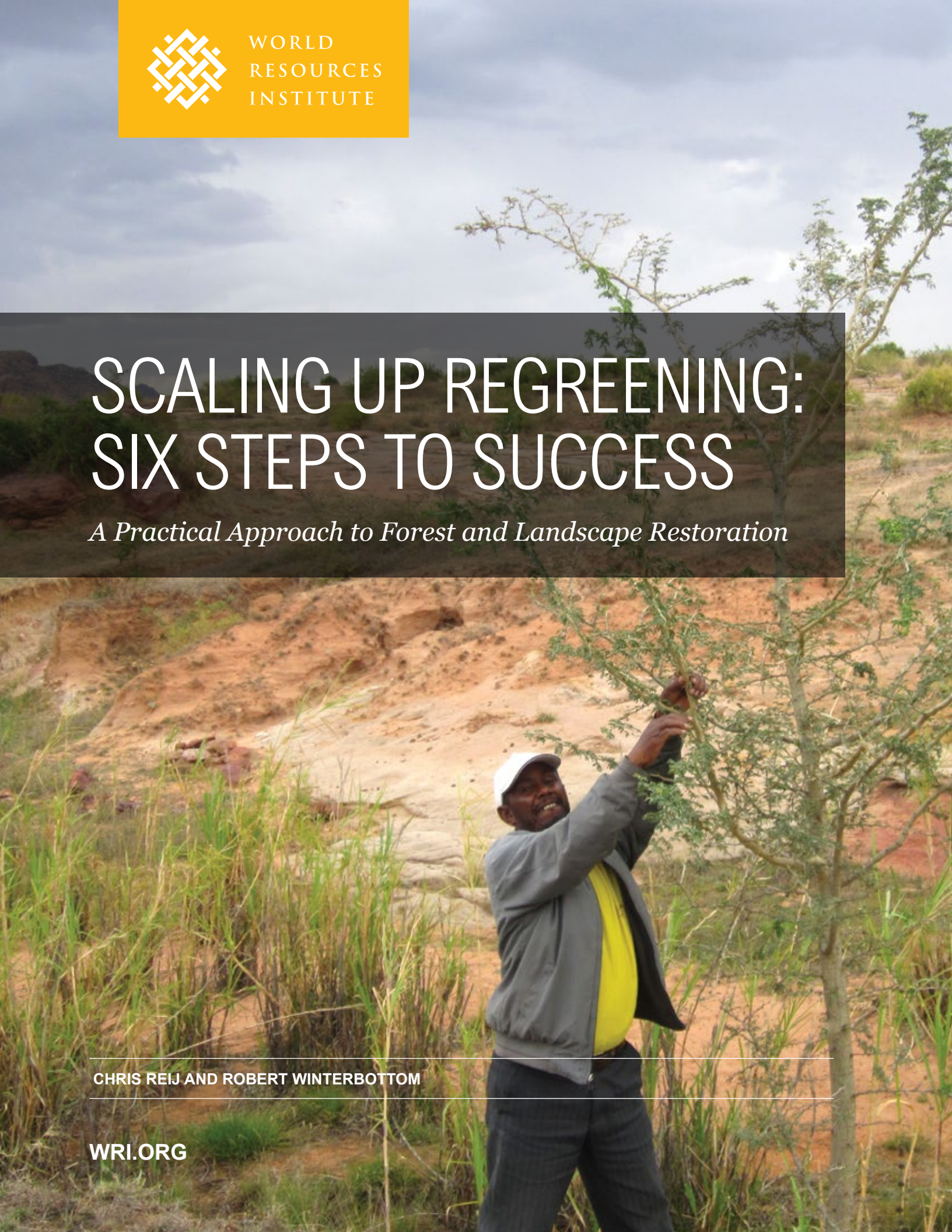

WORLD RESOURCES INSTITUTE

SCALING UP REGREENING: SIX STEPS TO SUCCESS

A Practical Approach to Forest and Landscape Restoration

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FOREWORD

In September 2014, the New York Declaration on Forests was formulated and signed during the UN Climate Summit. Signatories—governments, corporations, indigenous peoples' groups, and CSOs—pledged to restore 350 million hectares of degraded forestland by 2030. This historic commitment can be achieved only if the pace of forest regeneration is sharply accelerated. This report, *Scaling Up Regreening: Six Steps to Success* is intended to help make this more likely.

The authors of the report, two WRI senior fellows, have worked on landscape restoration in Africa's drylands since the mid-1970s, and bring deep practical experience to the debate about how to accelerate forest regeneration. Since the mid-1980s, farmers in densely populated parts of southern Niger have managed to increase on-farm tree densities on 5 million hectares. Recent research demonstrates the extremely high returns of such investments in terms of poverty reduction, food production, and in reducing vulnerability to drought and famine.

Despite these achievements, development practitioners have not yet devised a framework for scaling up regreening successes. Many national and international policymakers are unaware of the multiple benefits of smallholder investments in on-farm trees, and therefore provide little incentives to farmers to do so. Instead, in some countries significant barriers remain that hamper the widespread adoption of regreening practices.

This report presents a way forward. It reviews successful regreening efforts and describes how innovative farmers are increasing their on-farm tree densities. It lays out a path for working with farmers to facilitate and accelerate their regreening practices at scale and identifies barriers that need to be overcome. It provides guidance for development practitioners seeking to scale up regreening through targeted and cost-effective interventions, and to policymakers and others in a position to mobilize resources and improve the enabling conditions for scaling up. The report emphasizes the important role of communication, which often receives little or no attention and funding in development projects. Technically it is not complex to nurture trees, which regenerate naturally on farmland and across the landscape. The challenge lies in building village institutions to manage the new tree capital and enforce locally defined bylaws.

As the world grapples with food security, adaptation to climate change, landscape degradation, and rural poverty, the importance of taking solutions to scale is crucial. Evidence shows that farmer-managed regreening on degraded land is one proven solution to addressing these critical concerns. While many promising examples exist, there are many millions of rural households that could yet benefit from the accelerated spread of regreening. This report shows that farmers can do it, and suggests six steps to getting there.

Andrew Steer
President
World Resources Institute

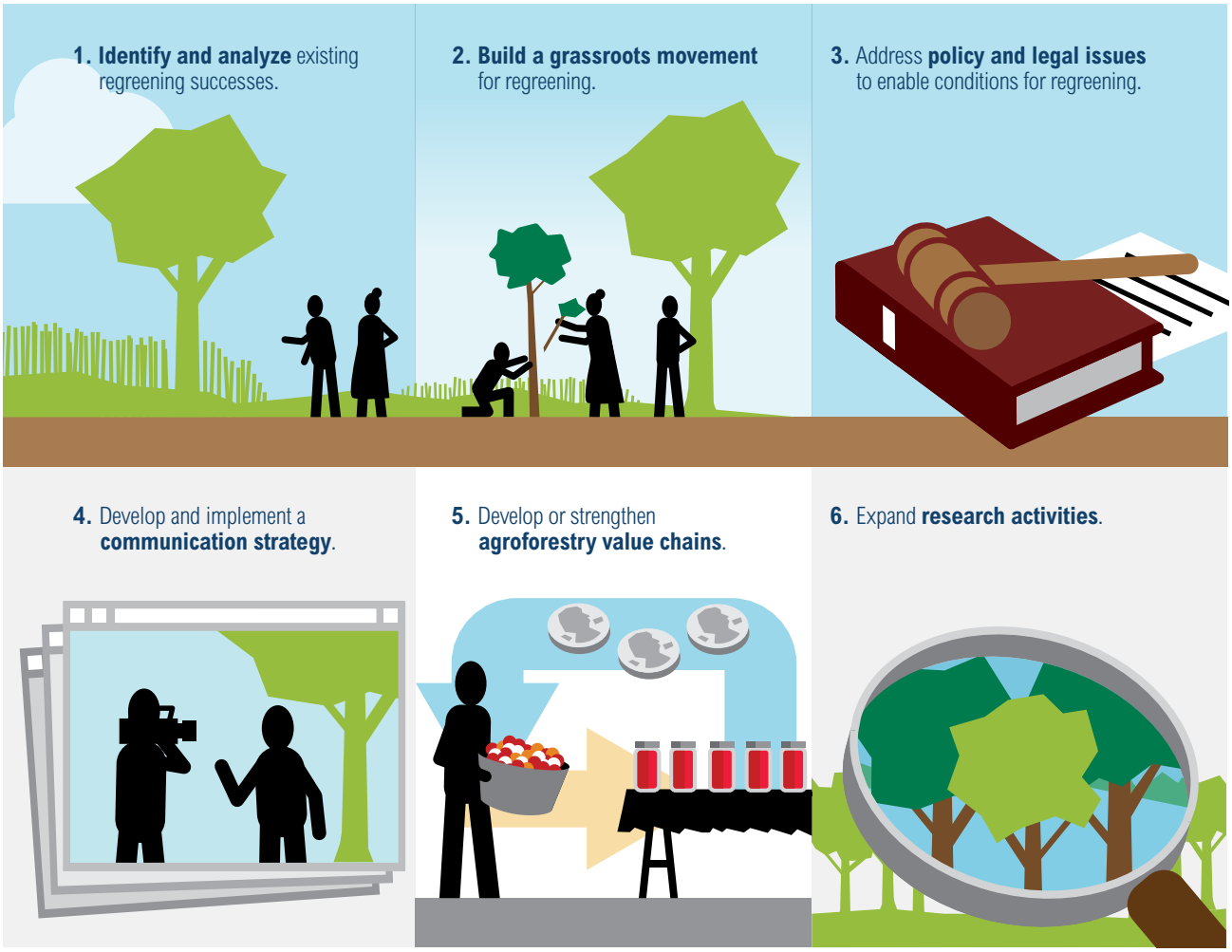
EXECUTIVE SUMMARY

In a world grappling with the challenges of food insecurity, climate change, landscape degradation, and rural poverty, regreening offers a path forward, especially in dryland areas. The transformation of degraded landscapes—restoring productivity and increasing resilience through the widespread adoption of agroforestry and sustainable land management practices—can deliver food, climate, and livelihood benefits.

Regreening delivers real economic benefits to farmers and communities, as borne out by experience in the West African Sahel. Despite these experiences, however, development practitioners have not yet devised a framework for scaling up regreening successes. This Report, *Scaling Up Regreening: Six Steps to Success* fills that void. It sets out a six-step framework for scaling up regreening, each step accompanied by a list of practical, on-the-ground activities to guide development practitioners and regreening advocates.

Regreening occurs at the landscape level through a variety of agroforestry and sustainable land management practices. In this report, we focus on a particularly promising agroforestry practice: farmer-managed natural regeneration (FMNR). In farmer-managed natural generation systems, farmers protect and manage the growth of trees and shrubs that regenerate naturally in their fields from root stock or from seeds dispersed through animal manure. FMNR is an easy, low-cost way for farmers to increase the number of trees in the fields.

Figure ES-1 | **Six Steps to Regreening Success**



Regreening delivers multiple economic benefits to farmers and communities.

Many farmers in the West African Sahel are already increasing the number of trees on their farms. Regreening successes have been documented in parts of the Sahel, and promising signs are emerging in other countries. In the regions of Maradi, Zinder, and across southern Niger, over 5 million hectares have been regreened. On-farm tree densities have dramatically increased over the past decade on 500,000 hectares of Mali's Seno Plain, and thousands of farmers in Malawi have begun to invest in protecting and managing trees on farms. By increasing the number of on-farm trees, these farmers have gained access to a range of benefits (see Box 1).

Regreening may be driven by many factors, but it is almost always led by farmers.

Local investments in regreening have been driven by a combination of factors, including the emergence of effective sustainable land management practices aimed at improving food security and increasing fodder and fuelwood. Demographic and land use pressures have also induced farmers to invest in on-farm trees, and more outside assistance has become available to farmers to respond to land degradation and climate change. Almost always, however, innovative farmers have taken the lead in regreening efforts. Experience from Burkina Faso, Ethiopia, Mali, Niger, and elsewhere shows that farmers, especially when supported by local regreening champions, are motivated to protect and manage trees on their farms. National governments and other stakeholders play key roles in establishing more favorable enabling conditions to trigger and accelerate the scale-up process.

Despite the many benefits of regreening, barriers remain to its wider adoption.

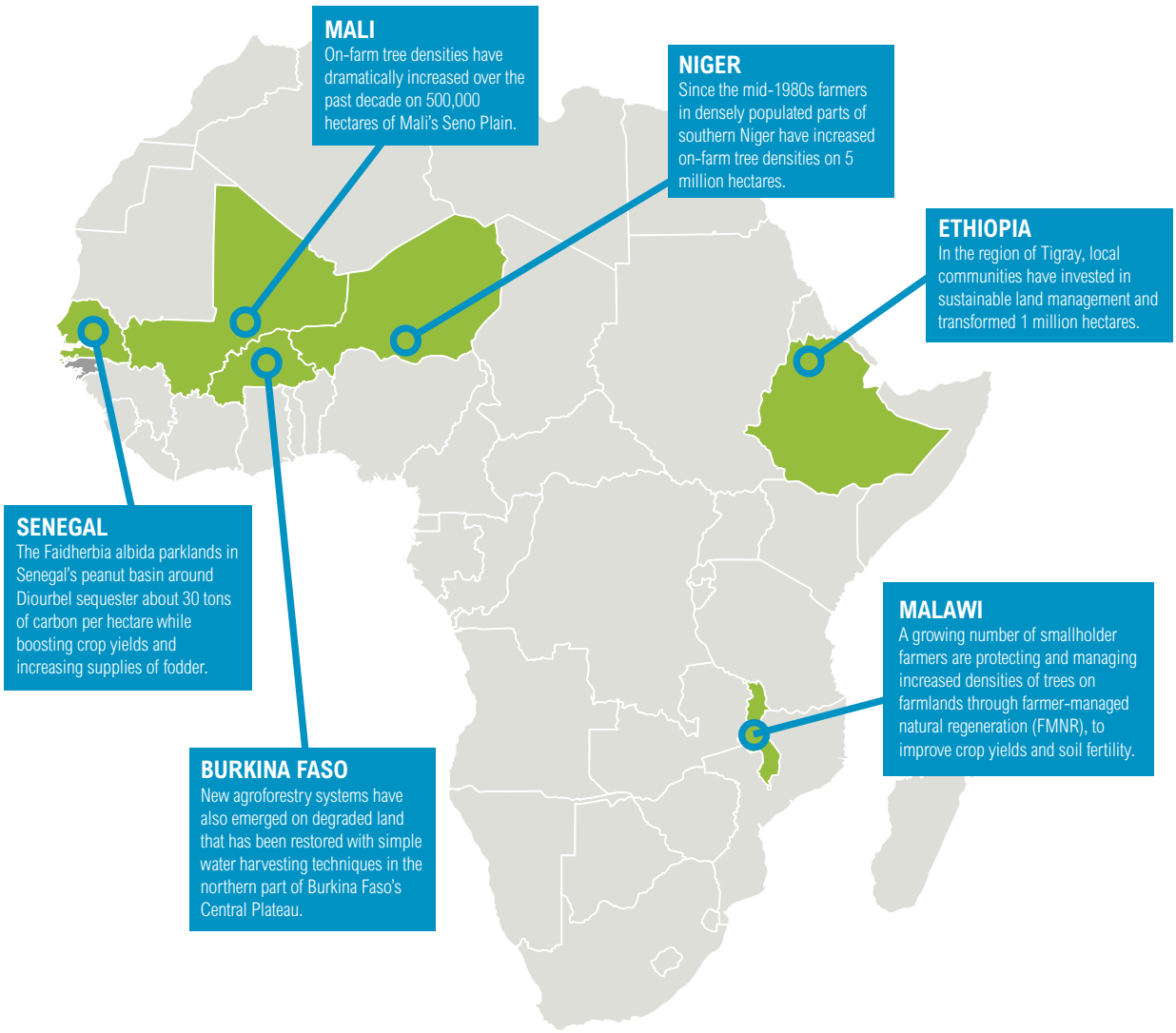
Millions of rural households could benefit from the accelerated spread of regreening. Nonetheless, barriers remain to scaling up regreening successes. In some cases, farmers and policymakers are unaware of the multiple benefits these regreening experiences bring to rural communities. Many agricultural development programs have not yet mainstreamed support for regreening, and the relatively long time frames over which benefits develop (as trees grow and mature) may not appeal to conventional approaches to planning development projects. Furthermore, quantifying the monetary benefits of regreening may be problematic, making it difficult to persuade policymakers that it is economically rational.

BOX 1 | MULTIPLE BENEFITS OF REGREENING

- Trees help restore, maintain, and improve soil fertility by maintaining or increasing soil organic matter.
- Trees help solve the household energy crisis by providing fuelwood, which alleviates the burden on women.
- Trees provide poles for construction and manufacture of furniture and tools, as well as fences for gardens.
- Regreening practices improve household food security and fruit and leaves have a positive impact on nutrition.
- Trees are assets that provide "insurance and banking services," which can be drawn on in crop-failure years and times of need.
- Many tree species in agroforestry systems produce nutritious fodder.
- Trees increase the total value produced by a farming system and help reduce rural poverty.
- Trees reduce wind speed and wind erosion.
- The shade of trees reduces soil surface temperatures and evapotranspiration.
- Trees contribute to biodiversity and the restoration of ecosystem services in agricultural landscapes.
- Increasing the number of trees in the landscape helps mitigate climate change by sequestering carbon.

Source: Adapted from Winterbottom, Reij, Garrity, Glover, Hellums, McGahuey and Scherr (2013).

Figure ES-2 | **Examples of Regreening Success in Africa**



To scale up regreening, development practitioners should consider six steps.

We propose six steps to scale up regreening, although not all of them may be applicable in every situation. Similarly, the steps and activities we propose are not necessarily sequential and are not meant to be prescriptive. Rather, they represent a pragmatic approach to accelerating the spread of regreening and are dependent on the local context.

1. **Identify and analyze existing regreening successes.** This will provide a solid foundation for scaling up regreening, based on an improved understanding of the scale and impacts of farmer-led innovations that are already taking place.
2. **Build a grassroots movement for regreening and mobilize partner organizations.** This will facilitate peer-to-peer learning and support training and the development of community-based institutions.
3. **Address policy and legal issues and improve enabling conditions for regreening.** This should be accomplished by analyzing barriers and adapting more conducive national policies, legislation, and development interventions. Arranging field visits for policymakers and elected officials and advocating for the mainstreaming of regreening in development programs is also helpful.
4. **Develop and implement a communication strategy.** This will help regreening advocates to systematically expand the use of all types of media to inform stakeholders and disseminate information about regreening benefits and experiences.
5. **Develop or strengthen agroforestry value chains.** Focusing on value chains will enable farmers to capitalize on the role of the market in stimulating the scale-up of regreening.
6. **Expand research activities.** Additional research can fill gaps in knowledge and feed that knowledge back into scale-up efforts.

The strategy we present in this report is based on activities already implemented by regreening stakeholders in the Sahel. These stakeholders include nongovernmental organizations (NGOs) like Réseau MARP (Participatory Rural Appraisal Network) in Burkina Faso, Sahel Eco in Mali, IED Afrique and World Vision in Senegal, and a major project in Niger funded by the International Fund for Agricultural Development (IFAD). In other words, this report offers a scaling strategy for regreening that is informed by the experience of practitioners working with communities, governments, and other key stakeholders to trigger and accelerate its spread.

PART I

INTRODUCTION

Recent research by the U.S. Geological Survey on land use and land cover changes in West Africa shows a significant decline in the past 40 years in the amount of natural vegetation in West Africa's Sahel.[1] Reduced rainfall, the expansion of cropland in response to population pressures and declining yields, and the spread of "modernized" agriculture all contributed to the disappearance of trees and shrubs. As natural vegetation became increasingly scarce, the supply of goods and services provided by this vegetation also dwindled. Not only do supplies of fuelwood and fodder depend on trees and shrubs, but soil fertility, household food security, and a host of other benefits are also linked to the presence of natural vegetation.

In response to declining tree densities, a growing number of farmers in the Sahel and other dryland areas are investing in on-farm trees as a low-cost way to sustainably increase agricultural production and improve food security. Increasing the number of trees on farms can also produce significant volumes of firewood; contribute to farm incomes through the sale of wood, fodder, edible leaves, and other products; and enhance household resilience by providing an alternative source of income in years of poor rainfall and reduced crop harvests. In short, increasing the number of trees on farms can deliver multiple benefits, to farmers and communities alike.

When aggregated on the landscape level, the transformations produced by increased on-farm tree densities amount to a "regreening" of degraded landscapes. ("Regreening" and other key terms used in this report are defined in Box 2.) Increasing the number of farmers and broadening the geographic areas involved in regreening are vitally important to the future of agriculture in the Sahel and in drylands and subhumid regions more broadly. This report takes a close look at regreening experiences to date and sets out a framework of steps for scaling up regreening successes.

In response to declining tree densities, a growing number of farmers in the Sahel and other dryland areas are investing in on-farm trees as a low-cost way to sustainably increase agricultural production and improve food security.

What is a Regreening Success?

We use the term "regreening success" to refer to situations in which significant numbers of farmers, individually or collectively, have developed ways to protect, regenerate, and sustainably manage an increased number of shrubs and trees in their farming systems. This includes an increased density of woody vegetation in cultivated fields as well as the increased protection and improved management of trees at scale, around homesteads, and in individual and community forests. If an agricultural landscape had only a few trees per hectare 20 years ago and there are now 40, 60, or more trees per hectare across large landscapes, we would consider this a regreening success.

In regreened landscapes, the increase in density of shrubs and trees generally fluctuates during the course of the year and from year to year. In drought years, farmers may cut and sell some trees to generate cash, but they may subsequently replant trees at higher densities. When yields are increasing and other benefits to local communities (such as firewood, fodder, and fruit) are being generated in association with an increase in woody vegetation and the adoption of sustainable land management practices at the landscape level, we consider this a regreening success.

Examples of regreening successes can already be found. In pockets of the Sahel, there are more on-farm trees today than there were 20 to 30 years ago. In Niger, which the United Nations Development Programme (UNDP) ranked as the poorest country in the world in 2013, farmers have regreened 5 million hectares since 1985—almost 50 percent of the country's total cultivated area (Reij, Tappan, and Smale 2009). This makes Niger an important learning ground for scaling up regreening successes.

What is Regreening at Scale?

The meaning of "regreening at scale" depends on the context. It can refer to farmers regreening thousands or even millions of hectares over the course of several years or a couple of decades. If millions of hectares of agricultural land are degrading because of wind or water erosion and depletion of soil fertility, then it does not help when these problems are addressed on a few hundred or even a few thousand hectares. The problem needs to be addressed on millions of hectares. This can only be achieved by involving millions of smallholder farmers and using simple and low-cost natural resource management practices, which produce significant economic benefits to farmers and their communities. Although the primary motivation for the widespread adoption of regreening practices lies with rural communities, there is a clear role for external financial and technical support, including contributions from policymakers, extension staff, and researchers.

This report is structured in five parts, beginning with this introduction (Part I). In Part II, we provide an overview of regreening, examining what regreening looks like on the ground (focusing on the Sahel), the range of activities it entails, and the conditions that induce farmers to invest in protecting and regenerating trees. In Part III, we explore the multiple benefits and the potential negative impacts of regreening. In Part IV, we describe the key components of a scale-up strategy, based primarily on experience in Burkina Faso, Mali, Niger, and Senegal. In describing the specific activities for scaling up regreening successes, the report serves as a practical resource for policymakers, development practitioners, and regreening advocates. Part V concludes the report by looking into where scaling efforts could be targeted and key constraints to be overcome.

The report draws heavily on the authors' many years of on-the-ground experience in Africa's drylands. Although the examples used are mainly from the Sahel and Ethiopia, the different activities to expand the scale of regreening successes can be adapted and applied in other agroecological situations and on other continents.

BOX 2 | KEY TERMS

AGROFORESTRY: The deliberate integration of trees and shrubs into farming systems. The trees and shrubs may be intentionally planted or may propagate naturally.

AGROFORESTRY PARKLAND: Area where multipurpose trees occur on farmlands as a result of election and protection (http://www.fao.org/docrep/005/x3940e/X3940E11.htm).

ASSISTED NATURAL REGENERATION: A method for enhancing the establishment of secondary forest from degraded grassland and shrub vegetation by protecting and nurturing the mother trees and their wildlings inherently present in the area (http://www.fao.org/forestry/anr/en/).

EVERGREEN AGRICULTURE: : An agroforestry practice that emphasizes the intercropping of trees directly in crop fields and grazing systems, thereby maintaining a green cover on farmlands throughout the year (Garrity et al. 2010).

FARMER-MANAGED NATURAL REGENERATION: The protection and management of naturally occurring trees and shrubs regenerated through roots and seeds present in the soil.

REGREENING: The transformation of degraded landscapes, where productivity (or production per unit area) and resilience have been restored and increased through widespread adoption of agroforestry and related sustainable land management practices.

SUSTAINABLE LAND MANAGEMENT: The integration of land, water, biodiversity, and environmental management to meet rising demands for food, fiber, and other goods while sustaining livelihoods and the range of services provided by healthy ecosystems.

PART II

HOW AND WHERE IS REGREENING HAPPENING?

Regreening is achieved at the landscape level. It involves a transition from relatively barren, deforested, and degraded landscapes to landscapes with higher densities of woody species than in the recent past.

Regreening can occur through a range of processes, including the following:

- The development of new agroforestry systems by farmers who protect and manage the natural regeneration of shrubs and trees on their cultivated fields or plant multipurpose or economically valuable tree species.
- The rejuvenation of old agroforestry parklands through planting tree crops like cashew or through natural regeneration of preferred agroforestry species like shea nut (*Vitellaria paradoxa*).
- The protection and management of natural regeneration on abandoned cropland and degraded land off the farm.
- Local protection, regeneration, and improved participatory management of natural forests by forest-user groups and rural communities.
- Reclamation and restoration of the productivity of degraded, abandoned cropland using rainwater harvesting and agroforestry practices.
- Improved management of livestock and grazing areas by pastoralists through the systematic protection and regeneration of trees and shrubs that are important sources of browse for livestock.
- Sustainable intensification of rain-fed crop production through a combination of improved land and water management practices (e.g., agroforestry, microdosing, and water harvesting). (Winterbottom, Reij, Garrity, et al. 2013)

Regreening practices generally fall into two nonexclusive categories: agroforestry and sustainable land management. Agroforestry encompasses a range of practices, including the intentional integration of trees into farming systems, farmer-managed natural regeneration, and assisted regeneration of trees on grazing lands. A suite of agroforestry practices are included in "evergreen agriculture," including farmer-managed natural regeneration, along with the active intercropping of trees with other crops and the integration of trees into improved farming practices known as "conservation farming" or no-till and reduced tillage.[2] Often, regreening practices will involve more than one agroforestry or sustainable land management practice.

In this report, we focus on farmer-managed natural regeneration, which we consider one of the most promising approaches to regreening. As we explain below, farmer-managed natural regeneration is simple, affordable, and familiar to many farmers in the Sahel.[3]

Farmer-Managed Natural Regeneration

In agroforestry systems, farmers deliberately grow woody species on their farmland in association with agricultural crops. Agroforestry often leads to complex production systems that integrate trees, crops, and livestock (see Figures 1 and 5 for an idea of what this looks like in practice). Farmers may plant the trees, but as experience in the Sahel shows, they more often protect and manage woody species that regenerate in their fields spontaneously.

Figure 1 | **Regeneration of Trees on Farms in Burkina Faso**

In 1985 this land in the village of Ranawa, in Zondoma Province, Burkina Faso, was barren, but now it shows a high density of trees with a crop of (young) millet growing under the trees.

BOX 3 | SOURCES OF NATURAL REGENERATION OF WOODY SPECIES

Woody species only regenerate naturally when roots or seeds are available in the soil. This may occur in three general ways.

LIVESTOCK AS A SOURCE OF NATURAL REGENERATION

Livestock manure often contains seeds from trees and bushes that the animals have browsed. When animals drop manure as they graze, they also spread seeds. Seeds that have gone through the digestive system of animals germinate more easily. Farmers who invest in on-farm water harvesting techniques, like planting pits, almost all use manure in the pits, which explains the emergence of woody species in such systems.

ROOT SYSTEMS AS A SOURCE OF NATURAL REGENERATION

A second source of natural regeneration is what Australian agronomist Tony Rinaudo calls "the underground forest" (Rinaudo 2007). The root systems of trees that were cut in the past are still present in many landscapes and across many types of soils. When farmers and communities protect and manage the regeneration from these root stocks, regrowth can give rise to new agroforestry parklands or other types of agroforests. Regrowth from mature root systems is usually rapid, which helps generate impacts quickly and can encourage farmers to invest in protecting and managing trees.

NATURAL REGENERATION FROM **"SEED MEMORY"**

A third source of natural regeneration is the seeds stored in the topsoil—sometimes called the soil's "seed memory." Some seeds can remain dormant for years, but given the right rainfall, they may sprout, and when the new seedlings are protected and managed, a new crop of trees can develop.

The very term "farmer-managed natural regeneration" underscores the centrality of farmers in protecting and managing the naturally occurring regeneration of woody plants as tree seeds germinate and cut-over stumps resprout.[4] Farmers usually protect and manage the regeneration of trees and shrubs on farms, but they can also do so off the farm, although this task is taken up by communities more often than by individual farmers. Community organization and commitment is necessary to protect regenerating shrubs and trees from bush fires, grazing livestock, fuelwood harvesting, and other land use pressures.

Farmer-managed natural regeneration (FMNR) is a simple technology accessible to farmers of all income levels. (See Box 3 for an overview of the sources of natural regeneration.) This explains in part why it has spread so fast in parts of the Sahel. There are some indications that poor farmers in Niger have higher on-farm tree densities than rich farmers (Yamba and Sambo 2012). One reason may

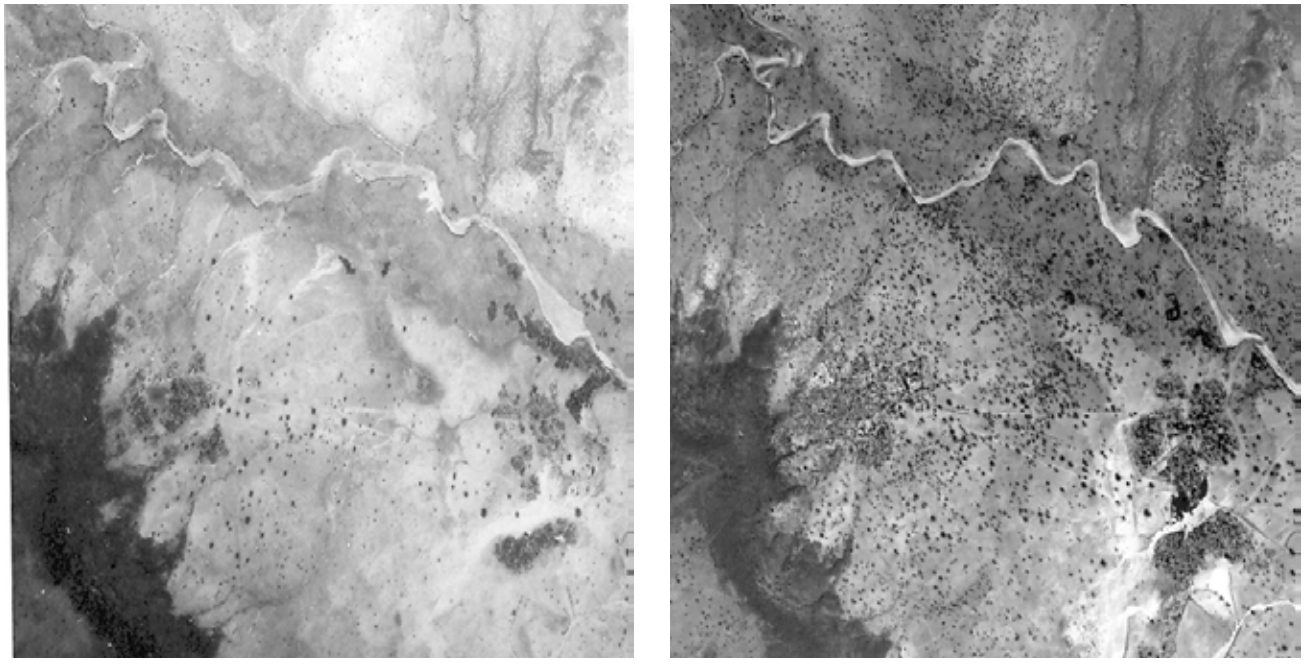
be that poor farmers depend strongly on their land to secure their livelihoods. One study indicates that rich farm families have higher incomes from FMNR than poor farm families, but this can be explained by their larger land holdings (Sambo 2008). On a per hectare basis, poor and extremely poor farm families generate higher incomes from FMNR than their richer counterparts.

Regreening Experiences in the Sahel

In the 1960s natural vegetation covered significant areas of the Sahel's less populated regions. In the 1970s and 1980s, however, this vegetation disappeared at alarming rates.[5] During the same time frame, crop yields declined and erosion intensified (Marchal 1977; Raynaut 1997). These trends were related in part to a significant decrease in rainfall, which led to tree mortality, and in part to population growth, which increased demand for food, wood, and natural resources. As rainfall declined, and as fallow periods were shortened and soil fertility diminished, farmers were forced to expand their cultivated land to compensate for falling crop yields. Expanding cultivated land usually entailed destroying natural vegetation. Another factor in the diminishing vegetative cover was the push to "modernize" agriculture: animal traction, mechanization, and other practices contributed to the removal of trees in fields. During this period, government agricultural extension services routinely advised farmers to remove most on-farm trees to facilitate plowing.

Contrary to what many people assume, the regreening that has occurred across parts of Burkina Faso, Mali, and Niger in recent decades is not the result of a massive tree-planting campaign led by government agencies and development assistance agencies. Rather, it has largely occurred thanks to the actions by farmers who have protected and managed the natural regeneration of trees and bushes, primarily on cultivated land. Figure 2 illustrates natural regeneration in the village of Galma in Niger's Tahoua region. The black dots are mature trees; their random distribution indicates that they regenerated naturally, not through planting. As the illustrations show, there were many more mature trees in 2003 than in 1975.

Figure 2 | **Comparison of Satellite Images Showing Tree Cover in Niger in 1975 and 2003**



Left image shows the village of Galma (Niger) in 1975. Right image shows the same village in 2003. Most of the black dots are mature trees. Courtesy Gray Tappan, USGS.

Under What Conditions Have Farmers in the Sahel Invested in On-Farm Trees?

Experience shows that farmers often increase the number of on-farm trees in response to demographic and resource-related constraints. First, farmers have tended to increase the number of on-farm trees in regions where high population densities and more intensive agriculture have displaced most of the natural woodlands. Higher numbers of on-farm trees are also associated with regions where fallow periods have been eliminated as a result of demographic pressures, pushing farmers to find other ways to restore and maintain cropland soil fertility.

For example, the southern part of Niger's Zinder region is densely populated and characterized by "wall-to-wall" agriculture: cultivated fields extend across virtually the entire landscape. Along with the expansion of cropland, population increases led to the reduction of tree cover in the early 1980s, both on and off of farms. In the last 25 years, however, Zinder has spectacularly regreened. Farmers report that the environmental and economic crisis of the 1980s and 1990s induced them to invest in trees (Larwanou, Abdoulaye, and Reij 2006). In their words, they had to "fight the Sahara," which meant grappling with severe sandstorms. In the 1980s, few trees were left to shield newly planted crops from the strong winds early in the rainy season. Crops were sandblasted, forcing farmers to replant three or four times to establish a crop. This shortened the growing season, with a negative impact on crop yields, and cost farmers in time and seeds.

Figure 3 | **Evolution of Land Use and Vegetation in Southern Niger from 1955–2005**

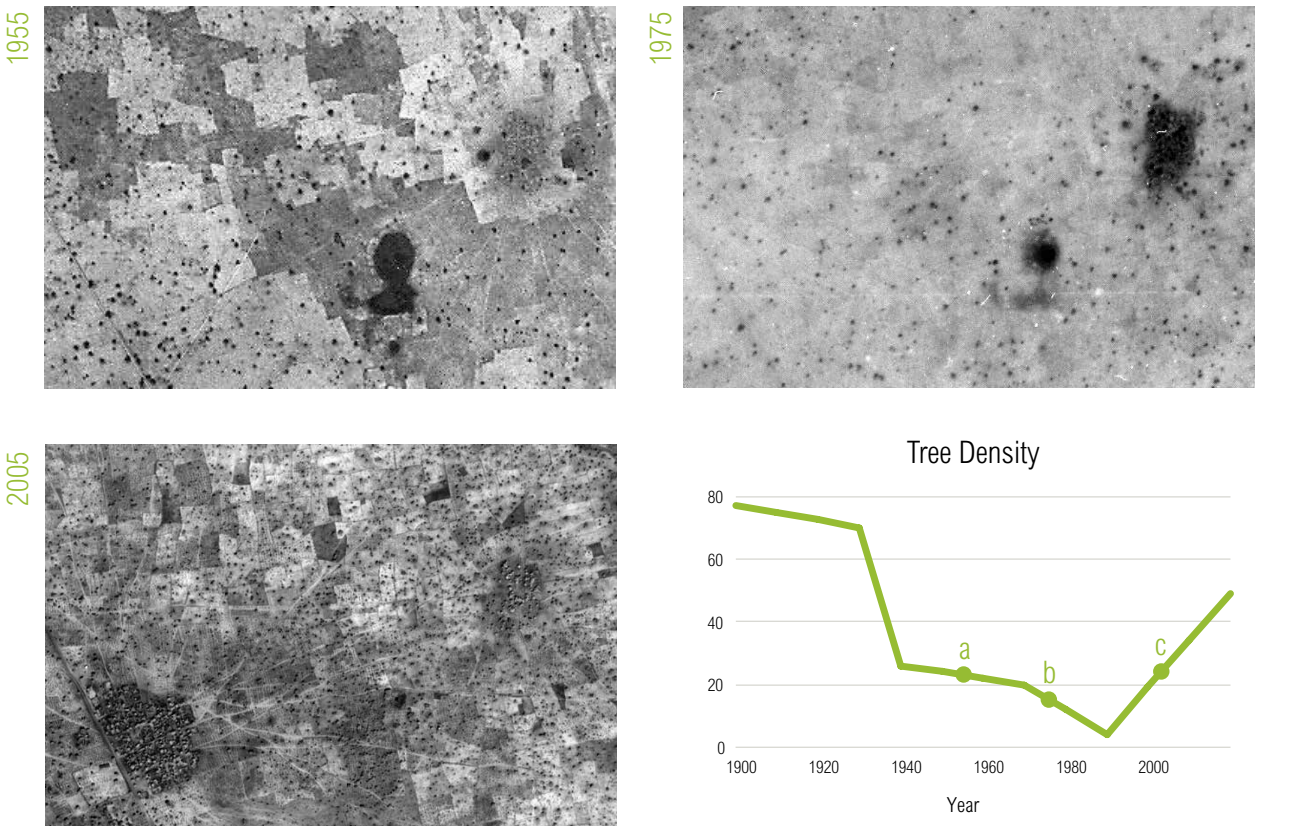


Figure 3 shows land use and vegetation in a village in southern Zinder region (Niger) in 1955, 1975, and 2005. Courtesy Gray Tappan, USGS. In 2005 the village had more people and more trees, as evident in the graph of tree density (bottom right). *Source:* Sendzimir, Reij, and Magnuszewski 2011.

In the 1980s women in southern Zinder had to walk an average of 2.5 hours a day to collect firewood, because both on-farm trees and natural vegetation had become scarce (Larwanou, Abdoulaye, and Reij 2006). Most livestock manure was used to cook food. The combined soil fertility, food, household energy, and environmental crisis prompted farmers to protect and manage natural regeneration of woody species on their farmland. Figure 3 shows land use and vegetation in the same village in southern Zinder in 1955, 1975, and 2005 (respectively points a, b, and c in the graph). In 1975 the number of on-farm trees was almost at its lowest, but the figure for 2005 shows bigger villages and more trees. It is a story of "more people, more trees."[6]

A second reason that the number of on-farm trees increase is as a co-benefit of investments in water harvesting techniques. Most of the regreening in the Sahel has occurred in areas with high population densities and sandy soils that root systems can easily penetrate. Regreening has also occurred, however, in areas with high population densities and barren, degraded soils with a hard lateritic layer. For instance, at the end of the 1980s, simple

Figure 4 | **Transformation of Degraded Land in Niger from 1990 to 2004**

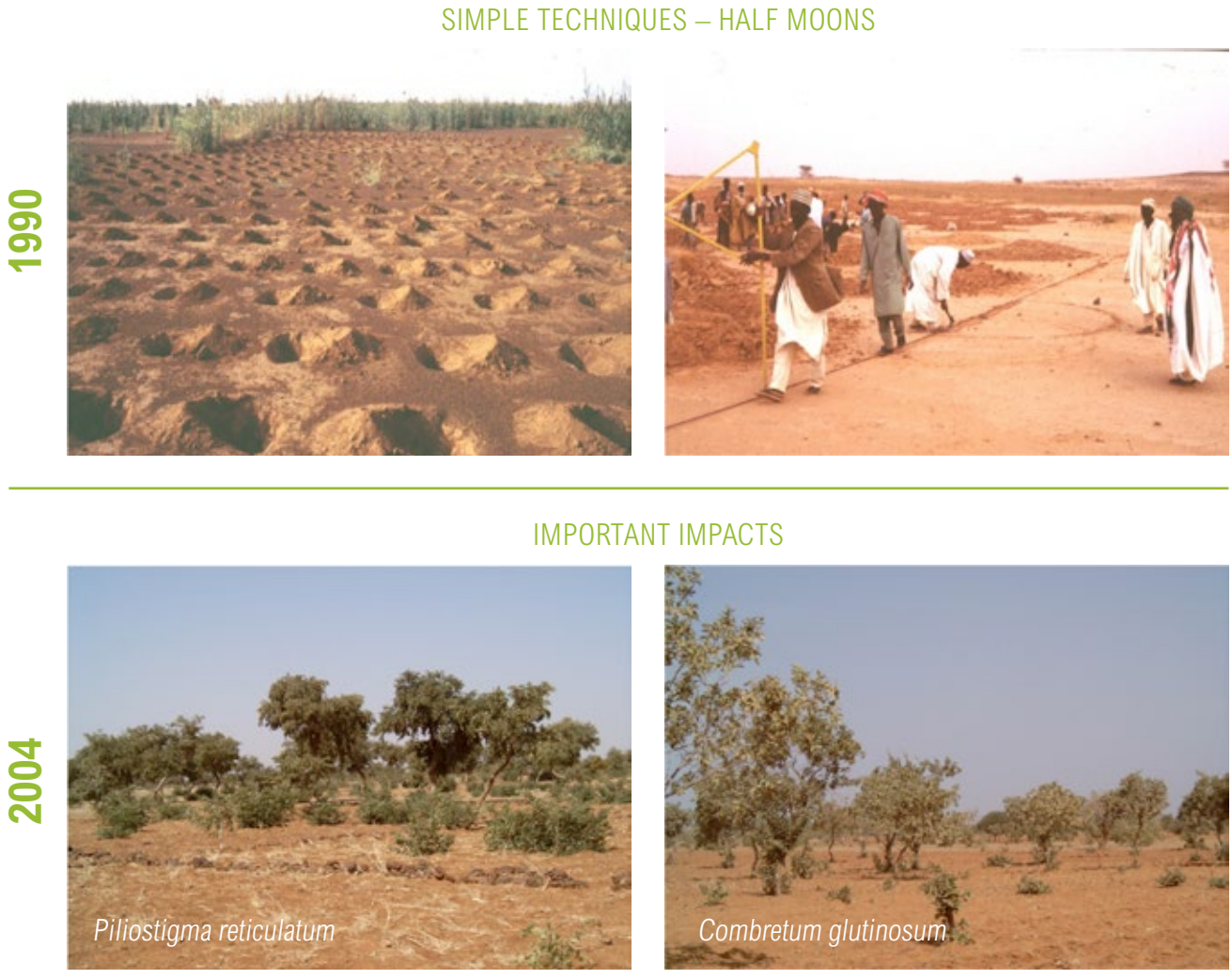


Figure 4 shows the same fields in 1990 and 2004. In 1990 the farmers had just begun to dig pits and half-moons to restore degraded land to productivity. In 2004 what used to be degraded land had been fully transformed into productive fields with an agroforestry parkland.

BOX 4 | LINKING REGREENING AND CLIMATE-SMART AGRICULTURE

Climate-smart agriculture is about achieving sustainable agricultural production for food security under climate change. According to the Food and Agriculture Organization of the United Nations (FAO), climate-smart agriculture combines the following elements:

- Sustainable increases in agricultural productivity and income
- Enhanced adaptation and resilience to climate change
- Removal or reduction of greenhouse gas emissions, where possible (FAO 2013)

Does regreening help sustainably increase agricultural productivity and income in drylands? Crop yields in many parts of the Sahel are low and stagnant. Many soils are poor and have low levels of organic matter, meaning that even if farmers could afford mineral fertilizers, their use would be inefficient. To improve soil capacity to store moisture and retain nutrients, soil organic matter must be increased, and smallholder farmers usually do not have enough livestock to adequately fertilize their fields (5–10 tons of fertilizer are typically required per hectare). In these circumstances, the best way to increase soil organic matter may be to increase the density of on-farm trees. Trees increase soil organic matter when they drop their leaf litter and through nitrogen fixation. Nitrogen-fixing species like Faidherbia albida can double crop yields, but this takes time: trees will not have their greatest impact until they are mature.

Does regreening help farmers adapt and build resilience to climate change? Resilience means that farmers and their communities can cope with and overcome the impacts of external shocks, like droughts or floods. Farmers in Africa's drylands regularly face extreme weather events. Rainfall has become more irregular, and when it does rain, the rainfall is more often intense, leading to higher rates of runoff, floods, and crop destruction.

Does regreening help remove greenhouse gases? Trees sequester carbon; how much they sequester depends on the type of trees and their growth rates. The 5 million hectares of farmer-managed regreening in Niger has sequestered about 25–30 million metric tonnes of carbon over the past 30 years (Stevens et al. 2014). This estimate does not include the carbon sequestered by the root systems. Since the agroforestry parkland in the regreened areas of Niger is still young, the quantity of carbon sequestered is likely to increase.

In short, regreening can be an important strategy for climate-smart agriculture.

water harvesting techniques (planting pits and half-moons) were introduced in Niger's department of Illéla to restore the productivity of barren soils with hard crust. Farmers break the hard crust with a hoe and dig a small depression (pit) or excavate a larger pit in the form of a half-moon to collect more rainfall and runoff. Data collected over 6 years, mainly on the same fields, show an average increase in crop yields of about 400 kilograms per hectare (Hassane et al. 2000).

Farmers who invest in water harvesting techniques also invest in improved soil fertility management. They use manure in the pits and half-moons, and the manure contains seeds from trees and bushes browsed by the livestock. The woody species germinate along with the planted crops. If the farmer decides to protect the young trees that emerge in the same pit as the millet or sorghum, the trees will develop quickly, as they benefit from the combination of harvested rainwater and improved soil fertility. Figure 4 shows a formerly degraded field that was restored to productivity through the combination of water harvesting and agroforestry.

Examples of successful regreening by individual farmers and communities abound across the West African Sahel, in landscapes covering tens of thousands of hectares or more. The beginnings of successful farmer-managed regreening are evident in Chad, Malawi, Zambia, and other countries. To learn how we can build on these experiences and expand the scale of regreening successes, we must first understand why, and under what conditions, farmers have increased the number of on-farm trees and adopted other improved practices. We must also understand the benefits they have realized from these actions. We turn to these questions now.

PART III

THE IMPACTS OF REGREENING

A growing body of literature attests to the positive impacts on crop yields associated with higher densities of trees on farms; farmers have doubled and tripled yields in fields through farmer-managed natural regeneration and other improved land and water management practices (Winterbottom, Reij, and Garrity et al. 2013). A growing body of economic research also shows that it is economically rational for farmers to invest in regreening, although most studies overlook the full range of benefits of regreening.

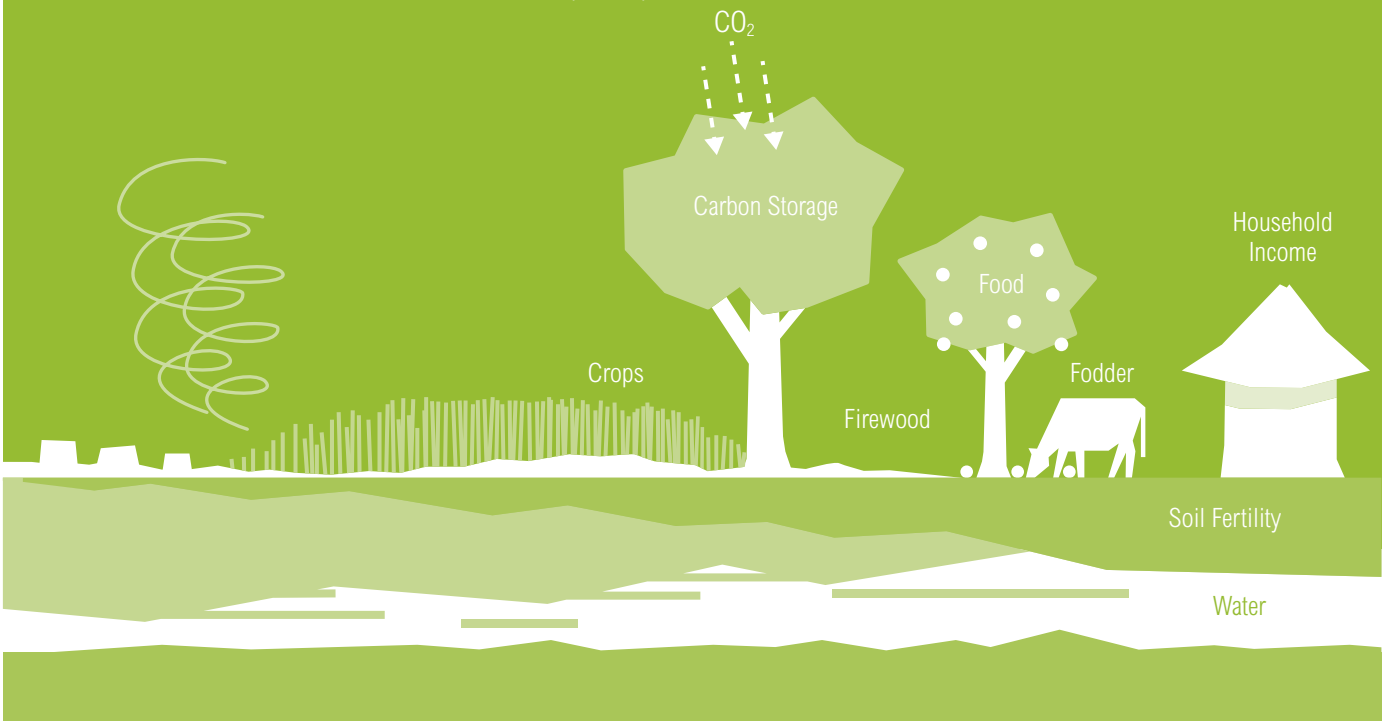
In 2006, two economists from Niger calculated the economic rate of return to investments in farmer-managed natural regeneration, tree planting, and water harvesting techniques (Abdoulaye and Ibro 2006). They arrived at internal rates of return of 37 percent for FMNR and 13 percent for tree planting. Their calculation of the benefits of FMNR was based on an estimation of the value of the on-farm trees over a period of 20 years and a 5 percent increase in crop yields and in the value of crop residues during the first 4 years. That is a significant underestimation of the multiple benefits of regreening. The 13 percent internal rate of return for tree planting is an overestimate, based on an assumed survival rate of 100 percent of all planted trees. In reality, survival rates of planted trees are often below 20 percent, which will significantly reduce the internal rate of return of tree planting.

Recently, the World Agroforestry Centre studied the economics of agroforestry systems in the Sahel (Place and Binam 2013). The study, which focused

BOX 5 | MULTIPLE BENEFITS OF REGREENING

- Trees help restore, maintain, and improve soil fertility by maintaining or increasing soil organic matter.
- Trees help solve the household energy crisis by providing fuelwood, which reduces the burden on women.
- Trees provide poles for construction and manufacture of furniture and tools, as well as fences for gardens.
- Regreening practices improve household food security and fruit and leaves have a positive impact on nutrition.
- Trees are assets that provide "insurance and banking services," which can be drawn on in crop-failure years and times of need.
- Many tree species in agroforestry systems produce nutritious fodder.
- Trees increase the total value produced by a farming system and help reduce rural poverty.
- Trees reduce wind speed and wind erosion.
- The shade of trees reduces soil surface temperatures and evapotranspiration.
- Trees contribute to biodiversity and the restoration of ecosystem services in agricultural landscapes.
- Increasing the number of trees in the landscape helps mitigate climate change by sequestering carbon.

Source: Adapted from Winterbottom, Reij, Garrity, Glover, Hellums, McGahuey, and Scherr (2013).



on the impact of agroforestry on grain production, found that fertilizer trees increase crop yields by 15 to 30 percent. The study estimates that basic fruit, pod, leaf, and wood tree products harvested by households are valued at about $200 per year per household. However, as with most other economic studies of agroforestry systems and regreening, it failed to quantify the full range of benefits of regreening.

A recent World Vision Australia report on the social return on investment for the Talensi Farmer-Managed Natural Regeneration Project in northern Ghana found that the social return on investment at the end of the project was 7:1. The report forecast that the social return on investment at 4 years after the end of the project would be 19:1 (Weston and Hong 2012).

Over the past 20 years, hundreds of thousands of farmers in Burkina Faso, Mali, Niger, and Senegal have invested in protecting natural regeneration and in increasing the number of on-farm trees. They have done so mainly for economic reasons, including improving soil fertility to increase crop yields and household food security (Yamba and Sambo 2012; Reij, Tappan, and Smale 2009; Botoni and Reij 2009). Many of these farmers have protected natural regeneration as a result of farmer-led innovation and farmer-to-farmer contacts, both with and without direct support from government programs and donor-assisted projects or the dissemination of best practices by research institutes.

Regreening Benefits

Box 5 summarizes the major benefits of regreening, some of which we explore in more detail below.

Trees help maintain and improve soil fertility

Most tree species produce large volumes of leaf litter, enhancing soil organic matter. Increased quantity of soil organic matter in turn increases the efficiency of fertilizer use. Furthermore, certain species fix nitrogen from the air in their root systems, which is a zero-cost environmental service to farmers. Depending on the age of the trees, a stand of *Faidherbia albida* fixes 80 to 90 kilograms of nitrogen per hectare. Figure 5 shows *Faidherbia albida* dispersed in fields of cultivated crops, and Figure 6 shows a dense stand of young *Combretum glutinosum* on Mali's Seno Plain.

Species like *Piliostigma reticulatum* and *Guiera senegalensis* are common in many drylands. Rural women in Mali ranked these species higher than *Faidherbia albida* in terms of impact on soil fertility.[7] This may reflect the role these species play

Figure 5 | **Agroforestry Parkland Landscape in the Badaguichiri Valley of Niger**

Parkland in the Badaguichiri valley (Niger) during the rainy season in September 2006. Farmers deliberately combine trees and crops. The trees without leaves are *Faidherbia albida*, which lose their leaves during the rainy season and fix nitrogen from the air in their root system. Farmers use the seed pods and leaves from the trees as fodder for livestock.

Figure 6 | **Regeneration of *Combretum glutinosum* on the Seno Plain of Mali**

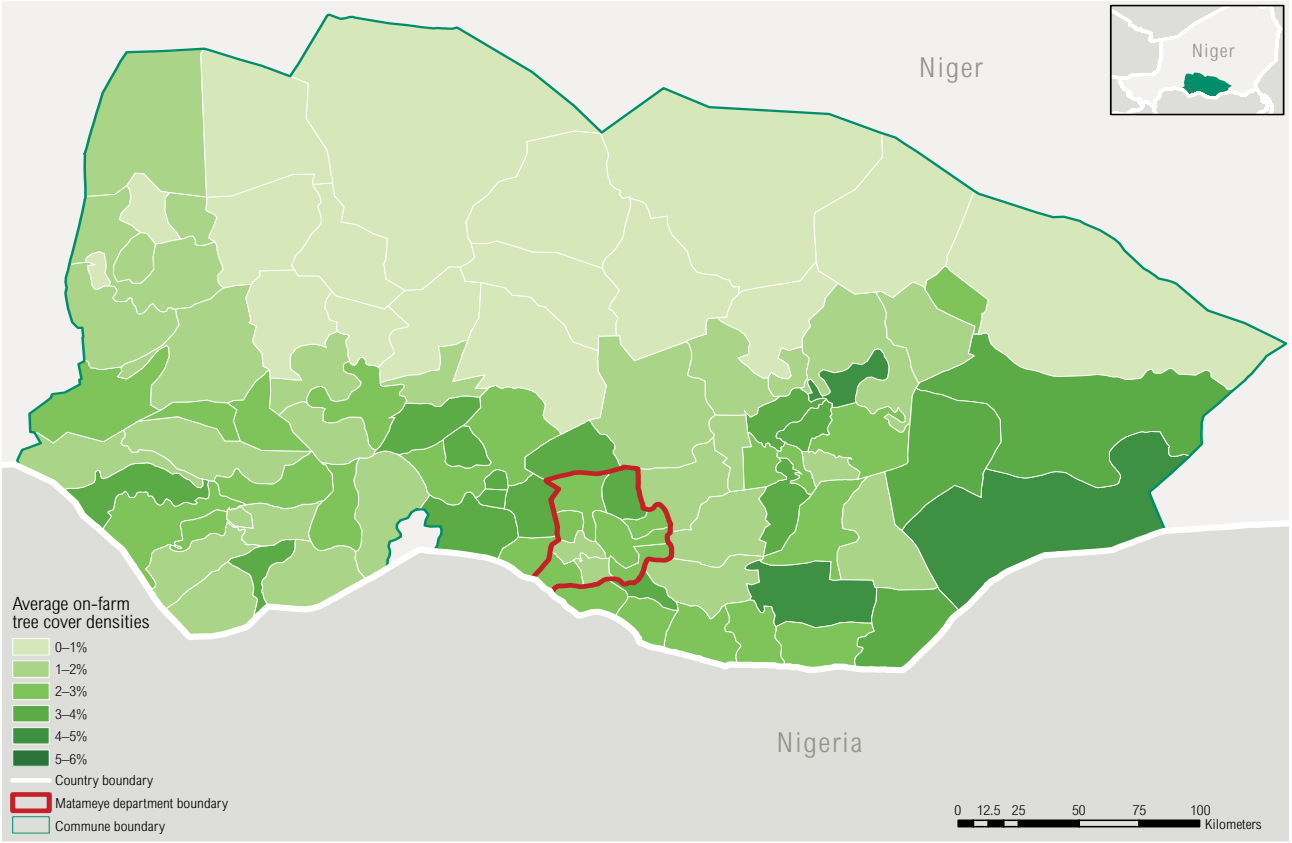
A dense stand of young *Combretum glutinosum*. Seno Plain, Mali, April 2011. Substantial quantities of leaf litter are visible on the soil.

in effectively capturing wind-blown dust, which contains soil nutrients.

The positive impact of agroforestry on soil fertility is of prime importance. Across Africa's drylands and subhumid regions, soil fertility has been declining, leading to lower crop yields (Winterbottom, Reij, Garrity et al. 2013). In many countries in southern Africa, such as Malawi, governments subsidize fertilizers to lower costs for farmers. However, fertilizer does not reach all smallholder farmers, and even when it does, it does not always increase crop yields.

Fertilizer use efficiency depends on the quantity of soil organic matter, which currently is very low in many soils. Soil organic matter has historically been replenished through fallowing, grazing livestock on crop residues, and spreading livestock manure. These methods are no longer sufficient, however, as fallow periods have been shortened or eliminated, and demand for crop residues and manure has expanded. This means that on-farm trees are an increasingly important source of soil organic matter. The dispersal of trees across farmland saves smallholder farmers the time and labor of transporting tons of leaf litter across their farms. Larger-scale mechanized farms will prefer to have trees aligned in rows to facilitate plowing.

Map 1 | **On-Farm Tree Cover in South-Central Niger**



Source: Cotillon, Suzanne, 2015, Mapping Conservation Practices for the Resilience in the Sahel Enhanced (RISE) Programs: U.S. Geological Survey, Earth Resources Observation and Science (EROS) Center, Sioux Falls, S. Dak. Internal poster produced for the U.S. Agency for International Development Sahel RISE Program.

Trees improve household food security

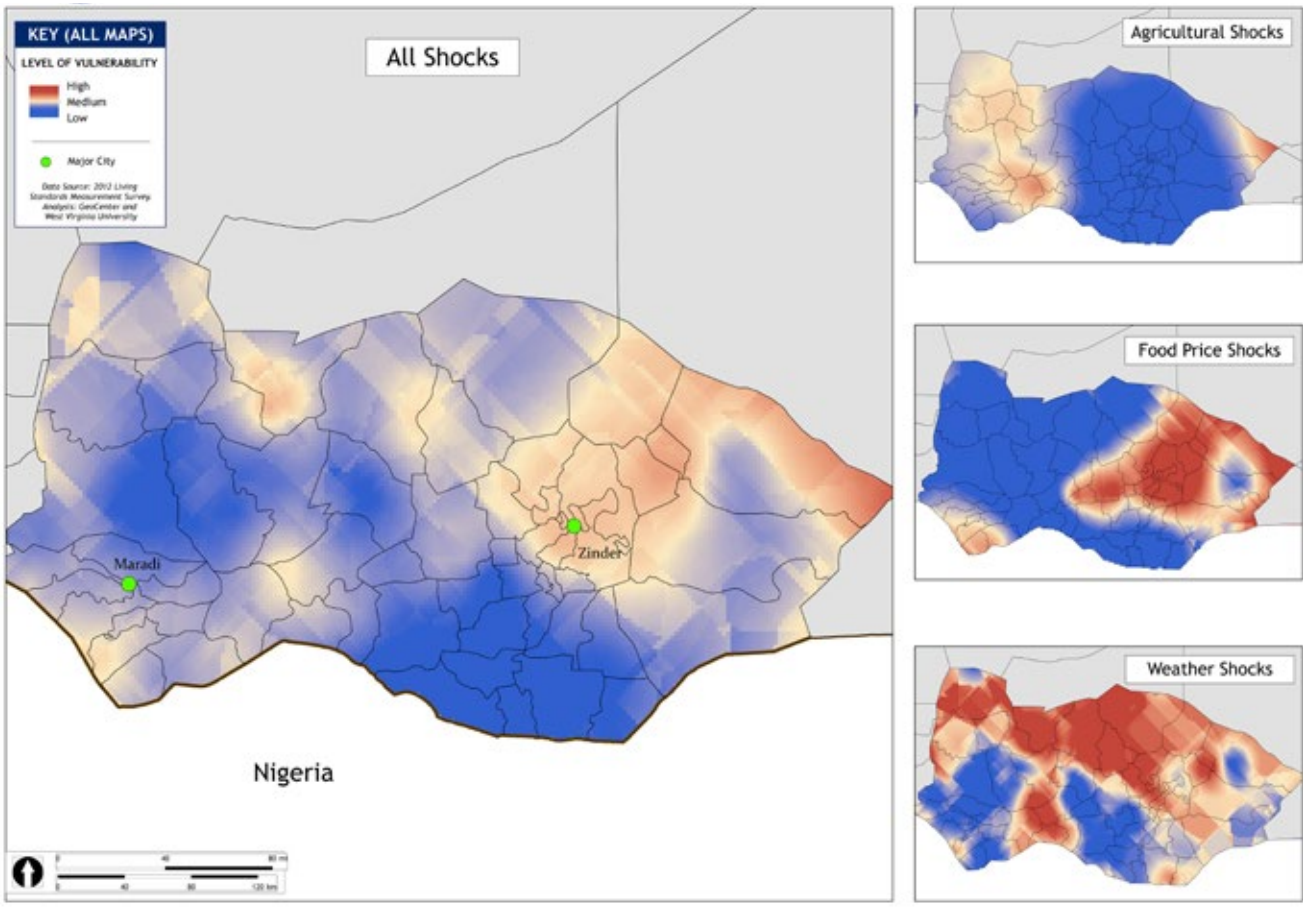
Having more trees in the landscape contributes to improved household food security as trees create more complex, resilient, and productive farming systems, which are more resilient to drought or storms. Even if crops fail, trees produce wood, fodder, edible leaves, fruits, and other useful products that contribute to household economies.

Trees improve household food security in two ways: They have a direct, generally positive impact on crop yields (depending on tree species and tree canopy management practices).

They provide fruit, leaves, fodder, firewood, poles, medicines, and other products that can either be used for domestic consumption or can be sold to generate cash that rural households can use to buy food.

The baobab (*Adansonia digitata*) is just one example of a tree species that generates cash to farmers. A single mature baobab in Niger's department of Mirriah produces leaves and fruit with an annual monetary value of at least $28 (Yamba and Sambo 2012). This allows a farmer to buy 70 kilos of cereals at high market prices during a drought year. An increasing number of farm fields in parts

Map 2 | **Vulnerability in South-Central Niger**



Source: USAID 2014.

of Niger and Burkina Faso have 20, 30, or more regenerated baobab trees per hectare.

The rainy season of 2011 was irregular in many parts of the Sahel, leading to major cereal deficits. In Niger alone, the cereal deficit was estimated to be about 600,000 tons. However, the district of Kantché in the department of Matameye in southern Zinder, which has a high population density as well as a high on-farm tree density, produced a grain surplus of almost 14,000 tons.[8] The Kantché district had also produced grain surpluses in the preceding 4 years (Yamba and Sambo, 2012).

Recent efforts to map on-farm tree cover in south-central Niger have identified where tree densities are relatively low, medium, and high. The department of Matameye is one area where average on-farm tree cover density is relatively high (see Map 1) (USGS and USAID 2014). It is interesting to juxtapose this map of tree cover with a recently completed analysis of the relative vulnerability of rural households in Niger to various types of shocks linked to climate change, including agricultural and food price shocks. This vulnerability analysis by USAID's GeoCenter shows the different levels of vulnerability across this part of Niger, and indicates that vulnerability is relatively low in many of the same localities where tree cover is higher (see Map 2) (USAID 2014).

Trees and shrubs are an important source of livestock browse and fodder

Across the Sahel, farmers and herders value the pods and leaves of *Faidherbia albida* as an excellent source of fodder for livestock. They also use many other indigenous species for fodder, including common species such as *Piliostigma reticulatum* and *Guiera senegalensis*. Fodder is often scarce at the end of the dry season, but in regreened areas, the strong increase in the number of on-farm trees, which produce fodder for livestock, means that fodder availability is less a constraint to raising livestock than it was 20 years ago. Tree fodder creates more opportunities for farmers to integrate agriculture, livestock, and forestry. Farm animals in the Sahel depend on tree fodder for up to 6 months a year.

Figure 7 shows goats tethered after harvest in young and dense agroforestry parkland dominated by *Faidherbia albida*, illustrating how some farmers control the movements and grazing of their livestock as livestock fodder from trees becomes more accessible. Figure 8 shows a farmer carrying *Ficus* leaves at the end of the dry season for the sheep he keeps tethered in an enclosure. (Tethering livestock makes it easier for farmers to collect manure for their fields.)

Figure 7 | **Tethering of Goats to Enable Regeneration of *Faidherbia albida***

Goats are tethered even after the harvest. In the background the young agroforestry parkland is dominated by *Faidherbia albida* (November 2010).

Figure 8 | **Collection of Tree Leaves for Livestock Fodder**

A farmer in southern Zinder collects *Ficus* leaves for his sheep (June 2006).

Trees have a positive impact on nutrition

Many agroforestry species are important sources of vitamins, minerals, and oil, and the fruits and leaves of many trees and bushes contribute to better nutrition in the drylands of Africa. For instance, the leaves of the baobab tree (*Adansonia digitata*) are rich in vitamin A, and its fruit is a good source of vitamin C. The fruit of *Ziziphus mauritania* is rich in vitamins A and C, and in fatty oils. The fruit of *Sclerocarya birrea ssp. caffra* is rich in vitamin C, and its seed is rich in oil and many minerals.

Moringa oleifera (drumstick tree) is becoming increasingly popular in the Sahel to increase production of leaves for human consumption. Trees for Life International notes that, gram for gram, the fresh leaves of *Moringa oleifera* provide seven times the vitamin C of oranges, four times the vitamin A of carrots, four times the calcium of milk, three times the potassium of bananas, and twice the protein of yogurt.[9] The nutritional, medical, and prophylactic properties of *Moringa oleifera* have been assessed in several publications.[10]

Figure 9 shows Ousséni Kindo, a farmer and innovator in the Yatenga region of Burkina Faso, with his 2-year-old *Moringa oleifera*. It is planted in soil that used to be barren and degraded.

Trees help farmers adapt to climate change by "turning down the heat" and by reducing wind speed

Figure 6 showed a dense stand of young *Combretum glutinosum* on Mali's Seno Plain. Some agronomists would argue that this on-farm tree density is too high to allow cultivation. They might worry that trees this dense will starve crops of nutrients and light.

Farmers would disagree with this assessment. They would note that they prune the trees early in the rainy season (June), providing leaf litter and firewood. Furthermore, the shade from trees protects crops from overexposure to the sun, reducing temperatures and evapotranspiration. Increased densities of trees in fields also help break the force of potentially damaging winds. In a context of rising temperatures, more erratic rainfall, and increasingly severe storms, these are important functions.

Many agroforestry species are important sources of vitamins, minerals, and oils, and the fruits and leaves of many trees and bushes contribute to better nutrition in the drylands of Africa.

Figure 9 | **Planting of *Moringa oleifera* to Provide Nutritional Benefits**

Ousséni Kindo with a young *Moringa oleifera* planted in soil that used to be barren. He has put a plastic bottle upside down close to the roots to water the tree during the dry season.

When on-farm tree densities become too high and risk competing with crops, farmers reduce the density. In the village of Dan Saga in Niger, farmers reduced high tree densities and used the culled trees to create a rural firewood market, which generated cash income.

Farmers in Niger also mention that trees reduce wind speed (Larwanou, Abdoulaye, and Reij 2006). Before the increase in the number of on-farm trees, strong winds early in the rainy season used to cover the farmers' young crops with sand, forcing the farmers to replant crops three or four times. Now they plant only once.

Trees significantly reduce soil surface temperatures

Agronomist Bob Mann measured soil surface temperatures during different times of the day in a village in northern Burkina Faso on November 12, 1989. November 12 is in the beginning of the cool season, which explains the "low" temperatures measured early in the morning. He noted:

> *On 12 November 1989 I recorded daytime temperatures at Oursi village as follows:*
>
> *Time, air temperature in the shade of trees, and air temperature on the bare ground in full sun.*

TIME	TREE SHADE	BARE GROUND
06.45 hours	25 C	23 C
10.30 hours	33 C	54 C
13.25 hours	36 C	71 C

> *Important microorganisms in the topsoil will die if exposed to temperatures of 55 C and over for more than 1 hour at a time. The value of woodland and vegetation cover in general is self-evident just from this one point of moderating daytime soil-temperature, quite apart from the other important values of micro-nutrient re-cycling from deep down back to the soil surface through leaf-litter fall and decomposition, along with greatly reduced wind speed and reduced soil-moisture evaporation which vegetation brings about.*[11]

Figure 10 | **Shade for Livestock from Trees in Fields**

Cattle enjoy shade in the middle of the day (Niger, January 2012).

Not only crops and people benefit from shade. Figure 10 shows livestock taking advantage of shade during the hottest part of the day. The land under and immediately around the trees receives a significant dose of manure, integrating agriculture, livestock, and trees.

Trees mitigate climate change by sequestering carbon

By reducing wind speed and decreasing local temperatures, trees help farmers adapt to climate change. The on-farm trees also sequester carbon, which helps mitigate climate change. The ageing *Faidherbia albida* parklands in Senegal's peanut basin around Diourbel (Figure 11) sequester about 30 tons of carbon per hectare each year.[12] The young agroforestry parklands in southern Niger (Figure 12) have sequestered 1.6–10 tons of carbon per hectare.[13] Considerable potential remains to sequester more carbon in Niger's young agroforestry parklands. However, it is important to keep in mind that farmers do not protect and manage on-farm trees for carbon; their primary objective usually is to improve soil fertility and produce more food.

Some observers have suggested that farmers should be rewarded for their contribution to the global benefit of carbon sequestration. At this juncture,

however, the increased flow of local benefits in the relatively short term has been sufficient to motivate farmers to invest in trees on farms, without relying on incentive payments related to carbon. The costs associated with monitoring, reporting, and validation systems, and the transaction costs associated with carbon payment schemes, have also been avoided. Perhaps more important, scaling up regreening can deliver the carbon benefits to the global community but still maintain the needed flexibility for farmers to harvest trees during periods of drought and reduced crop harvests.

Trees are an important source of household energy

Twenty years ago, many women in southern Niger spent on average 2.5 hours each day collecting firewood. Natural vegetation had largely disappeared, and women had to walk long distances to find shrubs. Now they prune on-farm trees, and it takes them on average 0.5 hours per day to collect firewood. Twenty years ago, manure and crop residues were the main source of household energy, but that is no longer the case. With increased supplies of locally produced fuel wood, all manure is now used on the cropland (Larwanou, Abdoulaye, and Reij 2006). Similar situations are found elsewhere in the Sahel where farmers have invested in trees.

Trees contribute to biodiversity conservation and a restoration of ecosystem services

Increasing on-farm biodiversity reduces the likelihood that crops will be damaged by pests and increases the diversity of products available to farm households. Biodiversity can be managed through crop diversification and by increasing the density and diversity of trees on farms (Snapp et al. 2010). In the initial stages, the regeneration of trees on farms is usually dominated by a limited number of species, which in the sandy soils of southern Niger often include *Guiera senegalensis*, *Combretum glutinosum*, and *Faidherbia albida*. Three general scenarios may determine the diversity of on-farm tree species:

Farmers may simply manage the seed reservoir available in the topsoil or the root stock that is still alive. For instance, in some areas of Mali's Seno Plain, *Combretum glutinosum* is the only species that emerges during natural regeneration.

Figure 11 | **Old Parklands of *Faidherbia albida***

Old agroforestry parkland in Senegal's peanut basin.

Figure 12 | **Young Parklands of *Faidherbia albida***

Very young agroforestry parkland in southern Zinder (Niger).

Farmers may deliberately select one species. For instance, in southern Zinder (Niger) *Faidherbia albida* dominates large areas characterized by high population densities and agricultural fields extending across much of the landscape. Farmers prefer *Faidherbia* as it improves soil fertility and produces large quantities of fodder. Although this has led to new agroforestry parklands, the diversity of trees is limited, which poses a risk in the event that *Faidherbia albida* is attacked by a disease. Research has noted regreening in central Senegal, but with reduced biodiversity (Hermann and Tappan 2011).

Farmers may directly or indirectly develop a large diversity of trees. For instance, where degraded land is restored to productivity using simple water harvesting techniques, this may lead to regreened landscapes with a higher diversity of trees than in surrounding areas.

New agroforestry systems have also emerged on degraded land that has been restored with simple water harvesting techniques in the northern part of Burkina Faso's Central Plateau. The diversity and the on-farm tree density are much higher on the restored land than they are on adjacent fields (Belemviré 2001).

Trees also contribute to biodiversity by attracting migrating songbirds. Every year millions of songbirds from Europe cross the Sahara and spend the winter in the Sahel. They benefit from more trees where they can hide and find shade. All migrating songbirds are insect-eaters, thus helping control pests.

Managing the Potential Negative Impacts of Regreening

From improving household food security to enhancing biodiversity, regreening can deliver a host of benefits to farmers, communities, and ecosystems. However, are all regreening impacts positive, or are there also potential negative impacts? We explore that question in this section.

Regreening sets the stage for further intensification of agriculture by increasing soil organic matter and, for some tree species, fixing nitrogen. However, for many years, conventional wisdom held that high on-farm tree densities were likely to increase competition with cereals for nutrients, water, and light. This led to a presumption that cereal yields may decrease in regreening areas.

When the density of certain species—like the shea butter tree (*Vitellaria paradoxa*)—increases, cereal yield many indeed decline. This is less likely to be the case, however, with nitrogen-fixing "fertilizer trees" like *Faidherbia albida*. Moreover, the multiple "ecosystem services" and other values provided by a variety of trees and shrubs through agroecological production systems more than offsets any anticipated reduction in grain production, particularly when farmers select the best tree species for their situations, prune the tree canopies appropriately, and maintain tree densities that obtain an optimal mix of benefits. Farmers are quick to appreciate the importance of managing total production per hectare (including the contributions of trees, shrubs, and other perennials, as well as annuals) and not just grain yields.[14]

The birds that trees attract are also considered by some farmers to be a negative impact of regreening. After all, birds can damage crops. However, some innovative farmers deliberately try to attract birds to help protect their crops against pests (Figure 21 shows an example). Also, as regreening covers more of the landscape, the bird populations are diluted across the fields and cause less concentrated damage. In addition to concerns about birds, some communities may be concerned about a possible increase in snake populations associated with increased densities of trees and shrubs in agricultural landscapes.

Farmer-managed natural regeneration can cause conflict between sedentary farmers and semi-nomadic herders. Nomadic herders may see the proliferation of trees as a threat to their dry season grazing rights, or as a free fodder resource to be taken advantage of when no one is looking. Once again, "management" is the key. Farmer-managed natural regeneration promotion programs should engage all land users from the outset, including nomadic herders, as difficult as this may be. The implication is that staff working on programs promoting FMNR should also prepare communication materials targeting herders, demonstrating the wide range of benefits that this technique holds for herders and their livestock.

PART IV

THE SIX STEPS OF SCALING UP REGREENING

This section describes the key components of a strategy to scale up regreening. This strategy is based not on theory but on analysis of on-the-ground experience in the Sahel and beyond.

More specifically, these sources of experience include the following:

- An analysis of the drivers and dynamics of large-scale regreening in Niger (Reij, Tappan, and Smale 2009).
- The experience of regreening initiatives implemented in Burkina Faso and in Mali between 2009 and 2012.[15]
- Results from an International Fund for Agricultural Development–supported project in Burkina Faso, Mali, Niger, and Senegal that sought to make national policymakers more aware of regreening by farmers (Reij 2013).
- Discussions with national and international partners involved in expanding regreening by farmers in the Sahel and in other drylands.
- Multiple field visits and discussions with farmers who have invested in regreening.

The scale-up strategy includes six major types of activities described as "steps" to be taken by development practitioners and others committed to promoting regreening. The steps are not necessarily sequential and not meant to be prescriptive. In other words, not every step is applicable in every situation, as one or more may have already been wholly or partially addressed. In adapting these steps to a particular setting, those responsible for designing scaling activities must consider the specific country context and tailor the components and priority activities of a scale-up strategy accordingly.

These are the six major "steps":

1. Identify and analyze existing regreening successes.
2. Build a grassroots movement for regreening and mobilize partner organizations.
3. Address policy and legal issues and improve the enabling conditions for regreening.
4. Develop and implement a communication strategy to systematically expand the use of all types of media.
5. Develop or strengthen agroforestry value chains to enable farmers to capitalize on the role of the market in scaling up.
6. Expand research activities to fill gaps in knowledge.

National governments have a key role to play: the agricultural development policies and forestry legislation they formulate could induce millions of smallholder farmers to invest in on-farm trees. However, it is unlikely that governments will do this without proof that regreening by farmers produces significant economic and environmental benefits. National policymakers thus need to be educated about existing successes and associated benefits, and a grassroots movement must be built that catalyzes the processes of regreening.

BOX 6 | ENHANCED OBSERVATIONS OF REGREENING DURING FIELD VISITS IN MALI

In 2009 NGO representatives traveled from Koro to Bandiagara on Mali's Dogon Plateau. Along the 60 kilometers of road through the Seno Plain between Koro and Kani Kombole at the foot of the Dogon Plateau, young and often dense agroforestry parklands were visible almost everywhere. The group stopped in a village to speak with a farmer about regreening and the impacts he observed. At the end of the day, a very experienced Malian agronomist remarked: "I've traveled this road many times and I've never 'seen' this regreening."

If someone does not look at on-farm trees, including their age and density, it is possible to overlook the fact that farmers are building new agroforestry systems. Even experienced national and international specialists may not be looking for regreening and therefore would not see what is happening. However, as soon as one starts paying attention and seeking out changes in farmer behaviors and associated changes in the density of trees across the landscape and from year to year, one can begin to see situations in which on-farm tree densities are increasing or relatively higher in one area than another.

Step 1. Identify and Analyze Existing Regreening Successes

Partners interested in scaling up regreening can use examples of success as a starting point and as a source of inspiration. Carefully identified and documented successes can be used for study and for learning. We have already noted some regreening successes in Niger, but there are also many smaller examples across numerous countries, ranging from individual farmers to one or more communities that have invested in agroforestry. How can regreening successes be more systematically identified and analyzed? One way is simply through enhanced observations during field visits (see Box 6).

Farmer-managed regreening can also be identified by analyzing aerial photos or satellite images. It usually requires a field visit for verification of the composition of the agroforestry parkland, the age classes of the trees, and what and who is driving the regreening. Besides direct observation while traveling in the field or through the use of remote sensing tools, one can also discuss recent developments with NGO staff, researchers, and staff of relevant ministries. If certain farmers or villages manage higher than average tree densities on or off their farms, someone may know about them (see Box 7).

Figure 13 shows an example of what regreening on Mali's Seno Plain looks like on the ground. It shows a high on-farm tree density and a diversity of species. Ninety percent of the trees on Mali's Seno Plain are less than 20 years old.

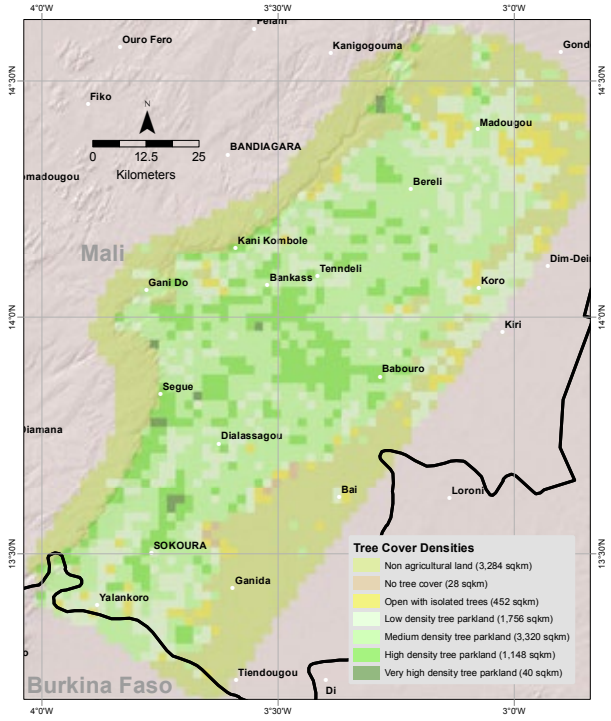
The scale of farmer-managed regreening in the densely populated parts of Niger's Maradi and Zinder regions has been gradually uncovered since 2004 (Reij, Tappan, and Smale 2009). Before 2004 researchers had observed higher on-farm tree densities in a number of study villages, but they had not systematically explored the scale of regreening (Mortimore et al. 2001).

The fact that several large-scale regreening successes have gone unobserved for many years may well mean that many more successes remain to be identified. This can be achieved through field visits, and nowadays Google Earth can fairly quickly provide a good sense of relative tree densities across large areas.

BOX 7 | FIELD SURVEY IN MALI

In April 2011 development agents working on the Seno Plain in Mali assumed that the scale of the agroforestry parklands on the Seno Plain was in the order of 18,000 hectares. A few weeks later Gray Tappan of the US Geological Survey communicated the results of his analysis of high resolution satellite images of the Seno Plain. The analysis revealed that the scale of the agroforestry parklands was 450,000 hectares of medium- to high-density parkland. Map 3 shows the scale of regreening on Mali's Seno Plain and the distribution of areas with medium- and high-density on-farm trees.

Map 3 | **Tree Cover Densities on Mali's Seno Plain**



Tree Cover Extent and Density in the Agricultural Parklands of the Seno Plains, Mali

Source: Gray Tappan, USGS.

Figure 13 | **Young Agroforestry Parkland on the Seno Plain of Mali**

Young, dense, and diverse agroforestry parkland on the Seno Plain (January 2010).

Step 2. Build a Grassroots Movement for Regreening

Working at the grassroots includes a number of activities, such as organizing farmer-to-farmer visits and supporting the development of village institutions that can promote, protect, and manage the new tree capital. While not necessarily sequential, the activities listed below have been effective in building a grassroots movement. Donors and NGOs interested in scaling up regreening can support these activities.

1. Select a partner organization with relevant experience in participatory natural resource management.
2. Organize farmer-to-farmer visits.
3. Build capacity through peer-to-peer training among farmers (men and women) and through training-of-trainers and regular follow-up visits by technical advisors.
4. Support the development of village institutions.
5. Develop agroforestry competitions at different levels.

Activity 1. Select a partner organization with relevant experience in participatory natural resource management (preferably with farmer-managed natural regeneration)

In most countries it will be easy to identify projects funded by NGOs or by bilateral or multilateral donors with experience in participatory approaches to natural resource management. It may be less easy to find projects with experience in farmer-managed regreening. Box 8 provides examples of NGOs experienced in promoting farmer regreening. In Niger the Ministry of Agriculture and the International Fund for Agricultural Development jointly built a long and unique track record in supporting NGOs to scale up regreening.

One of the roles of the selected partner organization(s) in each country is to build a movement of numerous organizations and projects that will together promote regreening by farmers. They jointly develop on-the-ground action, but they also engage together in a national policy dialogue around regreening. Projects should be designed and implemented with a view toward building on existing innovations and successes, and catalyzing

and accelerating the spread of proven practices by addressing the chief constraints to scaling up regreening.

For example, the government of the Netherlands is supporting a regional program to scale up agroforestry, water harvesting, and other sustainable land management practices in the Sahel and Horn of Africa.[16] In each of the targeted countries, a national lead organization works with a consortium of organizations that have track records in participatory rural development, a cadre of field agents to support extension, expertise in training and capacity building, and prior experience in addressing issues of food security, enterprise development, natural resource management, good governance, and climate change adaptation. One of the key partners in Mali is a savings and credit organization supported by OXFAM America that has a total membership of more than 300,000 women. A growing number of women recognize that soil fertility is declining and want to increase the number of on-farm trees to address this.

Activity 2. Organize farmer-to-farmer visits

Farmers are generally eager to learn from other farmers with relevant experience. Projects in Africa, Latin America, and elsewhere have capitalized on this by organizing farmer-to-farmer study visits (Winterbottom, Reij, Garrity et al. 2013). Such visits are effective for raising awareness, convincing skeptics, stimulating further innovation, and triggering widespread adoption through the provision of opportunities for practical training (see Box 9). In the experience of Sahel Eco in Mali, often more than half of the farmers participating in such visits subsequently try what they have observed on their cross-visit. It is vital that women farmers participate in such study visits. They have a lot of knowledge to share and to learn about trees and their different uses. This may help them diversify their livelihoods and increase their income.

Farmer study visits for men and women can be organized at different levels: between villages in the same region, between villages in different regions, and even between different countries. Organizing and implementing farmer-to-farmer study visits requires external funding. How much funding is needed depends on the number of participants and the distances to travel. From a project-cost perspective, it makes sense to first explore whether inspiring examples can be found at short distances. When close-by opportunities are not available, the example from Senegal mentioned in Box 9 shows that an investment in a visit between countries helped to catalyze the rapid spread of on-farm regreening.

BOX 8 | NGOS WITH FIRSTHAND EXPERIENCE IN SUPPORTING REGREENING

NGOs have been pioneering support of regreening. In Niger, the NGO Serving-in-Mission began promoting farmer-managed natural regeneration in the mid-1980s. In Mali, Sahel Eco has been driving farmer-managed natural regeneration for many years. In Malawi, Total Land Care has built relevant experience, and in Ethiopia, World Vision is mainstreaming FMNR in all its area development programs.

Aba Hawi, community leader of Ab'rha Weatsbha in the Tigray region of Ethiopia, notes that for long-term success, it is more important to focus on changing people's mindsets about trees and land management than on the techniques of farmer-managed natural regeneration. After all, to scale up regreening, it is often necessary to change deeply ingrained beliefs and practices.

Farmers must first be convinced of the benefits of farmer-managed natural regeneration before they will go to the trouble of practicing it. In the Yatenga region of Burkina Faso, Yacouba Sawadago was seen as a threat to his community for his pioneering work in land and tree restoration, and his neighbors did their best to discourage him. Despite the opposition, he patiently sought opportunities to educate others and to help them whenever he could. He eventually won them over, and now the techniques he pioneered are recognized as well-adapted, effective practices.

BOX 9 | NGOS EXPERIENCED IN ORGANIZING FARMER-TO-FARMER VISITS

In 1989 a group of 13 farmers (men and women) from the Illéla district in Niger visited the Yatenga region in Burkina Faso. Upon their return they began trying out improved planting pits to restore degraded land. This led to thousands of farmers in the Illéla district using this technique and the emergence of on-farm trees on what used to be barren land (see Figure 4).

In 2008 World Vision Senegal organized a visit by a farmer delegation from the Kaffrine district in Senegal to the Aguié district in Niger's Maradi region. The visit was expensive as it required flying farmers from Dakar, Senegal to Niamey, Niger, and subsequently farmers needed to be transported by bus to Aguié, another 800 kilometers away. Whether it is rational to invest so much in a visit depends on what farmers do upon their return. In this case, farmers immediately began to protect and manage natural regeneration on their farms. After 5 years this regreening has spread to over 50,000 hectares.

During a recent visit to Senegal, Tony Rinaudo of World Vision noted that the farmers who visited Niger were the most progressive with farmer-managed natural regeneration: they were protecting and regenerating more species of trees, and they were leaving more trees in their fields. They had never seen *Guiera senegalensis* as a tree until they went to Niger, and it was only after that trip that they began pruning it and considering it to be a valuable species.

Activity 3. Build capacity through peer-to-peer training among farmers (men and women) and through training-of-trainers

In Niger's Aguié district, farmers have developed so much experience with the protection and management of on-farm trees that an IFAD project has hired them to train other farmers. About 300 farmers (half of whom are women) are experts and able to train other farmers. Figure 14 shows Sakina Mati—one of the key women trainers in the Aguié district—showing a Nigerian delegation how to select and prune the stems of *Guiera senegalensis*. During all farmer-to-farmer study visits some form of training occurs, with farmers who are experienced in selecting stems for removal and pruning training those who are not.

Technical training for trainers as well as for land users in sustainable tree management and exploitation is also necessary. Many woody species that regenerate spontaneously develop into low bushes with numerous stems unless the number of stems is drastically reduced. The one or two stems that are preserved need to be pruned annually in order to develop a proper trunk and a canopy as well as to accelerate growth. Pruning is vital as it generates more economic and environmental benefits to farmers.

Technical training will usually include the following elements:

- Selection of stems that will be conserved.
- Cutting of stems that have to be removed.
- Marking of the remaining stem or stems, often with a piece of cloth so outsiders will recognize that this stem is deliberately managed and should not be touched.
- Training in proper pruning so as not to damage or kill the trees.

Conventional extension systems are weak in many countries, and one of the ways forward will be to rely more on farmers as experts. Farmers have the experiential knowledge needed to train other farmers.

Figure 14 | **Training in Pruning Techniques for Farmer-Managed Natural Regeneration**

Sakina Mati from the Dan Saga area (Niger) training a delegation from Nigeria in the selection of stems and in pruning. Note the abundant leaf litter and volume of added organic matter at the base of this tree. This helps explain why even species that are not nitrogen-fixing legumes can have a positive effect on crop yields.

Farmer-managed natural regeneration is an ideal technology for dissemination by farmer-experts.

It is also important to ensure regular follow-up visits by external technical advisors, regreening champions, extension staff, and farmer-trainers. This is an important part of building a grassroots movement: the support offered to farmers through such visits can encourage them to persevere in the face of setbacks. For farmers who are ready to adopt farmer-managed natural regeneration or other regreening practices, such outside support can spur them on, even before the benefits are fully realized.[17]

Activity 4. Support the development of village institutions empowered to play critical roles in the decentralized management of the new tree capital and regreened landscapes

The technical aspects of regreening are fairly simple. Individual farmers can protect and manage on-farm trees, and even create small forests on their own. It is much easier, however, if groups of farmers or entire communities join forces in regenerating trees. This creates possibilities for joint protection and management and pooling the labor involved. However, building village institutions for tree management can be challenging. It means ensuring the full participation of key stakeholders in the community to negotiate and agree on the rules governing access and sustainable use of trees and other resources, as well as building community support to enforce these rules. It requires regular meetings to discuss events and identify solutions to emerging problems. In some cases, it may be necessary to educate villagers on relevant laws and legislation, both so they know their rights and so they can avoid actions that may be perceived as illegal.

Village institutions for managing new tree capital can be linked to existing village development committees or to traditional institutions. IFAD's Project for the Promotion of Local Initiatives for Development of Aguié (PPILDA) in Niger is a good example of building new local institutions for tree management (village and intervillage institutions). The village of Dan Saga has a tree management committee composed of men and women. It also includes a representative of sedentary Fulani herders. Rules and regulations for protection and management have been agreed upon and are enforced. Figures 15a and 15b show a villager wearing a badge that indicates he is allowed to apprehend anyone who does not respect the rules. The village has defined sanctions for those who do not respect the rules. The village of Dan Saga is also part of a group of six neighboring villages that work together on tree management.

All Sahel countries have adopted and implemented national policies for decentralization. This means that decisions about natural resource management are increasingly made at local levels. In some cases this has led to the creation of community-based institutions for natural resource management that can be empowered to enforce rules governing the use of resources. Such institutions are critical to the success of regreening.

Figure 15 | **Village Meeting in Niger to Discuss Rules and Regulations to Protect Trees on Farms**

Figure 15a. A villager in Dan Saga (Niger) who has the authority to apprehend violators of rules and regulations set by the villagers to protect the village tree stock. Figure 15b. A close-up of his badge (June 2012).

Activity 5. Develop agroforestry competitions at different levels

Agroforestry competitions among rural communities can also help build a grassroots movement for regreening. Farmer study visits sometimes create a sense of competition. Sahel Eco in Mali has organized competitions to recognize the best regreening farmers. In the second and third year of the project, 861 farmers participated, and the fields of each farmer were visited by a small technical committee comprising extension agents, researchers, elected government officials, and administrators. Involving these stakeholders was a deliberate part of Sahel Eco's strategy to educate them about trees and farmers and thereby influence policy at all levels. Some members of these committees became regreening champions. All farmers received a piece of cloth with the slogan "*Reverdir le Sahel* [Regreening the Sahel]." When farmers wear this cloth, they can recognize each other as members of the regreening movement. Figure 16 shows a farmer in Mali receiving his prize from a national policymaker visiting regreening sites on the Seno Plain.

Competitions can be organized at different levels: within a village, between villages, between districts, and at the national level. It all depends on the capacity and means of the implementing organizations.

Figure 16 | **Awards to Farmers to Encourage the Adoption of Agroforestry Practices**

A farmer on Mali's Seno Plain who participated in the competition for best agroforestry farmer receives his award from a senior policymaker.

Step 3. Address Policy and Legal Issues and Improve Enabling Conditions for Regreening

It is vital to build a grassroots movement around regreening, but working only at the grassroots is rarely sufficient to accelerate the scaling of regreening, as progress may be constrained by policy and legal barriers. National governments and their policies and legislation strongly influence whether farmers invest in improved natural resource management in general and in trees in particular. Governments are in a position to create enabling conditions that favor farmer innovations and regreening, or they can fail to address policy and institutional barriers and discourage its scaling up. Accordingly, mobilizing a concerted effort to understand the barriers to community participation in regreening, and to identify possible incentives that could be reinforced to accelerate the widespread adoption of regreening practices, are especially important.

Experience with large-scale regreening successes suggests that changes in farmer behavior and the widespread adoption of farmer-managed natural regeneration and related practices can be triggered and accelerated by the following conditions:

- Exposure to innovative farmers who have adopted farmer-managed natural regeneration and other improved practices, who can discuss the barriers they overcame and how and why they engaged in regreening practices.
- Improved access to markets for wood and nontimber forest products.
- Strengthened local leadership and emergence of community-based organizations empowered to negotiate and enforce rules that limit cutting of trees being protected and managed by farmers in their fields.
- Reinforced community-based efforts to control free grazing of livestock and to limit browsing by livestock on regenerating trees and shrubs in fields.
- Knowledge and/or belief that farmers own their on-farm trees or have legal user rights to the trees they are managing.

Activity 6. Analyze barriers to community participation in regreening and engage key stakeholders in adapting national policies, legislation, and other enabling conditions to induce farmers to invest in trees

A critically important area for policy reform relates to land tenure and strengthening farmers' rights to manage trees and other resources. At a national workshop in Burkina Faso in 2013, innovative farmers examined the benefits of agroforestry and other sustainable land management practices and discussed strategies for scaling up the adoption of these practices. They stressed the importance of secure land tenure and clear rights to manage trees on their farms. Farmers were concerned about the risks of losing labor invested in protecting and regenerating trees, restoring soil fertility, and other practices aimed at increasing the productivity of their farms.

While secure land tenure is important to farmers who want to plant trees, it is not always important to farmers who want to protect and manage natural regeneration. The act of tree planting is regarded by farmers as an appropriation of land. Farmers who do not own the land they cultivate can protect and manage natural regeneration, because they perceive this to be different from planting trees.

Farmers will invest in managing trees when they have exclusive and legally confirmed rights to use and benefit from them. In some cases, perceptions about ownership and rights can be as important as the actual laws. For example, in Niger, following the introduction of democracy and policy reforms launched in the 1990s to support decentralized natural resource management, farmers acted on the perception that they had a right to manage the trees on their farms, even though the Forest Code still affirmed that trees belonged to the state. Relatively unrestricted harvesting and marketing of products from trees in fields will allow farmers to develop agroforestry value chains. This is currently not the case in many countries. Farmers often need permits from the forestry service to exploit on-farm trees they have protected and managed. Ironically, had they planted these trees, this requirement might not apply. Obtaining a permit can be complex and time-consuming. Farmers generally must pay for permits and may need to negotiate with forest agents responsible for issuing them. Forest agents tend to see themselves as the keepers of the trees and may not recognize the farmers as good stewards (Box 10).

Forest service culture and drivers of behavior need reform to move them from a focus on policing to an extension role. The practice of forest service agents is as important as forest policy and the texts of forest laws. For this reason, it is especially important to review training programs for forestry and extension agents and researchers so that they fully appreciate the benefits of FMNR and other agroforestry practices, and so they are primed to be agroforestry champions from the day they start their professional careers. As part of the approach to improve policy conditions, champions of regreening can negotiate with authorities to temporarily suspend the enforcement of regulations that discourage rural communities from investing in trees in pilot areas. As the effects are observed and monitored, the "exception" can become the new rule.

BOX 10 | EVOLUTION OF FOREST POLICIES AND LAWS

In 1985 the Forest Service of Niger routinely reminded rural communities that all trees belonged to the state. But policies and regulations have changed, and farmers are now allowed to manage their on-farm trees.

In Mali the 1994 forestry law was ambiguous. Farmers could exploit trees they planted, but they needed permission from the Forest Service to exploit naturally regenerated trees they protected and managed on their farms. At least this was what state foresters led farmers to believe; in fact, the law was aimed at a limited number of fully protected species.

In October 2010 Mali adopted a new forestry law that was a major step backward. Rather than clarify tree tenure and management rights for on-farm trees, the law focused on extracting as much tax as possible from the use of woody resources.

BOX 11 | DIAGNOSIS OF KEY SUCCESS FACTORS AND FAVORABLE ENABLING CONDITIONS FOR RESTORATION AT SCALE

IUCN and WRI have developed a diagnostic tool to identify which key factors and necessary enabling conditions are in place for enabling restoration at scale, and which are missing. The restoration diagnostic tool is applied by taking the following steps:

1. Identifying the targeted landscape.
2. Systematically evaluating whether or not an illustrative list of some 30 key success factors are in place.
3. Identifying strategies to address missing factors by reforming critically important laws, regulations, policies, and institutional frameworks or taking other actions needed to establish or reinforce critically important enabling conditions.

Examples of enabling conditions include generation of economic and social benefits; suitability of restoration practices to ecological conditions; availability of seeds, seedlings, or source populations; security of land and tree tenure; empowerment of local communities to adopt and enforce rules to govern the use of natural resources; sufficient capacity to transfer knowledge through peer-to-peer training or extension services; and identification and communication of the benefits of restoration.

It is difficult for a single organization to influence national policies and legislation. It is therefore important to build in each country a coalition of organizations interested in jointly negotiating with national policymakers and legislators. Starting a debate with national policymakers (ministers, senior technicians, and elected officials at all levels, including parliamentarians, who will have to approve changes in forestry legislation) may become easier with the support of regreening champions among policymakers and legislators. Much work remains to be done to adapt forestry legislation to encourage regreening, and this will be a long and difficult process as it involves many stakeholders.

A host of other policy issues that can constrain regreening efforts need to be considered. For instance, subsidies for agricultural mechanization or policies designed to promote the production of cash crops like cotton or tobacco may encourage the removal of on-farm trees. Also, high subsidies for mineral fertilizers discourage farmers from investing in nitrogen-fixing trees, replenishing soil organic matter, and other necessary soil fertility management practices. Such subsidies send the message to farmers that fertilizers are the only solution. Linking eligibility for input subsidies to the establishment of agroforestry on farms is increasingly seen as one way to deploy such programs in a positive way.

Over the past few years, WRI and the International Union for Conservation of Nature (IUCN) have collaborated to develop a methodology to systematically assess the extent to which favorable enabling conditions for scaling up regreening and other forms of landscape restoration are in place. An analysis of dozens of case studies of successful large-scale restoration projects revealed a set of "key success factors." These include inspired and motivated stakeholders; favorable ecological, market, policy, and institutional conditions; and the capacity and resources for implementation of restoration at scale (Box 11) (IUCN and WRI 2014).

Activity 7. Organize field visits by policymakers, elected officials, and technicians to areas regreened by farmers

National policymakers are not always aware of the successes in sustainable agriculture, increased food security, and climate change adaptation made possible by regreening. The same is true for international policymakers. Field visits may help foster awareness and generate a sense of pride. For instance, national policymakers in Niger have reason to be proud of the large-scale regreening that has occurred in the densely populated parts of the Maradi and Zinder regions since the middle of the 1980s—the biggest positive transformation of agricultural landscapes in the Sahel and maybe even in Africa. Until recently, very few people in Mali were aware of the large-scale regreening that has occurred on the Seno Plain. Policymakers are just beginning to appreciate the positive impact these regreening successes are having on food security, climate change resilience, and other areas. Transforming national policymakers into champions of regreening is important as they can create

the necessary enabling policies and legislation as well as mobilize financial support.

Activity 8. Create a presidential award for the best agroforestry village

Farmer-managed regreening will become more visible if a president, head of state, or other highly regarded leader endorses it by personally delivering an annual award to a village that has made an exceptional contribution to regreening. This could create both more political and more policy space for regreening and would increase a healthy sort of competition between villages. If national media reported on the prize, it would raise public awareness of regreening and its multiple impacts even further.

The draft national agroforestry strategy for Niger proposes the creation of a presidential award to recognize the achievements of local communities that have distinguished themselves in the adoption of farmer-managed natural regeneration and transformation of their landscapes and lives. As the benefits of FMNR become more widely known, national leaders should consider shifting attention from solely promoting tree planting to celebrating FMNR through the declaration of a national Farmer-Managed Natural Regeneration Day.

Activity 9. Mainstream support for scaling up regreening in existing and new agricultural development, food security, and climate change adaptation investment strategies and programs

At present, ministries of agriculture are mainly interested in "modernizing" agriculture, strengthening selected value chains, and increasing the use of improved seed, mineral fertilizer, and other inputs to boost the production and value of annual crops. Ministries of environment and forest departments are mainly interested in environmental protection and controlling tree cutting and stemming the loss of natural forests. Agroforestry seems to fall between these two spheres. Because agroforestry is about farming systems, food production, and agroforestry value chains, agricultural ministries are the most logical institutional anchor points for regreening initiatives. Forestry services also have a role to play, however, because of their technical expertise in the management of trees and as additional champions for agroforestry and sustainable land management.

To reach millions, or even tens of millions, of smallholder farmers, a good communication strategy is vital. Behavior change depends on successfully reaching targeted groups with critical messages and providing information designed to overcome barriers to change.

All countries have a range of agricultural or rural development projects, and most countries are committed to making progress in increasing food security, adapting to climate change, and reducing rural poverty. However, technicians and government decision-makers often fail to appreciate the relevance and potential contributions of regreening to achieving these national development goals. One way forward is to explore building a regreening component into existing investment strategies and national programs. Some of these programs and projects may have budgets for conventional tree planting, which, when redirected to the promotion of natural regeneration of woody species, is likely to have a much quicker and bigger impact than tree planting.

Agriculture and rural development project managers may also become interested in adjusting their budgets and prioritizing activities once they have learned more about the multiple benefits and cost-effectiveness of regreening. The choice of objectives and indicators can influence programs; an objective of "restoring tree cover" and inclusion

of an indicator on "cost-effectiveness" can help shift attention to farmer-managed natural regeneration and other effective regreening practices and away from conventional tree-planting programs. There are also opportunities to work with organizations distributing food aid, which can be programmed to provide short-term, catalytic support for farmers' initial investments in regreening.

The increased attention to the restoration of resilience in the drylands of Africa and to scaling up the adoption of climate-smart agriculture presents a significant opportunity to leverage the positive experiences with scaling up regreening successes. In fact, with leadership from the World Agroforestry Center (also known as the International Center for Research in Agroforestry, or ICRAF), World Vision, and other organizations in the EverGreen Agriculture Partnership, support is growing within the African Union and other bodies to scale up farmer-managed natural regeneration, assisted natural regeneration, and other evergreen agriculture practices. The African Union is developing a strategy to end hunger in Africa by 2025 that builds on the Malabo Declaration of June 2014 and affirms the vision of 25 million farmers practicing climate-smart agriculture by 2025.[18] At the second African Drylands Week, convened by the African Union in N'Djamena, Chad, in August 2014, participants recommended "that the drylands community, through the African Union and all collaborating and supporting organizations, commit seriously to achieving the goal of enabling every farm family and every village across the drylands of Africa to be practicing FMNR and ANR by the year 2025."[19]

Activity 10. Train the next generation of extension and forestry agents and researchers to be agroforestry champions

Until a decade ago, farmer-managed natural regeneration in drylands was barely on the radar screen of agroforestry researchers. It is there now, but development professionals and researchers still need training in agroforestry and education about the role farmers can play in protecting and managing natural regeneration, on and off the farm. This will most likely be a long process, but there are some good starting points. The African Network for Agriculture, Agroforestry, and Natural Resources Education has 137 member institutions (universities and colleges) in 35 African countries and could play an important role in strengthening agroforestry education.[20]

It is also possible to directly tap into the knowledge and experience of innovative farmers

in agroforestry. Their fields can be used as training grounds and sources of inspiration for both development practitioners and researchers. That has already been done in, for instance, Burkina Faso and Cameroon (Sawadogo et al. 2001; Tchawa, Tchiagam, and Bonneau 2001). Barthelémy Djambou, a farmer and agroforestry innovator in Cameroon even built a classroom in his fields where he gives training in agroforestry and other land management practices to farmers from different parts of Cameroon and to agronomy students from the University of Dschang. In addition, students from agricultural schools complete 2 to 3 months of practical training on his farm (Tchawa, Tchiagam, and Bonneau 2001, 27). The challenge is to identify farmers who are agroforestry innovators able and willing to share their knowledge and experience.

Step 4. Develop and Implement a Communication Strategy

To reach millions, or even tens of millions, of smallholder farmers, a good communication strategy is vital. Behavior change depends on successfully reaching targeted groups with critical messages and providing information designed to overcome barriers to change. Having a well-developed communication strategy can help catalyze adoption of regreening.

An effective communication strategy can include the following activities:

- Systematically use rural and regional radios to spread messages about regreening.
- Inform national and international journalists about successes in regreening.
- Produce documentaries for national and international TV about regreening and its impacts.
- Link mobile phone, radio, and other information and communication technology (ICT) to make the Web more accessible to rural people, to disseminate market information, and to facilitate sharing of experience among innovative farmers.
- Mobilize African champions and civil society organizations to spread the word about regreening.
- Organize national and regional experience-sharing workshops.
- Support communication and outreach to advocate for regreening at all levels.

The use of mass media should be a key component of extension strategies to spread information about agroforestry to millions of farmers. The mass media can also help inform policymakers and the general public about activities and impacts. Although there is without doubt a role for the latest developments in communications technologies, the effectiveness of relatively "low-tech" communication tools—such as cross-visits, training workshops, and conferences—should not be underestimated.

The descriptions of Activities 11 through 17 give additional details on the communication activities listed above.

Activity 11. Systematically use rural and regional radio stations to spread messages about regreening

Most regional capitals and large rural towns in the Sahel have a radio station. Some reach millions of people, as does *La voix du paysan* (The Voice of the Farmer) in Ouahigouya, Burkina Faso. In Mali, 23 rural radio stations are able to reach the majority of rural producers. Regreening partners in the Sahel have already used some of these rural and regional stations to share information about regreening.

The advantages of regional and rural radio stations are that they reach large numbers of listeners at low cost, and that many listeners identify with the radio station because it is in their region and may broadcast in the local language.[21] The challenge is convincing stations to provide airtime to farmers so they can inform listeners of their regreening activities. Usually a project has to pay for airtime, but the costs are low considering the number of listeners who can be reached. It is important to create regular programs that will be broadcast during "prime time."

Activity 12. Inform national and international journalists about successes in regreening

More and more international journalists are paying attention to positive news from the Sahel. Since 2006 major articles about regreening and restoration of degraded land have appeared in such publications as the *New York Times*, *Time*, *National Geographic Magazine*, *Le Monde*, *New Scientist*, *Der Spiegel*, *Süddeutsche Zeitung*, the *Sunday Times*, and the *New Yorker*. If kept informed, international journalists will likely continue to report on regreening successes.

The challenge now is to inform African journalists. In July 2012, a national NGO working in Burkina Faso—Réseau MARP (Participatory Rural Appraisal Network)—organized a field trip for senior policymakers from three ministries (agriculture, livestock, and environment) and invited journalists to visit regreening successes. During the following week, TV channels and regional radio stations reported the story at least 10 times. The journalists who participated in the field visit have since organized themselves into a small group called *Média Vert* (Green Media).

In Senegal, IED Afrique is working closely with a group of environmental journalists called GREP (Environment and Press Research Group), which regularly produces thematic reports on environmental issues. In March 2013, IED Afrique invited environmental journalists to join a group called "Parliamentarians for the Environment" for a meeting about regreening in Senegal as well as a field visit to the Kaffrine area, where FMNR is expanding rapidly.

National media attention comes at a cost. Usually, journalists require fees or airtime that must be paid for. If journalists are invited to join a field visit, their transport and living arrangements must be paid for and organized. This means that regreening projects should include a budget line for communication costs. However, the increased media coverage can help leverage additional financial support for scaling up regreening, and it can build support for reforms needed to improve the enabling conditions for regreening.

Activity 13. Produce documentaries for national and international TV about regreening and its impacts

In devising a communication strategy around regreening, it is important to reach as many people as possible in each country with stories of building more productive and drought-resilient farming systems. Although farmers in Niger have built new agroforestry parklands on 5 million hectares, many people in Niger are not yet aware of this large-scale transformation and regreening success.

One way to convey a positive message widely is through documentaries about successes for national and international TV channels. An example of a high-quality documentary suitable for television is *More People, More Trees: Environmental Recovery in Africa* by William Critchley. It revisits the same field sites and interviews the same people in Burkina Faso and in Kenya almost 2 decades apart. A powerful story about environmental transformation and building more productive farming systems, it has already aired on national TV in Burkina Faso.

Another powerful documentary is *The Man Who Stopped the Desert* by Mark Dodd.[22] It tells the story of Yacouba Sawadogo, one of the most innovative farmers in the West African Sahel. Yacouba Sawadogo improved a traditional water harvesting technique that has now been used in Burkina Faso and Niger to rehabilitate tens of thousands of hectares of severely degraded land. This documentary has been shown on national TV in France as well as in documentary film festivals in 20 countries, where it has won seven awards.

In June 2012 a team from the U.S. Public Broadcasting System program *NewsHour* produced a documentary about the famine in Niger. The PBS team decided to show footage not only about the famine but also about solutions. The solution chosen was regreening in Niger. The 10-minute documentary was broadcast across the United States in July 2012. Its title: "Amidst Drought and Famine, Niger Leads West Africa in Addressing Crisis."[23]

Activity 14. Link mobile phone, radio, and ICT to make the Web more accessible to rural people, to disseminate market information, and to facilitate sharing of experience among innovative farmers

The development of agroforestry value chains can increase rural household incomes. The development of value chains is influenced not only by proximity to markets but also by farmers' access to market information. One of the ways farmers can access information about market prices is through mobile phones and radio programs. One example is the VOICES program of the Web Alliance for Regreening in Africa (W4RA) (http://w4ra.org/).

The Network Institute of Free University Amsterdam and the World Wide Web Foundation were inspired by the African Regreening Initiatives to jointly create the W4RA. Although the Internet

The mobilization of African champions with leadership roles in civil society organizations can be an effective means to engage younger generations.

Workshops where participants can exchange regreening experiences within a country and within a region can be part of an effective community strategy.

offers a trove of information, it is inaccessible to the illiterate. Moreover, most websites offering information about Africa are written in English, French, and other European languages; few contain information in local African languages. The Web is only accessible with an Internet connection, which most rural households do not have, relying instead on radio and mobile phones for communication.

Consequently, in 2011 and 2012 the Network Institute and the World Wide Web Foundation developed the VOICES project, in collaboration with Sahel Eco and other partners in Mali. VOICES aims to make the Web accessible to rural people via voice, in local African languages, using mobile phones and community radio as interfaces. Text-to-speech technologies were developed and tested in French, Bambara, and Bomu. VOICES is now used in Mali to spread market information, which supports the development of agricultural as well as agroforestry value chains. The system has great potential to facilitate efforts by farmers to share their regreening experiences and to highlight farmer innovations. It can also become a major tool for peer-to-peer training, development of agroforestry value chains, and participatory monitoring and evaluation. This VOICES system is now ready to be rolled out in other African countries using other African languages.

Activity 15. Mobilize African champions and civil society organizations to spread the word about regreening

African regreening champions can be mobilized to communicate about the multiple impacts of regreening. Luc Gnacadja, until recently executive secretary of the UN Convention to Combat Desertification (UNCCD), is such a champion. He visited the large-scale farmer-managed regreening in Niger's Zinder region early in 2013. Since this visit Gnacadja has frequently mentioned his findings in interviews with the radio and the press, and in international conferences.

The mobilization of African champions with leadership roles in civil society organizations can be an effective means to engage younger generations. In 2014 Bishop Simon Chiwanga of Tanzania organized a workshop on farmer-managed natural regeneration for 60 educators. One outcome of the workshop was a commitment to create a curriculum on FMNR for primary, secondary, and tertiary levels, and to integrate this curriculum into Tanzania's education system within 12 months.[24]

Activity 16. Organize national and regional experience-sharing workshops

Workshops where participants can exchange regreening experiences within a country and within a region can be part of an effective community strategy. Regreening partners in Burkina Faso, Mali, Niger, and Senegal organized national experience-sharing workshops in 2012 and in 2013 to discuss a national agroforestry strategy. Niger has finalized the national agroforestry plan that emerged from the workshop in 2013, and Burkina Faso has generated consensus on key barriers that must be overcome if farmers are to capitalize on the potential contribution of agroforestry to adapting to climate change and reducing food insecurity.[25]

The costs attached to national and international workshops can be high, but if the meetings inspire policymakers and development practitioners to act and avoid reinventing the wheel, the investment may be justified.

Activity 17. Support communication and outreach to advocate for regreening at all levels

Whenever it is possible to inform national and international policymakers or the media about the multiple benefits of regreening, the opportunity should be seized. However, seizing unexpected opportunities requires flexibility and immediately available funds. Furthermore, advocacy requires patience and persistence. It may take 5 years or more to realize policy changes.

Since 2012 several regreening champions have given presentations at the U.S. Agency for International Development (USAID), the World Bank TerrAfrica/Global Environment Facility, the Netherlands Development Cooperation, and other donors. They emphasized the scale of regreening and its multiple benefits outlined in Box 5, including improved food security and increased resilience for communities facing changing weather patterns. These advocacy efforts may have helped convince the Netherlands Development Cooperation to fund a major food and water program that is trying to combine regreening by farmers, microdosing, and water harvesting in the Horn of Africa and three Sahel countries. USAID is also now funding major projects in Burkina Faso, Niger, and Mali with a regreening component. The Great Green Wall, funded by the World Bank TerrAfrica and the Global Environment Facility, aims to promote regreening by farmers and their communities through a $1.8 billion portfolio of projects across the Sahel.

Step 5. Develop or Strengthen Agroforestry Value Chains and Capitalize on the Role of the Market in Scaling Up Regreening

On-farm trees constitute a capital stock. Many tree species produce marketable products (including firewood, lumber, medicinal products, fruit, nuts, and fodder), and the development of agroforestry value chains can increase farm household income. Many farmers, particularly women, already process and market agroforestry products, but usually in small quantities. Accessing market price information through radio or mobile phones is one way producers can develop their value chains (see Activity 14). Another way is to increase the quantity

of goods they can sell and to reach buyers through the same communication channels.

The private sector can help scale up specific tree crops, like mango, cashew, and drumstick (*Moringa oleifera*). Regreening entails the sustainable intensification of smallholder farming. For equity as well as efficiency, it makes sense to promote forms of contract farming in which national or international firms work in partnership with farmers and play a role in the transformation and marketing of tree crops.

It is unlikely that private firms will be interested in promoting all types of agroforestry species, but they may be interested in working with farmers to increase the number of nitrogen-fixing trees on farms. This is already done in Zambia. It is also in the interest of private firms to ensure a sustained flow of marketable produce.

One example of a private fund specifically investing in agroforestry is the Moringa Fund (http://www.moringapartnership.com/web.php/16/en/about-us/organisation). Its vision is to create economic benefits for its investors and for locals while contributing to environmental and social resilience in land use. The fund invests

in permanent crops under tree shade, timber plantations with sequential agroforestry, fruit and nut trees with crops, and sylvopastoralist projects, which combine trees with livestock. The Moringa Fund focuses on sub-Saharan Africa and on Latin America.

Activity 18. Support the development of agroforestry value chains

Many regreening initiatives may initially focus on creating new agroforestry systems that increase food production. It is also important, however, to explore opportunities for developing new agroforestry value chains, which can diversify and increase the income of smallholder farmers. In most cases these opportunities are bigger in existing agroforestry parklands than in young agroforestry parklands. Cashew (*Anacardium occidentale*) is an increasingly popular species, for instance, in southern Mali and parts of Senegal. It offers a potential for developing a value chain based on commitments by smallholder farmers to grow cashews to supply local processing operations established to add value and meet market demands. Agroforestry value chains already exist in West Africa around shea nut, which is used in the pharmaceutical industry to develop skin care products.

The Wula Nafaa project in Senegal is a good example of the benefits that can be achieved by developing agroforestry value chains and associated enterprises based on natural resources. From 2003 to 2013 more than 40,000 people increased their collective income by $36 million, and an additional 10 million tons of food were produced across the targeted landscapes (Dozoretz et al. 2014). The Wula Nafaa project integrated support for enterprise development that protected the resource base and restored the productivity of managed resources, with interventions designed to strengthen environmental governance and equitable benefit distribution. Key enterprise development activities included organizing and training producer groups; assisting with quality

Figure 17 | ***Moringa oleifera*—One of Many Agroforestry Species With Significant Value Chain Development Potential**

Moringa oleifera (young green plants in foreground) on the road between Niamey and Torodi (Niger). This photograph was taken in June 2012 when the harmattan was blowing from the Sahara. This wind carries fine particles of sand, which reduces visibility.

control; facilitating investment in value-added processing of natural products, branding and marketing and other measures to strengthen targeted value chains for charcoal, baobab fruits, sterulia gum, and a range of other natural products (Dozoretz, Rassas et al. 2014).

Moringa oleifera (Sahel) and *Moringa stenotepala* (Ethiopia) have significant potential for both national and international value chain development. For instance, the Body Shop—an international chain with more than 2,000 shops worldwide—sells several products based on moringa, such as beautifying oil, body butter, shower gel, and soap. *Moringa stenotepala* is cultivated widely in parts of southern Ethiopia, while *Moringa oleifera* is expanding quickly in Niger, including around the capital, Niamey. All the green shoots on the foreground in Figure 17 are *Moringa oleifera*.

Step 6. Expand Research Activities to Fill Gaps in Knowledge About Regreening

Our knowledge about the multiple impacts of regreening and the emergence and dynamics of new and old agroforestry parklands is evolving. We should continue to fill gaps in our knowledge through targeted research. Several areas merit additional study:

- What is the impact of regreening on surface and groundwater hydrology? Much of what we know in this area is anecdotal and limited in scope; forest hydrologists can help fill this gap.
- What is the impact of on-farm trees on wind speed and local temperatures? Although it is certain that on-farm trees reduce wind speed and reduce soil surface temperatures, more hard data are needed under parkland conditions.
- What are the monetary impacts of regreening? The need for quantitative research in this area is urgent.
- How does regreening impact nutrition and health?
- How precisely does regreening impact food security and rural poverty reduction at the national and local levels?
- Who wins and who loses in regreening processes (women, herders, rich and poor farmers, etc.)?

Many funding agencies are reluctant to pay for research but are keen to develop adequate monitoring and evaluation systems. One option is to explore which gaps in knowledge can be addressed under regular impact monitoring and which require research funds.

Another area ripe for research is the processes through which old and ageing parklands are rejuvenated. After all, bringing regreening successes to scale will require not only new agroforestry parklands but also rejuvenate old parklands. For instance, southern Mali has 6 million hectares of old agroforestry parklands.[26] These parklands will become less productive in the future as the trees begin to die. There are already some examples in this region of farmers who have protected and managed natural regeneration, or who have planted cashew, but in-depth analysis of this emerging process is lacking.

Despite the importance of agroforestry parklands in southern Mali, it is hard to find research on their dynamics. It seems that researchers know a great deal about specific tree species and a few well-studied traditional agroforestry systems, but they know much less about the dynamics of emerging and restored agroforestry systems.

A critical area needing increased support is the monitoring of regreening. Existing programs to assess and map forest resources are poorly adapted to the needs of monitoring trees outside of forests and the dynamics of woody vegetation in drylands. As governments, donors, and investors seek to scale up regreening to benefit larger numbers of rural households, it will be important to better monitor the extent and impact of regreening.

PART V

CONCLUDING THOUGHTS

Now that we have identified and analyzed the key steps and activities of a scaling strategy for regreening success, three questions emerge. First, to scale up regreening successes, is it necessary to engage in all the activities outlined in Part IV? Second, are there places that offer "low-hanging fruit," that is, where results can be obtained quickly? Third, what constraints must be addressed to scale up regreening successes? We answer these questions below, before turning to some of the misunderstandings about regreening and reviewing five key messages of this report.

Do We Need to Engage in all the Activities to Scale Regreening Successfully?

In general, each activity is needed, and it makes sense to sequence the activities. However, depending on the context and what has already been achieved in each country, some activities may be unnecessary. Since a pragmatic approach is to expand the scale of current regreening successes, a logical first step is to identify and analyze those successes. Our experience is that in every country, there are innovative farmers who have developed solutions to the problems they face. Identifying successes as a first step also illustrates to national policymakers that practical answers do exist.

The components and activities presented in this report should not be considered a prescriptive blueprint. They are suggestions for developing critical building blocks and can be used to focus the discussion on what is strategically important and needed to fill gaps in order to accelerate the scaling up of regreening successes. Each country can adapt a scaling strategy to fit within its specific socioeconomic, agroecological, policy, and institutional context.

Where Should Regreening Efforts be Targeted to Produce Results Quickly?

Land degradation, climate change, and rural poverty are big problems that require big answers—and solutions that deliver results quickly. If all stakeholders worked together to mobilize tens of millions of smallholder farmers to invest in on-farm trees, their lives could be transformed within a few growing seasons. It is unlikely that this can be achieved, however, without favorable national policies, legislation, and enabling conditions, and without an extension strategy that will reach millions of smallholders in each country at low cost.

There is an urgent need to develop regreening initiatives that aim at quickly producing an impact for the largest number of people. Soil fertility in the drylands of sub-Saharan Africa is being steadily depleted, rainfall is becoming more erratic and extreme, and the population of sub-Saharan Africa as a whole is projected to increase from 0.9 billion to 2.1 billion between 2012 and 2050. This increase of 1.2 billion people will account for half of the planet's population growth and poses a serious food security challenge: 27 percent of sub-Saharan Africans are already undernourished in a region currently home to 44 percent of the world's hungry people (Searchinger et al. 2013).

Do current regreening successes in the Sahel offer lessons about the conditions under which regreening is likely to spread quickly? If we look at the experience of large-scale on-farm regreening in parts of Niger and Mali, we see that landscapes with a combination of the following conditions can be targeted to produce results quickly:

- **A sense of crisis** because of drought and erratic rainfall, land degradation, and declining crop yields.
- **Low on-farm tree densities** and scarcity of fuelwood and fodder.
- **High population densities, reduced fallow periods for cropland, and expansion of agricultural land use,** which have led to the loss of natural forests and woodlands, and reduced access to lands where communities can harvest wood or graze livestock.
- **Rainfall in excess of 400 mm/year.** Experience in the Sahel shows that regreening has spread most in areas with 400–800 millimeters of annual rainfall. This does not imply that regreening does not occur in regions with less than 400 millimeters, but growth rates of the vegetation in areas with low rainfall is usually much slower than in areas of higher rainfall.
- **Sandy soils.** Although regreening occurs on many types of soils, sandy soils make it easy for root systems to develop. Regreening has also occurred on crusted soils, but in these cases the crust had to be broken first, either manually or with machinery.

Where a combination of these conditions is found, farmers are likely willing to invest in on-farm regreening. These conditions are found, for instance, in northern Nigeria, where on-farm tree densities are low in many places.

The advantages of farmer-managed natural regeneration are particularly evident in arid and semiarid zones, and FMNR should be considered a foundational and essential natural resource management practice for farming systems in these zones. In dry subhumid zones, tree planting becomes a more practical complement to FMNR. In these zones, there are more options for successfully incorporating a range of multipurpose tree species into farming systems, and tree planting on farms becomes more important (Place and Garrity 2014).

Constraints to Scaling Up Regreening Successes

A variety of policy, institutional, and socioeconomic factors may constrain the scale-up of regreening successes. The most significant of these are explored below.

Promoting regreening requires a multifaceted approach, a long-term process, and commitment from all stakeholders

Scaling up regreening successes requires enabling policies and legislation that induce smallholders to invest in trees, as well as new approaches to extension to reach millions of smallholders at fairly low cost. Designing and adopting policy and legislative reforms can be complex and time-consuming processes. Experience in Niger and in other countries, however, shows that practice precedes policy. In the second half of the 1980s, staff from Niger's Forest Service began to work closely with the Serving-in-Mission project to promote the protection and management of natural regeneration by farmers in the Maradi region.

Mainstreaming agroforestry and regreening in agricultural development policies may take a long time. Agricultural development specialists tend to focus on new seed varieties, more fertilizers, agricultural mechanization, and irrigation. Many agricultural specialists do not yet perceive agroforestry as an integral element of dryland agriculture.

The cost of mainstreaming agroforestry into agricultural development projects is low where the focus is on farmers protecting and managing natural regeneration. Where the focus is on planting agroforestry trees in rows to allow for mechanized agriculture, the costs are modest. The cost of mainstreaming farmer-managed natural regeneration into conventional tree planting projects is nil; indeed, it will even reduce the costs of conventional tree-planting projects. The reason is that production of seedlings in nurseries, combined with their transport to planting sites and labor for planting of seedlings, is no longer needed when the focus shifts to protecting and managing natural regeneration.

Similarly, engaging with smallholders to change behaviors and land use practices can take significant resources for extension and capacity building at the local level. Building village institutions to create and manage the new tree capital is also a complex and time-consuming process, although villages that have developed by-laws and effectively implement them can offer valuable lessons. Developing partnerships with the private sector to strengthen targeted agroforestry value chains can also require significant time and resources.

While farmer behavior can change relatively rapidly, and some benefits of farmer-managed natural regeneration can be realized within a single cropping season, large swaths of agroforestry parklands cannot be built in just a few years. Multistakeholder partnerships that are willing to engage in a process of promoting regreening over longer periods are required. With the right long-term strategies in place, donor agencies may be willing to support regreening over longer periods, even if they continue to do so through the usual short-term project periods. Such multi-stakeholder partnerships are now emerging in Burkina Faso, Niger, and Mali.

Catalyzing scaling processes requires a combination of *flexibility*, *transparency*, and *minimum bureaucracy*, as well as a willingness to accept that it is impossible to predict where a participatory development process will be in 5 or 10 years. Working within these parameters will require a change from business-as-usual for most donor agencies, which are still caught in costly and rigid project design cycles defined by a desire to predict yearly project impacts.

A growing number of smallholder farmers are convinced of the rationality of investing in on-farm trees. If they were not, they would not invest in trees. Convincing national and international policymakers that it is economically rational to invest in regreening will require better economic data.

Donors may prefer high-cost projects and large investment portfolios

Since regreening is fundamentally about motivating local investments in improving land and water management, it does not necessarily require large amounts of external financing. Strange as it sounds, the relatively low cost of farmer-managed regreening may be a constraint to its expansion. Many governments and donor agencies seem interested in funding large infrastructure projects and other interventions with relatively high costs. Conventional forestry projects often require investments of $1,000 per hectare or more. At this rate, the cost of reforesting 1 million hectares amounts to $1 billion or more.

Farmers protecting and managing woody species on their farmland do not require investments in nurseries and funds to cover the transport of seedlings to planting sites. Depending on the effectiveness of the extension approach, and the scale of adoption of regreening by farmers, the direct on-site investment costs of farmer-managed regreening are low, and the farm household cash investment is very low or even zero. The low cost of these projects does not mean, however, that they do not pay real returns. Despite the relatively modest investments mobilized in the 1980s and 1990s by NGOs and development agencies, the return on these investments in regreening in Niger has been substantial, an estimated $500 million annually.[27]

The direct investment costs of all regreening projects in Niger's Maradi and Zinder regions have probably not exceeded $100 million over a period of 20 years. This means that the average external investment costs of regreening in this region are less than $20 per hectare.[28] This figure does not take into account the labor investments by farmers in the protection and management of trees, which are modest. This figure is much lower than the costs of conventional tree planting, which entails costs associated with nurseries and with transporting and planting seedlings. Furthermore, the survival rates of trees planted in the drylands is often well below 20 percent, while natural regeneration often has a high rate of tree establishment. When these factors are taken together, it becomes clear that the costs of natural regeneration are much lower than conventional tree planting (Reij 2011). Natural regeneration also does not create recurrent costs for governments: responsibility for protecting and managing trees is in the hands of farmers.

Quantifying the multiple benefits of regreening in monetary terms may be difficult

Agroforestry produces multiple benefits, including firewood, fodder, higher crop yields, medicinal products, improved nutrition, and a number of ecosystem services. Several studies have tried to calculate the costs and benefits of agroforestry in drylands, but these studies are limited by methodological shortcomings that fail to capture the full monetary value of the multiple impacts of regreening. Improving the analysis of the economics of regreening will require more work (Place et al. 2013).

A growing number of smallholder farmers are convinced of the rationality of investing in on-farm trees. If they were not, they would not invest in trees. Convincing national and international policymakers that it is economically rational to invest in regreening will require better economic data.

Monitoring and mapping systems are not well suited to measuring changes in the stocks of trees outside of forests

Another important constraint to scaling up regreening is the current limitation of most systems that are in place to monitor changes in forest cover, land use, and land use change. Forest inventories and monitoring systems typically rely on imagery and systems that are not well adapted to monitor trees outside of the forest, particularly in drylands. Changes in density of trees on farms are typically not assessed as part of land use and land cover mapping and assessments. With the increased accessibility of higher resolution imagery, it is now possible to better map agroforestry systems and monitor the spread of regreening practices, but few resources are currently available to support such efforts.

The dominant agricultural development paradigm excludes agroforestry

The dominant agricultural modernization paradigm in Africa revolves around a package of activities, including increased use of mineral fertilizers, high-yielding crop varieties, mechanization, irrigation, and improving input and output markets. In many countries, the implementation of this paradigm does not include significant support for agroforestry, usually because national and international policymakers are insufficiently aware of agroforestry and its multiple impacts. Furthermore, there is a tendency for any practice that involves trees to be assigned to forestry and environment departments. These departments are often preoccupied with conserving natural forests and promoting plantations, rather than championing farmer-managed natural regeneration and agroforestry.

Agroforestry is sometimes perceived as an alternative approach to agricultural development, rather than as a solid foundation for a stepwise process for the sustainable intensification of agriculture. Practice shows that farmers who have been the primary movers in scaling up regreening are keen to share their experience with other farmers, and they often add tree species that do not regenerate naturally. This shows their conviction that agroforestry constitutes the backbone of sustainable, climate-smart agriculture in drylands and subhumid regions, particularly when agroforestry is combined with water harvesting and other sustainable land management practices. And once farmers have found a means to slow and reverse land degradation and to restore soil organic matter, reduce rainfall runoff, and increase the productivity of their farming system, they are keen to add practices such as microdosing and integrated soil fertility management to intensify further.

The short-term impact of on-farm regreening on crop yields may be modest and will not keep pace with strong demographic growth rates. Given demographic pressures, increasing the use of chemical fertilizers is indispensable over the long term. Farmers are reluctant to use mineral fertilizers, however, when soil organic matter is depleted and fertilizer use efficiency is very low (Marenya and Barrett 2009). Regreening is not the complete solution but a first and indispensable step in a process of sustainable intensification (Winterbottom, Reij, Garrity et al. 2013).

Who is going to pay the costs of scaling up regreening?

Land users who protect and manage natural regeneration are ready to invest the costs of their labor. Experience shows that many are willing to do this on a voluntary basis, because they appreciate the multiple benefits of regreening. In situations of extreme poverty, however, it may make sense to provide food-for-work during a transition period, until the benefits of regreening become appreciable. Providing food on a temporary basis in exchange for protecting natural regeneration is especially justified when the regreening is undertaken on communal land.

The funding now going into conventional tree planting can be diverted at least partially to shift natural regeneration techniques. Because naturally regenerated trees tend to have a better survival rate than planted trees, more can be achieved with each dollar invested.

All new agricultural development projects should include a regreening component. Sustainable agricultural intensification depends on on-farm trees for soil organic matter, soil fertility, and shade, as well as many other ecosystem services. Accordingly, regreening should be part and parcel of new agricultural and rural development projects.

If a portion of existing funding for agricultural development were allocated to regreening, significant scale-up could be realized. However, given the regreening necessary in many countries, the ambitious national regreening targets and the global needs, additional new funding is also required. Private funding can be mobilized to restore large tracts of degraded land, in particular if the activities of the company have contributed to degradation.

Misunderstandings About Regreening

Will it take many years before local communities benefit from regreening?

Many people assume that if you plant or protect trees now, the benefits will not be reaped for a decade or more. This is often not the case. Many species have to be pruned to develop a trunk and a canopy. This means they have to be pruned from year 2 or 3, which creates early benefits to farmers in the form of fuel and fodder.

The Tigray region of Ethiopia has made vast efforts to promote natural regeneration of vegetation on degraded plots of land. Until recently the policy was to protect natural regeneration but not to touch it. This means that trees were not pruned to develop a trunk and a canopy. The result has been the proliferation of bushes and not trees. Sustainable management and periodic pruning and harvesting of regenerated vegetation have the potential to produce significantly more economic and environmental benefits than just leaving natural regeneration untouched (See Figure 18).

In fact, there can be severe competition between closely spaced *Acacia etbaica* trees; in these cases, the lack of pruning along with heavy gall infestations can contribute to slow growth. Farmers have found that heavy pruning enhances both growth rate and tree form (see Figure 19). Without thinning and pruning, the 15-year-old stands of *Acacia etbaica* averaged only 2–3 meters in height.[29]

Figure 18 | **Pruning of *Faidherbia albida* Trees in Ethiopia to Encourage Rapid Growth, 2010–2014**

Encouraged by the rapid growth of *Faidherbia albida*, community leader Aba Hawi has engaged his community in pruning about 930,000 Faidherbia trees since 2010. Growth rates like this, particularly from mature tree stumps, are not atypical, even in the Sahel.

Figure 19 | **Illustration of the Impact of Properly Pruning *Acacia etbaica* Trees in Ethiopia**

At left, pruned tree in a cultivated field. At right,1.5 meters growth in 12 months, illustrating the impact of properly pruning *Acacia etbaica* in Tigray (Ethiopia).

Of course, the growth of trees varies from one landscape to another and depends on species, soils, altitude, and rainfall, as well as on management practices. Experience in the Sahel shows that with good management, significant benefits can be obtained within 3 to 5 years. In regions with higher rainfall, natural regeneration is even faster than in the drylands. The natural regeneration of a degraded forest in the Humbo area in Ethiopia illustrates this point (Figure 20).[30]

Is land tenure a constraint?

In many regions, most smallholder farmers have a permanent land use right, which means that they do not face a land tenure constraint to farmer-managed natural regeneration or tree planting. In Malawi, and in a number of other countries, farmers who rent land are not inclined to plant trees, as this would be considered an appropriation of cropland owned by others. In Niger, the major constraint to farmers' willingness to practice FMNR is not land ownership but tree ownership. The Humbo project in Ethiopia was only really possible because the government provided a legally binding document granting "tree user rights." In Burkina Faso, farmers are allowed to sow tree seeds on borrowed land and to protect natural regeneration. Farmers consider protecting the natural regeneration of trees on cropland to be different from planting trees, which some landowners may discourage. And while insecure land tenure may not be a major constraint in some landscapes, as noted earlier, it is important to consider issues related to land and tree tenure, and especially to clarify and affirm rights to manage trees on farms as part of an effort to reduce barriers and improve the enabling conditions to scale up regreening.

Do higher tree densities in drylands lead to a lowering of groundwater levels?

This risk is higher where dense forests have been planted in drylands. The densities of on-farm trees are lower than forest plantations, however, which reduces the risk of groundwater depletion. Nevertheless, this is an issue worth monitoring. Numerous positive reports from Burkina Faso, Ethiopia, Niger, and other countries show that an increase in density of trees on farms, often in combination with the widespread adoption of rainwater harvesting and other soil and water conservation practices, can contribute to rising water tables (Reij, Tappan, and Smale 2009;

Figure 20 | **Restoration of Tree Cover on Humbo Mountain in Ethiopia**

Humbo Mountain in southern Ethiopia was barren in 2007, but the protection of natural regeneration by local communities restored vegetation by 2013.

Rinaudo 2009). This could result from the much more efficient infiltration of water in landscapes and farmlands with trees. In these regreened landscapes, farmers now have easier access to water in shallow wells and are able to benefit from the development of irrigated crops in the dry season.

What about negative impacts of increased numbers of on-farm trees? Foresters and agronomists may argue that high on-farm tree densities may compete with crops for scarce nutrients and that shading may have a negative impact on yields. We recommend that farmers decide for themselves how many trees they want in their fields, which species they prefer, and how many of each they want to protect and manage. They make their own cost-benefit calculations. The challenge is to increase the available options in their specific agroecological and socioeconomic context.

Several innovative farmers in Burkina Faso deliberately try to attract birds to their fields, because the birds' droppings contain tree seeds, and the birds help destroy some of the pests that could harm crops. Figure 21 shows Ousséni Kindo filling a clay pot with water during the dry season to attract birds to his farm in Yatenga Province.

Isn't tree planting the most direct and effective path to regreening?

There is no denying that planting trees can be useful in specific conditions, but experience shows that it is costly and survival rates are low. Ownership and management rights of newly planted trees are often unclear, and responsibilities and economic incentives for care and maintenance are often not clarified before the trees are planted.

As senior forestry officers in a Sahel country recently remarked, "We've been planting trees for almost 3 decades but have little to show for our efforts." Nonetheless, many funding agencies and governments tenaciously continue to push tree planting, and to define targets for the numbers of seedlings to be produced in nurseries. Part of the reason may be that forestry officers consider tree planting to be their core business. Their experience is in developing conventional tree planting project proposals with large budgets for the production and distribution of large numbers of tree seedlings. The encouragement of farmer-managed natural regeneration is a very different type of forestry project that is outside the standard paradigm of most forestry agencies.

Of course, tree planting may be warranted under some circumstances. For example, land users may want certain species, particularly higher-value species, in their production systems, such as moringa and mangoes. These varieties do not emerge through natural regeneration.

Figure 21 | **Providing Water to Attract Birds in Trees on Farms**

Ousséni Kindo (Yatenga Province, Burkina Faso) provides water for birds during the dry season to attract them to his farm.

Some Key Messages

1. Agroforestry by itself is not a silver bullet, but, as many farmers note, there is no future for rain-fed agriculture in the drylands without agroforestry. Agroforestry is not a form of alternative agriculture; rather, it should be mainstreamed as a key practice in the sustainable intensification of agricultural systems. Successful examples of regreening through the widespread adoption of farmer-managed natural regeneration, and related agroforestry and improved land and water management practices, have demonstrated the significant economic and environmental benefits associated with regreening at scale.

2. Unless we create conditions in which smallholder farmers in the drylands and subhumid regions invest their scarce resources in improved land and water management (including on-farm trees), farmers will not be able to sustainably increase food security and rebuild resilience. Governments have an important role to play in adopting enabling policies, removing legislative and regulatory barriers, and mobilizing support for the successful implementation of regreening strategies and programs. Governments also play an important role in monitoring application and enforcement of legislation, and in monitoring outcomes and adapting policies and legislation as needed to produce the desired outcomes.

3. A growing number of smallholder farmers in the drylands and subhumid regions are beginning to invest or have invested on a major scale in the protection and management of on-farm natural regeneration of woody species. The prospect of increased income generation is a major driver of regreening. Developing agroforestry value chains and capitalizing on the role of the market can contribute significantly to scaling up regreening.

4. Scaling up existing successes requires a comprehensive and well-developed strategy based on a deeper understanding of farmer-led regreening successes. Such a strategy needs to include ambitious communication programs, which put smallholder farmers (men and women) with relevant experience at center stage. It is particularly important to increase support for farmer-to-farmer exchange visits, training workshops, and outreach through rural radio programs.

5. The Climate Summit held in New York on September 23, 2014, led to the New York Declaration on Forests, which pledges to restore 350 million hectares of degraded forest land by 2030. Scaling up the existing successes in many countries in western, eastern, and southern Africa is a pragmatic way forward and a proven pathway to help achieve these ambitious restoration targets. There is a role for tree planting in specific situations, but our view is that this enormous target can only be achieved if the focus shifts to low-cost protection and management of natural regeneration of woody species by tens of millions of land users. Achieving success in scaling up is not always easy and straightforward, but we know what to do and how to it. It is time to invest in developing effective scaling strategies globally, regionally, and nationally.

Let's turn a crisis into an opportunity. Experience in the Sahel shows that farmers who protect and manage natural regeneration of woody species on their farms have transformed whole landscapes, and they have done so at low cost. They have invested their labor in the protection and management of natural regeneration. This approach can be used to restore degraded forests also, as long as the local land users reap the economic benefits of the restoration process. Land users should be encouraged to be responsible for regreening, they should be enabled to do so, and they should be the prime beneficiaries. If we think and act big and boldly, we can rapidly regreen major parts of our planet.

REFERENCES

Abdoulaye, T., and G. Ibro. 2006. *Analyse des impacts socio-économiques des investissements dans la gestion des ressources naturelles: Etude de cas dans les régions de Maradi, Tahoua et Tillabéry au Niger*. Etude sahélienne. Niamey: CRESA.

Belemviré, A. 2001. *Impact de la conservation de l'eau et des sols sur la régénération naturelle assistée*. Etude Plateau Central. Rapport de travail no. 1. Ouagadougou. Vrije Universiteit Amsterdam.

Botoni, E., and C. Reij. 2009. *The Silent Transformation of Environment and Production Systems in the Sahel: Synthesis Report*. Ouagadougou: CILSS and Center for International Cooperation, Vrije Universiteit Amsterdam.

Brown, D. R., P. Dettmann, T. Rinaudo, H. Tefera, and A. Tofu. 2011. "Poverty Alleviation and Environmental Restoration Using the Clean Development Mechanism: A Case Study from Humbo, Ethiopia." *Environmental Management* 48 (2011): 322–33.

Buttoud, G., O. Ajayi, G. Detlefsen, F. Place, and E. Torquebiau. 2013. "Advancing Agroforestry on the Policy Agenda." Agroforestry Working Paper no. 1. Rome: FAO.

Dawson, I. K., F. Place, E. Torquebiau, E. Malézieux, M. Iiyama, G. W. Sileshi, K. Kehlenbeck, E. Masters, S. McMullin, and R. Jamnadass. 2013. "Agroforestry, Food, and Nutritional Security." Background paper for the International Conference on Forests for Food Security and Nutrition, Rome, May 13–15.

Dozoretz, L., B. Rassas, E. Vickstrom, A. Javelle, and R. Winterbottom. 2014. *Synergies of Nature, Wealth, and Power: Lessons from USAID Natural Resource Management Investments in Senegal*. Washington, DC: USAID.

Fahey, J. W. 2005. "*Moringa Oleifera*: A Review of the Medical Evidence for Its Nutritional, Therapeutic, and Prophylactic Properties, Pt. 1." *Trees for Life Journal* 1, no. 5 (2005): 5-15.

Food and Agriculture Organization of the United Nations (FAO). 2013. *Climate Smart Agriculture Sourcebook*. Rome: FAO.

Garrity, D. P., F. K. Akinnifesi, O. C. Ajayi, S. G. Weldesemayat, J. G. Mowo, A. Kalinganire, M. Larwanou, and J. Bayala. 2010. "Evergreen Agriculture: A Robust Approach to Sustainable Food Security in the Sahel." *Food Security*: 197 – 214.

Hassane, A., P. Martin and C.Reij. 2000. *Water harvesting, land rehabilitation and household food security in Niger: IFAD's soil and water conservation project in Illéla District*. VU University Amsterdam/Rome: International Fund for Agricultural Development.

Hermann,S.M. and G.G.Tappan.2013. Vegetation impoverishment despite regreening: A case study from central Senegal. *Journal of Arid Environments* (90): 55-66.

International Union for Conservation of Nature (IUCN) and WRI. 2014. "A Guide to the Restoration Opportunities Assessment Methodology (ROAM): Assessing Forest Landscape Restoration Opportunities at the National or Sub-national Level." Working paper (road-test edition). Gland, Switzerland: IUCN.

Larwanou, M., M. Abdoulaye, and C. Reij. 2006. *Etude de la régénération naturelle assistée dans la région de Zinder (Niger): Une première exploration d'un phénomène spectaculaire*. Washington, DC: International Resources Group and USAID.

Leakey, Roger. 2012. *Living with the Trees of Life: Towards the Transformation of Tropical Agriculture*. Egham, UK: CABI.

Marchal, J-Y, .1985. La déroute d'un système vivrier au Burkina Faso: Agriculture extensive et baisse de production. *Etudes Rurales* 99-100:265-277.

Marenya, Paswel, and Chris Barret. 2009. "State-Conditional Fertilizer Yield Response on Western Kenyan Farms." *American Journal of Agricultural Economics* 91, no. 4: 991–1006.

Mortimore, M., M. Tiffen, B. Yamba, B., and J. Nelson. 2001. "Synthèse sur les évolutions à long terme dans le département de Maradi, Niger 1960–2000." Drylands Research Working Paper 39f. Crewkerne, U.K.:Drylands Research.

Place, F., and J. N. Binam. 2013. *Economic Impacts of Farmer-Managed Natural Regeneration in the Sahel*. End of technical project report for Free University Amsterdam and IFAD. Nairobi: World Agroforestry Center.

Place, F., B. J. Nyemeck, A. Kalinganire, H. Sigue, B. Moussa, T. Abasse, J. Dakouo, M. Bayo, D. Sanogo, D. Mouahamadou, M. Badji, and E. Haglund. 2013. *Socio-economic Assessment of Farmer Managed Natural Regeneration in the Sahel: Evidence from Four Selected Countries (Burkina Faso, Mali, Niger and Senegal)*. Technical report. Nairobi: World Agroforestry Centre.

Place, Frank, and Dennis Garrity. 2014. "Tree-Based Systems in African Drylands." Background paper prepared for the report on the Economics of Resilience in the Drylands of Sub-Saharan Africa. Discussion draft. Nairobi: World Agroforestry Center.

Pye-Smith, C. 2013. "The Quiet Revolution: How Niger's Farmers are Regreening the Croplands of the Sahel." World Agroforestry Center (ICRAF), Trees for Change no. 12. Nairobi: World Agroforestry Center.

Raynaut, C.1987.L'agriculture nigérienne et la crise du Sahel. *Politique africaine* 27: 97-107.

Reij, C. 2013. Overview of major achievements Supporting Farmer Managed Natural Regeneration in the Sahel (IFAD grant 1246-VUWA). Amsterdam: Center for International Cooperation. Vrije Universiteit Amsterdam.

Reij, C. 2011. "Investing in Trees to Mitigate Climate Change." In *State of the World: Innovations That Nourish the Planet*, ed. B. Halweil and D. Nierenberg. Washington, DC: World Watch Institute.

Reij, C., G. Tappan, and M. Smale. 2009. *Agroenvironmental Transformation in the Sahel: Another Kind of Green Revolution.* Washington, DC: International Food Policy Research Institute.

Reij, Chris, and Ann Waters-Bayer, eds. 2001. *Farmer Innovation in Africa: A Source of Inspiration for Agricultural Development.* London: Earthscan.

Republic of Rwanda, Ministry of Natural Resources. 2014. "Forest Landscape Restoration Opportunity Assessment for Rwanda." Working paper prepared with IUCN. September.

Rinaudo, T. 2001. "Utilizing the Underground Forest: Farmer-Managed Natural Regeneration of Trees." In *Combating Desertification with Plants*, ed. Dov Pasternak and Arnold Schlissel. New York: Kluwer Academic/Plenum.

Rinaudo, T. 2007. The development of Farmer-Managed Natural Regeneration. LEISA Magazine 23 (2):32-34.

Rinaudo,T. 2009. Trip report and recommendations. Regreening Tigray. Melbourne: World Vision Australia

Sambo, M. N. 2008. "Impacts de la régénération naturelle assistée des ligneux sur la réduction de la vulnérabilité des ménages: Cas du terroir de Kirou Haussa, dans la commune urbaine de Matameye (région de Zinder)." Mémoire DEA, Université de Niamey.

Sawadogo, H., F. Hien, A. Sohoro, and F. Kambou. 2001. "Pits for Trees: How Farmers in Semi-arid Burkina Faso Increase and Diversify Plant Biomass." In Reij and Waters-Bayer, 35–46.

Searchinger, T., C. Hanson, R. Waite, S. Harper, G. Leeson, and B. Lipinski. 2013. "Achieving Replacement Level Fertility." Working paper, installment 3 of *Creating a Sustainable Food Future.* Washington, DC: World Resources Institute.

Sendzimir, J., C. Reij and P. Magnuszewski. 2011. Rebuilding resilience in the Sahel: regreening in the Maradi and Zinder regions of Niger. *Ecology and Society* 16 (3) http://www.ecologyandsociety.org/vol16/iss3/art1/

Snapp, S., M. Blackie, R. Gilbert, R. Bezner-Kerr, and G. Kanyama-Phiri. 2010. "Biodiversity Can Support a Greener Revolution in Africa." *PNAS* 107, no. 48: 20840-20845.

Stevens, C., R. Winterbottom, J. Springer, and K. Reytar. 2014. *Securing Rights, Combatting Climate Change: How Strengthening Community Forest Rights Mitigates Climate Change.* Washington, DC: World Resources Institute.

Tchawa, P., N. Tchiagam, and Y. Bonneau. 2001. "The Career and Influence of Barthelémy Kameni Djambou in Cameroon." In Reij and Waters-Bayer, 23–27.

U.S. Agency for International Development (USAID). 2014. *A Geographic Analysis of Human Vulnerability in Niger.* Washington, DC: U.S. Global Development Lab–GeoCenter.

U.S. Geological Survey (USGS) and USAID. 2014. *Mapping Tree Cover and Conservation Practices for the Resilience in the Sahel Enhanced (RISE) Programs: On-farm Tree Cover Mapping.* Washington, DC: Government Printing Office.

Weston, Peter, and Reaksmey Hong. 2012. *Talensi Farmer-Managed Natural Regeneration Project, Ghana: Social Return on Investment Report.* Australian Aid and World Vision Australia. Accessed at www.wvi.org/world-food-day/publication/talensi-farmer-managed-natural-regeneration-project-ghana.

Winterbottom, R., F. Landsberg, and C. Reij. 2013. "Burkina Faso Farmers Lead the Way on Food Security and Climate Change Resilience." WRI Insights blog. August 15, 2013. http://www.wri.org/blog/2013/08/burkina-faso-farmers-lead-way-food-security-and-climate-change-resilience

Winterbottom, R., C. Reij, D. Garrity, J. Glover, D. Hellums, M. McGahuey, and S. Scherr. 2013. "Improving Land and Water Management." Working paper, installment 4 of *Creating a Sustainable Food Future.* Washington, DC: World Resources Institute.

Yamba, B., and M. N. Sambo. 2012. *La régénération naturelle assistée et la sécurité alimentaire des ménages de 5 terroirs villageois de départements de Kantché et Mirriah (région de Zinder, Niger).* Report for the International Fund for Agricultural Development. Etude FIDA 1246-VU University Amsterdam.

Yates, P. 2012. "The Low Hanging Fruit: Trees, Wild Foods and Nutrition." Draft paper. Charles Darwin University, World Vision Australia.

Young, Anthony. 1997. *Agroforestry for Soil Management.* Egham, UK: CABI.

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African Regreening Initiatives:
http://africa-regreening.blogspot.nl/

EverGreen Agriculture:
http://evergreenagriculture.net/

Farmer-managed natural regeneration:
http://fmnrhub.com.au/

Restoration:
http://wri.org/our-work/project/global-restoration-initiative

Landscape Management:
http://peoplefoodandnature.org/

ENDNOTES

1. See USGS. http://lca.usgs.gov/lca/theme5task1/docs/YJARE%201317%20Tappan.pdf
2. For more information on EverGreen agriculture, see http://worldagroforestry.org; http://www.profor.info/sites/profor.info/files/Evergreen-Agriculture-brochure.pdf
3. Although this report focuses on enabling smallholder farmers (men and women) to increase the number of trees on their farms, increasing the number of trees across the entire agricultural landscape is equally important to rural communities. In many countries, improved vegetation management by pastoralists is critically important, together with the restoration of the productivity of cultivated croplands.
4. For more information on farmer-managed natural regeneration, please see http://fmnrhub.com.au/ managed by the Food Security and Climate Change team, World Vision Australia.
5. See, for example, remote sensing and GIS analysis by Gray Tappan, U.S. Geological Survey, cited in this report in association with Figures 2a–b and Figures 3a–d.
6. The low on-farm tree densities in 1955 result mainly from colonial agricultural development policies. In colonial days, farmers were perceived to be modern if they farmed their crop as a monoculture and removed most on-farm trees to facilitate plowing the land.
7. Personal communication with Roland Bunch (May 2013)
8. Yamba and Sambo 2012, quoting Famine Early Warning Systems data and the National Committee for the Prevention and Management of Food Crises.
9. See http://moringa4all.com/
10. Fahey 2005. See also references cited in documentation posted by Trees for Life International. http://www.tfljournal.org/article.php/20051201124931586
11. Personal communication with Bob Mann (November 2011)
12. Personal communication with Gray Tappan June 4, 2014.
13. Unpublished data G.Tappan and M.Larwanou (2006/2007).
14. Personal communication with Tony Rinaudo, 2014. A related point is that many agronomists have been trained to focus on the planted annual crop and in many respects do not take account of anything else. And many forestry agents only take account of planted trees, particularly “exotic” species promoted by reforestation programs, and they pay less attention to indigenous trees and shrubs, which may not produce large volumes of commercial timber, although other benefits may be quite significant and are appreciated by farmers.
15. For more information, see posting on the African Regreening Initiatives blog: http://africa-regreening.blogspot.nl/
16. For more information, see http://www.worldagroforestry.org/newsroom/highlights/rural-eastern-africa-communities-reap-huge-benefits-new-dgis-programme
17. Personal communication with Tony Rinaudo, 2014.
18. http://www.nepad.org/sites/default/files/Malabo%20Synthesis_English.pdf
19. See http://afforum.org/node/21140
20. See http://anafe-africa.org/
21. See African Regreening Initiatives update November 2014 with report on Web Alliance for Regreening in Africa (W4RA): http://africa-regreening.blogspot.nl/
22. See http://www.1080films.co.uk/yacoubamovie/
23. See http://www.pbs.org/newshour/bb/africa-july-dec12-niger_07-12/
24. http://fmnrhub.com.au/kisiki-hai/#.VRHDbE05DIU; http://fmnrhub.com.au/releasing-the-underground-forest-in-mpwapwa-tanzania/#.VRHDrE05DIU
25. See http://reseaumarpbf.org/IMG/pdf/Rapport_final_de_l_atelier_de_plaidoyer_sur_la_RNA_copy.pdf
26. Personal communication with Gray Tappan. 2012
27. Data from Place et al. 2013 and Pye-Smith 2013 show that the economic benefits of regreening range from $200-$1000 per household. Farm size for rural households in Niger is about 4 hectares, where 5 million hectares have been regreened. Using a conservative estimate of $100/hectare in economic benefits, this amounts to $500 million in annual benefits for rural households.
28. This estimate is based on authors experience and data from Tony Rinaudo, World Vision Australia.
29. Personal communication with Tony Rinaudo. 2014
30. Brown et al. 2011. See also video documentary on Humbo at fmnrhub.com.au/projects/humbo/#.VH3h_THF-VM.

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ABOUT WRI

World Resources Institute is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity and human well-being.

Our Challenge

Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

Our Vision

We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

Our Approach

COUNT IT

We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

CHANGE IT

We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure our outcomes will be bold and enduring.

SCALE IT

We don't think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and business actions that improve people's lives and sustain a healthy environment.

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