PRODUCTIVE LANDSCAPES (PROLAND) WORKING PAPER

AGRICULTURE'S FOOTPRINT: DESIGNING INVESTMENT IN AGRICULTURAL LANDSCAPES TO MITIGATE TROPICAL FOREST IMPACTS

DECEMBER 2021

This publication was produced for review by the United States Agency for International Development. It was prepared by Tetra Tech.

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The Productive Landscapes (ProLand) project supports USAID Missions to improve land use management using a systems approach to resilient development that integrates ecological, economic, and governance aspects. Using primary and secondary research, ProLand develops and disseminates evidence-based guidance around best management practices for sustainably intensifying land use. The ultimate objective of the guidance is to help USAID achieve integrated impacts related to increased food production, reduced biodiversity loss, reduced greenhouse gas emissions, and increased resilient and inclusive economic growth. Accordingly, USAID tasked the ProLand team to review the evidence-based literature to develop guidance on how governments and their development partners may limit the risks of deforestation that may result from investments in agriculture.

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Photo: Smallholder mixed agriculture and agroforestry, northern foothills of Mount Kenya. Credit: Ben Caldwell.

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ACRONYMS AND ABBREVIATIONS

AgMIP	Agricultural Model Intercomparison and Improvement Project
CCAFS	CGIAR research program on Climate Change, Agriculture, and Food Security
CGIAR	Consortium of International Agricultural Research Centers
DRC	Democratic Republic of Congo
EFI	European Forest Institute
FAO	United Nations Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FSC	Forest Stewardship Council
GIS	Geographic Information System
ICDP	Integrated Conservation and Development Programs
IDIQ	Indefinite Delivery, Indefinite Quantity contract mechanism
NGO	Nongovernmental Organization
PES	Payments for Ecosystem Services
ProLand	Productive Landscapes Project
REDD+	Reducing Emissions from Deforestation and Forest Degradation
REPLACE	Restoring the Environment through Prosperity, Livelihoods and Conserving Ecosystems
USAID	United States Agency for International Development
WOCAT	World Overview of Conservation Approaches and Technologies
WRI	World Resources Institute
WWF	World Wildlife Fund

EXECUTIVE SUMMARY[1]

CONTEXT

If it causes deforestation, it is not "sustainable"

Much of the world's forests are threatened by agricultural expansion. Specialists have theorized for decades that increasing agricultural yields decreases, or even reverses, agricultural expansion, and thus reduces pressure on forests and other natural lands. Unfortunately, even though agricultural intensification has slowed deforestation at a global scale, clearing new land for agricultural production continues to be a major cause of tropical deforestation. This paper shows that successful agricultural intensification stimulates additional investment, which results in additional agricultural expansion in the tropics. When farmers create new fields, whether they are smallholders or commercial firms, they select lands of lesser value and that cost less. Most often, these are unprotected standing forests.

Driven by rising global demand, an increase in agricultural commodity production has become the lead driver of deforestation across the planet, and intensification plays a key role. Conventional "agricultural intensification" includes: 1) the process of increasing yields per hectare; 2) adopting farming technologies that typically enable this increased production, such as agrochemical inputs and monocultures; and 3) reliance on capitalization and commercialization. Global demand channeled through international commodity markets absorbs dramatic increases in production with little impact on prices. As a result, investment continues, further expanding intensive farming across the landscape. When returns on investment decline, corporations shift production to other areas. International markets are not the only reason agriculture's footprint is expanding; domestic demand and population growth play a secondary role. However, even in Africa, where international markets have had less impact, distant markets are progressively driving forest loss.

Governments, philanthropic donors, civil society, and research institutions invest to make agriculture, including agricultural intensification, more sustainable. Programs promote reduced runoff, erosion and pollution, and create management plans to protect waterways and sensitive ecosystems. Governments monitor and regulate some agricultural pollutants. Yet these investments usually fail to address agriculture's impact on forests. To be sustainable, agricultural investments must stem deforestation.

Obstacles to truly sustainable programming investments in agricultural intensification

Truly sustainable intensification of agriculture requires rebalancing power. The influential institutions that promote agricultural intensification have strong support because agricultural intensification generates economic growth that can lift people out of poverty and increase food security. Stakeholders committed to forest conservation also have support because forests help sustain the world's biodiversity, mitigate climate change, and support global economic growth and local food security. However, forest conservation advocates have only modest sway over agricultural policy and the design of agriculture development projects, perhaps because the benefits that forests confer tend to be realized over longer timescales and are more diffuse, with smaller, less powerful constituencies promoting them. As a result, global investment in land use often favors agricultural expansion.

Stemming deforestation is also difficult because governments and their partners influence only a few of the factors that determine farmer decisions. Agricultural systems vary greatly because farmers adapt their practices to different agroecological conditions, business contexts, and the constraints and

[1] For ease of reading, we have removed the citations from this executive summary. References to research supporting the statements made here may be found in the body of the paper.

incentives of local and national institutions. The responses to national and international actions unfold differently in each field, market, and forest.

THE SCOPE OF THIS STUDY

This paper focuses on two key areas of opportunity: 1) practices farmers adopt to intensify production, and 2) government actions that influence agricultural expansion into forests. Our findings are intended to inform the design and implementation of investments to reduce agriculture's footprint.

We limited the scope of this paper to core issues:

- Tropical forests, where donors invest heavily and deforestation is greatest;
- The food and agriculture production systems, primarily field and tree crop-based systems, that have the greatest potential impact on tropical forests globally, either positive or negative;
- Governance actions that systematically result in a large or direct impact on land use change, whether positive or negative, such as payments for ecosystem services and land tenure support.

What this paper does <u>not</u> explore in depth:

- Indigenous Peoples' management practices and resource conflicts;
- The potential benefits of inclusive approaches to land governance;
- Gender in natural resource management and differing access to governance and market actions;
- Power relationships and political and economic aspects of the food and agriculture system that enable it to drive deforestation;
- The impact of raising livestock on deforestation;
- Many ways that agricultural systems affect communities, such as attracting migrants, influencing health and food security;
- How change in agricultural systems may create economic growth and widely shared increases in wealth, or increased inequality, worse living conditions for some populations, and conflict;
- Temperate or boreal forested landscapes;
- Parts of the agriculture and food system that do not require extensive lands and that therefore do not drive deforestation, such as horticulture and animal husbandry;
- Drivers of deforestation other than agriculture, such as trans-national land acquisition.

To address these challenges, the authors reviewed over three hundred publications from the science and development literature.

FINDINGS

Production strategies that impact agriculture's footprint

Our review identified six common strategies farmers use to intensify agricultural production that impact surrounding forests. We grouped them into two broad categories (see full report Table 1). With "Conventional Intensification," farmers raise yields by using capital-dependent strategies such as monoculture cropping and commercial inputs. When conventional intensification reduces deforestation, it does so by sparing land. With "diversification," farmers include multiple crops, livestock, and perennials. Strategies based on diversification increase food security principally by providing for home or local consumption. Because farming systems based on diversification are often weakly integrated into international markets, and rarely raise short-term yields dramatically or attract external investment, the great pressure to expand and clear forests tends not to appear. When effective, this approach increases productivity over time, reduces vulnerability to individual threats, lowers pest burdens, and improves soils. In addition, introducing trees into agricultural systems may reduce demand for forest trees and may strengthen land rights. Common to traditional agricultural strategies, but also used in more capital-intensive systems, diversification has generally received less support from governments, research institutions, and the private sector than conventional intensification.

Governance actions that impact agriculture's footprint

Our review identified thirteen governance actions that substantially influence the location and rate of agricultural expansion into forests (see full report Table 2). We subdivided these actions into three groups: 1) broad governmental functions that stimulate or dampen agricultural growth; 2) government actions that influence land use directly; and 3) market system approaches.

1. Governments indirectly influence agricultural expansion through policies that direct finance, trade, and migration. Although the relationships between these policies and land use often go unrecognized, these understudied impacts can be profound, as with transportation policy.
2. Government actions that target expansion of farming into forests include programs and policies for land-use planning and zoning; designating areas for agricultural investment; restoring degraded land; siting and managing protected areas; allotting concessions; and establishing property rights and land tenure.
3. In recent decades, governments and nongovernmental actors have attempted to fill a perceived weakness in natural resources governance through market-based approaches. This category of government actions includes fostering forest-based enterprises, certification regimes, and payments for ecosystem services schemes designed specifically to inhibit forest clearing.

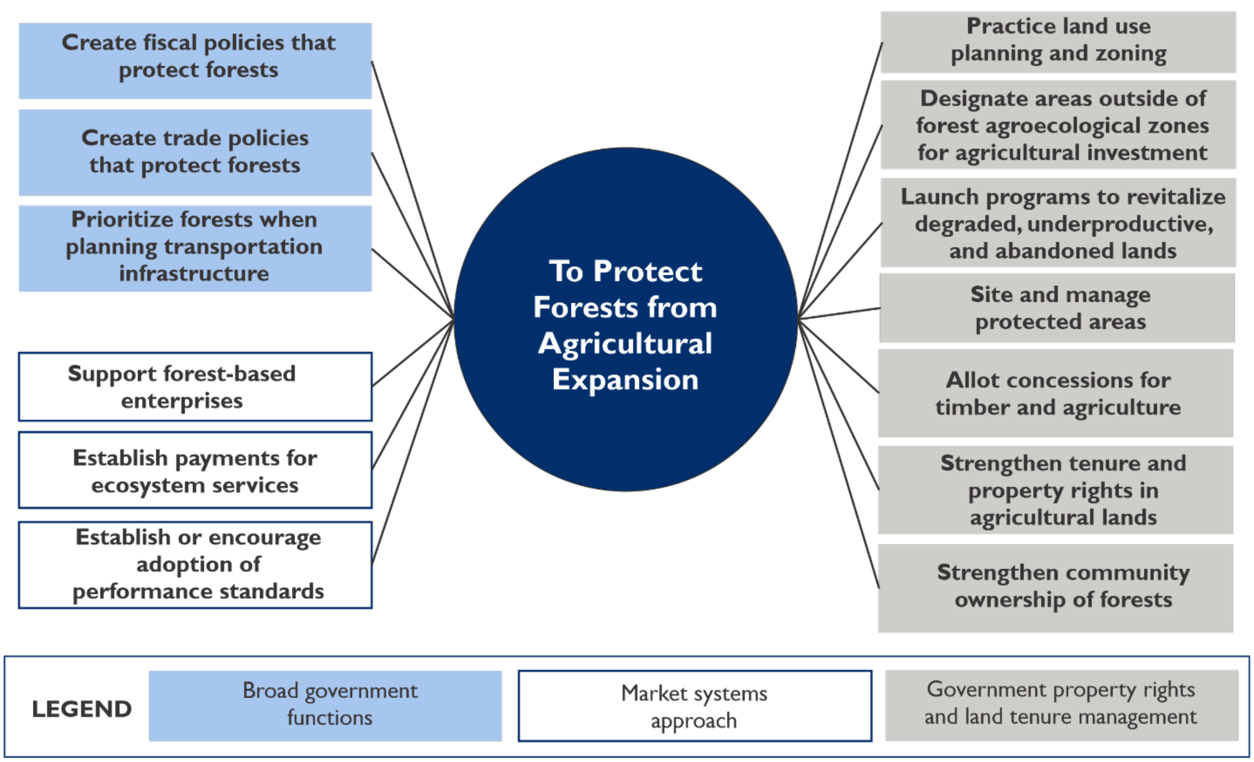

Figure 1. Governance approaches that can reduce agriculture-driven deforestation

CONCLUSIONS AND RECOMMENDATIONS

Three pathways to managing agriculture's footprint

The research reviewed for this report strongly supports the conclusion that any investment in agricultural intensification will increase pressure on unprotected tropical forests. Addressing the drivers of agricultural conversion of forests will become even more urgent and challenging as demand for food grows in the coming years.

None of the production strategies discussed in this paper can independently resolve the opposing objectives of increased production and forest protection over the long term. Conventional intensification strategies lead farming to expand across the landscape as they generate income for producers, companies, and governments. Strategies based on diversification assert less immediate pressure on land but generate fewer short-term yield and income benefits and are more difficult to scale.

Each of these production strategies requires government intervention to counterbalance the pressure agriculture exerts on forests, yet none of 13 the governance actions we describe has consistently proven effective. Some, like trade policy, are blunt tools often bound to objectives that conflict with forest conservation. Governance actions that more directly target land use require strong oversight and enforcement capacity which often does not exist. Land tenure regimes are rarely effectively implemented or equitably enforced. Their impact on agricultural expansion into forests is often unknown. Market-based strategies to deter agricultural expansion into forests target specific locations and populations, and their success depends on the larger context that governments create.

Governments and the development community will need to undertake new and adaptive approaches. Among the diverse institutions that need to be engaged, development practitioners have particularly wrestled with the divisions between agriculture and forest conservation institutions. These fall into different management sectors and depend on different funding streams. Staff learn from different schools of research and respond to different constituencies. Deliberate, persistent efforts to bridge this and many other institutional divides will likely play an important role in establishing effective suites of production and governance approaches.

We propose three pathways to reduce the impact of agricultural investment on forests, corresponding to three scales of institutional focus: on-the-ground programs; country strategy and guidance developed by donors, ministries, and other institutions; and national and international policy.

Governments and their partners should

- Address risk to forests in agricultural investments (project design and implementation);
- Frame agricultural intensification priorities broadly, to explicitly include equally important development objectives such as equity and conservation (strategy and guidance); and
- Strengthen land governance domestically and internationally (national and international policy).

We address each of these three pathways below.

1. Address forest impacts in agricultural investments

    - **Gauge the risks that activities pose to forests.** Consider biophysical and economic trends, political will, government capacity, and the potential for leakage.
    - **Balance agricultural growth objectives with forest protection objectives** Invest in approaches such as tenure, protected areas, and payments for ecosystem services to reduce agricultural expansion into forests.

- **Tip the scales towards long-term sustainable land use.** Emphasize combinations of technical solutions that sustain natural resources while increasing yields on land already under production, with finance mechanisms and market approaches that help farmers offset the short-term costs and long-term risks of adopting new production strategies without expanding into forested areas.
- **Monitor and adapt.** Initial estimates of deforestation rates and the location of deforestation fronts can indicate the threats to forests and the need to address agricultural expansion. Rigorous and continuous monitoring of the impact of agricultural investments on forests can inform adjustments during implementation.

To design and implement activities that incorporate these four recommendations, practitioners will need to draw from agriculture, conservation, market systems, and governance. They will need to coordinate local agricultural activities with long-term countrywide policy initiatives. Enabling governments to undertake the fundamental changes necessary to protect their forests, manage concessions, or improve tenure security may go beyond the resources and traditional mandates of agriculture sector projects.

Actions to Prevent Agriculture-Driven Deforestation

Balancing yield growth with other stakeholder priorities opens the door to reducing the impact of agricultural investment on forests. Therefore, when utilizing the broad array of governance and market activities that may stem agriculture-driven deforestation, governments and their partners should:

- Design agricultural investments to address the many priorities of the communities we support.
- Define equitable growth objectives that align with long-term sustainable land use.
- Emphasize reducing climate-induced productivity losses rather than raising yields.
- Align market system approaches with strategies that increase farmer resilience and efficient natural resource use.
- Incorporate forest conservation and related food security benefits when defining food security objectives. This should include developing a landscape-scale governance strategy.
- Reinforce regional and domestic policies and institutions that protect forests.
- Support international collaboration to protect forests.

2. Frame agricultural intensification priorities broadly, to explicitly include equally important development objectives such as equity and conservation

- **Focus on equitable growth aligned with sustainable land use.** Targeting intensification narrowly may aggravate inequities, for example by dislodging marginal populations or accelerating the concentration of wealth. Approaches that increase long-term land productivity using diversification may support equity and inclusion goals and are less likely to drive land-use change.
- **Emphasize resilience, reducing crop loss and maintaining stable production.** Investments that increase long-term production stability; household-wide incomes; and land resilience to climate change, may help meet agricultural demand as the climate grows increasingly volatile.
- **Undertake inclusive market system approaches to increase farmer resilience and efficient natural resources use**. Appropriate investments in markets may accelerate uptake of diverse technologies including for storage and reduced waste, which can reduce the land needed for production.
- **Integrate the objectives above (equity, resilience, and inclusive markets) alongside the conservation of forests in food security strategies.** Increasing food security requires

attention to diverse objectives including inclusive and equitable governance and improved nutrition and health (most directly achieved through greater agricultural diversity).

While acknowledging the challenges and opportunities of cross-sectoral programming, governments and donors increasingly recognize that efforts to intensify agriculture should also support inclusive and equitable growth, climate resilience, strong market systems, and food security. Meeting the world's demand for agricultural products entails more than increased production.

3. Strengthen land use governance domestically and internationally

- **Reinforce domestic policies and institutions that protect forests.** For the government actions presented in this document to reduce deforestation, they must be implemented transparently by effective governments in an integrated manner. Attention to governance of *land* explicitly is critical because as government capacity in producer countries increases and the business environment improves, progress towards development objectives like building infrastructure, supporting technology for intensification, and connecting to export markets can greatly increase rates of agricultural expansion.
- **Support international collaboration to protect forests.** The enormity of the challenge to help producer countries fundamentally strengthen environmental governance leads to our final observation: the management of global land use requires international coordination. The policies of both producer and consumer governments create the context for agriculture's footprint on forests. Governments of consumer countries stimulate international demand for commodities that put forests at risk and create a deep market for products that generate emissions.

When governments stimulate agriculture, whether in their own country or another, and do not also create and enforce effective controls or provide incentives to manage the expansion of agriculture, they help drive forest loss. Domestic policies and international cooperation need to complement and reinforce each other to achieve forest conservation, food security, and economic growth in development.

1.0 PURPOSE, METHODS, AND SCOPE

This paper was commissioned to inform efforts to reduce tropical deforestation associated with agricultural intensification. Our growing and increasingly affluent global population demands ever-increasing agricultural yields. Increased agricultural productivity also plays a role in meeting the needs of the world's food insecure populations, estimated to be between 720 and 811 million in 2020 (FAO, 2021). International development agencies invest heavily to help farmers produce enough to meet these needs. In 2018, Organization for Economic Co-operation and Development (OECD) countries provided US$10.2 billion of official development assistance for agriculture.[2] USAID contributed a significant portion of this assistance, totaling $875 million in investments in agriculture the following year.[3] Donors intend to help countries meet their food security objectives sustainably, yet as production increases, so do agriculture's negative impacts on the environment. Of these impacts, the expansion of lands used for agriculture may be the greatest threat to the world's most biodiverse, carbon-rich ecosystems. When farmers convert wetlands, savannas and forests to fields, plantations, or pasture they degrade or destroy those ecosystems. Transforming natural landscapes to cultivated fields also alters the carbon balance. Land-use change, largely the replacement of forests by agriculture, is the second greatest source of human-created CO2 emissions (IPCC, et al., 2013). By one estimate, agricultural expansion accounts for around 70 percent of global land-use change emissions, most of this through deforestation (Frank et al., 2017).

Levels of forest disturbance vary

Because agriculture systems support a range of biodiversity, the conversion of natural lands alters ecosystems to varying degrees. One review of research found that the conversion of natural forest to smallholder agroforestry systems results in an average 32% reduction in species, while conversion to shifting agriculture may result in a loss of over 54% of species (Chaudhary et al., 2016). Conversion of natural forest to permanent field crops, of course, causes even greater loss of species and ecosystem services.

Donors and governments recognize the risk agricultural growth poses to forests but they have been unable to stop the expansion of agriculture's ecological footprint. Many factors determine how and when farmers clear new land. Agroecological zones, farming systems, and markets all play a role. Governance of land use plays a critical part. To help clarify and organize what is known regarding this complex relationship and identify the most viable investment strategies, ProLand reviewed the available literature with three objectives:

- Summarize the evidence regarding the relationship between investment in agriculture and the conversion of forest lands.
- Describe the relationship between specific agricultural systems and deforestation.
- Describe how governments and their partners may reduce agricultural expansion into forests.

The authors reviewed over three hundred publications from the scientific and development literature. We relied heavily on the most recent research, and on studies that employed rigorous methods. We gave greater credence to meta-analyses, systematic reviews, and studies employing panel data modeling, counter-factual matching, or methods and statistical tools particularly adapted to the evaluation of changes in landscapes.

[2] Data from Donor Tracker, a website that covers 14 major OECD donors and over 80 percent of the world's official development assistance. https://donortracker.org/sector/agriculture

[3] Foreign Aid Explorer. Accessed 7/13/20. https://explorer.usaid.gov/aid-dashboard.html.

We limited the scope of this paper, using a number of parameters to concentrate on core issues relevant to the topic:

- Tropical forests, where donors invest heavily and deforestation is greatest;
- The food and agriculture production systems, primarily field and tree crop-based systems, that have the greatest potential impact on tropical forests globally, either positive or negative;
- Governance actions that systematically result in a large or direct impact on land use change, whether positive or negative, such as payments for ecosystem services and land tenure support.

This paper does <u>not</u> explore in depth:

- Indigenous Peoples' management practices and resource conflicts;
- The potential benefits of inclusive approaches to land governance;
- Gender in natural resource management and differing access to governance and market actions;
- Power relationships and political and economic aspects of the food and agriculture system that enable it to drive deforestation;
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- Parts of the agriculture and food system that do not require extensive lands and that therefore do not drive deforestation, such as horticulture and animal husbandry;
- Drivers of deforestation other than agriculture, such as trans-national land acquisition.

Societal Impacts of Agricultural Growth

Agricultural intensification rarely distributes its economic benefits equitably. Numerous case studies document the likelihood that elites will disproportionally profit from new incomes. Equitable results from agricultural change requires an explicit focus on inclusive governance (Mansuri & Rao, 2013; Dawson et al., 2019; Anderson, Bruil, Chappell, Kiss & Pimbert, 2019; Fischer et al., 2020; Rietveld, et al., 2021; Mdee et al., 2021). The social change resulting from agricultural growth varies widely, and consensus on methods to influence the impact has not been reached. Some research suggests that factors such as government commitment to the process, responsiveness to stakeholders, and flexibility to evolving conditions may foster engagement in participatory processes which will in turn increase equity in the long run (Mansuri & Rao, 2013; Barletti, Larson, Hewlett & Delgado, 2020).

Would more inclusive governance better protect forests?

Inclusive approaches may improve natural resource governance and be critical to managing the impact of agricultural intensification on forests. Rigorous case studies have found that by including women, forest management groups in India and Nepal improve resource governance and conservation outcomes (Leisher, et al., 2016). However, sufficient research directly demonstrating the impact of inclusive project design and/or equitable governance on the agricultural conversion of forests has not been conducted. As a whole, the general topic of the relationship between inclusiveness in governance and land use in general has been the subject of limited research (Mansuri & Rao, 2013; Leisher, et al., 2016). The question presents an important research gap to address.

In this paper we examine two key areas of opportunity: the practices farmers at all scales, from smallholders to managers of large commercial enterprises, adopt to intensify production, and government actions that influence agricultural expansion into forests. We grouped agricultural practices into six production strategies and present the evidence on how the adoption of each may influence land use and affect forest cover. We then describe thirteen governance actions and present evidence on how each results in stimulating agricultural expansion, and the potential for these actions to control agricultural expansion into forests instead.

ProLand also produced two additional sets of materials that complement the body of this paper:

1) **A list of high-quality documents for practical application.** The key conclusions presented in this paper are based on academic research that answers precisely defined questions. Text boxes formatted in gray in the paper provide brief descriptions of high-quality documents that offer more practical guidance regarding the implementation of the strategies and actions reviewed here. Annex A provides a complete annotated list of these documents as well as several others cited within the text.
2) **ProLand case studies.** The ProLand case studies explore more fully five of the approaches addressed briefly in this paper. They are included in the list of abstracts and links in Annex A.

2.0 THE RELATIONSHIP BETWEEN AGRICULTURAL INTENSIFICATION AND DEFORESTATION

Despite dramatic increases in yields across the globe, agriculture continues to drive tropical deforestation. In modern history, agricultural production has increased more by raising yields on existing farmland than by increasing the amount of land farmed. Indeed, between 1961 and 2005, farmers increased their production by 135 percent (by weight) but expanded agricultural land by only 27 percent (Burney et al., 2010).

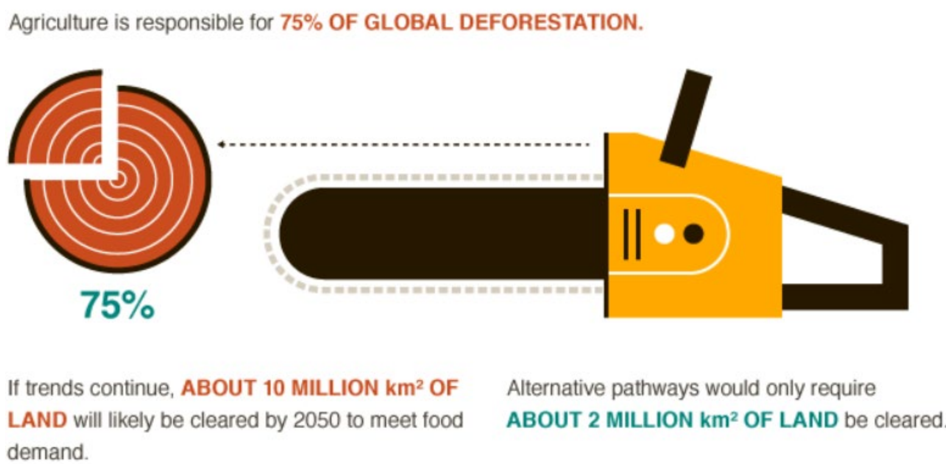

Figure 2. Global deforestation. For more "big facts" on climate change, agriculture, and food security, see the CGIAR/CCAFS page: https://ccafs.cgiar.org/bigfacts/#

Nevertheless, farmlands continue to replace global forests. One recent analysis found that the world lost 76.8 million hectares of forest between 1990 and 2000. Of this deforestation, 40.5 million hectares took place in Latin America, 19.7 in Africa, and 16.6 in Asia. In each region, agriculture was the dominant use of the land after deforestation (De Sy et al., 2019). Agriculture continues to drive loss of the world's tropical forest today (IPCC, 2019a).[4]

To protect forests, we must resolve this challenging relationship between agriculture and deforestation. Food demand is expected to increase between 59 and 98 percent by 2050 (Valin et al., 2014).[5] This projection, based on a "middle-of-the-road" socioeconomic growth scenario, integrates the expected impact of climate change and the expansion of bioenergy. As with other "business as usual" projections, it excludes pathways, such as dramatic reductions in food demand that could result from concerted efforts to eliminate spoilage and waste, or to modify consumption patterns away from meat and milk and increase equity in food distribution. It is possible that these demand-side approaches will be

[4] Other studies present different estimates, and the IPCC reports there is great uncertainty in global deforestation assessment. The differences in methods, geographic scales, and time periods selected by different researchers can generate vastly different results. Definitional challenges also arise. Some studies distinguish between land that has been permanently deforested and land "disturbed" by temporary activities, such as shifting agriculture. Regrowth is difficult to measure. Measuring the potential for regrowth presents a greater challenge. One early and widely cited study of satellite imagery concluded that during the 1980s and 1990s, more than 80 percent of the land claimed by agricultural expansion was tropical forest (Gibbs, 2010). A more recent study found that between 2000 and 2010, only half of the agricultural deforestation took place in tropical areas (Leblois et al., 2017). The use of higher resolution data in the second study may account for this discrepancy. It is also possible that in recent decades deforestation has slowed in tropical areas relative to the rest of the world. On the balance, the IPCC has concluded that much of the world has experienced a net increase in forest and tree cover, yet there is "robust evidence and high agreement" that in recent decades the tropics have experienced a net loss (IPCC, 2019a).

[5] The range of projections was produced by 10 participants in the Agricultural Model Intercomparison and Improvement Project (AgMIP), a major international effort linking the climate, crop, and economic modeling communities with cutting-edge information technology to produce improved crop and economic models and the next generation of climate impact projections for the agriculture sector. For more on AgMIP, see http://www.agmip.org

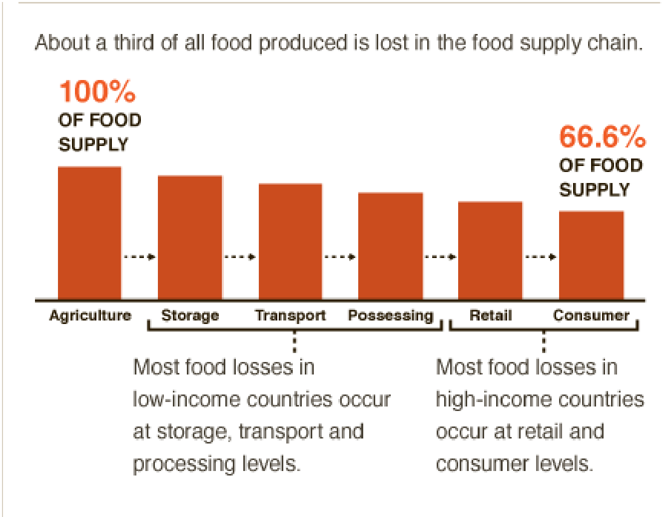

Figure 3. Reducing food loss would decrease demand and reduce pressure on forests. For more "big facts" on climate change, agriculture and food security, see the CGIAR/CCAFS page: https://ccafs.cgiar.org/bigfacts/#

effective. The past several years have seen significant strides in the market for plant-based meat and dairy alternatives, and numerous institutions champion reduced food loss and waste. Innovative approaches to producing food, such as ocean and landless cultivation, also show promise (Ullmann & Grimm, 2021; Rahmann & Grimm, 2021). Given the critical need to conserve high-carbon forests, we need to develop and employ all available approaches to alter the current relationship between agriculture and deforestation.

One key opportunity is to increase yields and use land more efficiently at a vast scale without impacting forests. To be sustained and widely adopted, intensification must generate widespread benefits. Intensification may result in improved conditions on farms (such as healthier soil) or reduced risk in production or sale, but the benefits that receive the greatest attention, the ones that most strongly drive the adoption of more intense practices, are often financial. Successful agricultural intensification includes both an increase in the amount produced on a given area, and an increase in the value of that produce compared to the costs of production. Agricultural intensification that expands to a large scale includes both higher yields and higher returns.

The Royal Society (2009) and Montpellier Panel (2013) are two prominent publications that make the case that to be "sustainable," agriculture must not expand into natural lands. The term "sustainable agriculture intensification" does not always capture this meaning.

While generating benefits, new practices and technologies that raise yields may also cause new negative environmental impacts or aggravate old ones. This has not gone unnoticed. Donors, governments, and agricultural research institutions have given much attention to identifying ways to mitigate the negative impacts of intensification on fields and in the larger landscape. Research on the concept of "sustainable intensification" [6] has focused on the impacts of agricultural practices on fields, associated farms, contiguous landscape, and the larger watersheds. Key topics include mitigating the impact of agrochemicals and increasing water use efficiency. Less attention has been given to the topic of this paper: the relationship between agricultural intensification and deforestation.

At the scale of the globe, agricultural intensification does "spare" land. From the turn of last century, specialists have theorized that by increasing yields we may limit or even reverse global drivers of agricultural expansion. The idea was popularized by Norman Borlaug, a key contributor to the Green Revolution. Intensification through technological improvements, such as the adoption of new varieties, better crop and resource management practices, and improved crop protection, reduce the overall land used for a given amount of produce. This argument has been made most convincingly regarding the impact of new cereal varieties. One recent estimate concluded that the adoption of improved crop germplasm saved an estimated 18 to 27 million hectares from being brought under cultivation between

[6] Many variants on the term "sustainable agricultural intensification" have been proposed, each with their own emphasis. These include ecological intensification, Eco-Efficiency, Doubly Green Agriculture, Agro-ecological Intensification, Eco-Agriculture, Green Food Systems, Evergreen Agriculture, and LivestockPlus (Cassman, 1999; Garnett & Godfray, 2012; Pretty & Bharucha, 2014; Rao et al., 2015).

> **Enabling Conditions for the Borlaug Effect**
>
> - Yield increasing technology is most likely to save land when:
> - It is adopted over broad areas.
> - Labor is scarce and in migration is limited.
> - Price reductions do not spur large increases in demand.
>
> Source: Lobell et al. (2013)

1965 and 2004 (Stevenson et al., 2013). By raising production per hectare, agricultural intensification may have slowed total deforestation at the global scale.

The relationship does not hold at the local level, however. Despite the global impact of intensification, at the local scale, intensification often results in the use of more land. A concept called the Jevons paradox helps explain how this happens. It posits that greater efficiencies in the use of a resource may increase—rather than decrease, as might be expected—the demand for that resource. Applied to the agricultural context, when farmers use agricultural land more efficiently, profits increase. Whether these profits benefit farmers themselves, or other actors in the value chain, greater profitability creates an incentive to increase investment in that agricultural system. This increased investment comes in many forms. At first, it may manifest simply as additional labor by farmers or by migrants to the area. Farmers may take loans, choose more profitable crops, or purchase more inputs. Once successful intensification is recognized, attention may draw additional technical assistance from NGOs, provoke changes in government agricultural policy, or lead to the development of new crop varieties and agrochemical inputs. In the long term, more efficient use of land attracts investments and leads to an increase in the amount of land farmed.

> **Soybeans in Brazil**
>
> International commodity markets may fuel the expansion of intensified agricultural systems into a country's forests. Growth in soybean productivity allowed Brazil to lower prices and increase sales on international markets, which in turn financed dramatic agricultural growth, and further expansion of soybean fields into forests (Yao et al., 2018).

International markets enable farmers to intensify their practices and expand land use to new areas. The adoption of new farming technologies forms the kernel of intensification, but markets facilitate and scale the intensification process. When farmers increase productivity, they usually increase the total amount produced. In the aggregate, their increased returns may dampen prices in smaller markets and stall investment. In contrast, large international markets absorb dramatic increases in produce with little impact on prices. Investment continues, further expanding intensive production across the landscape. When optimal conditions for production decline in one area, corporations may shift production to another. Although farmers may replace more extensive methods when they sell commodities to international markets, they also clear new land as they increase production (Matson & Vitousek, 2006; Hertel et al., 2010; Byerlee, Stevenson, & Villoria, 2014; Byerlee, Kyaw, Thein, et al., 2014).

For both smallholders and large corporations, forestland often proves to be the best option for expansion. When smallholders select new land to clear, they assess their own resources, including their access to labor, capital, inputs, and technical knowledge. Their farming methods are important, as is the productivity of their current holdings, and their property or land-use rights (Angelsen & Kaimowitz, 2001). The characteristics of the land options available to them may be equally important. They look for areas agronomically supportive of the type of farming they are considering. They also assess restrictions on its use tied to socio-economic factors, such as legal restrictions, competing claims to the land, insecurity and market access (Angelsen & Kaimowitz, 2001). Corporations, whether they intend to work through individual farmers or establish their own large holdings, use similar criteria in deciding where to invest. Access to international markets increases the options available to them, and the drive for profits directs their investment in regions with the greatest revenue potential. Corporations give less weight to proximity than do smallholders, but market-driven intensification leads them both to concentrate commodity agriculture into areas where governments poorly protect forests growing on fertile soil (Meyfroidt et al., 2014; Byerlee, Stevenson, & Villoria, 2014; Busch & Ferretti-Gallon, 2017).

The term telecoupling highlights distant drivers of land use change

As globalization shrinks our planet, behavior in other countries new trade patterns, government policy, agronomic innovation influences local agricultural strategies more strongly. In recent years, land systems scientists have begun using the term "telecoupling" to focus attention on this dynamic relationship between distant drivers and local land use change. The concept applies particularly well to the relationship between commodity agriculture and deforestation by smallholders (Friis et al., 2016; Creutzig et al., 2019).

Documented historical cases where the introduction of intensive commodity production has not "saved land" include oil palm expansion in Southeast Asia, soybean expansion in Brazil and Argentina, and the earlier expansion of banana cultivation in Latin America. There is strong evidence that yield increases drove the agricultural conversion of forests in tropical South America between 1970 and 2006 (Ceddia et al., 2013). Between 2000 and 2011, the production and export of four commodities (beef, soybeans, palm oil, and timber products) was found to be responsible for 40 percent of total tropical deforestation in Argentina, Bolivia, Brazil, Paraguay, Indonesia, Malaysia, and Papua New Guinea (Henders et al., 2015).

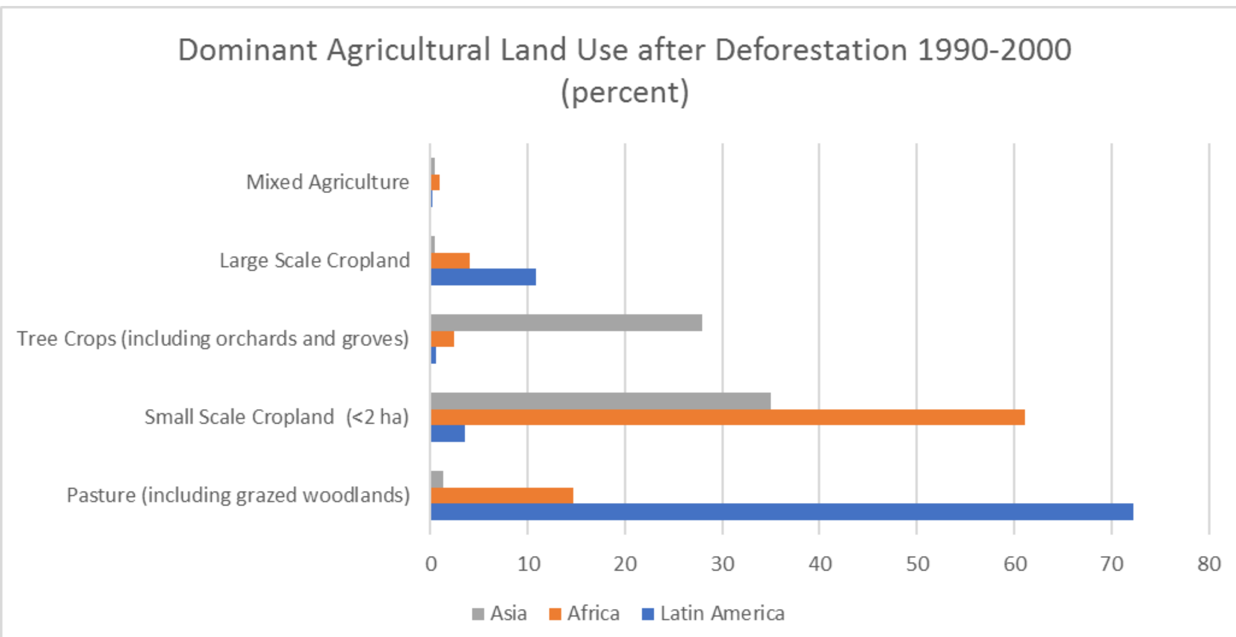

Figure 4. Dominant agricultural land use after deforestation 1990-2000 (percent). Adapted from De Sy et al. (2019)

The dominant forms of agriculture vary geographically, as do the drivers of intensification and deforestation. Despite their global importance, international commodity markets are not the sole drivers of agricultural intensification, nor the sole cause of deforestation driven by agriculture. In some parts of the world, demand from domestic markets and home consumption are the prime factors stimulating agricultural expansion. This more local demand less often stimulates agricultural intensification. Published studies have not definitively mapped these relationships, but the information available nevertheless suggests some important trends:

In Latin America, the expansion of pasture for livestock has been the main direct cause of deforestation. In this region, commercial agriculture has driven an estimated two-thirds of total deforestation (Kissinger et al., 2012; De Sy et al., 2019). In Central America and the Andean region, small-scale agriculture also plays an important role in deforestation (Curtis et al., 2018).

In Asia, smallholder agriculture and tree crops were the prime drivers of deforestation between 1990 and 2000 (De Sy et al., 2019). In Southeast Asia, small-scale farmers have given way to large producers as the primary driver of deforestation, as well-capitalized agribusinesses clear lowland forests to produce crops, principally oil palm and rubber, for international markets (Rudel et al., 2009; Henders et al., 2015; Leblois et al., 2017).

In sub-Saharan Africa, domestic markets and population growth continue to be the primary forces behind agricultural deforestation (Somarriba et al., 2012; Byerlee & Rueda, 2015; Henders et al., 2015; Ruf & Varlet, 2017; Curtis et al., 2018; De Sy et al., 2019; Creutzig et al., 2019). Commodity production for international markets may soon alter this pattern following changes in deterrents that have discouraged international investment in many African countries. Improvements in governance, inhospitable business contexts, insecurity, poor infrastructure, and tenure may invite greater investment (Megevand, 2013; Ordway et al., 2017). In the heavily forested Congo basin, governments have historically provided relatively little support for agriculture, instead relying heavily on oil and mineral wealth to drive the economy and imported cereals to feed the urban population (Rudel, 2013). As governments become stronger and more stable and increase investment in their own agricultural sectors, international investments may also grow. Some evidence already points to a growing influence of distant markets on land-use change throughout sub-Saharan Africa. For example, between 2000 and 2013, oil palm exports increased by 171 percent (Ordway et al., 2017).

Conflict can both stimulate and prevent deforestation

Governmental collapse in DRC resulted in forest loss between 1990 and 2000 as people sought refuge from conflict in the interior (Nackoney et al., 2014), while in the following decade, over the continent as a whole, a decrease in conflict was also associated with forest loss presumably because it enabled investment in forest extraction industries and agriculture that was impossible under less stable conditions (Leblois, 2017).

The relationship between agriculture and forests is a challenge for donors because investments that result in more efficient land use may stimulate greater deforestation. Local specificity and global interconnectedness further complicate the challenge. Agriculture's footprint will need to be better managed through a process that is adapted to individual landscapes yet takes into account the impact of international markets. The transformation must be worked out over time in fields and value chains through a process informed by scientific findings. In this paper we present two key areas of opportunity: first, the relationship of the world's major food producing systems to forest use; and second, the tools available to governments to manage potential expansion resulting from the intensification of these systems.

3.0 PRODUCTION STRATEGIES THAT IMPACT AGRICULTURE'S FOOTPRINT

Our review identified six major strategies farmers use to intensify production that can impact agriculture's footprint on forests both positively and negatively. We have grouped them into two broad categories (see Table 1 below). In the first category, which we label "Conventional Intensification," farmers raise yields by using capital-dependent technologies such as farming in monocultures, introducing hybrid seeds, and relying on agrochemical inputs. This approach typically relies on capitalization and commercialization. Where these strategies reduce deforestation, they do so by sparing land.

The second category, which we label "Diversification," describes farms that include multiple crops, livestock, and perennials. When effective, diversification increases the productivity of land over time. However, diversification strategies function primarily to provide an array of benefits and reduce risk. Diversified agricultural portfolios increase farmers' overall resilience to production and market risk by reducing vulnerability to any individual threat. Farmers diversify to improve soils, alleviate the pest burden, and produce other ecosystem products and services. The second and third strategies in this category may reduce forest degradation by introducing trees into agricultural systems. They generate products that would otherwise be harvested from forests and are sometimes said to share agricultural land with forests. Common to traditional agriculture, but also used in more capital-intensive systems, diversification has generally received less support from governments, research institutions, and the private sector than conventional intensification. Because farming systems based on diversification are often weakly integrated into international markets, and rarely raise short-term yields dramatically or attract external investment, the great pressure to expand and clear forests tends not to appear (Cairnes & Garrity, 1999; Altieri, 2004; Altieri & Nicholls, 2017; Delacote et al., 2019; Liebman & Schulte-Moore, 2015).

Table 1, from left to right, presents a brief description of each production strategy; examples of the strategy; opportunities for reducing land use; and major risks of agricultural expansion that accompany this strategy when employed. The opportunities column describes how the corresponding strategy is most likely to limit expansion, while the Major Risks column indicates the most likely ways a strategy would fail to reduce agricultural expansion into forests.

Although here we present these six strategies separately to better reflect and highlight discussions found in the literature regarding the impact of each on agricultural expansion, in practice agricultural systems commonly combine elements from several strategies. Farmers often use multiple practices associated with conventional intensification simultaneously. They may also diversify in multiple ways. Strategies from these two categories may also be combined. For example, farmers may use chemical inputs while diversifying their crops. The ProLand Case Study Reducing the Impact of Cocoa Cultivation on Forests: Full-Sun and Shade Cultivation in Indonesia (Miller & Young, 2021) describes the clash of conventional intensification and agroforestry in the cocoa industry.

This overlap between agricultural strategies does not mean any one of them is suitable everywhere. Farmers must adapt each to their fields and resources, and some strategies are more appropriate than others in some locations. The agroecological context, current farming practices, market, and economic factors constrain and enable their adoption. Local agroecological and socio-economic characteristics of farmers also influence how they may be used in combination, and the extent to which they impact forests.

In the following chapter, we present a description and examples of each of the six agricultural strategies, excluding conventional crop intensification, which has been discussed above and is therefore truncated below. We then describe the way the strategy may reduce expansion into forests. If there are other benefits associated with the strategy, such as reduced forest degradation, we also describe them. We also illustrate major risks of adoption and/or common barriers to adoption of the strategy. We conclude with a summary of the evidence regarding how adoption may impact agricultural conversion of forests.

Some of the agricultural strategies described in this paper cannot be understood without discussion of the political and governmental support that enables them. We also, therefore, when appropriate summarize the role of governments and other actors in promoting some of these practices. Later in chapter 3 we further elaborate on the relationships between agricultural expansion and governance actions.

Table 1. Major production strategies: opportunities and risks from intensification

		Production Strategy	Examples	Opportunities	Major Risks
CONVENTIONAL INTENSIFICATION	1	Intensify annual crop production	Use hybrid seeds, agrochemical inputs, and monocultures to increase yields.	May dramatically increase yields and incomes from current land holdings.	Successful intensification may attract additional investment, driving more expansion.
	2	Transition farmers from shifting cultivation to continuous cultivation of fields	Replace fallowing with the use of agrochemicals to retain soil fertility.		Success will result in permanent forest loss. Decline in soil fertility over time may drive more forest clearing.
	3	Monocrop trees	Establish plantations that produce palm oil.		Monocropping may attract international investment in commodities, driving more expansion.
DIVERSIFICATION	4	Diversify the types of annuals cultivated and livestock raised	Rotate cereal crops with legumes; raise livestock in addition to field crops.	May raise yields gradually, extend productivity of land use, reduce risk, and help meet household livelihood goals from current land holdings.	Reduced area dedicated to staple crops may not be compensated for by increases in yields, resulting in farmers clearing more land.
	5	Diversify by introducing other crops into tree crop systems	Intercrop cacao with orange and avocado trees; intercrop coconut with cacao, clove, nutmeg, coffee, black pepper, or mulberry.		Intercropping commodities may not deter international investment that drives expansion.
	6	Diversify by introducing trees into crop and livestock systems	Plant rows of trees in or around fields producing annuals; cultivate trees at low densities in pastures.		Adoption may be limited and thus have little impact on agricultural expansion.

Table 1, from left to right, presents a brief statement of the production strategy; examples of the strategy; opportunities for reducing land use; and major risks of expansion. Opportunities describe the pathway through which the category of strategies is most likely to limit expansion, while Major Risks indicate the most likely ways a strategy may fail to reduce agricultural expansion into forests.

3.1 CONVENTIONAL INTENSIFICATION

3.1.1 INTENSIFY ANNUAL CROP PRODUCTION

Conventional agricultural intensification relies on hybrid seeds, chemical inputs, and monocultures. Capital intensive and often conducted on a large scale, it typically includes systemic irrigation and mechanization as part of production design. Conventional intensive agriculture constitutes the defining approach in large-scale commercial operations, yet smallholders may adopt some of these methods to raise yields. Elements of conventional intensification were fundamental to the Green Revolution referred to in Section 2. Largely driven by genetic improvements of staple crops, the approach requires efficient field management, the proper use of agrochemicals, and access to markets for the larger harvests produced.

> *"Trends, Drivers, and Impacts of Changes in Swidden Cultivation in Tropical Forest-Agriculture Frontiers: A Global Assessment"* presents the argument that over the first decade of the twenty-first century, shifting system intensification generally increased incomes in the tropics, but the transition was also associated with greater risks to households, agricultural expansion and deforestation. Communities that undergo the transition from fallow system to capital-intensive agriculture also often experience increases in inequality and land conflict (van Vliet et al., 2012).

Not all developing countries provide the enabling conditions necessary for a complete conversion to conventional intensification. They may lack the transportation services, credit mechanisms, input supply chains, market efficiency, or supportive governance structures. The partial transition to agricultural intensification in these cases may speed deforestation. For example, in Eastern DRC, cash constraints led farmers to plant improved varieties in the absence of the fertilizer necessary to maintain soil fertility (Lambrecht et al., 2014). Incomplete soil fertility management leads to reduced soil productivity and, in the long term, greater efforts to seek and clear new land, a progression that has been seen across much of Africa (Jayne et al., 2014).

In those contexts where the conditions support a shift to more capital-intensive agriculture, even if the conversion is partial we often see a "rebound effect" associated with the Jevons paradox, described in Section 1.3, as farmers reinvest new revenue into clearing more land. International commodity companies, with the support of governments and research institutions, provide ongoing investment and support to supercharge this growth. The transition to conventional intensification may also result in forest degradation by exposing farmers to climate and market risk. For example, intensive rainfed single-crop systems risk severe crop failure. Where farmers have no recourse, a lost harvest can force households to fall back on the forest and its products as a safety net. Few countries have been able to manage the expansion of intensive agriculture.

3.1.2 TRANSITION FARMERS FROM SHIFTING CULTIVATION TO CONTINUOUS CULTIVATION OF FIELDS

Farmers employ shifting cultivation systems (sometimes called "slash and burn") to let fields rest, or "fallow," while they cultivate elsewhere. The natural vegetation that regrows on the fallow land draws nutrients from the soil and returns them to the surface as litter. After a number of years, cutting the regrown vegetation and burning it with the litter prior to taking up cultivation of fallow fields makes the nutrients available to the subsequent crop. Shifting to a system of continuous cultivation of the same land, using fertilizer and other inputs to maintain soil quality, can produce markedly higher yields, in some cases doubling or tripling harvests (Ruthenberg, 1971; Bationo et al., 2007).

Both agricultural systems and the communities that support them must undergo fundamental transformation to abandon fallow agriculture. To adopt an input-based system, farmers must learn and adapt to a completely new form of farm management, one that requires more labor, different skills, new knowledge, and new commercial networks (Bationo et al., 2007). Certain conditions favor a transition from shifting cultivation to input-based agriculture. These include accessible input suppliers and markets with high product prices. Farmers are more likely to adopt input-based techniques if they currently depend on short, less effective fallows (often adopted as a result of population increases and, consequently, insufficient land area to maintain longer, traditional fallows). Restrictions on forest clearing may also accelerate the shift from fallow to input-based agriculture. Absence of these conditions will strongly impede efforts to promote the transition (van Vliet et al., 2012).

Deforestation often follows the successful transition from systems based on fallow to those based on agricultural inputs, despite increases in yields. On the new fields, vegetation that previously grew back during fallow periods will be permanently lost. Where intensification draws increased investment of labor and other resources, farmers may extend their cleared lands well into, or even beyond, lands they previously left in fallow. International commodity supply chains commonly provide the technologies and markets that drive a transition from shifting systems to more intensive farming (van Vliet et al., 2012; Curtis et al., 2018; Pendrill et al., 2019).

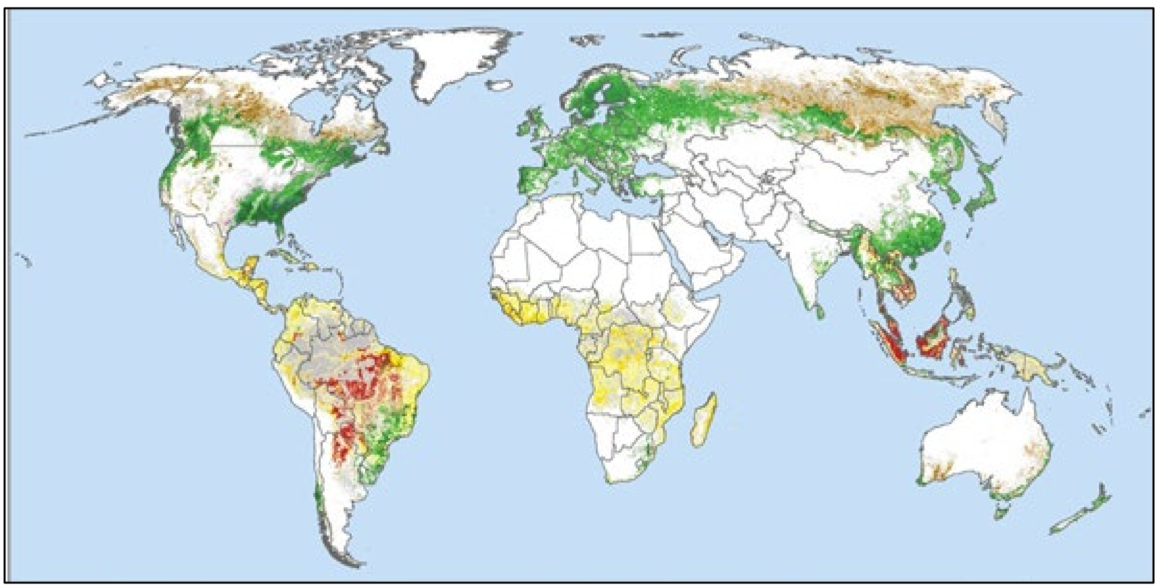

Figure 5. Primary drivers of forest cover loss. Between 2001 and 2015, land use did not change significantly in areas of shifting agriculture. Over the same period, commodity-driven agriculture drove permanent forest loss. Yellow: Shifting agriculture. Red: Commodity-driven agriculture. Green: Forestry. Brown: Wildfire. Source: Curtis et al. (2018).

Few targeted efforts by governments and donors to stimulate the adoption of agricultural inputs have been completely successful. Farmers transitioning away from shifting agriculture may confront serious agronomic challenges, such as declines in soil fertility and accelerated soil erosion. Across Southeast Asia, reduced fallow periods have seen increased demand for labor to weed fields as well as declines in soil fertility (Roder et al., 1997; Bruun et al., 2009). In the Peruvian Amazon, new and more competitive weeds emerged over time when farmers shifted to continuous cultivation. In response, communities eventually returned to fallowing their fields and using the old practice of clearing forest to do so (Fujisaka et al., 2000).[7]

[7] Again, the context and land-use history matter. Elsewhere in the Amazon, in Brazil, more intensive cultivation of fallows has increased weed populations, which both reduce yields and absorb labor (Jakovac et al., 2016).

3.1.3 MONOCROP TREES

Farmers monocrop isolated stands of trees in individual plots as well as on large industrial plantations. In the tropics, smallholders and large companies commonly monocrop rubber, cocoa, and oil palm. While companies farm products for sale, smallholders may keep the produce for either household use or sale on domestic or international markets. Both companies and smallholders use the methods and inputs of conventional intensification—such as pesticides, fertilizer, and high-yielding variety seedlings—although smallholders typically use far fewer inputs than larger companies.

> *"Large-scale oil palm investments are concentrated in tropical forest countries with little potentially available cropland outside forests, namely the Congo Basin, where expansion is accelerating"* (Ordway et al., 2017).

In theory, increased intensive monocropping of oil palm, coffee, cocoa, and other tree crops could reduce deforestation. Oil palm provides perhaps the best example. It is one of many tree crops that may be intensively cultivated more easily than annuals in the tropics, yielding higher revenue and, in some cases, higher calories per hectare. Annual food crops now commercially cultivated in the tropics, such as soybeans, corn, and what, were originally temperate plants. Limiting the cultivation of less well-adapted annual crops in tropical countries and relying more on the intensive cultivation of tree crops could possibly increase revenue gained per hectare at the landscape level and reduce agricultural expansion (Searchinger, 2011; Kahn et al., 2011).

> *Oil Palm and Biodiversity: A Situation Analysis by the IUCN Oil Palm Task Force* presents an accessible and current review of the palm oil sector and its impact on deforestation, with a focus on oil palm in the context of biodiversity conservation. It aims to provide a constructive pathway to addressing sustainability challenges in the palm oil industry (Meijaard et al., 2018).
>
> The CIFOR infobrief *Sustainable Development of the Palm Oil Sector in the Congo Basin* discusses deforestation threats and recommendations to improve the sustainability of the palm oil sector in the Congo Basin. It advocates for a regional strategy involving smallholders and informal markets (Ordway et al., 2019).

The agronomics support this theory. Commercial oil palm trees are most often cultivated as a monocrop, except in Africa where oil palm is often integrated into agroforestry systems. In either case, it is the most land-efficient method to produce vegetable oil. Oil palm trees generate one ton of oil on 0.26 hectares. In contrast, rapeseed plants need 1.5 hectares, sunflowers 2.0 hectares, and soybean 2.2 hectares (European Palm Oil Alliance, 2014; Meijaard et al., 2018). Oil palm also outperforms many annuals (including soybean, maize, wheat, and sugar cane) in terms of maintenance of soil quality, net bioenergy production, water conservation, and nitrogen and energy use efficiency. The crop requires low pesticide inputs relative to the net energy production (de Vries et al., 2010; European Palm Oil Alliance, 2014). Cultivating of oil palm is labor-intensive because harvesting is largely manual, so, like other tropical perennials, oil palms may engage labor that would otherwise be producing food crops or employed to clear forest for annual crops (Tomich et al., 2001; Byerlee, Kyaw, Thein, et al., 2014).

Observation, however, does not support this theory. The higher yields and greater revenues per hectare produced by intensively monocropped trees have not prevented deforestation. Rather, intensive monocropping provides a clear example of the Jevons paradox. Smallholders use the new income generated to purchase labor and expand production into surrounding forests. Increased agricultural profitability encourages in-migration, which also fosters agricultural expansion. Further, farmers who begin farming tree crops often cultivate them in addition to existing food crops, not as a replacement, so the new crops increase the total land area they farm. Where produce is sold on international markets, the new supply does little to impact demand or dampen prices, and growth continues. Governments may boost this growth by allotting concessions to companies, and, as noted in Section 2 above, governments, corporations, and their partners all provide support for revenue-generating commodity crops, fueling further expansion. The transition from shifting agriculture to monocropping has accompanied the loss of much of the world's forests. To return to our example, from 2000 to 2011, oil palm was responsible for an average 270,000 hectares of annual forest conversion in major palm oil-exporting countries (Henders et al., 2015).[8] In Indonesia, the expansion of oil palm production was responsible for almost half of the emissions from forest loss between 2010 and 2014 (Pendrill et al., 2019).

3.2 DIVERSIFICATION

3.2.1 DIVERSIFY CULTIVATED ANNUALS AND LIVESTOCK VARIETIES

Farmers have numerous ways of diversifying their agricultural systems. Common strategies to diversify agricultural production are generally limited to four crop types or a mix of seven crop and animal types per hectare, as benefits have been shown to decline with greater numbers of cultivars (Waha et al., 2018). Typical examples include planting cereal varieties alongside legumes, and/or seasonally rotating cereal crops with legumes and broadleaf crops. Farmers also add livestock to field crop cycles such as introducing fish to rice paddies, and rotating grain crops and pasture (Rao et al., 2015). In the two sections below, we describe the integration of trees with annual cultivar and livestock production.

Diversification can raise yields. Traditional systems in Southeast Asia employ various forms of diversification to improve fallows and increase productivity (Thrupp et al., 1997). Rotation with nitrogen-fixing crops and cover crops can increase cereal yields (Smith et al., 2008). The proper inclusion of livestock into a cropping system has also been shown to increase the productivity of land (Rao et al., 2015). A recent meta-analysis of research concludes that intercropping may substantially improve yields, with the productivity of "mixed" crops producing yields just short of a fifth higher than "solo" cropping (Yu et al., 2015).

"Resilience in Agriculture Through Crop Diversification: Adaptive Management for Environmental Change" explores how farmers can improve their resilience to climate change through diversification and presents reasons behind slow adoption rates (Lin, 2011).

Farmers rely on diversification to generate ecosystem benefits, (such as improved soils, and fewer pests), and to manage risk and remain productive without spending cash or incurring debt. Diversification mitigates risk and increases resilience to production and market threats by reducing vulnerability to any one threat. With multiple crops planted, a farmer reduces loss from rainfall stress or a drop in price affecting one crop (Sunderlin et al., 2001; Pretty et al., 2006; FAO, 2013). For this reason, farmers increasingly use diversification as a strategy to adapt to climate change (Delacote et al., 2019). Because diversification does not require agrochemicals, it is an available tool to remote and cash poor farmers.[9] Diversification is more environmentally sustainable for the same reason. The cultivation of multiple crops and animal types may also promote more nutritious diets in local communities with limited market access to healthy foods (Ickowitz et al., 2019).

In central Mozambique, vulnerable farmers reduce the risk of crop failure and improve productivity, profitability and food security by intercropping maize with pigeon peas (Rusinamhodzi et al., 2012).

Farmers have long relied on diversity in their agricultural systems. Most smallholders in developing countries continue to rely on it. In West and Central Africa, farmers plant multiple crops in various spatial and temporal arrangements. For example, farmers in the Sahel intercrop cowpea, millet,

[8] Again, the dynamic shows remarkable variation by location. By one estimate, 45 percent of post-1989 palm oil expansion in Southeast Asia has taken place the expense of forests, while 31 percent of plantations in South America replaced forest, compared to 7 percent in Africa and 2 percent in Mesoamerica (Vijay et al., 2016).

[9] In fact, some studies have found that the application of nitrogen fertilizer on mixed crops planted and harvested at the same time has a negative impact on yield (Yu et al., 2015).

sorghum, and groundnut to simultaneously meet subsistence and cash needs (Jodha, 1980; Singh & Ajeigbe, 2002; Waha et al., 2018). In South Asia, where seasonal rotation of rice and wheat constitutes one of many ancient forms of multicropping (Petrie & Bates, 2017), farmers are responding to declining yields in the rice-wheat system by integrating short-duration crops, such as potato and soybean, into their systems (Ladha et al., 2003; Gangwar & Singh, 2011). Indigenous groups in the Amazon also improve soil management through diversification (Hecht, 1989).

To adapt their diversification strategies to evolving conditions, farmers can use knowledge-based, resource-neutral changes in agricultural practices: modifying agricultural calendars or the location of crops and livestock. Farmers may also diversify by adopting new varieties of plants or animals. Integrating new crops or types of livestock may require changes in input supply or other modifications to the value chain (FAO, 2013).

Governments and their partners may support these production strategies by embracing complexity in agriculture and increasing options available to farmers (Ickowitz et al., 2019). This will require significant changes in policies and investment strategies. In some countries, economic policy incentives constrain crop and livestock diversity by promoting and subsidizing intensive cultivation of monoculture crops (Lin, 2011; Waha et al., 2018). For example, farmers participating in the Farm Input Subsidy Program in Malawi reduce the amount of land dedicated to unsubsidized crops (Chibwana et al., 2012). Governments and their partners may also support diversification through assistance in adopting and marketing new crops. Research will also need to diversify, broadening from a focus on key staple crops to include neglected and underutilized crops (Ozturk et al., 2018; Waha et al., 2018; Ickowitz et al., 2019).

The FAO *Climate Smart Agriculture Sourcebook* (2013) provides a practical discussion of strategies to reduce climate risk through diversification.

Annual crop and livestock diversification may reduce dependency on forest products as a coping strategy (Illukpitiya & Yanagida, 2008; Torres et al., 2018). Isolated case studies suggest this form of intensification also reduces the need for farmers to clear additional land. Yet even these studies underscore that the relationship is not direct and depends on household socioeconomic status and context factors such as the availability of labor, inputs, and markets. In some cases, the increased incomes generated by diversification, or labor released in the process, may be applied to increased forest clearing (Caviglia-Harris & Sills, 2005; Bottazzi et al., 2014).

A recent literature review found little evidence demonstrating that households deforest less when they diversify to adapt to weather shocks in Africa (Delacote et al., 2019). Similarly, our own review of the available literature found no case studies demonstrating that increased crop and livestock diversity reduced agricultural expansion into forests.

3.2.2 DIVERSIFY BY INTRODUCING OTHER CROPS INTO TREE CROP SYSTEMS

Many tree crops may be monocropped in full sun or in conjunction with trees and other crops under shade. Coffee and cocoa, for example, may be produced either in "full sun" or under the shade of other trees. Farmers produce tree crops under the cover of standing forests, under the remnants of partially cleared forests, and under planted trees. They may also diversify these different "shade systems" by adding annual and perennial crops. The relationship among the trees providing shade, the tree crops, and the additional crops may evolve over time, so that the diversification may take place both sequentially over years and simultaneously on the same land. A few examples:

"Understanding the Roles of Forests and Tree-based Systems in Food Provision," presents a thorough treatment of the relationship between forests, tree-based systems and food production (Jamnadass et al., 2015).

In southern Asia, farmers intercrop coconut with other perennials such as cocoa, clove, nutmeg, coffee, black pepper, mulberry, and breadfruit (Thomas, 2010; Ginigaddara et al., 2016).

In India, farmers intercrop cashew trees with annuals such as tapioca, pulses, turmeric, ginger, yam, and maize (Visalakshi et al., 2015).

The ProLand *Case Study: Using Shade to Reduce the Impact of Cocoa Cultivation on Forests: A Synthesis of the Evidence and a Case Study from Indonesia* discusses the drivers and hazards of full-sun cocoa cultivation systems, and presents alternative agroforestry systems approaches that have the potential to better meet livelihood, production, and ecosystem objectives (Miller & Young, 2021).

In Côte d'Ivoire farmers intercrop cocoa with orange and avocado trees (Koko et al., 2013).

The diversification of tree crop systems does not dramatically increase yields in the short term, yet it can maintain long-term productivity, and can reduce certain costs and risks to production. Properly managed, diverse systems produce the ecological services that support crops. They may improve nutrient cycling and limit weeds and undergrowth, reducing requirements for fertilizer, pesticides, and herbicides. Smallholders who diversify their agroforestry systems often make them more resilient to climate variation, drought, and other extremes (Senanayake & Jack, 1998; Ashton & Ducey, 2000; Young, 2017). Smallholders may also increase their resilience to market fluctuations by intercropping high-value tree products such as timber, fruit, nuts, spices, and medicines (Ruf et al., 1995; Smiley & Kroschel, 2008; Somarriba et al., 2013; Mithöfer et al., 2017; Jezeer et al., 2017).[10]

Producers face technical and financial challenges when they choose to farm diversified tree crop systems. They may require technical support to learn new approaches to manage pests and/or weeds. This may be a particular barrier to people with limited access to extension service, such as women in many contexts (Nchanji et al., 2021). They will also need to plan for the cultivation of a more varied set of crops. Producers will incur opportunity costs as they wait for new perennial crops to become established and find markets for new products. For many smallholders it makes great economic sense to opt for the short-term profits of full-sun systems over the longer-term investment and less-certain future returns of diversified agroforestry systems (Ruf, 2011).

Policies regarding agricultural subsidies, taxes, and exchange rates may also favor more simple systems that rely on capital and agrochemicals. Easy access to forest lands often supports an approach that relies on access to virgin forest rather than sustainable land use (Akiyama & Nishio, 1999; Jassogne et al., 2013; Witjaksono, 2016; Leblois et al., 2017; Combes et al., 2018). We discuss these governance actions further in Chapter 4.

The diversification of tree crop systems may slow deforestation as it vertically intensifies growing space and strengthens smallholder resilience to market and climate variability and extremes. These systems nevertheless expand into forests as they grow and, over time, replace them. When tree crop systems are successful, like other forms of agricultural intensification, they attract investment and more farmers. The international markets in tree crop commodities that have driven deforestation across the globe purchase shade-grown commodities as they do full-sun. In some cases, they offer a premium for organic shade-grown commodities, without regard for whether forest was degraded or cleared to produce it. Scaling diversified tree crop systems alone is not the solution to deforestation.

[10] See Rice and Greenberg (2000); Bos et al. (2007); and Rajab et al. (2016) on pest/disease outcomes. See Siebert (2002); Lin et al. (2008); Moser et al. (2010); Tscharntke et al. (2011); and Rajab et al. (2016) on drought responses. *See* Montagnini & Nair (2004); Rice & Greenberg (2000); Ong et al. (2004); Bhagwat et al. (2008); Nair et al. (2009); Jose (2009); and Schroth et al. (2011) on ecosystem services regulated through shade agroforestry systems.

3.2.3 DIVERSIFY BY INTRODUCING TREES INTO CROP AND LIVESTOCK SYSTEMS

Farmers use agroforestry, the cultivation and conservation of trees in agricultural systems, in many ways and for many purposes. They may cultivate trees as the dominant crop, a form of agroforestry we addressed in the previous production strategy. Farmers also cultivate trees and shrubs by planting them or fostering their regrowth in systems that serve primarily to produce annuals or raise livestock. They may, for example, plant rows of trees in or around fields of annuals or cultivate trees at low densities in pastures.

> *An Introduction to Agroforestry* presents a global survey of the great diversity of agroforestry systems in the tropics and presents brief notes on about 50 of the multipurpose trees and shrubs commonly used in agroforestry (Nair, 1993).

Across India, farmers have traditionally cultivated trees in fields (Viswanath & Lubina, 2017). In Latin America, livestock producers often cultivate trees and shrubs within pastures. In Asia, farmers create live fences with shrubs (Nair, 1993). In Africa in recent decades, farmers have increasingly cultivated trees in fields, a trend labeled the rise of "evergreen agriculture" (Ajayi et al., 2005; Garrity et al., 2010). In one well-known success story, farmers have "regreened" over 5 million hectares in southern Niger by protecting and managing trees on their farms (Reij & Winterbottom, 2015).

Producers use these forms of agroforestry to increase yields, feed livestock, maintain soils, and increase overall land productivity. Nitrogen-fixing trees in fields improve soil by providing fertilizer. Trees planted in a row may serve as a windscreen and reduce erosion (Nair, 1993; Minang et al., 2014). Producers may use the leaves trees produce as forage or fodder for animals. Trees planted in or around fields or pastures may produce nuts or fruit that may be sold or contribute to diversity in local diets.

Sometimes trees that farmers cultivate reduce pressure on nearby forests by providing products that would otherwise be harvested from forests. Farmers increasingly cultivate on-farm trees to meet timber and fuel demands in many tropical countries (Robiglio et al., 2011). In eastern Tanzania, rotational woodlot systems significantly outperform vegetative growth of traditional fallows in producing fuelwood, enriching soils, and maintaining carbon stocks (Kimaro et al., 2011).

Trees in agricultural systems may also improve ecosystem services unrelated to productivity by providing habitat, regulating water, and storing carbon (Buck et al., 1998; Harvey et al., 2004; Montagnini, 2006; Minang et al., 2014). Agroforestry has also demonstrably reduced pollution from agrochemicals in multiple contexts (Pavlidis & Tsihrintzis, 2018). One meta-analysis found that agroforestry systems stock approximately one fifth more carbon than neighboring cropland or pasture, although there is substantial variation by type of agroforestry and geographic location (Shi et al., 2018).

Farmers have not adopted agroforestry as widely as one might assume, given the benefits researchers have identified (Rahman et al., 2017). The introduction of trees to fields can face technical, resource, and cultural barriers. Two sets of recommendations come from successful cases of introduction of the practice into agricultural systems: 1) The use of trees must be closely adapted to existing agricultural systems. As with other forms of intensification, producers may need new appropriate inputs, tenure conditions, technological information, credit, or markets for new products. Farmers are more likely to adopt practices that require minimal changes in labor, field planning and resource management. 2) In some contexts, the higher cultural value of the existing system constrains adoption. To tailor the introduction of trees into crop and livestock systems and build local acceptance the extension of practices should be designed and implemented in collaboration with the community (Garrity et al., 2002; Rahman et al., 2017). As with other forms of diversification, governments can do more to support this strategy (Rahman et al., 2017).

Agricultural systems that integrate trees into annual cultivation or livestock raising may reduce pressure on forests. Research has demonstrated that these practices can raise yields, reduce risks to production, and provide products and services that forests also produce. On a practical level, the cultivation of trees

World Agroforestry (ICRAF) provides evidence, information and ideas to inform policies and practices that harness the benefits of trees for people and the environment. World Agroforestry merged with the *Center for International Forestry Research (CIFOR)* in 2019.

may encourage farmers to continue to cultivate where they are. When they cultivate trees, farmers invest in their land. The practice may also lead to further investment in existing fields. New trees often strengthen land rights, especially if they are used as a fence or live hedge. These rights, and this investment may deter cultivation elsewhere. In Gunung Salak Valley in West Java, Indonesian farmers growing trees on farmland alongside crops clear less forest and collect fewer forest products than nearby farmers practicing shifting cultivation (Rahman et al., 2017). In some locations in the Philippines, agroforestry practices have dramatically reduced the conversion of forest to agriculture and limited the extraction of forest products in national forests (Garrity et al., 2002). These are two of a very small number of studies that focus on the forest impacts of this type of agroforestry. More research is necessary to validate theories regarding the contexts and conditions under which the adoption of agroforestry practices impact deforestation (Angelsen & Kaimowitz, 2004).

4.0 GOVERNANCE ACTIONS THAT IMPACT AGRICULTURE'S FOOTPRINT

During our review of the literature regarding controls and incentives available to governments to manage deforestation, we identified thirteen actions governments and their partners undertake that substantially influence the location and rate of agricultural expansion into forests. We group these as 1) broad governmental functions that stimulate or dampen agricultural growth; 2) government actions that influence land use directly; and 3) market system approaches.

> Three ProLand case studies assess the effectiveness of governance actions in promoting diversification strategies described in the previous section:
>
> *What Do Experience and Research Tell Us About Using PES to Limit Deforestation? A Synthesis of the Evidence and Case Studies from Uganda and Colombia*
>
> *The Role of Governments in Making Certification Effective: A Synthesis of the Evidence and a Case Study of Cocoa in Côte d'Ivoire*
>
> *Restoring Abandoned Degraded Land for Agriculture: A Synthesis of the Evidence and Case Study from Indonesia*

The broad government functions indirectly influence the extent of agriculture-driven land-use change by stimulating or dampening agricultural growth, while other categories more specifically create controls and incentives that direct land use. Indirect actions include fiscal and trade policy, as well as policies that influence migration and population growth. Consequences of these policies on land-use and land-use change may be unintended and the relationships can go unrecognized. Even where a general relationship has been identified, the precise impact is often difficult to quantify but may nevertheless be substantial (Lambin et al., 2014). Transportation investments also have a profound, if often indirect, influence on agricultural expansion, and transportation planners rarely take this into consideration.

Governments use the more direct and localized actions described in the second category to manage the expansion of farming into forests. These actions include land-use planning and zoning; designating areas outside of forest agroecological zones for agricultural investment; launching programs to revitalize or restore degraded land; siting and managing protected areas; allotting concessions; and establishing and implementing property rights and land tenure regimes.

In recent decades, governments and nongovernmental actors have also attempted to fill a perceived weakness in the governance of natural resources through market-based approaches. This third category of government actions includes fostering forest-based enterprises, certification regimes, and payments for ecosystem services (PES) schemes designed specifically to inhibit forest clearing. Governments do not always lead the market system actions we discuss here, but government intervention is necessary for the success of approaches that attempt to leverage private-sector incentives to protect forests.

Strategies to sustainably exploit forests require governmental action to avoid conflict, ensure equity, and prevent overexploitation of forest products or the degradation of the ecosystem services they produce. Market system approaches that target sustainable and successful commercialization of forest products and ecosystem services require clear tree and land tenure and effective monitoring, regulation, and accountability to ensure sustainable use of resources. A country's government must also provide a supportive context for formal transparent and efficient markets and business transactions. Creating this context may require governments to undertake broad reforms, such as transforming land tenure regimes, improving regulation, reducing corruption, reforming judicial and financial systems, and changing policy regulating agriculture and forest use. Market system approaches intertwine with the larger context, and often require parallel investment in governance (Shames et al., 2011; Guariguata et al., 2012).

Cross Sectoral Guide: Sustainable Landscapes (SL) and Democracy, Human Rights, and Governance (DRG)

USAID designed the SL-DRG Guide to support more participatory democratic governance processes, and enhanced progress on partner countries' climate change mitigation efforts. This guide is intended mainly for USAID staff and implementing partners, particularly those with responsibility for SL and DRG activities. In addition, the guide is useful for any development professionals seeking sustainable, equitable, and scalable climate and citizen action.

Governments may undertake several of these actions simultaneously. They may negotiate new trade policies while revising land tenure law and regulating protected areas, for example. When actions are undertaken at the same time their impacts on rates of deforestation may cumulate, with one reinforcing the other. Strengthening government capacity in timber concession management improved the effectiveness of land-use plans (Evans, 2021). Conversely, they may produce conflicting incentives. For example, trade policy may increase the pressure on protected areas. Despite the potential power of a coordinated approach, the topic of simultaneous investment in multiple governance actions falls beyond the scope of this paper. For this reason, and for the sake of clarity, the sections that follow present the thirteen actions separately. We return to the question of overlap and coordination among governmental actions in the paper's conclusion.

The description of each strategy begins with a potential impact statement derived from our literature review describing how each action can reduce agricultural expansion into forests. A brief description of the action and its application follows. We then focus on how the action may influence agricultural growth, either nationally or locally, and how it may be used to constrain agricultural expansion into forests. This is followed by a description of challenges facing governments and their partners using this action, and a brief evaluation of the potential for using this action in limiting agricultural conversion of forests. Table 2 summarizes the thirteen actions.

Table 2. Governance actions that impact deforestation driven by agriculture

	Governance Actions	Example(s)	Potential Impact	Major Challenges
BROAD GOVERNMENTAL FUNCTIONS				
1	Create fiscal policy that protects forests	Tax concessions and government procurement of products; market and price support for agricultural products	If governments modify fiscal policy to dampen agricultural incentives, *agriculture will expand less into forests.*	The relationship of fiscal policy to deforestation is indirect and often unrecognized. Changes in fiscal policy that reduce agricultural expansion often also reduce agricultural growth. Current policies may be supported by strong constituencies.
2	Create trade policies that protect forests	Tariffs; import quotas; international trade agreements	If governments modify trade policy to dampen incentives for producing international commodities associated with deforestation, *agriculture will expand less into forests.*	Requires negotiating complex economic and political interests. Constraints on international trade may conflict with the goal of export-driven economic growth.
3	Prioritize forests when planning transportation infrastructure	New or improved roads, ports, rail lines	If governments plan for the potential impacts on forests when they invest in infrastructure, *they will achieve socioeconomic objectives with less impact on forests.*	Making forests a priority in an already complex process requires significant political will. Effective infrastructure planning requires daunting technical capacity.
GOVERNMENT PROPERTY RIGHTS AND LAND TENURE MANAGEMENT				
4	Practice land-use planning and zoning	Plans for the siting and management of protected areas, concessions, and zones for agriculture; zoning separating forested areas in a permanent and non-permanent forest estate	If governments plan for land use, *they will improve the management of agricultural expansion and conserve forests.*	Plans require significant technical capacity to develop, and political will to implement. Budget and political will for monitoring and enforcement can be limited.

	Governance Actions	Example(s)	Potential Impact	Major Challenges
5	Designate areas outside of forest agroecological zones for agricultural investment	Development corridors; special investment zones; growth poles; and agroparks	If countries meet their agricultural needs through farming methods not suitable to forests, *farmers will clear less forest.*	Intensification increases agricultural expansion into high value non-forest ecosystems.
6	Launch programs to revitalize degraded, underproductive, and abandoned lands	Adopt practices to improve slope management or water efficiency; introduce perennial crops.	If farmers improve the productivity of degraded lands or reclaim abandoned land, *they will clear less forestland.*	High cost may limit adoption and thus have little impact on agricultural expansion. Costs may also skew benefits to wealthy investors.
7	Site and manage protected areas	Nature reserves, wilderness areas; national parks; protected areas with non-consumptive or low-intensity use of natural resources	If governments establish and manage protected areas effectively, *they will prevent agricultural expansion into designated forests.*	Absence of government capacity to enforce regulations and prevent encroachment into large remote areas
8	Allot concessions for timber and agriculture	Government allocation of large tracts of land under specified conditions for defined periods of time, often for commercial uses, such as plantation agriculture, timber, and mining	If governments allocate land to companies under specified conditions, *the companies will reduce agricultural expansion into forests.*	Absence of government capacity to monitor and enforce agreements with companies producing high-value commodities in large remote areas
9	Strengthen tenure and property rights in agricultural lands	Titling or certification of farmland to individuals	If farmers have greater tenure security, *they will intensify investment in existing lands and expand agriculture less into other lands, including forests.*	Tenure systems are deeply integrated into socioeconomic context and require significant investment and many years to reform.
10	Strengthen community ownership of forests	Community forests; the allocation of land to indigenous peoples	If governments devolve forest ownership to local communities, *those communities will manage forests to reduce agricultural expansion.*	Absence of local and national management capacity to implement at a large scale Absence of national government capacity to prevent displacement of deforestation to other locations

	Governance Actions	Example(s)	Potential Impact	Major Challenges
		MARKET SYSTEMS APPROACHES		
11	Support forest-based enterprises	Strengthen forest product value chains such as woodfuel, fodder, nuts, fruits, and gums.	If the economic value of intact forests is increased, *then agriculture will expand less into forests.*	Value chains are often difficult to scale while maintaining sustainability of harvest.
12	Establish payments for ecosystem services	Payments incentivizing land-users to maintain trees or plant new trees	If beneficiaries provide payments to land users to voluntarily adopt certain practices, *agricultural expansion into forests can be eliminated.*	Complexity adapting to the local contexts; implementation has high transaction costs and requires substantial technical inputs from government and nongovernment entities.
13	Establish or encourage adoption of performance standards	Coffee and cocoa certification schemes	If civil society and private sector partners leverage transnational market forces to provide incentives to value chain actors, they can compensate for the absence of local governmental regulation *and reduce agricultural expansion into forests.*	Standards must be applied across the supply zone to avoid the risk of expansion into forests being shifted to other locations.

Table 2. presents brief statements of thirteen governance actions that prevent agricultural intensification from leading to forest clearing, with examples of each action. The Potential Impact statement describes the key means by which the government action, if successful, would impact agricultural expansion into forests, while the Major Challenges column includes barriers to using the action to reduce agricultural expansion into forests.

4.1 BROAD GOVERNMENTAL FUNCTIONS

4.1.1 GOVERNMENT FISCAL POLICY

Potential Impact: If governments modify fiscal policy to dampen incentives for agricultural expansion, agriculture will expand less into forests.

Fiscal policy often stimulates change in land use. Of the diverse set of instruments governments use to influence the economy, the incentives they establish to stimulate the agriculture sector impact agricultural expansion into forests most directly. A partial list of the methods governments use to stimulate agricultural value chains includes grants, guarantees, and cash and in-kind payments. Governments may also offer tax concessions and procure products. They provide market and price support for agricultural products. Through fiscal policy, governments increase farmer access to capital, natural resources, services, and infrastructure (Kissinger, 2015). In tropical countries, the value of government subsidies to the agriculture sector vastly outstrips domestic and international donor investments in reducing deforestation (Kissinger, 2015; Duchelle et al., 2019).

By fostering agricultural growth these policy measures—especially agriculture sector incentives—may stimulate aggressive agricultural expansion into forests. Economic modeling has found that higher public spending and greater access to credit are associated with forest loss in developing countries, especially in those countries with the greatest forest cover (Combes et al., 2018). In a well-studied example of this impact of fiscal measures, demonstrated by their removal, restrictions on agricultural credits in Brazil contributed to reductions in deforestation rates (Nepstad et al., 2014).

Input subsidy programs can go wrong, even when done right

A challenging tool to use, the design and implementation of agricultural input subsidies often prevent them from increasing productivity and production as intended. Inefficiency, corruption and unreliable performance have plagued these programs over the years (Gautam, 2015; Hemming et al., 2018; Holden, 2019). However, at least in Africa, even if governments successfully use new methods developed to address these perverse outcomes, cheaper fertilizer may, in the long run, foster more extensive use of agricultural lands rather than raise yields and intensify land use (Jayne, Mason, Burke, et al. (2018).

Agricultural Input Subsidies. In other cases, the relationship between fiscal incentives and deforestation is less direct. Some studies conclude that agricultural subsidies on inputs such as seeds and fertilizer may result in more extensive use of agricultural lands over the long term. This is because farmers who use inorganic fertilizer must also practice complementary methods to maintain the health of soil in their fields over time (Jayne et al., 2019). When subsidies are in place, farmers tend to rely on cheap fertilizer and not utilize, or even abandon, the other soil management practices. Poorly maintained soils respond less well to fertilizer and yields eventually decline (Jayne, Mason, Burke, et al. (2018). This is exemplified by Zambia, where fertilizer subsidy programs reduce the likelihood that producers engage in other natural resource management practices essential to maintain soil health and agricultural productivity (Morgan et al., 2019). The result has been more extensive land use and the expansion of farmed land.

Taxes—the inverse of fiscal incentives—can also be used to disincentivize agricultural expansion. Governments tax agriculture and forestland and its products; however, few governments have attempted to employ targeted taxes to reduce forest conversion to agriculture. This is despite substantial discussion about the potential of taxes as an instrument to stem deforestation and many modeling exercises, particularly regarding a tax on carbon,

Numerous factors reduce the likelihood that governments will modify fiscal policies to limit their impact on agricultural land use. Lack of recognition of the relationship between fiscal policy and deforestation may be among the most important of these factors. Few countries have made this connection in their readiness planning for REDD+ ("Reducing Emissions from Deforestation and Forest Degradation plus conservation, sustainable management of forests and enhancement of carbon stocks"). In their plans, very few countries assess fiscal incentives and propose reforming them to attain their REDD+ forest carbon emission goals (Kissinger et al., 2019).

Fiscal tools such as subsidies and taxes are flexible and adaptable, but governments have rarely used fiscal tools to address the impact of agriculture on forests (Kissinger et al., 2019). Governments that choose to implement fiscal incentives, modifying and applying these policies will require determination, persistence, and diplomacy. The initial step, assessment, is complicated by policy outcomes that present both diffuse benefits and risks for multiple stakeholder groups. Their cross-sectoral impact also means that planning modifications may require a process of clarifying and revising agency roles and responsibilities. Government agencies with little or no responsibility for forest management implement fiscal policy. The complex nature of fiscal incentives for forest conservation may require a cross-sectoral or even whole-of-government approach. Powerful constituencies that benefit from current fiscal forest-threatening incentives, and government agencies that generate revenue by managing them, may resist change. Governments may find it difficult to balance the various benefits and risks across sectors. Further resistance may come from within the agriculture sector, because protecting forests via fiscal tools may dampen growth and discourage international and domestic investment in agriculture. Modifying agricultural incentives may also negatively impact rural communities and their economies (Pham et al., 2019; Kissinger et al., 2019). Governments commonly condition agricultural support, but rarely in ways intended to limit deforestation.

Fiscal incentives for agricultural commodity production: options to forge compatibility with REDD+

This UN-REDD Programme working paper briefly presents the range of subsidies and fiscal incentives governments use to encourage agricultural growth and provides examples of countries that have successfully reduced forest loss by reversing government incentives. The paper includes a decision tree for finding complementarity between agricultural incentives and efforts to reduce forest loss (Kissinger, 2015).

The constraints noted above limit government use of fiscal tools to address agriculture's impact on forests. There are, however, some positive examples. Brazil attached conditions on agricultural credit and extension services that required farmers to undertake certain forest management practices. This modification resulted in the recovery of degraded lands and reduced encroachment into forests. In another case, India began including forest cover as a criterion for the redistribution of tax revenue to states in 2014 to incentivize forest protection and restoration. As results come in, this early experiment in ecological fiscal transfers will provide useful lessons for future policy efforts (Busch & Mukherjee, 2018).

4.1.2 TRADE POLICY

Potential Impact: If governments modify trade policy to dampen production incentives for international commodities associated with deforestation, agriculture will expand less into forests.

Like fiscal policy, trade policy can stimulate or constrain agriculture. Governments use trade policy primarily to make domestic products competitive on the international market. Using trade policy tools governments can influence the prices of imports relative to the prices of exports, also known as the "terms of trade." They use tariffs (taxes on imported products); quotas (limits on imports); and other measures to restrict imports and protect local production. Incentives that governments provide to domestic producers, such as those discussed in the previous chapter, may also play a role in a country's trade policy. Agricultural incentives allow producers to sell at lower prices, thus improving their terms of trade.

Trade policy also includes the global and regional agreements through which countries align their trade policies. This alignment often takes the form of reductions in national restrictions on trade. Removing protectionist national policies and opening international trade (also called "liberalizing" trade) boosts trade and, in turn, stimulates production in the economies of the participating countries. It promotes export-led growth. Because trade liberalization helps reduce the price of goods and services, it benefits lower-income households and is considered to be a means of ending global poverty.

Trade policy also influences rates of deforestation. It does so by improving the competitiveness of export commodities associated with forest loss. It creates demand for these "forest-risk" commodities and stimulates their production.

Countries that attempt to use trade policy to mitigate domestic forest loss risk economic consequences. Trade enables the relocation of production to countries with the lowest additional costs of increased production. International companies engage selectively across the globe and source products from the countries where agriculture can expand most inexpensively. As a result, when countries lower subsidies and more strictly regulate the production of forest-risk products, they lose competitiveness and production investment moves elsewhere. This mobility of international capital undermines national trade policy responses to deforestation and production becomes concentrated in countries with abundant, poorly defended forests (Meyfroidt et al., 2014; Leblois et al., 2017; Ingalls et al., 2018). [11] In the case of global soybean, oil palm, and beef markets, for example, models suggest that the global liberalization of trade would increase deforestation by over a third in South America and by almost a fifth in Indonesia and Malaysia as production increased in these countries (Beckman et al., 2017).

International trade agreements, like domestic trade policy, have proven to be unwieldy tools for addressing the impact of international commodity production on the world's forests. Countries engage in negotiations with each other to liberalize trade, not impede it. Efforts to establish agreements to limit trade in forest-risk commodities face stiff resistance. Indonesia and Malaysia, for example, aware of the potential impact on their economies, prevented implementation of proposals to restrict imports to the European Union included in a 2017 European Parliament report on palm oil (Gupta & Weatherley-Singh, 2018).

The complexity of trade agreements also hinders their use in addressing deforestation. Policies bridge the concerns of countries at different levels of development, with different amounts of available forest and different systems of agricultural and forest-resource governance. Although the impact of trade on deforestation is widely recognized, researchers have struggled to describe the causal relationships between trade in international commodities and tree cover change. No clear and common understanding exists regarding how modifications to trade agreements may influence levels of deforestation in individual countries (Ingalls et al., 2018).

Consensus on how trade agreements might be used to stem deforestation is made more difficult because countries feel the costs and benefits of trade in forest-risk commodities differently. Increased trade does not affect tree cover in countries that have cleared their forests (Leblois et al., 2017). These countries, unable to produce forest-risk commodities, benefit from trade liberalization at no risk to their forests. The commodities they buy embody deforestation,

Carbon Emissions in our Food

Commodities can be said to "embody" the emissions generated when forests are cleared to produce them. When "embodied emissions" are taken into account, Belgium and Japan import more agricultural emissions than they generate through their own domestic agriculture (Pendrill et al., 2019).

[11] International markets are not the only vector for deforestation to "leak" from one country to another. Deforestation pressure may also move across borders on the feet of migrants who take up farming in their new country.

displaced from forest-rich countries (see box, "Carbon Emissions in our Food").

Policymakers have only begun discussions on the topic of deforestation and trade. Thus far, the studies, reports and negotiations have not resulted in the implementation of effective policy measures. The EU's Renewable Energy Directive, one of the few attempts over the years, required the introduction of sustainability criteria to ensure that biofuel production did not threaten biodiverse primary forests. The Directive had no impact, apparently because its development and implementation prioritized state interests in energy security and was highly responsive to the influence of private sector stakeholders (Oliveira et al., 2017).

Given the economic and political interests involved in the complexities of embodied deforestation, it is very unlikely that solutions will be designed, implemented, and enforced in the near term. Various approaches have been proposed for developed countries with little remaining forest to take on some of the responsibility for the deforestation their consumption produces in less developed, less well-regulated, countries with remaining forest. Options include increased supply-chain transparency and due diligence; restrictions on imports; support for certification schemes; support for local production; and providing consumers better information regarding agricultural commodities and their impacts (Gupta & Weatherley-Singh, 2018). Be that as it may, in the end, governments and their partners must deploy counterbalancing policies and actions to prevent trade policy favorable to agricultural commodity growth from accelerating agricultural expansion, especially in heavily forested countries (Leblois et al., 2017). Trade leads to an ecologically unequal exchange and the burden of addressing international deforestation drivers still largely remains on developing countries.

4.1.3 TRANSPORTATION INFRASTRUCTURE

Potential Impact: If governments plan for the potential impacts on forests when they invest in infrastructure, they will achieve socioeconomic objectives with less impact on forests.

The many choices governments make in developing transportation infrastructure influence the growth of agriculture and whether it expands into forests. New roads, rails, ports, and airports allow settlements to become established and to expand. Roads and other transportation infrastructure enable farmers to migrate and to transport goods to market. Where infrastructure does not exist, underdeveloped networks provide "passive protection" for forests. The poor road networks in the greater Congo Basin impede settlement and inhibit both settlements and large-scale agricultural investment and land acquisitions. Where infrastructure is built or improved, transportation enables the expansion and intensification of agriculture (Megevand, 2013; Busch & Ferretti-Gallon, 2017; Restivo et al., 2018).

Investment in transportation does not always increase agriculture's footprint. The potential for transportation investments to drive deforestation is influenced by the amount of forest in a country, and the suitability of that forest to agriculture. The impact of investment in transportation will also depend on the size of urban centers and markets to which farmers gain access. The marginal impact of infrastructure also decreases over time, as more land is converted to agriculture. In certain cases, improved transportation may have negligible impacts on agricultural growth. This may happen when transportation favors nonagricultural livelihoods, such as when roads connect peri-urban farm communities to cities. Transportation improvements may also reduce new investment in agriculture locally, and thus reduce pressure on local forests by improving access to more distant arable lands (Busch & Ferretti-Gallon, 2017; Smith et al., 2018).

Given the potential range of outcomes, investment must be carefully considered to reduce the impact on forests. Transportation forms the backbone of economies; provides access to essential healthcare, education, and other public services for remote communities; and underlies poverty alleviation and community resilience. The governments of tropical forested countries will continue to implement their ambitious plans to upgrade their transportation systems. Rather than curtailing investment in transportation, the focus must be on satisfying economic and social objectives in ways that pose the least risks for forests. Countries have many options in determining the location, capacity, and quality of transportation infrastructure.

> *Road Planning Software*
>
> The World Bank Simplified Roads Economic Decision Model (RED) supports the decision-making process for the development and maintenance of low-volume roads by helping users perform the economic evaluation of road investments.

The complexity of transportation infrastructure development, and the high stakes involved make planning a critical step in the process. The impact of planning decisions—the number, length, and capacity of roads, for example—is rarely straightforward, yet the outcome of the planning process will greatly affect the distribution of benefits. Informed, evidence-based decision-making can contribute to rational choices and direct investments to the intended social and economic objectives. If properly implemented, effective planning can also reduce the potential for unnecessary roads, identify and reduce the potential impact on high-value areas, and minimize unintended deforestation (Patarasuk, 2013; Busch & Ferretti-Gallon, 2017; Smith et al., 2018).

Planners use a variety of methods to estimate the potential short- and long-term impacts of transportation infrastructure development. Models may integrate geographic information systems (GIS) and use location-specific economic and population data to assess the potential impacts of different options. Tools such as the World Bank *Roads Economic Decision Model* (Archondo-Callao, 2004) can estimate economic and social impacts and inform policy decisions concerning the location and level of infrastructure investments. The maps produced characterize locations in terms of risk to the environment and economic benefits (Damania et al., 2016).

Data and expertise are not always available to conduct sophisticated analysis of investments in roads that raise the threat of agricultural expansion into forests. Given the stakes involved, politics and corruption may also undermine careful planning. Some practical steps may be taken nevertheless. The framework presented in Figure 5 lists less technical, easily identifiable indicators of risk levels. Developing compromise solutions through a transparent process of risk assessment with stakeholders early in the design process, and engaging experts to assess and estimate the potential impacts, may result in alternatives that meet the intended development objectives for less or equivalent cost (Caro et al., 2014).

The application of transportation planning to minimize impacts on forests has not been institutionalized. Steep barriers remain to reducing agriculture's impact on forests through improved investments in transportation. Transportation investments are highly complex decisions based on a myriad of factors, including current politics and predictions of future human behavior. Estimating the actual outcomes of investments is subject to considerable uncertainty. Even governments equipped with improved planning resources, clear scientific evidence, transparent communication, and resources for transparent stakeholder participation may invest in suboptimal transportation infrastructure with an outsized impact on forests (Caro et al., 2014).

High Risk	Medium Risk	Low Risk
• New road built to a high standard of construction (paved) • Road connects areas with large populations • Road opens up major new markets (domestic or export) • Extensive forest resources remaining in the area • Absence of protected forest areas • Good agricultural potential • Relatively flat terrain • Low elevations • High pressures on land for human settlements, infrastructure, energy, or mining	• New road built to a medium standard of construction (gravel) • Major improvement of existing road • Road connects areas with moderate populations • Road connects to medium-size markets (domestic) • Moderate forest resources remaining • Designated protected area with weak enforcement • Moderate agricultural potential • Moderately steep slopes • Moderately high elevations • Moderate pressures on land for human settlements, infrastructure, energy or mining	• New road built to a low standard of construction (dirt) • Moderate improvement of existing road • Road connects areas with low populations • Road connects to small markets (domestic) • Few forest resources remaining • Protected areas with good enforcement • Low agricultural potential • Steep slopes • High elevations • Low pressures on land for human settlements, infrastructure, energy or mining

Figure 6. Framework for assessing deforestation threats from road investments
Source: Smith et al. (2018)

4.2 GOVERNMENT PROPERTY RIGHTS AND LAND TENURE MANAGEMENT

4.2.1 LAND-USE PLANNING AND ZONING

Potential Impact: If governments plan for land use, they will improve the management of agricultural expansion and conserve forests.

Governments employ land-use planning to optimize the use and management of land and natural resources to achieve socioeconomic and natural resource objectives. They use this spatial planning process to clarify trade-offs and negotiate the distribution of rights and responsibilities among potential users of zones defined in plans. In theory, land-use planning determines the siting and management of protected areas, concessions, and zones for agriculture—and in the process, clarifies and weighs the benefits and losses of specific decisions regarding deforestation in each zone. Properly executed, land-use planning can be part of a country's transition away from deforestation. While some research supports the argument that the greater capacity and objectivity of actors at the national level makes planning at this scale most effective, provincial governments have also successfully undertaken land-use planning to mitigate deforestation (Nolte et al., 2017). China, Vietnam, and India have successfully employed land-use planning, combined with different mixes of agricultural intensification, forest protection, increased imported food and wood products, and foreign capital investments, to slow or stop deforestation—often displacing pressures to clear forest elsewhere (Lambin & Meyfroidt, 2011).

Today, land-use planning is a well-established development practice. Leading practitioner organizations such as the United Nations FAO (FAO, 1993); the German development agency GIZ (Wehrmann, 2012); and USAID (Barber et al., 2015) all recommend a similar implementation process that can be summarized in five steps:

1. Define objectives for land use as well as present and future needs of land-users and other stakeholders;
2. Assess the suitability of land available to meet stakeholders' needs; develop alternative scenarios for land use; make trade-offs and uncertainties explicit;
3. Identify and attempt to resolve conflicts among stakeholders over competing land uses;
4. Choose the preferred alternative(s); design and implement the plan; and
5. Monitor implementation to assess how well it achieves stakeholder-determined goals; revise and adapt the plan as needed.

Practitioner Guidelines from the United Nations FAO, GIZ, and USAID provide useful recommendations, examples from developing countries around the world, and additional references for land-use planning:

FAO. (1993). *Guidelines for Land-Use Planning*

GIZ. (Wehrmann, 2012). *Land Use Planning: Concepts, Tools, and Applications*

USAID LEAF Program. (Barber et al., 2015). *Guidance on Low Emission Land Use Planning*

This process may involve actors working at different scales, through national, regional, and/or local governments. Planners working at each scale pursue their objectives independently, but ideally they will work together to integrate planning across scales (FAO, 1993; GIZ, 2012; Barber et al., 2015). National-level planners typically focus on setting national strategies and policies, including laws, regulations, and macro-level zoning, as well as funding and coordinating efforts through government agencies. Regional planners focus more on specific landscapes, watersheds, ecoregions, protected areas, and transportation or other infrastructure networks. They work with provincial or district governments, may develop regional zoning regulations, and can help link national land-use priorities to local implementation. Local land-use planning usually involves a village or group of villages, where councils and planning committees work with landowners and users to define rules of access and allocation and implement land-use plans. Although cooperation and integration across scales is desirable, it can be difficult in practice. Land-use planning in developing countries often is more like an organized anarchy, where stakeholders form strategic alliances to pursue their own objectives, and resolving conflicts can take many years (Rudel & Meyfroidt, 2014). In most instances, governments do not undertake this process holistically; they plan land use in an ad hoc manner, focusing on zoning specific high-priority areas (Lambin et al., 2014). Often, countries do not implement or update land-use plans after developing them. Many countries in Africa have done little to enforce their planned protected areas. In Indonesia and India, designated "forestland" areas have persisted with no tree cover for decades (Lambin et al., 2014).

Governments must be willing and able to realize the decisions produced through the land-use planning process. Even then, not all land-use planning efforts have had a positive conservation impact on the forests of the countries implementing them. In some cases, integrated land-use planning at the national level has sped the transition of natural forest to plantations (Bauch et al., 2014; Weber et al., 2011).

The ProLand case study on land-use planning draws on the relative success of Cameroon (see box) and available research to describe five conditions for successful land-use planning in developing countries:

- Land-use planning should be authorized by laws or regulations with mechanisms to enforce compliance. Clarity on the qualities of different local land rights is fundamental.
- Land-use planning should be based on accurate information that permits a thorough assessment of land resources in the planning area. Mapping biophysical features and socioeconomic conditions play critical roles.
- Practitioners should have relevant technical capacity to interpret information regarding land resources, and managerial capacity to coordinate actors and oversee implementation.
- Land-use planning should include broad participation of multiple stakeholders to combine national and regional priorities with local needs and interests. Transparency and negotiation among participants are essential to avoid future conflicts.
- Funding for planning and strategy for continued funding during implementation are essential.

The ProLand case study *National Land-Use Planning to Prevent Deforestation at the Agricultural Frontier: A Synthesis of the Evidence and a Case Study from Cameroon* summarizes the research literature to describe five conditions for land-use planning success and develop a case study of land-use planning in Cameroon that illustrates how land-use planning has helped prevent agricultural expansion and slow deforestation. The paper also highlights common challenges encountered by practitioners in Cameroon and elsewhere (Evans, 2021).

Agricultural expansion into forests is a difficult development problem not only because there are so many pressing needs for scarce land resources but also because sustainable solutions to meet these needs are invariably complex. Good governance is essential to adjudicating how people will use land and forest resources to address the "collision" between food security, biodiversity conservation, and climate change adaptation and mitigation. When evaluating and implementing a land-use planning initiative, donors and practitioners should plan for a long and costly process; design support for both planning and implementation at national, regional, and local scales; and assess and design for reducing the power of entrenched interests and support the government in anti-corruption efforts.

4.2.2 DESIGNATING AREAS OUTSIDE OF FOREST AGROECOLOGICAL ZONES FOR AGRICULTURAL INVESTMENT

Potential Impact: If countries meet their agricultural needs through farming methods not suitable to forests, farmers will clear less forest.

Researchers have long asserted that the intensification of agricultural systems not suitable to forest agroecological zones may reduce encroachment on forests. This theory is regularly tested in the programs that governments implement to meet economic growth and food security objectives through agricultural investment in specific locations. Geographically targeted agricultural investments may be conceived as "development corridors," "special investment zones," "growth poles," and "agroparks." Often undertaken as public/private collaborations, these and similar policies are designed to leverage the synergies of economic "agglomeration" through the collocation of the services necessary for the production, processing, and transportation of products (Gelb et al., 2015). The approach has been undertaken aggressively in Africa in recent years. Over the past two decades, governments on the continent have developed 36 agricultural growth poles and 9 corridors. If completed, they will span 3.5 million hectares in 23 countries (Picard et al., 2017).

Governments do not always engage with geographically focused agricultural investment with the intention of reducing agricultural encroachment on forests. Observers argue that for this approach to reduce the impact of agriculture on forests, programs must: 1) be located distant from forests; 2) support types of agriculture poorly adapted to newly cleared forest; 3) demand high labor inputs; and 4) dampen demand for products otherwise cultivated in newly cleared forest.[12]

"Ecosystem services and land sparing potential of urban and peri-urban agriculture" reviews 320 peer-reviewed papers to describe how the expansion of urban and peri-urban agriculture may both increase ecosystem services in urban areas and reduce pressure to convert sensitive non-agricultural ecosystems to agriculture (Wilhelm & Smith, 2018).

In theory, programs designed to intensify horticulture in the degraded soils of peri-urban areas distant from forests may meet these criteria. Perishable crops such as vegetables and fruits must be produced close to markets, so their cultivation is less likely to extend to the forest frontier, nor are they especially suitable to recently cleared forest soils. Their adoption may also increase labor demands, drawing labor rather than releasing migrants to farm on the forest frontier.

In countries with large rural populations drawing migrants from the forest frontier may prove critical to reducing forest clearing. Investments in irrigated rice may create a strong demand for labor by multiplying the number of harvests per season. Shively and Martinez (2001) describe one such situation in the Philippines. In this case, investments between 1995 and 1999 introduced irrigated rice production and enabled farmers to achieve multiple annual harvests instead of a single harvest. To make this change, they had to hire more labor. In the process, they tripled their employment of nearby upland farmers living on the margins of a forest. The upland farmers, once better capitalized, began to farm their plots more intensely. The rate of forest clearing was reduced by about half over the period studied.

Müller and Zeller (2002) report a similar dynamic between intensification and deforestation in two districts of the Central Highlands of Vietnam. Here, paddy rice and shifting cultivation expanded at the expense of forest between 1975 and 1992. In the 1990s, investments in roads, irrigation, and rice technologies led rice yields to triple and farmers to abandon shifting cultivation. Grasslands reverted to forest. Key to this change was the labor-absorbing impact of the intensified cultivation techniques.

Protecting forests may have unintended environmental costs

Farmers dissuaded from clearing forests may clear other equally valuable lands. Africa's high rainfall savannas support as many species as nearby forests if we include bird varieties. The lower productivity of savanna soils compared to newly cleared tropical forest further reduces the net value of the trade off between these two land types (Searchinger et al., 2015; Laurance et al., 2015).

The economic and food security objectives of agricultural agglomeration programs are likely to overshadow environmental ones. In Africa, agriculture investment zones are usually undertaken to promote agricultural growth, with little regard for protected areas and forests. Without clear safeguards, the risks are substantial. The trade-offs inherent to this approach disadvantage forests, as they pit forest protection against food security and economic growth. The large-scale expansion of transportation networks by development corridors, for example, opens up extensive areas to new environmental pressures. Rather than protecting them, development corridors appear to create a significant threat to the forests and protected areas of the continent (Laurance et al., 2015; Sloan et al., 2017). Even if this approach succeeds in relieving pressure on forests, it may allow agriculture to expand

[12] In this paper we present only few highlights from a long and ongoing debate. For the larger discussion of this approach to limit agriculture's impact on forests see: Yanggen and Reardon (2001); Angelsen and Kaimowitz (2001); Angelsen (2010); Rudel (2012); and Angelsen and Rudel (2013).

into other land types. The wetlands selected for irrigation or horticulture may support valuable ecosystem services.

With few mature examples and little research available, it is early to talk about the success or failure of agricultural growth zones. It is nevertheless clear that the geographic concentration of agricultural services presents significant challenges. Their design may be exceedingly complex and their implementation costly and hampered by operational constraints. The creation of agglomeration zones that meet their objectives and effectively limit encroachment on forests and other biodiverse natural lands requires uniquely effective governance (Picard et al., 2017; Enns, 2018). (See "A challenging approach" text box.)

A challenging approach

The Bukanga Lonzo agropark in the Democratic Republic of Congo was undertaken with the explicit objective of reducing agricultural encroachment into forests. Alongside economic objectives, the agropark was to create one million jobs, drawing and retaining migrants who would otherwise move to forested areas. Launched in 2014, the ambitious program collapsed in 2017 under challenges including land disputes, absence of technical support, mismanagement, and corruption (Miller & Hagen, 2016; Mousseau, 2018).

4.2.3 REVITALIZING DEGRADED, UNDERPRODUCTIVE, AND ABANDONED LANDS

Potential Impact: If farmers improve the productivity of degraded lands or reclaim abandoned land, they will clear less forestland.

The presence of degraded land provides an important opportunity for diverting agricultural expansion away from forests (Economics of Land Degradation Initiative, 2013; Global Commission on the Economy and Climate, 2014). Overexploitation of soil, water, and biodiversity have caused close to one quarter of the world's agricultural land to become degraded and unproductive (Millennium Ecosystem Assessment, 2005; Global Commission on the Economy and Climate, 2014). According to recent studies, there are at least two billion hectares of degraded land around the world that could be restored to more productive landscapes (Minnemeyer, 2011; Bastin et al., 2019). Through the Bonn Challenge of 2011 and the New York Declaration of 2014, international coalitions of NGOs and governments have made joint commitments to reclaim millions of hectares of degraded lands for productive use.

The ProLand report *Restoring Abandoned Degraded Land for Agriculture: a Synthesis of the Evidence and Case Study from Indonesia* synthesizes evidence from the scientific literature regarding restoring abandoned degraded land and using it for agriculture and discusses resources and decision tools that practitioners can use to determine the suitability of this strategy and to evaluate prospects for success in different development contexts (Evans, 2020).

Land degradation can be seen on actively farmed lands as well as abandoned lands, and restoration strategies can be applied in both circumstances. Farmers on marginal lands employ a broad spectrum of techniques to stop or reverse degradation and increase yields. These include conservation tillage, improved slope management, introducing perennial crops, integrated pest management, and improved water efficiency (Pretty & Hine, 2001; de Vries et al., 2008). In 2000, 110 projects in Africa supported nearly 1.8 million farmers managing almost two million hectares to increase yields by a factor of two and a half by practicing improved land and water management strategies (Pretty et al., 2006). A more recent survey of 286 projects showed that farmers in 57 countries had adopted practices that increase productivity (at an average of 79 percent) while improving the supply of environmental services on 37 million hectares of farmland. The most effective practices increase water use efficiency or soil organic matter, and support integrated pest management (Pretty et al., 2006; Noble et al., 2008). In Brazil, investments in farmer training, farm equipment, inputs and upgrading the value chain could raise the productivity of degraded land from one third of its potential back to half of its full carrying capacity. These investments could forestall the need to expand pastureland in Brazil for the next 20 years (Strassburg et al., 2014).

Natural resource management is fundamental to agriculture. Governments and their partners currently dedicate a significant portion of agricultural investment to restoring degraded lands. Our review of the literature found no global estimates of the potential forest impact of investments to revitalize currently farmed land, but the evidence, some of which is sampled above, suggests this may form one element of a successful pathway to reduce agriculture's impact on forests.

Key Restoration Resources

The IPBES Assessment Report on Land Degradation and Restoration identifies a mix of governance options, policies and management practices that can help support stakeholders working at all levels to reduce the negative environmental, social and economic consequences of land degradation and to rehabilitate and restore degraded land (IPBES, 2018).

Guide to the Restoration Opportunities Assessment Methodology (ROAM) provides a flexible and affordable framework for countries to rapidly identify and analyze forest landscape restoration (FLR) potential and locate special areas of opportunity at a national or sub-national level (IUCN, 2014.)

The WOCAT Global Database on Sustainable Land Management comprises searchable documentation of over 1,800 field-tested technologies and approaches to inform the design of land restoration investments.

Programs to help farmers reclaim abandoned land have been less successful. One of the most frequently cited opportunities to restore abandoned degraded land for agriculture is in Indonesia, where more than 19 million hectares of low-carbon-stock grasslands are dominated by the invasive grass species *Imperata cylindrica* (Gingold et al., 2012; Shahputra & Zen, 2018). Unlike some degraded lands that may revert to forest if protected, bushfires prevent Indonesia's *Imperata* grasslands from returning to a forested state. Revitalizing and using these lands for productive oil palm cultivation could spare Indonesia's rainforests from additional expansion. However, agronomic and economic factors can impede investment in degraded land restoration. Farmers who establish palm trees on *Imperata* grasslands in Indonesia forego the benefits of harvesting and selling timber from recently cleared forest. Similarly, in Côte d'Ivoire, farmers invest approximately twice as much labor when cultivating reclaimed cocoa plantations compared to recently cleared forest. This is largely due to differences in the quantity of weeds and their aggressiveness, but soil fertility of the abandoned fields also affects tree survival and growth (Ruf & Siswoputranto, 1995, cited in Ruf & Schroth, 2004).

Government land-use planning and land management may further constrain the restoration of degraded abandoned land. In some countries, degraded land suitable for agriculture is not zoned to permit it (Stickler, 2012; Lambin et al., 2013; Sales et al., 2016). Land tenure claims and local people's interests and land-use rights may also constrain restoration efforts (Corley, 2009; Ruysschaert et al., 2012; IPBES, 2018). The investments in infrastructure (such as roads) and increases in productivity associated with the restoration may enable the agricultural conversion of previously protected forest (Gibbs & Salmon, 2015). As is the case with all change in agricultural systems, reclaiming abandoned agricultural land will incur socioeconomic trade-offs. In one documented example, vulnerable farmers in Sumatra lost access to land when revitalization increased productivity and attracted farmers with greater wealth and status (Tomich et al., 2001). Effective landscape governance engaging people at all scales is needed for successful land restoration (Stanturf et al., 2019).

Restoring degraded land can produce **BENEFITS** for people and the environment	Practitioners should also consider **CONSTRAINTS AND TRADE OFFS**		
	ECONOMIC	ENVIRONMENTAL	LEGAL and SOCIAL
• Increase agricultural production • Improve livelihoods • Reduce deforestation • Conserve biodiversity • Improve water quality • Replenish groundwater • Mitigate climate change	• Cost of restoration • Utility of the land for agriculture • Opportunity costs, including other viable options for developing the land	• Ecological feasibility of restoration • Potential for the land to provide passive protection to forests • Potential for the land to revert or be restored to a more productive ecosystem, serve as wildlife habitat, or mitigate climate change • Possible environmental harms from restoration	• Legal classification of the land • Land tenure and land rights • Local peoples' interests in using the land

Figure 7. Restoring Degraded Land through Agroforestry: Potential Benefits, Constraints, and Trade-offs. Source: ProLand case study *Restoring Abandoned Degraded Land for Agriculture: A Synthesis of The Evidence and a Case Study from Indonesia* (Evans, 2020)

Despite global commitments and apparent governmental will, global efforts at restoring degraded lands have not met expectations. Efforts have fallen far behind national commitments articulated in the Bonn Challenge. Similarly, rates of reforestation have slowed over the past decade (NYDF Assessment Partners, 2019). Critics argue that restoration takes too long, costs too much, and produces too few benefits to justify public or private expenditures. The approach has yet to prove itself (Stanturf et al., 2019).

4.2.4 SITING AND MANAGING PROTECTED AREAS

Potential Impact: If governments establish and manage protected areas effectively, they will prevent agricultural expansion into protected forests.

The widely used International Union for Conservation of Nature classification of protected areas includes seven categories with varying levels of conservation and use (Dudley, 2008). Depending on the classification or designation of protected area, governments may exclude virtually all direct resource use or permit loosely regulated extractive and non-extractive activities. In determining the location of protected areas and the activities allowed within them, governments must consider both the value of biodiversity protection and the economic opportunity costs of land-use restrictions, including the agricultural potential of lands to be protected.

IUCN Protected Area Categories

- Ia Strict Nature Reserve
- Ib Wilderness Area
- II National Park
- II Natural Monument or Feature
- IV Habitat/Species Management Area
- V Protected Landscape/ Seascape
- VI Protected area with sustainable use of natural resources

(Dudley, 2008)

Governments commonly take into consideration levels of biodiversity and the potential for disrupting local economic activity when determining protected area location and the management strategy to be applied. Remote areas are often the easiest to classify because fewer people desire to exploit them. They often also have the highest biodiversity value. Research suggests that attention to threats from current land practices may also be important. A number of case studies have shown that by prioritizing zones vulnerable to agricultural expansion rather than levels of biodiversity, efforts to protect forests may be made more effective (Hill et al., 2015). This approach has been an important factor in slowing deforestation in Brazil (Nepstad et al. 2014), as demonstrated clearly in Brazil's Acre State (Pfaff et al., 2014).

The impact of protected areas on local livelihoods—the benefits communities receive from forests—plays a role in the effectiveness of conservation schemes. A meta-analysis of 165 protected areas found an association between greater restrictions on forest use and weaker negative conservation outcomes. When governments engage local stakeholders in the decision-making process as co-managers and work out sustainable use plans, higher economic benefits to local communities coincide with higher conservation outcomes. Protected areas are more effective when they empower local people, reduce economic inequalities, and maintain cultural and livelihood benefits. Ongoing support from conservation organizations in delivering benefits to local communities reinforces these results (Oldekop et al., 2016).

There is no doubt that, on the global average, protected areas contain higher levels of biodiversity and experience less deforestation than comparable areas outside and around them, especially in the tropics (Joppa & Pfaff, 2009; Nelson & Chomitz, 2011; Gray et al., 2016; Busch & Ferretti-Gallon, 2017). A recent review of research focusing on the impact of protected areas in South America finds that government protected areas have "increased carbon storage and have avoided considerable levels of deforestation, fire occurrence, and degradation of forests" (Schleicher, 2018).

The causes of these higher levels of biodiversity continue to be debated. Governments often create protected areas in locations with low population and economic pressures. Government designation and enforcement efforts may play little or no role in protecting these areas (Joppa & Pfaff, 2009; Busch & Ferretti-Gallon, 2017). Among the protected areas of South America considered effective, research has been unable to identify and prioritize specific causes beyond the "passive protection" provided by location (Schleicher, 2018).

Conservation Concessions

The objectives of conservation concessions (CC) resemble those of protected areas. Governments grant nongovernment actors the access, management, and exclusion rights of public lands for conservation purposes. When implemented on lands previously under a commercial concession, they can be designed to restore, manage, and rehabilitate the damage caused by the initial concession (Tegegne et al., 2018). Although the approach continues to evolve, the limited research available suggests that on average CCs are effective in reducing deforestation and forest degradation. Some case studies have found them to be more effective than protected areas (Schleicher, 2018; Gray et al., 2020). Due to their small size and limited duration, CCs do no more than complement government managed protected areas (Schleicher, 2018).

Nor has research clearly measured the cost of enforcement relative to different rates of deforestation (Gaveau et al., 2009; Nolte & Agrawal, 2013; Ferraro et al., 2013). Undoubtedly, effective protection requires good policy, political will, and sufficient resources. Effective monitoring of forest use and the enforcement of penalties for non-compliance present serious challenges that many countries are unable to overcome. Excluding smallholder farmers from forests often requires more resources than many countries have available. As a result, in some cases governments under pressure to protect their forests have resorted to forceful removal campaigns. The brutal implementation of such policies has caused conflict that has resulted in political backlash and decreased protection efforts (Mascia et al., 2014).

On the balance, it is not surprising that support for protected areas in many countries is inconsistent at best. Numerous governments have decided that protected areas cost more in resources and political capital than the benefits they generate. Between 1900 and 2010, 57 countries in Africa, Asia, Latin America, and the Caribbean downsized, degraded, or degazetted more than 503,591 km2 of protected lands and waters (Mascia et al., 2014; Keles et al., 2018; Lewis et al., 2019; Naughton-Treves & Holland, 2019).

4.2.5 CONCESSIONS FOR TIMBER AND AGRICULTURE

Potential Impact: If governments allocate land to companies under specified conditions, the companies will reduce agricultural expansion into forests.

Governments create commercial concessions through the time-delimited allocation of large tracts of land to private-sector entities for uses such as plantation agriculture, timber, and mining. Concessions generate jobs, increase the tax base, and create investment in rural infrastructure. Governments may also seek to improve the management of forests through concessions. Some commercial concessions include conditions regarding forest stewardship; others are granted specifically for the purposes of carbon storage and sequestration, watershed protection, tourism, and biodiversity conservation.

The Voluntary Guidelines Regarding Concessions developed by the Food and Agriculture Organization of the United Nations and the European Forest Institute (EFI) (Tegegne et al., 2018) emphasize four dimensions critical to the sustainable management of concessions: Effective governance; income to the concession holder and government; benefits to local communities; and environmental integrity of the concession.

Even concessions effectively designed and regulated may allow for the conversion of forest to farming. The magnitude of the impact depends on the original status of the forest, the designated use, and post-allocation management practices. For example, the conversion of natural forest to reduced impact logging can have negligible impact on species diversity, while conversion to timber plantations reduces species diversity by an average of 40 percent. By definition, allotting forest concessions for tree crop plantations accelerates forest conversion to agriculture. On average, conversion of natural forest to oil palm plantations cuts species richness by half (Chaudhary et al., 2016).[13] Converting logged concessions to palm oil plantations, a common practice, leads to significant loss of forest carbon (Burton et al., 2017).

Concession Guidelines

Voluntary Guidelines Regarding Concessions presents research concerning sustainable forest management in public natural production forests in tropical regions. The Guidelines promote an approach that emphasizes inclusion of communities in the development of concessions. Their goal is to increase the effectiveness of concessions to address the Sustainable Development Goals, as well as Nationally Determined Contributions under the Paris Agreement (Tegegne et al., 2018).

In many cases, over time, concessions create the opportunity for other land uses not included in the original agreement, such as clearing for agriculture (Edwards et al., 2014). In addition to the impact of formally recognized activities, concessionaires enable forest clearing by constructing roads that connect uncleared forest to markets and urban centers and thus enable migration, settlement, and farming. Governments and concessionaires commonly fail at preventing such encroachment, as has been amply demonstrated in the Congo Basin (Nasi et al., 2012; Megevand, 2013).

The FAO guidelines assert that forest concessions may be sustainably managed to prevent deforestation (FAO & EFI, 2018). Research on this question has not settled, as it depends on the capacity of governments to establish and regulate concessions.[14] Even concessions supported by certification programs require effective intervention from the government (Karsenty & Ferron, 2017). For example, in the Republic of Congo, where logging concessions received certification in sustainable forest management practices and expanded their activities as a result, the government has not been able to effectively regulate the increase in activities and overextraction and deforestation have risen (Brandt et al., 2016).

[13] For a case study of the (slight) positive impact of reduced impact logging and co-management in Guyana, see Roopsind et al. (2017).

[14] For recent debate concerning concessions in the Congo Basin, see Karsenty and Hardin (2017) and Brandt et al., 2016.

Lacking a more effective alternative, governments, often under pressure from the international community, have on occasion attempted to limit forest destruction resulting from commercial forest exploitation by discontinuing the allocation of new concessions altogether. In Indonesia, a concession moratorium has reduced rates of deforestation (Busch et al., 2015). Also employed by Liberia, DRC, and Brazil, the moratorium is a blunt tool. It constrains economic activity and cuts off the production of commodities for domestic use and export, and may give birth to black markets. For national-scale bans to be effective for forest conservation, complementary policy may need to ensure alternative supplies (Durst et al., 2001). Moratoria are not always effective, even if they are extensively applied. Had Indonesia implemented its moratorium policy over a decade, it would have only reduced emissions by an estimated 2.5 to 6.4 percent, far short of the country's goals. This may be because curtailing new concessions does not address other causes of deforestation, only deforestation resulting from concessions. While effective in reducing uncontrolled deforestation in the short term, moratoria only serve as a bridge until more comprehensive policies are developed and implemented (Busch et al., 2015).

The sustainable management of industrial-scale concessions appears to exceed the management and regulatory capacity of many governments. Countries where moratoria have been applied suggest that the best way to improve their impact on forests is to discontinue them. Governments will nevertheless allocate concessions despite their limitations. In the Congo Basin, the business context currently constrains international commercial investment and concessions are scarce. These countries nevertheless have ambitious targets for growth in forestry and agriculture (Megevand, 2013; Burton et al., 2017). In the long term, investment will come and the Congo Basin and other tropical countries will employ concessions to organize the timber and palm oil production expanding out of Asia (Karsenty & Hardin, 2017). As governments continue to invite investment in commodity production into their tropical forests, donors investing in agricultural intensification will be challenged to support the strategic use of concessions to meet both economic and environmental objectives.

4.2.6 TENURE AND PROPERTY RIGHTS IN AGRICULTURAL LANDS

Potential Impact: If farmers have greater tenure security, they will intensify investment in existing lands and expand agriculture less into other lands, including forests.

The land-use rights that an individual farmer or farm household have can strongly influence investment in that land. The concept of land rights, or "rights in land," is not simple. In much of the developing world, rights in land derive from an overlay of multiple sets of evolving rules, customs, and habits that are often unwritten, poorly understood, and open to negotiation. Whether based on customary practices, certificates that recognize customary use, or formal titles, effective land tenure systems require coherent laws and regulations that stakeholders see as legitimate. They require transparent administrative processes that are not overly burdensome, accessible and trusted adjudication institutions, and a well-functioning information management system.

Governments and their partners who have sought to improve these complex systems have historically focused on clarifying land rights, assuring consistent, widespread application, and making them more secure. They take many approaches to doing this. They seek to reform or harmonize land laws and regulations, simplify administrative processes, decentralize land administration services, and make information meaningful and easily available. Increasingly, they work to formally recognize customary rights that are held jointly by members of a community. They may also support the rights of communities or indigenous peoples in the negotiation of contracts with external investors, or strengthen local dispute resolution capacity (USAID, 2013a; Shames et al., 2011).

A principal reason governments and their partners attempt to secure tenure is the belief that farmers with a greater sense of ownership will, given the potential for long-term control, invest in both more intensive and sustainable farming . This seems to be true; farmers do tend to respond to strengthened tenure by increasing their investment in farming and intensifying their production methods in the hope of raising yields and income.[15] This does not always mean they will farm less land, however. In line with the Jevons paradox discussed in Section 2.0, when stronger tenure leads farmers to intensify land use, they, or others attracted to the greater value of land, may expand the area farmed. The intensification stimulated by stronger tenure may foster agricultural expansion and, especially at the forest edge, forest clearing (Angelsen, 2010). Liscow (2013) found this to be the case in Nicaragua.

Yet stronger tenure does not always lead to deforestation, and the exceptions can be important. In some contexts, improved tenure may result in greater investment and intensification, and yet not produce increased forest clearing. In Sumatra, Indonesia, farmers with titles to their fields were found to be less likely than farmers without titles to expand cultivation into forests. Sumatra's tenure rules help explain this. Local farmers (and any migrants attracted to the area) cannot seek title for forest they clear. Without title they risk loss of land they invest in, and opt to convert land from the poorly monitored forest. Farmers with titles intensify their farming and have less need to clear and farm forest land (Kubitza et al., 2018). In this case, greater security of tenure was associated with reduced expansion into forests. However, as the authors note, this result was dependent on relatively unique "spatial patterns of land titling and intensification." When greater tenure security results in intensification it may have very different results, depending on the context.

Key Tenure Resources

The UN's *Voluntary Guidelines Regarding Tenure* provide advice on an effective and inclusive process of collaboration with government, the private sector, and civil society actors (UN, 2012).

The USAID *Land Tenure and Property Rights Framework* provides an overarching methodology with tools, assessments, and designs to guide investment in land tenure and property rights on both agricultural and forested lands (USAID, 2013b).

Farmers not only respond to tenure rules, but they also exploit them, for example, by using tenure policy to secure and farm more land. Both formal and customary regimes across the world grant rights in land on the condition that individuals put it to productive use; farmers lay claim by clearing and cultivating forest land. Investment in agriculture in these contexts mobilizes incentives to convert and claim lands. Prior to 2000 in the Brazilian Amazon, landholders cleared and planted land to undermine claims by settlers asserting their own claims in the same manner (Araujo et al., 2009). A similar dynamic between tree clearing and tenure also figures strongly in the history of cocoa expansion in West Africa. Migrants to Côte d'Ivoire aggressively removed natural shade trees that might otherwise provide evidence of ownership by indigenous populations (Ruf & Schroth, 2004).

The complexity of tenure regimes may be the major constraint governments and their partners face when they attempt to change agricultural rights in land to reduce deforestation. Tenure is woven into the local context. Rights in land vary geographically and are influenced by land type, land use, and local and national culture, laws, and norms. Different sets of stakeholders may hold rights to access, exploit, manage, or sell land, and these rights may be distributed differently among the different resources on the land, such as trees, water, or wildlife. Modifying agricultural land tenure has social, economic, and political ramifications.

Due to this complexity, the vulnerability of forests to changes in tenure may be difficult to predict. While in most cases it may be safe to assume that stronger land rights will result in increased agricultural investment, the long-term impacts are difficult to predict over time as soils degrade, markets change, and additional forest is cleared. In-migration and natural population growth will also influence

[15] Greater security of rights in land does not automatically lead to increased agricultural investment. Tenure creates the opportunity, but other factors are also required, such as resources for investment, and demand for the goods that can be produced. Favorable governance and economic conditions are necessary to enable investment. In some cases, the expected—such as credit—do not materialize, as in Northwestern Petén, Guatemala, prior to external assistance (Gould, 2006; Hodgdon & Lowenthal, 2015).

outcomes. The balance of government enforcement of land rights held by individuals, communities, and companies, and enforcement of regulations pertaining to nearby forest play a critical role.

Investments to improve agricultural land tenure should be informed by an evaluation of the threat of expansion into forests, other stakeholder claims to local forest resources, and the nature and effectiveness of local forest management institutions. Change in tenure that successfully prevents agricultural expansion into forests requires sustained investment and adaptive programming.

4.2.7 TENURE AND PROPERTY RIGHTS IN FORESTS

Governments can help prevent agricultural conversion of forests by strengthening land rights in nonagricultural land. National governments may distribute power to local individuals and/or authorities to achieve governance, environmental, and development objectives. South Korea, Mexico, and Nepal represent long-standing examples of village level authority over forest management. Approximately 70 percent of the forest of South Korea is owned by private individuals and local organizations (GIZ, 2015). Communities control 60 percent of Mexico's forests (Madrid et al., 2009).

Other than in rare cases like South Korea and Nepal, governments have historically limited the power of local communities to simple management tasks, such as fire prevention or tree planting. Only over time have they begun to grant local institutions significant authority. Today, local communities manage approximately 17 percent of total carbon stored in forestlands (RRI, 2018). The level of local management of these forests varies greatly, with less than half of this area under legally recognized community tenure regimes. Even among the countries in which land rights have formally been granted to local actors, the differences remain significant. In some countries, such as Côte d'Ivoire and Ghana, the government allots local communities a simple consultative role. In others, such as Tanzania and the Gambia, the government grants management powers to local authorities (Wily, 2002). Variations in levels of local management also continue in different regions of individual countries.

USAID LANDLINKS

This web platform provides background and theory, research reports, tools, and guidance regarding land tenure and property rights, including impacts on forests.

Community members may be effective stewards of forests for many reasons. They often know the forest better than any other group and because of their proximity, can monitor forest exploitation by both community and non-community members. Some research has found that devolving forest management authority to local residents and communities may act to stem deforestation, particularly in countries where the financial and human resources of national governments are limited (Robinson et al., 2014; Stevens et al., 2014a; Yin et al., 2014). One recent meta-analysis of spatially explicit econometric studies found that policies supporting the continued management of forests by Indigenous peoples have the potential to reduce deforestation (Busch & Ferretti-Gallon, 2017). Numerous case studies demonstrate that strengthening the tenure of Indigenous communities has produced positive results in Bolivia, Peru, and Brazil. Granting community-level concessions has been successful in Guatemala. Community forest management has also produced successful forest conservation outcomes in Nepal, Niger, and Tanzania (Nepstad et al., 2006; Bluffstone et al., 2015; Stevens et al., 2014b; Blackman et al., 2017). Granting forest management authority to community councils in the central Himalayas of India costs less and "does no worse and possibly better" than state management (Somanathan et al., 2009). Communities have sustainably managed forests in India for decades (Agrawal & Chhatre, 2006).

Despite these positive examples for community-managed forests, research has not documented a consistent relationship between local forest management and slowed deforestation. Forests in which communities have property rights perform better than unmanaged open access, yet co-management by communities and states is not consistently better than state management of forests (Ojanen et al., 2015). The 2014 Busch and Ferretti-Gallon meta-analysis also found no significant correlation between tenure arrangements and deforestation rates (Busch & Ferretti-Gallon, 2014). In Africa, community forestry projects supported by the development community have not demonstrated much success (Hagen, 2014).

ProLand Resources on Community Forestry

An Assessment of Critical Enabling Conditions for Community-Based Forestry Enterprises collects and synthesizes the "state of knowledge" on enabling conditions for establishing and maintaining community-based forestry enterprises (Deshmukh & Donahue, 2018).

A Sourcebook for Community-Based Forestry Enterprise Programming: Evidence-Based Best Practice and Tools for Design and Implementation aims to inform design and implementation of community forestry interventions that seek to deliver social, environmental, and economic outcomes in developing countries. (Deshmukh & Donahue, 2020).

In a study of community engagement in protected areas, Blackman (2015) underscores the potentially overriding impact of historical and institutional characteristics of communities. The cohesion of forest communities (or lack thereof) may play a more important role than arrangements established with the national government (Ferretti-Gallon & Busch, 2014). Beyond these findings regarding the importance of community coherence, research has provided little guidance on when local management will work effectively, or how to make local management more effective in a particular case. The variety of biophysical and socioeconomic contexts in which communities manage their forests, and the wide range of institutional relationships between communities and forests—joined with limitations in the evidence gathered—have precluded the formulation of reliable models, or even of consistent and specific guidelines for supporting community forestry (Samii et al., 2014; Ojanen et al., 2015). It is clear that local ownership contributes to success, as do local rulemaking, enforcement, and monitoring, but the causal relationships among these and other factors remains unknown (Yin et al., 2014).

Programs designed to establish community forests, whether to prevent agricultural incursion into forests or achieve other objectives, face considerable challenges. Governmental promulgation of regulations allowing for local forest ownership is just the beginning of a lengthy process of learning and growth by communities and their partners. Local institutions often lack the internal capacity to govern, regulate business, and manage forests simultaneously. Passage of laws and regulations to empower local actors must be followed by support to build local governance, technical, and business capacity.[16] During this process, national political, administrative, and business interests may see this change as a threat and vigorously contest it. Government's support for the arrangement must continue over the long term.

4.3 MARKET SYSTEM APPROACHES

4.3.1 FOREST-BASED ENTERPRISES

Potential Impact: If the economic value of intact forests is increased, then agriculture will expand less into forests.

The idea is that people protect things (natural resources in this context) that provide them income. The theory that land is allocated to the use that generates the highest profit (or "rent") is core to land-use science (Angelsen, 2007). Economists have invested substantial effort modeling potential land management responses to market shifts in the value of timber, for example (Tian et al., 2018). Increasing returns generated by land through agricultural intensification, as we have seen, leads to an expansion of the use of land for that purpose. So, it is not surprising that over the past 50 years conservationists have developed a variety of approaches to increase the revenue derived from intact forests. The overall

[16] See Gilmour (2015) for a more detailed list of the typical hurdles communities face, specifically in the commercialization of timber.

strategy of this conservation enterprise[17] approach has been to introduce sustainable forest-based livelihoods to reduce pressure from activities that degrade or destroy forests, such as smallholder farming, commercial agriculture, and timber extraction (Brown, 2002; Roe et al., 2014; Wicander & Coad, 2015).

Of course, forests already provide considerable benefits to members of the communities living in and around them. Millions of smallholder farmers across the developing world meet much of their dietary needs and earn a significant proportion of their household income from foraging in forests and wildlands (Powell et al., 2015; Wunder et al., 2014). Many people depend on forests for basic necessities, for fuelwood or as a safety-net strategy (New York Declaration on Forests, 2014), and for many others the commercialization of sustainably harvested forest products serves as the basis for viable livelihoods. Forests hold great potential for providing additional benefits to local communities. Under the right conditions, increased value can be derived from the sustainable management of a wide range of timber and non-timber products (NTFPs), such as various types of fodder, nuts, fruits, woodfuel, and gums (Foster & Rosenzweig, 2003; Chomitz et al., 2007).

Practitioners, often staff of conservation NGOs in donor-sponsored projects, use the conservation enterprise approach to protect high-value ecosystems from the impact of extractive activities such as overharvesting timber and hunting game. They also commonly introduce forest-based enterprises to protect forests at risk of being cleared for farming. Examples include the sustainable extraction and commercialization of NTFPs, reduced impact logging, and ecotourism. Conservation enterprises may rely on the sustainable exploitation of existing products, such as reduced-impact logging, or the sustainable exploitation of new products, such as honey.

Despite years of investment in the conservation enterprise approach, there is a lack of solid evidence supporting its effectiveness. Due to this lack of positive evidence justifying investment into conservation enterprises and the closely associated alternative livelihood (AL) approach, in 2012 the IUCN called for its members to "rigorously measure the impacts of AL projects" and requested that they and "donors develop best practice guidelines" (IUCN, 2012). A subsequent review that screened over 22,000 studies published between 1993 and 2015, and closely examined 22 of the most rigorous studies, found little empirical evidence demonstrating success, either in reducing forest encroachment or achieving other objectives (Roe et al., 2014). Only nine of the 22 studies that met the reviews quality standards reported positive conservation outcomes. These related to changes in behavior, attitudes, or the condition of the area being conserved. Of all the projects studied, only one presented reliable evidence of positive change in the health of forests.

An influential article (Wright et al., 2016) analyzing the inability of alternative livelihood projects to achieve their objectives presents three key weaknesses, two of which are relevant to agricultural encroachment into forests: 1) projects are unlikely to create enough disincentive to persuade people to stop unsustainable resource use. To the contrary, rather than adopting new income generating activities as an alternative, community members often use the new income to supplement existing livelihoods sources. Members of farming communities may even invest new revenue in expanding their crops further into forests; and 2) forest product value chains do not easily scale to include all possible users of the resource. While some household members may become engaged in the new practice, other family members, members of the community, or in-migrants may continue with business as usual (Wright et al., 2016).

Considerable barriers impede the successful introduction of conservation enterprises and growing them to a meaningful scale. Establishing commercially viable forest-based enterprises may require specialized

17 The term "conservation enterprises," used most often in USAID publications, overlaps with the term "alternative livelihoods," which is more common in the literature of the international donor community. We employ the term "conservation enterprises" because it relates more directly to our theme and is more familiar to our expected audience.

skills beyond existing community capacity. Forest-dependent communities often face technical, regulatory, business, market, and organizational challenges that they are unable to overcome. Multiple barriers hamper the cost-effective sustainable extraction of dispersed low-value products in compliance with traditional norms and national regulations. Communities find it difficult to navigate market systems, identify and negotiate terms with buyers, and subsequently meet buyer expectations for product volumes, quality, and timeliness (Macqueen, 2008).

In the effort to protect forests by increasing their relative value, the economics favor farming over forest enterprises. While investment in agriculture can clearly raise the value of agricultural land and lead to its expansion, it is unlikely that investment in forest enterprises alone will lead to the preservation of forests, let alone their expansion. The conditions necessary for successful community-based forest enterprises include secure tenure and land-use rights; effective governance, organization, and management; a viable social enterprise model; and partnerships with value chain actors (ProLand, 2018). Attaining these conditions is less daunting for the expansion of agriculture, which does not require the creation of new institutions and for which market systems often already exist.

4.3.2 PAYMENTS FOR ECOSYSTEM SERVICES

Potential Impact: If beneficiaries provide payments to land-users to voluntarily adopt certain practices, agricultural expansion into forests can be eliminated.

Governments and their partners also implement projects to raise the value of forests by monetizing ecosystem services, such as water and air purification, wildlife habitat, and carbon storage. The most common way they do this is by employing payments for ecosystem services (PES) approaches to create incentives for improved stewardship practices. PES employs voluntary, monetary contributions made by external buyers to maintain or enhance specific ecosystem services. Buyers may be private-sector entities, governments, or other public institutions. Buyers provide payments to land-users (e.g., farmers, ranchers, loggers, or households) to modify their practices to minimize negative externalities, such as water pollution, erosion, or carbon emissions. Land-users may agree to enhance ecosystem services by adopting new practices (such as planting trees) or by discontinuing current practices (such as harvesting trees). Providers are paid only if they implement agreed-upon changes in practices, and sometimes only if there is additional evidence that implementing the practice has produced the targeted ecosystem service (Wunder, 2015).

Buyers can be motivated by several factors including corporate social responsibility goals; international commitments, such as the commitments to reduce greenhouse gas (GHG) emissions codified in the Paris Agreement; or the opportunity to avoid future costs, such as dredging silt from dams or building water treatment facilities. When the buyers receive more value in improved ecosystem services than their total payments, and land-users receive more in payments than it costs them to change their practices, both parties benefit. Since its emergence in the early 1990s use of PES has grown rapidly, with growth since 2005 especially strong. PES currently accounts for an estimated $36 to $42 billion globally in annual payment transactions (Salzman et al., 2018).

PES is a complicated, demanding, and highly context-specific policy tool (Borner et al., 2017). Although PES schemes are sometimes presented as a market-based approach to conservation, they are often launched by non-market actors and not integrated into existing market systems. When PES are introduced as part of a project, the conservation or mitigation practices rarely continue after project support ceases (Hiedanpää & Bromley, 2016). Studies also identify a danger inherent in monetizing and accentuating individual services in what are complex ecosystems (Muradian et al., 2010; Kosoy & Corbera, 2010). An assessment of the available research found that PES programs produce positive environmental outcomes slightly more than half of the time, and they produce positive economic and social outcomes slightly less than half of the time (Burivalova et al., 2019). A recent systematic review of

The ProLand case study *[What Do Experience and Research Tell Us About Using PES to Limit Deforestation? A Synthesis of the Evidence and Case Studies From Uganda and Colombia]* uses examples from projects in Uganda and Colombia to illustrate contexts in which PES works best and presents essential design elements in using PES to effectively mitigate deforestation (Miller & Winsten, 2020).

the literature on PES approaches was unable to find rigorous research demonstrating a positive impact of PES policies on deforestation (Samii et al., 2014; Chavis, 2014).

While knowledge gaps have so far constrained our ability to refine the PES approach so that programs consistently achieve their objectives, research based on 25 years of experience has nevertheless enabled us to identify necessary initial conditions and design elements critical to successful PES programming.[18]

Initial conditions. The PES approach will not be successful everywhere. Initial conditions necessary for a PES approach to be successful and cost-effective include the following:

- A solid foundation of trust and collaboration among stakeholder groups. PES payments may represent a considerable change in income, and both participants and nonparticipants must understand the rationale for the payment system and see the conditions for payment and the amounts as fair.
- Land-users must hold clear rights to make the proposed changes. The absence of recognized authority to modify the target behaviors may undermine program success.
- Buyers must be willing to offer payments sufficient to attract land-users to participate. The value they assign to the changes they "purchase" must surpass the costs land-users assign to the changes they agree to make in their land management practices.

Design elements. Even where the necessary initial conditions outlined above exist, PES programs must be carefully designed to be effective. Design elements that require attention include the following:

- The structure of payments, including their duration, target recipients, criteria for payment, and the mechanism used for their delivery
- Monitoring and verification, so that programs can be adapted to account for unforeseen responses to payments and unexpected impacts from changes in participant behaviors
- Cost-effective methods of strategically selecting sites and participants for greater impact
- Design complexity, which can increase cost-effectiveness yet raise the management burden make the program difficult to administer
- Payments may bias participants already engaging in target practices and wealthy participants predisposed to adopt them. Programs require careful design and transparent communication to equitably and cost-effectively generate ecosystem services and prevent weakened program cohesion.

The IPCC Special Report on Climate Change and Land recognizes that PES is an emerging and sometimes contested approach that "needs to be carefully designed to be effective" (Hurlbert et al., 2019). PES has the potential to be a key tool in the fight to protect our world's forests. PES practitioners must make hard decisions to attain their objectives with a minimum of management burden and cost.

4.3.3 PERFORMANCE STANDARDS

Potential Impact: If civil society and private-sector partners leverage transnational market forces to provide incentives to value chain actors, they can compensate for the absence of local governmental regulation and reduce agricultural expansion into forests.

18 The lists of initial conditions and design elements are adapted from Miller & Winsten (2020).

Since the early 1990s, industry associations and NGOs have employed voluntary incentive programs to promote social and environmental objectives.[19] Such certification schemes take many forms, but all include offering benefits to producers and other value chain actors on the condition that they adhere to specific practices, or "standards." Common incentives offered include price premiums, preferential market access, and agronomic training. Companies then market certified products as supporting principles associated with the standards, such as sustainable agriculture or fair-trading.

Findings from the USAID Lowering Emissions in Asia's Forests (LEAF) Program

Common design weaknesses of eco-certification programs:

- No definition of "forest"
- No geographic delineations
- No public reporting
- Weak chain of custody standards

See recommendations to address these in Stanley et al. (2015).

The certification approach has spread and is increasingly mainstreamed into agricultural commodity markets. Over the four years between 2008 and 2012 alone, the area dedicated to standard-compliant production more than tripled, rising from 3 to almost 10 million hectares (Potts et al., 2014).[20] Crop area dedicated to certified commodities has continued to expand— for some crops, dramatically.

Standards designed to reduce deforestation usually focus on conserving primary forest and require that the commodity be produced on land converted to agriculture no more recently than a specified year (Stanley et al., 2015). Some eco-certification schemes also include standards that exclude incursion to other types of forest, in which case the standards vary widely among programs and are generally less constraining than those pertaining to primary forest. All 12 major agricultural crop certification programs require producers to meet legal obligations relating to protected areas, and most exclude incursions into primary forests. Only two (Rainforest Alliance and Proterra) prohibit all deforestation (Tayleur et al., 2017).

Few certification programs have effectively limited deforestation. Rainforest Alliance coffee certification was found to have reduced forest degradation in Ethiopia (Takahashi & Todo, 2017). Similarly, eco-certification in Colombia's coffee landscapes enhanced tree cover and forest connectivity (Rueda et al., 2015). However, meta-analysis suggests these individual examples are outliers. As currently implemented the approach does not consistently prevent agricultural commodity value chains from driving deforestation (Kroeger et al., 2017; Ruf & Varlet, 2017; Van der Ven et al., 2018; Lambin et al., 2018; Komives et al., 2018; Blackman et al., 2018).

The use of certification to address deforestation presents challenges common to all voluntary standards programs. Among the challenges, geographic coverage is fundamental. Certified production endeavors cover a small portion of total production. In addition, voluntary participation opens the door to selection bias. Programs attract producers who already meet standards, or who can meet them by making minimal changes in their practices, or who are most able to meet them because they are wealthy or have other advantages. In programs with deforestation standards, this choice skews participation toward farmers who already cultivate land cleared before the cut-off date. Their neighbors who farm recently cleared land simply do not participate, and because they are outside of the program's influence,

[19] Private-sector actors also use certification to strengthen brands, improve consumer loyalty, reduce reputational risk, and increase sales and profits.

[20] Based on the eight commodities for which data are available: banana, cocoa, coffee, cotton, palm oil, soybeans, sugar, and tea.

they may continue to clear forest. As a result, the overall impact of the program on deforestation may be minimal.

The role of governments in making certification effective: a synthesis of the evidence and a case study of cocoa in Côte d'Ivoire explores one country's experience to summarize recent research assessing certification, describe the major challenges of the approach, and identify promising directions for curtailing the impact of our chocolate consumption on the world's tropical forests. (Miller, 2020).

The challenges of working in remote areas—common to commodity certification generally—may reinforce this gap in coverage. Weakness in "traceability" appears to be the most critical. Buyers are often unable to determine the exact origin of produce, creating a loophole for nonparticipating farmers to sell through certified neighbors. This local "leakage" not only undermines the incentive to participate but the higher price received by nonparticipating farmers may motivate them to produce more, and to clear more forest to do so.[21] In remote areas, programs also have trouble auditing and enforcing standards among participants.

Nor have certification programs been able to leverage market forces as planned. Certified production has outpaced demand. For example, in 2012, 22 percent of cocoa produced was certified, while only 7 percent sold was labeled certified. A large percentage of produce enters the market as "conventional" in part due to the logistical challenges of coordinating production with market integration at the local level, but market strategy also plays a role. Certification organizations have acted on the understanding that a proven supply must be demonstrated before putting a product on the market. Despite its potential strategic value, this oversupply has lowered the price of certified products and reduced the price premiums and other benefits certification schemes offer producers to participate (Potts et al., 2014; Van der Ven et al., 2018).

Research suggests that certification schemes require support beyond the certification process itself. To adopt standards (of any type), value chain actors often need substantial assistance in business development, production techniques, finance, and marketing. Increasingly, certified producers receive such support from government extension agents, producer groups, certification programs, and other NGOs (Loconto et al., 2014; Ingram et al., 2017; Oya et al., 2017).

To correct the fundamental weakness in voluntary programs, compliance must be enforced throughout the population of producers across the landscape (Tscharntke et al., 2015; Ingram et al., 2017; Van der Ven et al., 2018). Governments can support standards programs to do this. Governments can eventually perform the governance roles that certification was intended to perform, as has been the case in Indonesia and Argentina (Giessen et al., 2016). In Guatemala's Petén, there is a legal requirement for forest concessions to be certified (Bray et al., 2008; Blackman, 2015).

Potential Roles for Governments in Certification Programs

Private-sector and civil society actors need government collaboration on:

- *Legality:* improving governance and law enforcement in the supply chain.
- *Transparency:* monitoring deforestation and evaluating the impact of incentives.
- *Integrated planning:* coordinating strategies regarding long-term trends in production, markets, and climate.
- *Scale:* implementing effective incentives and regulation and limiting leakage.

(Kroeger et al., 2017)

Government regulation differs from the incentive approach of non-state programs by a potentially complementary command-and-control approach. The threat of government sanctions encourages industry self-regulation: governments both endorse and reinforce standards through the threat of stronger public regulation.

[21] In theory, certification programs may drive larger-scale leakage by constraining production through the enforcement of standards, thus displacing the production, and deforestation, to other regions of a country, or in some cases to other countries (Lambin et al., 2018). We found no studies demonstrating that agricultural commodity certification causes this larger-scale leakage.

The most decisive role a government might take in supporting standards is to enforce them nationally, using regulatory power to produce a mandatory, cohesive state system (Giessen et al., 2016.; Lambin et al., 2018; Lambin & Thorlakson, 2018). Although results vary by location and scheme, research has found that, as currently implemented, performance standards for commodity production "does not remove deforestation from the commodity overall" (Kroeger et al., 2017; Ruf & Varlet, 2017). In the end, performance standard schemes may at best serve as a useful complement to traditional government policies (Heilmayr & Lambin, 2016).

5.0 CONCLUSION AND RECOMMENDATIONS: THREE PATHWAYS TO MANAGING AGRICULTURE'S FOOTPRINT

The research reviewed for this report strongly supports the conclusion that any investment in agricultural intensification will increase pressure on unprotected tropical forests. International agricultural commodity production is driving rapid forest loss in Latin America and Asia and is a looming threat to the forests of Africa. Addressing the drivers of agricultural conversion of forests will become more challenging as demand for food grows in the coming years.

None of the production strategies discussed in this paper can independently resolve the opposing objectives of increased production and forest protection over the long term. Conventional intensification strategies lead farming to expand across the landscape as they generate income for producers, companies, and governments. Strategies based on diversification assert less immediate pressure on land but generate fewer short-term yield and income benefits. They are more difficult to scale because they are more complex and have place-specific requirements. Strategies based on diversification also principally provide for home or local consumption and are often weakly integrated into markets. For this reason and others, they are less likely to drive large-scale land use change.

Each of these production strategies requires government intervention to counterbalance the pressure they put on forests, yet where researchers have looked, none of the governance actions described above have consistently proven effective. Some, such as trade and fiscal policy and transportation infrastructure, are blunt tools that are often bound with other, sometimes conflicting, objectives. Governance actions that more directly target land use test the capacity of the governments. Property rights and land tenure regimes are rarely effectively implemented and equitable enforced. Their impact on agricultural expansion into forests is often unknown. Market-based strategies to deter agricultural expansion into forests target specific locations and populations, yet their success depends on the larger economic and political context that governments create. Far from turnkey solutions, their track record falls short of their potential.

These approaches could be successful if governments and the development community tailor them to address the many context-specific challenges and enabling conditions discussed in this report during both the planning phase and implementation. To succeed, cross-sectoral collaboration and building associated government capacity will be needed with a level of dedication not frequently encountered to date. Practitioners will need to draw on knowledge and skills from agriculture, conservation, market systems, and governance. They will need to program geographically specific agricultural activities in the context of longer-term countrywide policy initiatives that may encourage forest clearing. Governments will need to undertake fundamental changes to protect their forests, manage concessions, or improve tenure security. However, the institutions that guide efforts focused on these different objectives often compete for resources and influence. To many influential actors, the benefits that forests generate are less tangible than the food, individual incomes, and corporate revenue that agriculture generates. That power differential, not a focus of this report, will need to be addressed.

Among the diverse institutions that need to be engaged, development practitioners have particularly wrestled with the divisions between agriculture and forest conservation institutions. These fall into different management sectors and depend on different funding streams. Staff learn from different schools of research and respond to different constituencies. Deliberate, persistent efforts to bridge this and many other institutional divides will likely play an important role in establishing effective suites of production and governance approaches.

We propose three pathways to reduce the impact of agricultural investment on forests, corresponding to three scales of institutional focus: design and implementation of activities; country-level strategy and guidance by donors, ministries, or other institutions; and national and international policy. Governments and their partners should: 1) scope, design, and implement agricultural intensification projects to address the risks these projects pose to forests; 2) create an approach to programming that frames agricultural intensification priorities broadly, to explicitly include equally important development objectives such as equity and conservation; and 3) strengthen land governance through national and international policy.

1. Scope, design, and implement agricultural intensification projects to address the risks these projects pose to forests

Gauge the risk to forests. Resources are increasingly available to assess levels and drivers of ongoing forest loss. In addition to case studies of at-risk forests and remote sensing materials such as the World Resources Institute's Global Forest Watch, international investments in climate change mitigation have increased available resources for on-demand studies. Political will, government capacity, and the potential for leakage are equally important, but more difficult to assess than biophysical changes. Be sure to allocate sufficient resources and time to evaluate these threats.

Balance agricultural growth objectives with forest protection objectives. Once risks to forests have been identified, measures to reduce the increased pressure produced by investment in agricultural production can be considered. The resources provided in this paper identify best practices when investing in tenure, protected areas, PES, and other approaches to mitigate the impact of agricultural growth on forests. Although this paper focuses on the relationship between agricultural intensification and deforestation, there are likely other land-use deforestation drivers, such as those associated with transnational land acquisition, that will also need to be assessed and addressed.

Tip the scales towards sustainable land-use. Emphasize the value of natural resources management and helping farmers extend the productivity of the land they currently farm. Consider both technical solutions presented in this paper, and finance mechanisms and market approaches to help farmers offset the associated short-term costs and long-term risks of adopting new production strategies, such as improved input markets, adapted forms of credit, approaches to upgrading value chains, and governmental incentives that may be used to support farmer investment in sustaining and restoring their lands.

Monitor and adapt. The baseline deforestation rates measured when gauging initial forest vulnerability provide a foundation for rigorous and continuous monitoring of the impact of agricultural investments on forests. This monitoring can then be used to inform strategy adjustments during implementation. Governments and donors can require implementing partners to develop forest risk mitigation plans, and monitor and report on implementation progress.

2. Create an approach to programming that frames agricultural intensification priorities broadly, to explicitly include equally important development objectives such as equity and conservation

Focus on equitable growth aligned with sustainable land use. Targeting intensification narrowly may produce negative societal changes by dislodging marginal populations, fostering disruptive migration, displacing vulnerable livelihoods, accelerating the concentration of wealth, or enriching domestic or distant elites. By comparison, approaches diversifying existing production systems are often more accessible to poorer households and marginalized farmers, and thus appropriate to a wider population. As a result, increasing long-term land productivity through strategies that rely on diversification may help attain equity and inclusion goals. While diversification can lead to deforestation, research shows it to be much less of a threat than intensification

Emphasize resilience and shift the focus to reducing crop loss and productivity. Although highly efficient under optimal conditions, intensified agricultural systems are also vulnerable when conditions change (e.g., extremely hot days occur more commonly; inputs are not available). Therefore, as the climate grows increasingly volatile, agricultural intensification may increase the risk that crops will fail or that yields will be low. This risk is particularly pronounced for vulnerable farmers. Investment in livelihood resilience practices that increase stability of productivity; household portfolio-wide incomes over time; and long-term land sustainability and resilience to climate change may help meet agricultural demand, particularly associated with local consumption, without sharp increases in yields that may drive land-use change. [22]

Undertake inclusive market system approaches to increase farmer resilience and the efficient use of natural resources. Governments and their development partners recognize the potential of value chains to stimulate agricultural intensification. The research summarized in this paper illustrates not only how governments leverage that impact, but the weaknesses of the various tools available to governments to rein in the expansion in land use resulting from that stimulation. Yet investments in markets may do more than increase demand. New, resilient crops and farming technologies may be introduced to farmers through markets. Supply may be increased as investments in the storage, transformation, and the proper use of crops and livestock reduce waste and spoilage. Further up the value chain, shifts to non-meat foods and to ocean and landless cultivation may also reduce the amount of land needed for agriculture.

Integrate the objectives above (equity, resilience, and inclusive markets) alongside the conservation of forests in food security strategies. Increasing food security requires attention to objectives that are rarely achieved through an exclusive focus on increasing yields, such as gains in inclusive and equitable governance. While agricultural intensification targeting specific crops may reduce dietary diversity, food security nutrition and health objectives are often most directly achieved through greater agricultural diversity. A focus on yields that results in forest loss, may further reduce access to diverse and nutritious food sources. Some commodity crops commonly subject to agricultural intensification efforts, such as coffee and cocoa, add no direct nutritional benefit to the laborers producing them or their families. For these crops, the indirect contribution to food security, via income generation, needs to be proven on a case-by-case basis. Effective application of a food security framework to agricultural programming requires greater responsiveness to social factors, and the needs of marginalized populations.

3. Strengthen land governance through national and international policy

Reinforce domestic policy and institutions that protect forests. If the government actions presented in this document are to be effective at reducing deforestation, they must be implemented transparently by effective governments in an integrated and coordinated manner. Research suggests that simultaneously applying several approaches by different ministries through a "polycentric" governance model has been important in reducing deforestation in Brazil (Duchelle et al., 2014). An integrated solution contains many components: regulation and policy reforms; effective administration; an improved business climate; greater market access; and the capacity to transparently negotiate the trade-offs between agricultural growth and forest loss.

The overall quality of governance in a producer country may have enormous yet divergent impacts on rates of deforestation. The limitations of a country's national government may hinder investment in agriculture, as they have in Africa, and thus provide the "passive" protection of forests. On the other

[22] One global-scale modeling exercise, Lobell et al. (2013), concludes investing in helping farmers avoid the negative impacts of climate change, especially in South and East Asia, could have important co-benefits in avoiding cropland expansion.

hand, limitations to good governance such as corruption, characterized by powerful vested interests, weak institutions, and unenforced rule of law, can also prevent the sustainable management of forests in low-income tropical countries (Transparency International, 2011; Sitko & Jayne, 2014), as well as middle-income tropical countries (Barbier et al., 2005).

As government capacity in producer countries increases and the business environment improves, progress towards development objectives like building infrastructure, supporting technology for agricultural intensification, and connecting to export markets can greatly increase rates of agricultural expansion. More functional, higher-capacity governments are more likely to adopt policies that improve the international competitiveness of their commodities. Alongside these policies, and in collaboration with international corporations and research institutions, national governments support the development and adoption of the technologies necessary for the transition to conventional intensification of agricultural commodities that put forests at risk. Between 2000 and 2010 in South America, progress in reducing government corruption, and increasing political voice, accountability, and rule of law enabled rather than curtailed farmland expansion into forests (Ceddia et al., 2014).[23]

If we are to limit deforestation, then as governance improves generally, explicit attention to governance in specific areas including land must build upon that foundation. When improvements in governance increase the risk of deforestation, governments can protect their forests by improving the policy that impacts land use, reinforcing ownership rights, fostering NGOs working to conserve biodiversity, supporting civil society organizations educating and advocating for forest conservation, and enforcing the rule of law (Wehkamp et al., 2018). The absence of these and other elements of governance that protect the environment can allow strengthened economic actors to harm forests.

Support international collaboration to protect forests. The enormity of the challenge of helping producer countries fundamentally strengthen environmental governance leads to our final observation: The management of global land use requires international coordination (Creutzig et al., 2019). The policies of both producer and consumer governments create the context for agriculture's footprint on forests. The governments of consumer countries stimulate international demand for commodities that create markets for products that cause wide-scale deforestation and land use change. When governments stimulate agriculture, whether in their own country or another, and do not also create and enforce effective controls or provide incentives to manage the expansion of agriculture, on the balance, they help drive forest loss (Sayer et al., 2012; Byerlee, Stevenson, & Villoria, 2014; Meyfroidt et al., 2014; Henders et al., 2015; Busch & Ferretti-Gallon, 2017).

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[23] Not all research has found a significant relationship between high-level changes in governance and deforestation. Leblois et al. (2017) found no significant correlation between governance freedom indices and deforestation. They attribute this result—different from previous studies—to the time period and scale of the data they utilized, (2000–2010 rather than the 1961–1994 of previous studies; national-scale rather than subnational indicators). Other, earlier research found that a shift towards greater civil rights and democracy correlates with more sustainable forest management (Van & Azomahou, 2007), except where highly centralized governments support forest protection and reforestation, such as Bhutan and China (Bhattarai & Hammig, 2001).

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ANNEX A: DOCUMENTS PROVIDING KEY INFORMATION OR PRACTICAL GUIDANCE, LISTED BY CHAPTER

1.0 PURPOSE, METHODS, AND SCOPE

No documents for this section.

2.0 THE RELATIONSHIP BETWEEN AGRICULTURAL INTENSIFICATION AND DEFORESTATION

IPCC: Climate Change and Land is a special report on desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. The report highlights the multiple interactions between climate change and land status and use. It assesses the economic and social dimensions of addressing the challenges of land degradation, desertification, and food security in a changing climate. It also assesses the options for governance and decision-making across multiple scales (IPCC, 2019b).

Big Facts on Climate Change, Agriculture, and Food Security (CCAFS) is a CGIAR Research Program on the CCAFS online platform that presents facts relevant to the nexus of climate change, agriculture and food security. It is intended to provide a credible and reliable platform for fact-checking amid the range of claims that appear in reports, advocacy materials, and other sources. Full sources are supplied for all facts and figures, and all content has gone through a process of peer review (https://ccafs.cgiar.org/bigfacts/#).

Reaping the Benefits: Science and the Sustainable Intensification of Global Agriculture, a report published by The Royal Society, examines the contribution of the biological sciences to food crop production. Experts in agriculture, international development, conservation biology, and plant science discuss the need for a sustainable intensification of global agriculture in which yields are increased without adverse environmental impact and without the cultivation of more land. The report begins by setting out the challenges to increasing food crop production. It goes on to examine the various technologies that might be used to enhance production, with the conclusion that a diversity of approaches is needed. Finally, consideration is given to the consequences and complications of food crop innovation (Royal Society, 2009).

Sustainable Intensification: A New Paradigm for African Agriculture, a Montpellier Panel Report, describes how Sustainable Intensification techniques are being used by smallholder farmers in Africa to address the continent's food and nutrition crisis. It begins by examining the process and elements of intensification itself, before considering how we then ensure that the intensification is sustainable, and concludes with practical solutions in action today across the African continent that underline the positive impacts the framework can produce if scaled up more effectively (Montpellier Panel, 2013).

The book *Agricultural Technologies and Tropical Deforestation* includes a theoretical framework and18 case studies that address the question of whether improvements in agricultural technology protect or endanger tropical forests. It includes eight case studies from Latin America, four from sub-Saharan Africa, and 4 from Southeast Asia, in addition to two studies on the historical experience of developed countries in Europe and the U.S. The studies weigh the view of many in the development, environmental, and agricultural research communities—that better agricultural technologies can save forests by producing more food on the existing land area—against the premise from basic economic theory that anything which makes agriculture more profitable should stimulate land expansion and deforestation (Angelsen & Kaimowitz, 2001).

3.0 PRODUCTION STRATEGIES THAT IMPACT AGRICULTURE'S FOOTPRINT

3.1 CONVENTIONAL INTENSIFICATION

3.1.1 INTENSIFY ANNUAL CROP PRODUCTION

No documents for this section.

3.2.1 TRANSITION FARMERS FROM SHIFTING CULTIVATION TO CONTINUOUS CULTIVATION OF FIELDS

The article "Trends, Drivers, and Impacts of Changes in Swidden Cultivation in Tropical Forest-Agriculture Frontiers: A Global Assessment" presents a meta-analysis of land-cover transformations of the previous 10–15 years in tropical forest-agriculture frontiers world-wide through a review of 157 case studies. It argues that swidden agriculture decreases in landscapes with access to local, national, and international markets that encourage cattle production and cash cropping, including biofuels. Conservation policies and practices also accelerate changes in swidden by restricting forest clearing and encouraging commercial agriculture. From an environmental perspective, the transition from swidden to other land uses often contributes to permanent deforestation, loss of biodiversity, increased weed pressure, declines in soil fertility, and accelerated soil erosion (van Vliet et al., 2012).

3.1.3 MONOCROP TREES

Oil Palm and Biodiversity: A Situation Analysis by the IUCN Oil Palm Task Force is an accessible and current review of the palm oil sector and its impact on deforestation that primarily focuses on oil palm in the context of biodiversity conservation based on literature published before 31 January 2018. It aims to provide a constructive pathway to addressing sustainability challenges in the palm oil industry (Meijaard et al., 2018).

The CIFOR infobrief *Sustainable Development of the Palm Oil Sector in the Congo Basin* discusses deforestation threats and recommendations to improve the sustainability of the palm oil sector in the Congo Basin. It advocates for a regional strategy involving smallholders and informal markets (Ordway et al., 2019).

3.2 DIVERSIFICATION

3.2.1 DIVERSIFY CULTIVATED ANNUALS AND LIVESTOCK VARIETIES

"Resilience in Agriculture Through Crop Diversification: Adaptive Management for Environmental Change" explores how agricultural crop diversification can improve agricultural systems' resilience to climate change and the reasons behind slow adoption rates, and discusses the options available to farmers to increase resilience and provide economic benefits (Lin, 2011).

The *Climate-Smart Agriculture Sourcebook* draws together a wide range of knowledge and expertise on the concept of Climate-Smart Agriculture (CSA) to better guide policymakers, program managers, sectoral experts, academics, extensionists, and practitioners to make the agricultural sectors (crops, livestock, fisheries, and forestry) more sustainable and productive while responding to the challenges of climate change and food security. The CSA online platform includes the 23 modules across three main sections of the Sourcebook related to CSA Concept, Production and Resources, and Enabling Frameworks (FAO, 2013).

3.2.2 DIVERSIFY BY INTRODUCING OTHER CROPS INTO TREE CROP SYSTEMS

"Understanding the Roles of Forests and Tree-based Systems in Food Provision," Chapter 2 of the International Union of Forest Research Organizations' (IUFRO) *Global Assessment Report on Forests, Trees and Landscapes for Food Security and Nutrition*, provides case studies to highlight the relevance of forests and tree-based systems for food security and nutrition, and indicates where there is a need to further quantify the roles of these systems, allowing proper integration of their contribution into national and international developmental policies (Jamnadass et al., 2015).

3.2.3 DIVERSIFY BY INTRODUCING TREES INTO CROP AND LIVESTOCK SYSTEMS

The book *An Introduction to Agroforestry* presents a global survey of agroforestry practices and an overview of the great diversity of agroforestry systems in the tropics. It discusses the history of the development of agroforestry and underlying concepts and principles; the major agroforestry systems in the tropics; soil productivity aspects; design and analysis of agroforestry systems; and agroforestry developments in the tropics and developing countries as well as in the temperate zone, and includes brief notes on about 50 of the multipurpose trees and shrubs commonly used in agroforestry (Nair, 1993).

World Agroforestry (ICRAF) is a center for science and development that provides evidence, information, and ideas to inform policies and practices that harness the benefits of trees for people and the environment. Studies focuse on four key interacting themes By combining more productive *trees* with more resilient and profitable agricultural *systems* and a sounder understanding of the health of the *soil*, land and people that is part of "greener," better-governed *landscapes*, ICRAF provides knowledge products and services to the global community as it tackles the major challenges of the Anthropocene. These include dealing with climate change; low soil carbon; widespread forest, tree, and soil loss leading to degradation; poverty; demographic upheavals and conflict; and securing equitable futures for all with a special focus on women and children.

The ProLand Productive Case Study): Using Shade to Reduce the Impact of Cocoa Cultivation on Forests: A Synthesis of the Evidence and a Case Study from Indonesia discusses the drivers and hazards of full-sun systems, and identifies effective approaches that better meet livelihood, production, and ecosystem objectives. In this case study, the experience of Sulawesi, Indonesia, illustrates how rapidly full-sun systems can take hold, and how difficult it is to promote more sustainable agroforestry systems (Miller & Young, 2021).

4.0 GOVERNANCE ACTIONS THAT IMPACT AGRICULTURE'S FOOTPRINT

USAID's *Cross Sectoral Guide: Sustainable Landscapes (SL) and Democracy, Human Rights, and Governance (DRG)* aims to help development practitioners integrate SL and DRG approaches and activities in support of improved development outcomes. Improved development outcomes include improved effectiveness and sustainability of interventions, more participatory democratic governance processes, and enhanced progress on partner countries' climate change mitigation efforts. This guide is intended mainly for USAID staff and implementing partners, particularly those with responsibility for SL and DRG activities. In addition, the guide is useful for any development professionals seeking sustainable, equitable, and scalable climate and citizen action.

4.1 BROAD GOVERNMENTAL FUNCTIONS

4.1.1 GOVERNMENT FISCAL POLICY

The *Fiscal Incentives for Agricultural Commodity Production: Options to Forge Compatibility with REDD+* UN-REDD Programme working paper briefly presents the range of subsidies and fiscal incentives governments use to encourage agricultural growth. It illustrates their impact on land use in Indonesia and Ecuador. The paper also provides examples of countries that have successfully reduced forest loss by reversing governmental incentives and proposes a decision-tree for finding complementarity between agricultural incentives and efforts to reduce forest loss (Kissinger, 2015).

4.1.2 TRADE POLICY

The "Participation of Developing Countries in Global Value Chains: Implications for Trade and Trade-Related Policies" policy paper empirically tackles the questions of: i) what drives global value chains (GVC) participation; ii) what the benefits associated to growing participation are; or iii) how developing countries engage and benefit from GVCs. The evidence indicates there are important economic benefits to be had from wider participation in terms of enhanced productivity, sophistication and diversification of exports. Structural factors, such as geography, size of the market and level of development are found to be key determinants of GVC participation. Trade and investment policy reforms, as well as improvements of logistics and customs, intellectual property protection, infrastructure, and institutions can, however, also play an active role in promoting further engagement. A more in-depth analysis of GVC participation and policy context in five developing sub-regions in Africa, the Middle East, and Asia highlights key differences and similarities, and can be a starting point for policy makers in the regions to assess their countries' GVC engagement and to consider policy options (Kowalski et al., 2015).

4.1.3 TRANSPORTATION INFRASTRUCTURE

The World Bank Simplified Roads Economic Decision Model (RED) supports the decision-making process for the development and maintenance of low-volume roads by helping users perform the economic evaluation of road investments. It is one of several software tools and models found on the World Bank Road Software Tools website that support monitoring, planning, programming, and the economic valuation of roads and highway works.

The USAID report *The Impacts of Rural Road Development on Forests, Greenhouse Gas Emissions, and Economic Growth in Developing Countries* examines the literature on rural road construction, improvement, and use in developing countries and impacts on forests, greenhouse gas (GHG) emissions, and economic growth. It includes a framework for a qualitative assessment of deforestation and forest degradation impacts based on road project attributes. It discusses methods to quantify the GHG emissions from deforestation and forest degradation and also offers recommendations for reducing these impacts. One important approach for reducing impacts from roads on forests is to establish or improve protected forest area conservation. Improved road network planning and use of rail transport can also reduce the direct and indirect impacts of greater accessibility (Smith et al., 2018).

4.2 GOVERNMENT PROPERTY RIGHTS AND LAND TENURE MANAGEMENT

4.2.1 LAND-USE PLANNING AND ZONING

ProLand Case Study: National Land-Use Planning to Prevent Deforestation at the Agricultural Frontier: A Synthesis of the Evidence and a Case Study from Cameroon presents a synthesis of the research and development literature regarding the effectiveness of national land-use planning to prevent agricultural expansion into forests. Land-use planning can help people in developing countries achieve agreement on land use, but implementation is often fraught with challenges, many of which stem from weak governance. Governments need the capacity and motivation to act efficiently and equitably, and achieving sustainable land-use goals requires long-term financial support. Examination of the experience in Cameroon in this case study illustrates how governments can use land-use planning to prevent agricultural expansion and slow deforestation. Cameroon provides an example of several steps that governments should take when implementing this approach. It also highlights common challenges that practitioners are likely to encounter (Evans, 2021).

FAO's *Guidelines for Land-Use Planning* publication summarizes experiences gained by FAO on land use planning through numerous field projects. The guidelines describe the nature and purpose of land use planning: what it is, why it is needed, who benefits from it, at what scales is planning carried out, by which people. They outline a 10-step logical sequence of activities, from the first meeting between planners and potential users to the implementation of the land use plan. The guidelines also include some of the technical methods available (at the time) for planning, some of which may require additions and updating. The guidelines are primarily intended for people engaged in preparing land use plans as well as administrators and decision-makers in developing countries. The key messages of the guidelines are: (i) good land use planning is fundamentally a learning process, (ii) it can best be learned by doing, (iii) it is not top-down but should involve the active participation of all land-users; and (iv) each planning situation is unique, therefore instruction manuals are unfeasible (FAO,1993).

Guidance on Low Emission Land Use Planning is a document developed by the USAID Lowering Emissions in Asia's Forests (USAID LEAF) program and the United States Forest Services (USFS) International Program in support of USAID LEAF's regional effort to build capacity for substantive and meaningful emission reductions in the forest and land use sector. The guidance provides a general framework that is flexible, replicable and adaptable to different contexts with the goal of developing a low emission land use plan. The guidance also supports USAID LEAF's regional climate change curriculum development work and is used as a "textbook" for the Low Emission Land Use module (Barber et al., 2015).

4.2.2 DESIGNATING AREAS OUTSIDE OF FOREST AGROECOLOGICAL ZONES FOR AGRICULTURAL INVESTMENT

"Ecosystem Services and Land Sparing Potential of Urban and Peri-Urban Agriculture: A Review" summarizes the research conducted on the expansion of urban and peri-urban agriculture (UPA) from 320 peer-reviewed papers published between 2000 and 2014. Specifically, it explores the availability of data regarding UPA's impact on ecosystem services and disservices, and assesses the literature for evidence that UPA can contribute to land sparing. The study finds that the growth in UPA research over this time period points to the emerging recognition of the potential role that UPA systems play in food production worldwide. However, few studies place UPA in the context of ecosystem services, and no studies in the review explicitly quantify the land sparing potential of UPA. Additionally, while few studies quantify production potential of UPA—data that are necessary to accurately quantify the role these systems can play in land sparing—rough estimates suggest that agricultural extensification into the world's urban environments via UPA could spare an area approximately twice the size of the U.S. state of Massachusetts (Wilhelm & Smith, 2018).

4.2.3 REVITALIZING DEGRADED, UNDERPRODUCTIVE, AND ABANDONED LANDS

The IPBES Assessment Report on Land Degradation and Restoration identifies a mix of governance options, policies, and management practices that can help support stakeholders working at all levels to reduce the negative environmental, social, and economic consequences of land degradation and to rehabilitate and restore degraded land (IPBES, 2018).

Guide to the Restoration Opportunities Assessment Methodology (ROAM) provides a flexible and affordable framework for countries to rapidly identify and analyze forest landscape restoration (FLR) potential and locate special areas of opportunity at a national or subnational level (IUCN, 2014).

The WOCAT Global Database on Sustainable Land Management comprises searchable documentation of over 1,800 field-tested technologies and approaches to inform the design of land restoration investments.

The ProLand report *Restoring Abandoned Degraded Land for Agriculture: a Synthesis of the Evidence and Case Study from Indonesia* synthesizes evidence from the scientific literature, and illustrates key issues associated with restoring abandoned land by discussing a frequently proposed opportunity in Indonesia: restoring the degraded Imperata grasslands to grow oil palm. It also discusses resources and decision tools that practitioners can use to determine the suitability of the strategy, and to evaluate prospects for success, in different development contexts (Evans, 2020).

4.2.4 SITING AND MANAGING PROTECTED AREAS

"A Global Assessment of the Social and Conservation Outcomes of Protected Areas" is a global meta-analysis of 165 protected areas (PAs) using data from 171 published studies. It assesses how PAs affect the well-being of local people, the factors associated with these impacts, and, crucially, the relationship between PAs' conservation and socioeconomic outcomes. Protected areas associated with positive socioeconomic outcomes were more likely to report positive conservation outcomes. Positive conservation and socioeconomic outcomes were more likely to occur when PAs adopted co-management regimes, empowered local people, reduced economic inequalities, and maintained cultural and livelihood benefits. Whereas the strictest regimes of PA management attempted to exclude anthropogenic influences to achieve biological conservation objectives, PAs that explicitly integrated local people as stakeholders tended to be more effective at achieving joint biological conservation and socioeconomic development outcomes. Strict protection may be needed in some circumstances, yet the study's results demonstrate that conservation and development objectives can be synergistic and highlight management strategies that increase the probability of maximizing both conservation performance and development outcomes of PAs (Oldekop et al., 2016).

4.2.5 CONCESSIONS FOR TIMBER AND AGRICULTURE

Making Forest Concessions in the Tropics Work to Achieve the 2030 Agenda: Voluntary Guidelines contains research regarding the promotion of sustainable forest management in public natural production forests in tropical regions. The goal of the Guidelines is to increase the effectiveness of concessions to address the Sustainable Development Goals, as well as Nationally Determined Contributions under the Paris Agreement (FAO & EFI, 2018.)

4.2.6 TENURE AND PROPERTY RIGHTS IN AGRICULTURAL LANDS

The *Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security* serve as a reference and set out principles and internationally accepted standards for practices for the responsible governance of tenure. They provide a framework that States can use when developing their own strategies, policies, legislation, programs, and activities. The Guidelines allow governments, civil society, the private sector, and citizens to judge whether their proposed actions and the actions of others constitute acceptable practices (UN, 2012).

USAID's Land Tenure and Property Rights Framework serves as an overarching methodology with tools, assessments, and designs to guide investment in land tenure and property rights on both agricultural and forested lands. (USAID, 2013b).

4.2.7 TENURE AND PROPERTY RIGHTS IN FORESTS

The USAID LANDLINKS web platform provides background and theory, research reports, tools, and guidance regarding land tenure and property rights, including impacts on forests (USAID, no date).

An Assessment of Critical Enabling Conditions for Community-Based Forestry Enterprises collects and synthesizes the "state of knowledge" on enabling conditions for establishing and maintaining community-based forestry enterprises (Deshmukh & Donahue, 2020).

A Sourcebook for Community-Based Forestry Enterprise Programming Evidence-Based Best Practice and Tools for Design and Implementation aims to inform design and implementation of community forestry interventions that seek to deliver social, environmental, and economic outcomes in developing countries (Deshmukh & Donahue, 2020).

4.3 MARKET SYSTEM APPROACHES

4.3.1 FOREST-BASED ENTERPRISES

The FAO Sustainable Forest Management Toolbox has a broad collection of tools, case studies, and other resources for forest owners, managers, and other stakeholders. It comprises 34 Technical Modules. Two of these, "Community-Based Forestry" and "Development of Forest-Based Enterprises," are especially relevant, but others are potentially important resources for community-based forestry enterprises (CBFEs): "Forest Inventory"; "Forest Management Planning"; "Forest Management Monitoring"; "Management of Non- Wood Forest Products"; "Reducing Deforestation"; "REDD+"; and "Forest and Landscape Restoration." Each module includes a set of tools, as well as case studies and further learning resources. These modules provide a framework for thinking about the various aspects of CBFEs rather than how-to resources that can be directly applied to or by CBFEs themselves. Of interest to many national government (and for advocacy to national governments), the various modules reference how the subject supports SDG progress.

Forest Connect, a knowledge network for agencies that supports locally controlled forest enterprises, is one of the many tools and publications of the International Institute for Environment and Development (IIED) Small and Medium Forestry Enterprise Series. The series aggregates worldwide experience with CBFEs from several "business" perspectives (institutional challenges, funding and financial viability, and value chain partnerships) for international and national development professionals designing, facilitating, and implementing projects.

USAID's report *The Nature of Conservation Enterprises: A 20-Year Retrospective evaluation of the Theory of Change Behind This Widely Used Approach to Biodiversity Conservation* uses a theory of change to examine assumptions and draw upon lesson learned from six sites across the globe on the conditions needed for enterprise and conservation sustainability (Boshoven, 2018).

4.3.2 PAYMENTS FOR ECOSYSTEM SERVICES

Productive Landscapes: What Do Experience and Research Tell Us About Using PES to Limit Deforestation? A Synthesis of the Evidence and Case Studies from Uganda and Colombia describes the PES approach and uses examples from projects to illustrate contexts in which PES works best, and presents essential design elements in using PES to effectively mitigate deforestation (Miller & Winsten, 2020).

The article "The Devil in the Detail: A Practical Guide on Designing Payments for Environmental Services" provides guidance in dealing with this complexity through a comprehensive review of PES design that is accessible to both academics and practitioners. Practitioner guidelines on deciding whether PES is the best approach and for selecting among alternative design features are presented. The article also discusses the need for PES design to start from a careful understanding of the specific ecological and socioeconomic context (Engel, 2016).

Effects of Payment for Environmental Services (PES) on Deforestation and Poverty in Low and Middle Income Countries: A Systematic Review is a report based on a systematic review of studies on the impact of payments for environmental services (PES) that set natural forest conservation as the goal on deforestation and poverty in developing countries. A search for rigorous impact evaluation studies identified 13 quantitative and nine associated qualitative evaluation studies assessing the effects of PES. The methodological rigor of these studies varied widely, meaning that the evidence base for the impact of PES policies is limited in both quantity and quality. Given the evidence available, we find little reason for optimism about the potential for current PES approaches to achieve both conservation and poverty reduction benefits jointly. It calls for the production of high-quality impact evaluations, using randomization when possible, to assess whether the apparent incompatibility of conservation and poverty reduction might be overcome through programming innovations (Samii et al., 2014).

4.3.3 PERFORMANCE STANDARDS

The Potential of Voluntary Sustainability Initiatives to Reduce Emissions From Deforestation and Forest Degradation assesses the potential of VSIs to contribute to reductions in emissions from deforestation and forest degradation in developing countries based on their substantive and procedural requirements (Stanley et al., 2015).

The *Eliminating Deforestation from the Cocoa Supply Chain* report examines the cocoa supply chain, its associated deforestation, and the role and limitations of certification schemes to reduce deforestation. The deforestation-related commitments from cocoa companies are analyzed across the value chain by looking at commitment types, implementation, and the enabling environment. These findings are compared with lessons from palm oil, since it has the most similarities to cocoa due to its large contingent of smallholder producers and limitations that exacerbate deforestation. Finally, a vision for zero-deforestation cocoa with key principles and strategies is described. This work is meant to inform industry, governments, and development partners to be effective actors in a zero-deforestation cocoa future (Kroeger et al., 2017).

The ProLand case study *The Role of Governments in Making Certification Effective: A Synthesis of the Evidence and a Case Study of Cocoa in Côte d'Ivoire* summarizes recent research assessing certification, describes the major challenges of the approach, and identifies promising directions for curtailing cocoa-drive deforestation. It concludes by underscoring the essential role governments play in enabling certification to effectively mitigate deforestation (Miller, 2020).

5.0 CONCLUSIONS AND RECOMMENDATIONS: THREE PATHWAYS TO MANAGING AGRICULTURE'S FOOTPRINT

The Women's Empowerment in Agriculture Index (WEAI), launched in February 2012 by IFPRI, the Oxford Poverty and Human Development Initiative (OPHI), and USAID's Feed the Future, is a comprehensive and standardized tool for measuring women's empowerment and inclusion in the agricultural sector. The WEAI is composed of two sub-indices: one measuring women's empowerment across five domains in agriculture, and another measuring gender parity in empowerment within the household. The tool also measures women's empowerment relative to men within their households (WEAI).