can also take place. In particular, technological improvements in farming can lead to inward migration into these areas and stimulate additional forest loss due to the resulting population increase (Shively and Martinez 2001) and/or replacement of labour and the movement of displaced workers into new areas. This has been the past experience in cocoa markets in Ivory Coast and Indonesia (Sulawesi) whereby labour saving technologies and a mobile labour market prompted migration of displaced workers into neighbouring forest areas where they cleared land to start new plantations (Ruf 2001. Graham and Vignola 2011). This example illustrates the importance of both labour migration and the relative effect of technology improvements on labour demand.

Wudner (2001) also illustrates how the introduction of labour intensive banana production in Ecuador, coupled with road construction and a flexible labour market, drove major expansions in banana production and subsequent deforestation. Such trends are often referred to as commodity booms. Commodity booms generally occur when cheap labour is readily available and is combined with several other factors: large demand from international markets; policies supporting forest conversion to the new crop; abundant forest areas; and capital availability to finance the expansion (Angelsen and Kaimowitz 2001). There are many examples from around the world — from cattle production in Latin America to the large scale coffee expansion in the Central Highlands of Vietnam — where there was a large movement of labour to exploit the new opportunities from coffee production and fertile soils. In some cases, such migration is promoted and planned by the government authorities.

6. Sector experiencing technical change

Intensification targeted at commodities produced in lowland areas is typically considered the most conducive to the land sparing effect (Angeslen and Kaimowitz 2001). This effect is consistent with the spatial element of the agriculture-forest rent picture that was discussed earlier. This relates to where the intensification takes place; clearly if it is further away from the forest frontiers it is less likely to impact the forest. In particular, concentrating intensification in lowland areas has the effect of increasing the rents (profits) available on these lowland areas, making upland frontier areas which are generally less accessible relatively less attractive for expansion.

The converse is clearly also the case; intensification of crops in forest frontiers will bring them into direct competition for land with forests and potentially have a far more devastating impact.

7. Scale of adoption

The scale at which the new technologies are adopted will also be a fundamental factor in determining the relationship between agricultural expansion and forest protection. If there is large scale adoption of new technologies which help increase yields, this can add significantly to the global output. The likely effect on forests of such an increase in output has already been discussed.

If the level of adoption is relatively localised, the increase in production will likely have minimal effects on commodity prices. Therefore, with prices maintained, farmer incomes will likely increase. This would provide farmers with the option of reinvesting into expanding their land area. Efforts to promote new technologies/intensification in forest frontiers in specific landscapes may have little effect, except to improve the possible rents for farmers to expand. This is particularly the case if the commodity of focus is sold on international markets. This further highlights the challenge of ad hoc efforts to promote intensification as a solution to saving forests.

8. Time horizon

Technological changes can affect forest clearing in distinct ways and even opposite directions over time (Angelsen and Kaimowitz 2001). The short-term effects of technical change which generate benefits for forests can be reversed over time as other factors begin to undo the effects driving the positive change.

This effect is highlighted by Holden (2001) in the case of cassava production in Zambia. Here, improvements in cassava production were associated with short-term reduced pressures on deforestation (Holden 2001). However, as local markets developed and became more accessible over time, more people were attracted to cassava farming, provoking the clearing of forests to open up land for exploitation (Holden 2001). Similar effects are shown in the country's maize sector in the 1970s which saw intensification promoted through government fertiliser subsidies (Holden 2001). This initially resulted in a decline in deforestation rates. Overtime, however, the fertilisers were associated with soil acidification resulting in an abandonment of the programme and a return to production activities that were less intensive, but more extensive (Holden 2001).

These eight factors clearly show the highly complex relationship between efforts to intensify agricultural production and the impact on forests. This makes prescribing general solutions extremely difficult. A critical issue which will strongly influence the impact any efforts at agricultural intensification will have on the forest areas is the underlying policy and regulatory context.

3.3 The importance of the policy and regulatory context

Sectoral and general macroeconomic policies help determine both technology adoption and the impact technological change has on the environment (Angelson and Kaimowitz 2001). The changes brought about through intensification will have a much more positive effect if they are reinforced by other policy signals, such as effective regulations restricting farmers' encroachment on protected areas. Some other supporting policies are shown in Table 2. However, it is often the case that governments will prioritise policies to promote food security, boost supply and/or improve the country's trade balance at the expense of the forest. There are examples throughout the world where government policies have supported the movement of people to open up areas to exploit for agricultural conversion (e.g. soy production in the Amazon, coffee in the Central Highlands of Vietnam and cocoa in Western Ghana). Governments may promote the expansion of certain crops, either through economic incentives, such as subsidies or tax breaks, and/or production quotas, as part of the national agriculture strategy. For example, cassava (in Batouri) and oil palm (in Nguti) in forested areas in Cameroon.

The importance of the policy and regulatory context within a country to address deforestation has been clearly highlighted in the case of Brazil. Between 2006 and 2011, Brazil managed to reduce its deforestation rate by more than two-thirds from the 1996-2005 average, making the country the largest contributor worldwide to reducing GHG emissions (Boucher et al. 2013). This accomplishment was made despite high beef and soy prices, which had led to increased deforestation in previous years. In Brazil's Matto Grasso region the implementation of soy farm moratoriums in combination with stricter law enforcement to penalise illegal encroachment assisted in promoting soy farm expansion on degraded land rather than forested areas (Macedo et al. 2012). During the same time, Brazil made major social improvements in reducing poverty, hunger and inequality. Many actors are responsible for this success, including governments (both at the federal and state levels and from other countries such as Norway), businesses, indigenous peoples and NGOs; the key factor was the strong role of the state and the policies introduced to combat deforestation. The factors deemed to have contributed to this success are shown in Box 2 (Boucher et al. 2013).

However such leadership in combatting deforestation has not been seen in many other countries. It is important that Brazil's success story is held up as an example which other countries can follow and efforts are introduced to introduce supporting policies and regulations.

Box 2: Success factors for combatting deforestation in Brazil

Established policy framework

Both the national strategy, through the National Climate Change Plan, which aims to reduce Brazil's emissions from deforestation by 80 per cent by 2020, and the Amazon-wide commitments, provided the basic policy framework to address deforestation.

Soy and beef moratorium

As a leading soybean and beef exporter, Brazil's forests have been massively cleared during the previous decades to free-up land for production. After concerted pressure from civil society and considerable vision from officials a moratorium on deforestation from these industries was introduced. For soybean this came in 2006, for beef in 2009. After the moratorium, both industries have continued to grow healthily, even as deforestation rates slowed-down (USDA Foreign Agricultural Service 2011).

State actions

Most deforestation in Brazil takes place in a few states. State governors acted themselves and pushed the federal government to develop stronger policies against deforestation, which led to substantial reductions in deforestation levels in these states (Macedo et al. 2012).

Financial support from Norway

At the Conference of the Parties (COP13) to the United Nations Framework Convention on Climate Change (UNFCCC) in 2007, Norway pledged USD2.5 billion during five years to finance REDD+ programs worldwide, of which USD1 billion was reserved for Brazil's Amazon Fund.

Civil society and the changing political dynamic

The political pressure generated by the civil society contributed significantly in convincing government institutions to take actions. A broad coalition of NGOs launched the Zero Deforestation campaign in 2008.

Political leadership

On the political side, key people that contributed to reduce deforestation are Luiz Inácio Lula da Silva, former president, and Marina Silva, former minister of the environment and responsible for implementing the government's actions to reduce deforestation.

Table 2: Policies to support agriculture development and forest protection

Policy	Link to agriculture		Examples
Certification & standards	Voluntary agriculture standards are a commonly used way for producers to indicate the sustainability of their production methods. They focus on different elements of sustainability such as fair pricing (Fairtrade), biodiversity protection (Sustainable Agriculture Network) and greenhouse gas emissions mitigation (International Sustainability and Carbon Certification) (Gibbon et al. 2014). Certification and standards can help to promote zero-deforestation by providing incentives to move towards sustainable production (e.g. through price premiums and waste reduction).		• Aquaculture Stewardship Council (ASC); Fairtrade International; Global Aquaculture Alliance's Best Aquaculture Practices (BAP); International Sustainability and Carbon Certification (ISCC); Naturland Roundtable on Sustainable Palm Oil (RSPO); Sustainable Agriculture Network (SAN); UTZ Certified
Payments for ecosystem services (PES)	PES works by placing a value on services provided by the forest, including carbon, water quality and soil quality. This essentially increases the value of the forest and the opportunity cost of clearing or degrading it. PES can support land by incentivising forest protection and thus providing an additional source of income alongside improvements to local agricultural practices.		• Brazil: Acre State PES (see McDermott 2012) • Costa Rica: PES National Forestry Financing Fund (FONAFIFO) (see Herbert & Tepper 2012) • Mexico: Payments for Carbon, Biodiversity and Agroforestry • Services (PSA-CABSA) (see Corbera (2011) • Vietnam: Payments for Forest Environmental Services (see Pham Thu Thuy et al. 2013)
Macro-tools	Macro-economic (dis)incentives such as taxes and subsidies in the agricultural sector can be used to target technology that is more conducive to sustainable intensification.		• Taxes (subsidies) on agricultural inputs that facilitate (prevent) land clearing can help to support land sharing and sparing by distorting market signals in favour of more sustainable production.
Education	Supporting efforts to improve community awareness around forest conservation efforts can facilitate understanding and create a sense of ownership and responsibility.		• A joint initiative between Rainforest Alliance and Olam International (a major buyer of coffee) in Ghana has leveraged the support of local schools by providing children with education around the importance of reforestation efforts to support local shade-grown coffee initiatives alongside localised climate change mitigation and adaption. The education has proved a useful means of communicating these key messages through to older family members directly involved in reforestation efforts (Mistiaen 2013).
Trade restrictions/ agreements	The globalised markets for which most agricultural commodities are traded provides a useful platform to restrict (promote) the trade of illegal (sustainable) commodities through the use of trade barriers (incentives).		• The Netherlands has committed to importing only palm oil accredited under the Roundtable of Sustainable Palm Oil (RSPO) by the end of 2015 under the Dutch Taskforce on Sustainable Palm Oil (Routers 2010).
Moratoriums	Bans placed on logging and other practices influencing forest cover.		• Indonesia's Forest Moratorium instigated in 2011. Brazil's Soy Moratorium.

3.4 The need for a landscape approach

The preceding discussion clearly highlighted how the impact of agricultural intensification will depend on where it takes place within the landscape, which precipitates the need to look at the agriculture-forest relationship at this level. Such thinking has been clearly articulated under the Alternatives to Slash and Burn Partnership for the Tropical Forest Margins (ASB). Since 1994, ASB has worked to raise productivity and the income of rural households in the humid tropics without increasing deforestation or threatening essential environmental services. During the twenty years of work on these topics, the research of the ASB programme evolved from the Borlaug hypothesis, in which there is a sharp edge between land for forest and land for agriculture, to a holistic landscape approach in which the focus is on reducing emission from all land uses (REALU). Four distinct phases can be identified in this evolution (Tomich et al. 2007, Minang et al. 2014).

Phase I: The Borlaug hypothesis was the dominant idea at the start of the ASB programme. This hypothesis supposes that agricultural intensification will reduce the need for land expansion and therefore reduce deforestation. This idea was rejected in the 1990s by early studies, which concluded that intensification is necessary, but not sufficient to reduce deforestation. Increased productivity could also accelerate deforestation when agriculture becomes more profitable and attracts migrants to the area, stimulated by global demand. This was called the Pandora's Box Problem.

Phase II: In the second phase, the win-win hypothesis received support, in which intensification is accompanied by policies such as forest protection and resource tenure laws. The idea was that development and conservation can both be met when there is the right mix of technology change, institutional innovation and policy reforms at the national level. Evidence for strong trade-offs between local and national development agendas and global environmental concerns, such as ecosystem conservation and carbon sequestration, led to growing criticism for this integrated conservation and development concept. The criticism was rather pointing to the weaknesses in the implementation activities, instead of disagreeing with the underlying theory.

Phase III: This led to the incentives hypothesis in the third phase. The hypothesis supposes that with the right incentives, sustainable land use solutions are found in middle-pathway land uses that provide both productivity, economic and environmental benefits, for example, agroforestry. This thinking was inspired by the findings that the costs of win-win solutions, integrating both development and forest conservation, are high and cannot be financed by governments of developing countries, therefore requiring global investments or payment schemes. To manage the landscapes sustainably, creative and efficient solutions were needed.

Phase IV: It was perceived that the earlier proposed solutions to integrate agricultural development and environmental conservation did not adequately consider functions such as climate regulation, biodiversity, hydrological functions, food security and other economic functions. This led to the support of the sparing-sharing-caring hypothesis, meaning that every landscape needs to consider all the multiple functions at a landscape level (so in various land uses) and is linked to payments for ecosystem services. Emission reductions and synergies between climate change adaptation and mitigation is a focus point in this holistic landscape approach.

Learning these lessons they further highlight the need to adopt a landscape approach when exploring and introducing solutions which achieve both forestry and agriculture ambitions. Working at this level allows coverage of key jurisdictions and allows alignment with local or district planning processes (for example, for agriculture and forestry). It also facilitates cross departmental dialogue, which is ultimately required to balance objectives across the agriculture and forest sectors. By properly understanding the landscape and the forces at work that drive land-use change, better targeted solutions can be introduced.

A planning approach at the level of subnational administrative units – state, province, district, etc. - affords a scale large enough to address many of the governance, market and policy failures that typically underlie the drivers of deforestation and forest degradation, as well as marginalisation of the rural poor and persistent biodiversity loss. It also allows for a more nuanced contextualisation not possible at the national strategy level. Integrating climate change mitigation objectives into land-use planning at the subnational level permits stakeholders to negotiate a triple bottom line — economic, environmental and social returns — across the productive landscape as part of low-emissions development planning.

Planning and introducing solutions at the landscape level also allows trade-offs to be examined. It may be possible to meet both agriculture production and forest conservation objectives through better planning in the landscape. A number of studies have indicated that the expansion of agriculture on degraded land is a promising option to mitigate the negative impact on forests and associated greenhouse gas emissions, while accommodating increased production (Daily 1995, Casson 2000, Fargione et al. 2008, and Ecofys 2009).

Potential for expansion on Responsible Cultivation Areas

Estimations on the amount of degraded land available for expansion of agriculture ranges widely (Nijsen et al. 2012, Smit et al. 2013). In addition to the question of how much of this land is available, the potential yields on such degraded lands and their economic viability are difficult to estimate. Some studies indicate the potential could be very significant. For example, both Hoogwijk et al. (2005) and Tilman et al. (2006) estimate around 500 million hectare of degraded land is available for agricultural expansion and predict these areas can produce an average yield of 4.5 Mg ha/yr (Nijsen et al. 2012).

Although in some cases costly, agricultural expansion onto degraded land is an economically feasible (Fairhurst et al. 2009, Garrity 1998) and viable strategy to meet the multiple objectives of socially and environmentally sustainable economic growth (Koh et al. 2009). Degraded areas are, however, in many cases used by people. More than 1.5 billion people directly depend on degrading areas for their livelihood (Bai 2008). Thus, in developing methods and strategies for sustainable agricultural expansion in such areas, their needs must be taken into account.

One method in which considerations for biophysical suitability, conservation values and impact on livelihoods are accounted for in an integrated assessment is the Responsible Cultivation Area (RCA) methodology (Ecofys 2009). In this method, suitable areas are selected based on criteria from leading sustainability initiatives such as Roundtable of Sustainable Palm Oil (RSPO), Renewable Energy Sources Directive and Roundtable Sustainable Biofuel for agricultural suitability, biodiversity and human wellbeing. In line with the RCA approach, SNV is working on methods and tools that can contribute to providing alternatives for agricultural expansion in forest areas. This is done through: 1) selecting priority areas for sustainable agricultural expansion according to leading sustainability standards; 2) visualising the potential impacts of these sustainability standards; and 3) providing guidance on trade-offs between economic development and sustainable land-use planning. From our work on these methods so far it is clear it is possible to facilitate both development and conservation objectives in (land-use) planning. In the next section the tools will be presented that we use to assess trade-offs between agricultural expansion and forest protection. This can be used to develop a vision and pathways towards sustainable development and mitigate the impact of agriculture on forests.

Section 4:

A Siting Tool for Designing Integrated Forest and Agriculture Solutions Across the Landscape

The development of a tool to assist in the analysis and understanding of some key considerations for integrating agriculture development with forest conservation has the potential to offer SNV and other organisations a pathway for finding pro-poor and sustainable solutions across landscapes. Given a growing commitment to no deforestation in supply chains, it is more important than ever to understand the forest-agriculture linkages and prescribe appropriate solutions. Various initiatives have been established such as the Tropical Forest Alliance 2020, which is public-private partnership committed to reducing tropical deforestation associated with key global commodities. Companies are unilaterally making commitments to tackle deforestation[3] while national governments are introducing procurement requirements to purchase commodities that are certified, for example, the Dutch Task Forces on Sustainable Soy and Palm Oil and the Belgian Alliance for Sustainable Palm Oil.

Given the preceding text, which defines the relationship between forests and agriculture, it is critical that any assessment contains the following elements: (i) covers both agricultural and forestry objectives, variables and indicators; (ii) applicable at multiple scales and allows for landscape wide application; and (iii) can explore trade-offs in the landscape; this would imply finding compromise solutions.

Understanding these elements will help in balancing agriculture and forestry objectives within a landscape to help improve livelihoods through better agricultural practices while reducing pressure on forests.

A siting tool has been developed for this purpose that allows agronomical, social and environmental concerns to be examined and trade-offs to be explored. This provides a landscape analysis to understand which commodities are suitable for improved practices and in which areas these improved practices should, and should not, be promoted. The tool is being developed across a number of landscapes where SNV and/or partners are present. It is expected that this will be refined based on the outcomes, lessons and practical applications. It should also be stressed that many other tools and guidance documents exist which could be used.

3. See for example recent commitments by MARS http://www.mars.com/global/about-mars/mars-pia/our-supply-chain/our-strategy-and-priorities.aspx and L'Oréal http://www.loreal.com/csr-commitments/sharing-beauty-with-all.aspx

4.1 The siting tool for sustainable agricultural expansion

In order to help better understand the different forest-agricultural land classifications, to provide an initial overview of existing agriculture suitability and distribution of conservation priority areas and to gain broader appreciation of the agriculture-forestry trade-offs across the landscape, SNV developed a siting tool (Smit et al. 2013). It should serve as an important initial step to understanding the spatial dynamics of the landscape.

The general approach of the tool is to select the most relevant standard(s) in the agriculture sector(s) and then translate the sustainability criteria into spatially relevant, measurable indicators. Combined with spatial data on the distribution of areas biophysically suitable for the target crop(s), options for sustainable agricultural expansion in the landscape are then demonstrated. As the tool was initially designed for identifying options for sustainable oil palm expansion, the relevant sustainability standards, including those of the RSPO principles and criteria (P&C) were used. The RSPO's P&C refer to the high conservation value (HCV) toolkit to assess the suitability of an area. As the HCV toolkit is used in many standards, the general approach developed for the siting tool is relevant in the context of a range of commodities. Also, the HCV is relatively complete when it comes to identifying environmental values and can be used to verify compliance with other standards addressing environmental values (see also Smit 2013).

An important characteristic of the toolkit is that it does not necessarily forbid the conversion of an area once a value is identified, but requires that the values are managed. Only identifying HCVs and considering those as unsuitable areas is an oversimplified approach and in practice may not be useful for end-users. To provide additional detail to the HCV analysis, SNV developed additional risk categories that demonstrate the risk of violating the standard. This allows compromise (trade-offs) solutions to be examined.

As a result, the tool enables the user to prioritise areas suitable for sustainable agricultural expansion and areas where forest should be conserved, as well as a suite of options in-between, depending on the suitability. The options and trade-offs between forests and agriculture are visualised in the Risk Indicator Map (see Figure 6). The siting tool has been tested in Indonesia for oil palm, coffee, rubber and cocoa and is now being rolled out globally.

Once the spatial information has been synthesised it is possible to select which intervention options might be available and the types of risk involved with each. To assist in selecting the options available Table 3 presents an overview of which tools and approaches are likely most appropriate in the dominant forest and agriculture landscapes. The solutions will clearly differ from one landscape to the next based on the agriculture-forest interface and the underlying socio-economic, market and policy factors that underpin the likely impact of agricultural on forests.

Application of the siting tool can help to overcome some of the shortcomings in previous efforts in trying to balance forestry and agricultural objectives. Starting from the perspective of the suitability of agricultural production helps to ensure that the major driver of deforestation is also viewed as the potential solution. Working at the landscape level, indicating different levels of suitability, allows trade-offs to be examined that can align with government and local community priorities and needs. Of course, there will not always be win-win scenarios, but understanding the risk categories allows trade-offs to be better managed.

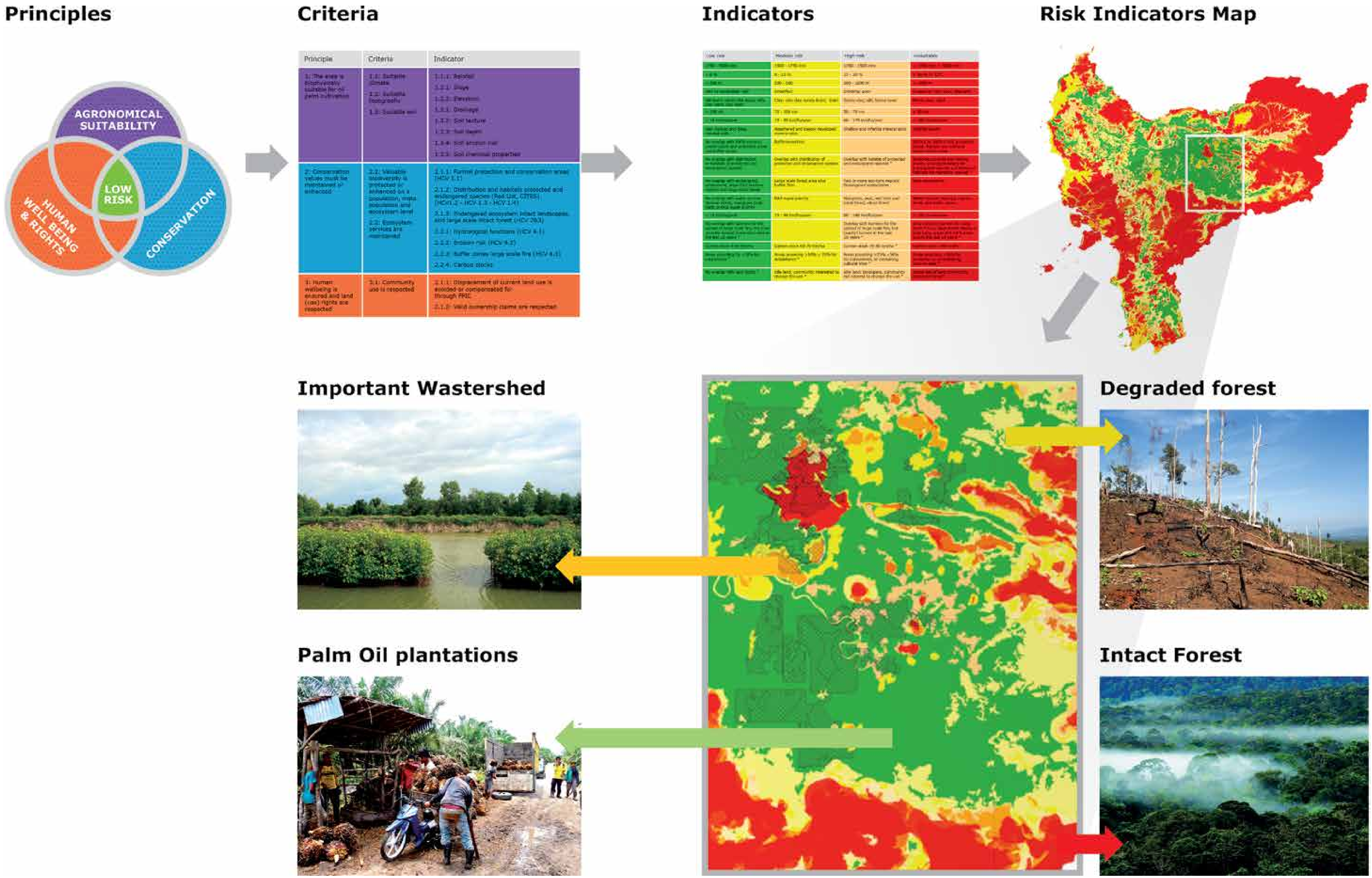
The different intervention options will likely be able to attract different potential finance streams. Multiple investment streams are necessary conditions for achieving multiple landscape-level objectives (Bernard 2013). For example, commodity companies may be willing to invest in more sustainable supply chains, national authorities in payments of ecosystems services, consumers for certified supply and carbon markets for any emission reductions. It is important to identify and help access these multiple finance streams in order to support low emissions productive landscapes. Possible financing streams are shown in Table 3.

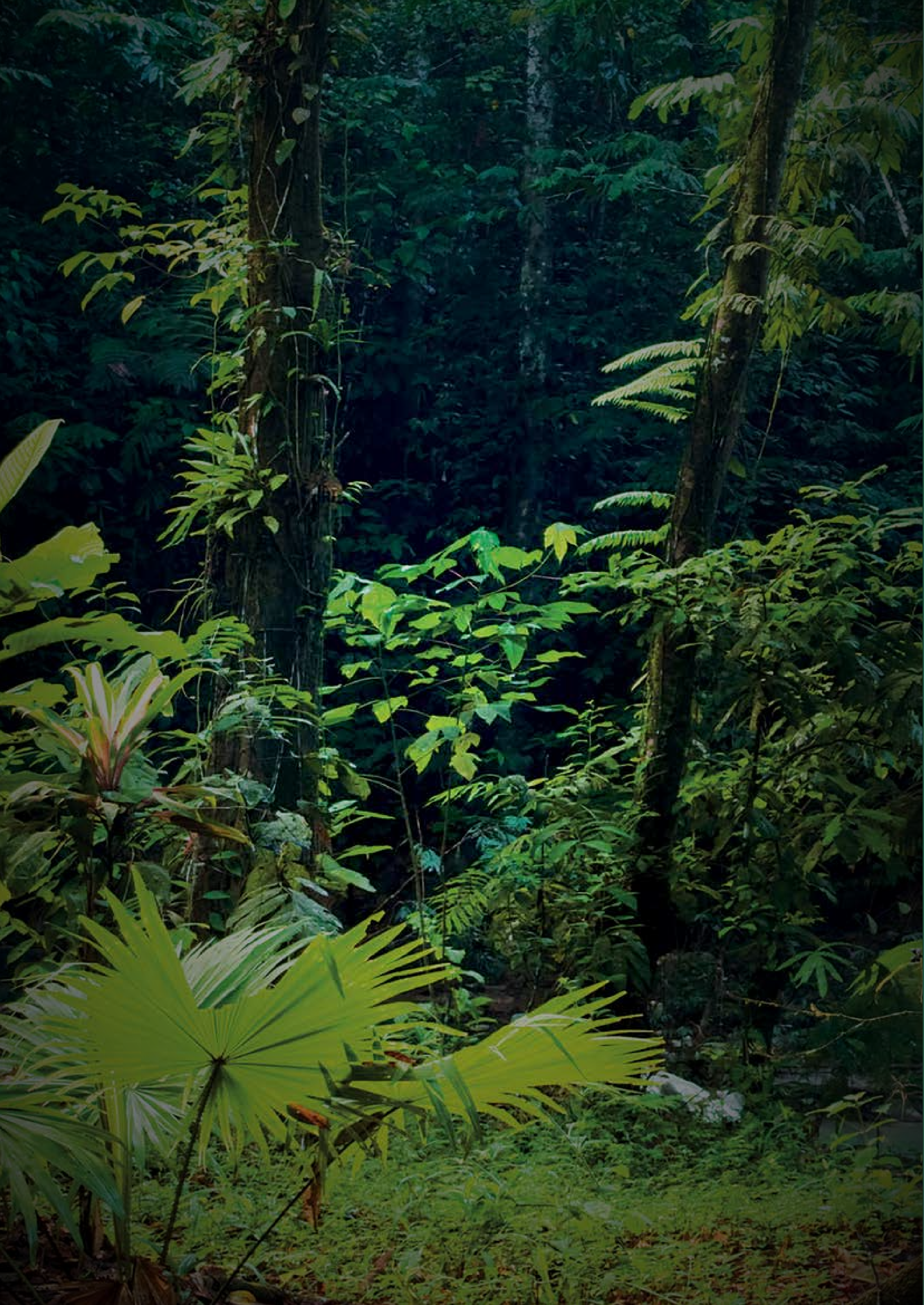
Table 3: Potential intervention options in different agriculture-forestry systems

	Risk category			
	Low	**Low to medium**	**Medium to high**	**Very high**
Dominant agriculture system	Intensive high value agriculture (e.g. lowland rice, cash crops)	(Semi) intensive agriculture; semi extensive; tree crops	(Semi) extensive (e.g. extensive pasture, shifting cultivation); commercial and subsistence	Small scale subsistence
Forest landscapes	Minimal natural forest	Forest mosaic; degraded land; forests plantation for timber	Forest mosaic; degraded forests and bare land; forest frontiers	Generally undisturbed forest
Approach	Promote intensive agriculture	Plantations for timber and wood-fuel; agroforestry; tree planting; certification	Subsistence agriculture for food security; REDD+ finance; certified commodities; enrichment planting; woodlots for timber/ fuelwood; better efficiency stoves etc.; PES	Subsistence agriculture; PES, eco-tourism, NTFPs (highly regulated), REDD+
Tools and actions	Agricultural technology research for development	Agriculture technology research for development; carbon market assessment; value chain analysis; low emission planning	Opportunity cost; REDD+ assessment; certification market assessment; livelihoods analysis; benefit distribution systems; low emission planning	Economic valuation; NTFP market analysis; participatory forest monitoring; benefit distribution systems
Financing	Commodity companies; investment funds etc.	Green investors; commodity companies; investment funds	REDD+ funds and markets; bonds; carbon markets; consumption of certified goods; ODA funds; PES, etc.	Domestic PES markets; domestic funds for forest protection; international funds for biodiversity conservation; markets

Detailed analyses on the socio-economic situation, market conditions and policy contexts should then be carried out depending on where activities in the landscape will be introduced. As highlighted earlier, activities in one part of the landscape will have a bearing on what happens in forest frontiers, so it is important to continue to understand the overall dynamics across the landscape, even when activities are focused in a particular area within the landscape.

Figure 6: Workflow of siting tool (from left to right): defining Principles, selection of standard, translating in spatial indicators, develop Risk Indicator Map, select priority area





Section 5:
Conclusion

Agricultural expansion has fuelled deforestation and forest degradation and economic development, arguably benefiting billions of people. However, in the context of climate change (and for reasons beyond climate change), there is a need to keep forests standing and to move out of this long phase during which forests have been sacrificed in the pursuit of economic growth. With global food demand expected to double in the next 50 years, alongside increasing demand for agricultural commodities for non-food products such as biofuels, this competition for land remains a key challenge.

Examining the basic incentives that lead to the conversion of forest for agriculture land highlights that the dynamics and causes of deforestation and forest degradation are multiple and highly complex. The global integration of markets and the political economy motivations clearly highlight the difficulty in changing the incentive structures.

CBFM, payments for ecosystems services and REDD+ do not provide the silver bullet but they can help and are critical ingredients for dealing with the agriculture-forest interface. Addressing this challenge will also require more innovative, integrated solutions, including the development of improved technologies and policies that promote more ecologically efficient food production while optimising the land allocation for conservation and agriculture. It will often be the case that such win-win outcomes cannot be found and this requires the need to accept trade-offs and to establish processes to be able to better deal with them.

One commonly cited option to reconcile agricultural development and forest protection, which has garnered much support, is through agricultural intensification. The basic hypothesis is that if we can increase agricultural yields per area in order to meet the growing global food demands this will reduce the need for more land and hence avoid further encroachment into forest areas. While this likely holds at the global level, at the local level a number of factors will condition what impact agricultural intensification will have on forest areas. As we move towards a more globalised system of commodity production, pressure is only likely to increase, with excess supply rapidly absorbed and the economic value from agricultural land increasing. This balance can be addressed through stricter regulation and enforcement. Positive examples, such as Brazil, show how this can be achieved. However, for the foreseeable future in many of the tropical forest countries this regulatory framework will not exist.

This paper highlights the need to better understand the relationship between agriculture and forests; in particular the need to better understand where and how agriculture is produced, as well as the types of activities that need to be introduced to support this sector. Given the growing commitments from companies and governments to no deforestation in supply chains, it is more important than ever to fully understand this forest-agriculture relationship and to prescribe appropriate solutions. We propose a basic siting tool that, when applied, can help to understand this relationship and identify pro-poor and sustainable solutions across landscapes. The tool helps identify the suitability of different agricultural commodities across a landscape, which includes potential risks to forest conversion. The initial spatial assessment will allow trade-offs to be examined and help in deciding priority sites and potential approaches to balance forest and agriculture in the landscape.

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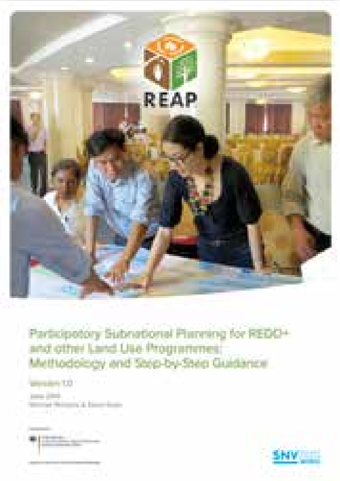

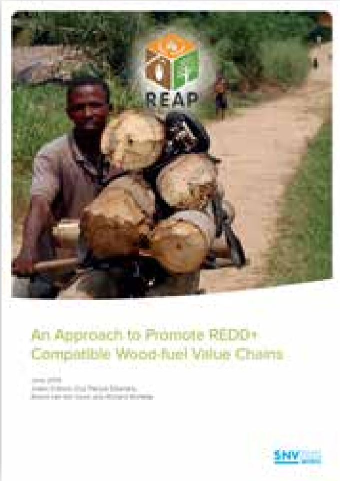

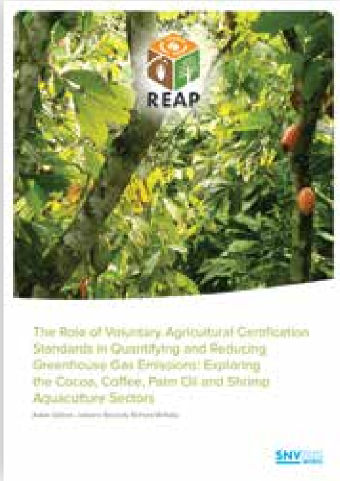

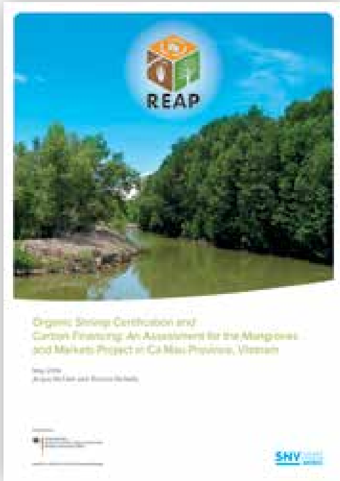

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