Trees help to increase crop yields

In Niger, Faidherbia trees help to increase crop yields.

Photo: World Agroforestry

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CHAPTER EIGHT

Zinder: farmer-managed natural regeneration of Sahelian parklands in Niger

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Highlights

- Farmer-managed natural regeneration (FMNR) of trees on croplands has spread to 7 m ha in Niger and now occupies about 21 m ha across the Sahelian countries. Sahelian croplands now have 16% tree cover on average, which can be further increased and intensified in many ways.
- The broader spread of FMNR will be enhanced by deeper forest policy reform to avoid disincentivizing farmers from growing trees on their farmlands, and by government and international support for adopting these agroecological practices
- FMNR scaling-up complements other agricultural improvements. It should be embedded into all rural projects in the region
- Further development of tree product markets will enhance the uptake of FMNR.

8.1 Introduction

There is little doubt that a remarkable 'regreening' has taken place in part of the Sahel in recent decades. After severe episodes of drought and famine in the 1970s and 80s, that caused massive crop and livestock losses, and human migration and mortality, a process of agroforestation on more than 5 million hectares of farmlands has 'regreened' the southern part of Niger[1]. This has had major positive consequences in improving crop and livestock productivity, and it has enhanced the resilience of these agricultural systems to drought and temperature extremes in the face of climate change. The practice of farmer-managed natural regeneration (FMNR; Box 9.1) of trees on farmlands is now accelerating across all of the Sahelian countries. Currently, trees occupy 16% of the total area of croplands in the semi-arid and subhumid zones of the Sahel[2], and 23% in the West Africa savannas. Nearly 100% of this tree cover is a result of the practice of FMNR by the millions of small-scale farmers of the region. The how and why of this regreening process has been an interaction of actors, policy changes, behavioural changes and practices[3]. This chapter examines current understanding of

the drivers of change, the change itself and its implications for the future of agriculture in the drylands of the Sahelian region and beyond.

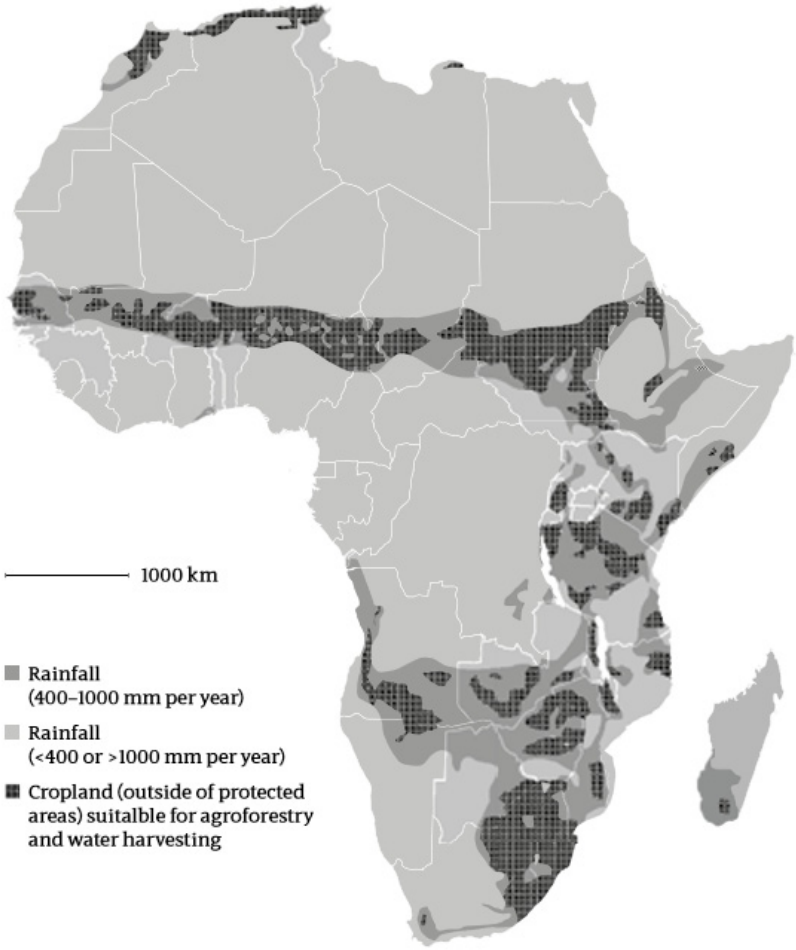

Figure 8.1 Map of dry semi-arid zone of Africa[4], with the star indicating the Zinder region in Niger

Box 8.1 What is farmer-managed natural regeneration?

Farmer-managed natural regeneration (FMNR) – *régénération naturelle assistée (RNA)* in French, *sassabin zamani* in Hausa – is a practice which involves identifying and protecting the wildlings of trees and shrubs that establish themselves on farmlands. It depends on the existence of living root systems and seeds. Shoots from roots grow more rapidly than saplings from seed because of better- and well-established root systems, and they make up the bulk of the protected woody matter on farms in southern Niger. Farmers will generally choose one to five of the strongest stems from stumps they wish to retain on their land, pruning away the remainder. These stems are managed to grow into full-canopy trees that are harvested to provide fodder, biofertilizer, fruits, medicine, firewood, and timber. The species favoured vary from place to place; as does the density of the trees in the crop fields. Some projects have advised farmers to keep at least 40 trees per hectare, but densities of over 150 trees per hectare are not unusual.

The context

Interest in the development of the African drylands has increased in recent years, but widespread concerns over 'desertification' of the region go back to at least the 1970's[5]. This has been driven mainly by recognition that they have been the target of considerable humanitarian aid over the last three decades, and they are currently the cause of great concern about rising insecurity and conflict. But comparatively little effort has been invested in their development to increase people's resilience and to address insecurity and dependency on aid. This reawakened interest has translated into support for livestock and crop-based development pathways, and efforts to foster resilient livelihoods revolving around agricultural commodities. Such efforts, however, will be of limited impact without attention to a broader systems approach that builds on the synergies that trees provide in these systems based on a crop-tree-livestock perspective.

Dryland peoples and their communities have acquired, through the millennia, considerable resilience to these conditions. This enables them to recover following droughts and other nature-induced shocks like floods and fires. However, the recent very-high rate of human population growth in the drylands, and the increasing frequency and intensity of droughts, are both seriously undermining the resilience of both the land and the people. In the agricultural domain, production of the most important dryland crops is already typically associated with dispersed trees in the farm fields. This form of land use is referred to as agroforestry parklands in the Sahelian context[6]. Variants of the parkland system are also common in the Eastern and Southern Africa drylands (or *Miombo*)[7].

When parkland trees are pollarded or die the full positive effect on soil fertility is revealed. Photo: World Agroforestry

Often, the trees in these systems directly provide an important product such as wood, gum, oil or fruit. In other cases, they provide an input into the production of other major products

such, as foliage used as fodder for meat and milk production, tree nectar for honey, and tree leaves as biofertilizers for improved soil health and crop production. A considerable number of well-recognized species and products are associated with the African drylands. These include the baobab tree (*Adansonia digitata*), which provides nutritious fruits and leaves; the shea tree (*Vitellaria paradoxa*) that provides butter used in cooking, in chocolate and cosmetics; gum arabic (*Acacia senegalensis*) that provides a gum used in many food items; and the acacia tree *Faidherbia (Acacia) albida,* which enriches soils and provides valuable pods and foliage for fodder[8]. The environmental services derived from trees on farmlands provide another significant stream of benefits, such as soil and water conservation, and a more favourable microclimate for crops to withstand wind and heat and drought stress[9,10,11].

Farmer-managed natural regeneration (FMNR) on agricultural lands, and assisted natural regeneration (ANR) on community lands, provide the most cost-effective way of achieving a widespread increase in the number of valuable, adapted, and diverse trees. What these practices have in common is that in both cases, people (individual farmers or entire communities) actively influence the natural biological regeneration processes to achieve tree patterns that best suit their needs.

On agricultural lands, farmers identify naturally regenerating tree seedlings or sprouted rootstocks in their fields. They protect and manage them to provide various benefits (for direct products and for better crop and/or livestock production). On community lands, local groups may adopt the same practices, and they may also introduce grazing management systems at the community level that are designed to allow successful tree regeneration in the targeted areas. Under both systems, protecting and weeding around young trees, and thinning the trees as they grow, may be necessary to help them survive and flourish.

In recent years, FMNR has gained in popularity in many dryland areas in western, eastern and southern Africa. Because it requires very little or no cash investment, FMNR can expand rapidly through farmer-to-farmer and village-to-village diffusion. The case of Niger provides the most dramatic example of how quickly and how extensively the practice can spread[12]. But Niger is not unique. A recent study carried out in Niger, Mali, Burkina Faso and Senegal has found that almost all farmers are now actively regenerating trees on their farms[13].

The products and services derived from FMNR vary from location to location, depending on the tree species that are present in the area, and that are valued by farmers. Throughout the Sahel, more than 110 different woody species are being managed by farmers through natural regeneration[14]. These trees provide a high level of value to local people[13]. They contribute products for human consumption (more than $200 per household per year), and nutritious fodder for livestock during the late dry season, and they have positive effects on crop yields (accounting for roughly 15-25 percent of the variation in millet and sorghum yields).

A healthy parkland agroforestry system would include both mature trees that provide benefits today, along with some younger trees to replenish the system for the future[15,16]. However, demographic, economic, environmental and social developments during the past 40 years have put serious pressure on the traditional land-use systems of the Sahel. Modern Sahelian forest laws that banned the cutting of trees without a license, and the ways that they are locally enforced, discouraged farmers from engaging in optimum parkland management

practices, and led to the degradation of the parklands to a varying extent across the region[12]. This was particularly the case in Niger.

What happened in Niger and how did it happen?

During the 1970s and 1980s, Nigerien farmers faced massive tree losses from drought, and human population pressures, resulting in widespread desertification of the agricultural landscape. After conventional reforestation projects had consistently failed, pilot projects were initiated during the mid-to-late 1980s, followed by larger development projects, that began to emphasize FMNR as a way to re-establish useful trees in the desertified agroecosystems of southern Niger[17].

Interest in FMNR was further stimulated in the 1990s when the successful experiences of several pilot projects were shared with government policymakers. This encouraged the government to relax the restrictive forestry regulations (Code Forestier) that had severely limited farmer management of their own trees. Farmers had previously been strongly discouraged in regenerating and managing trees on their own land because foresters claimed this was illegal. Farmers were threatened with imprisonment if they so much as pruned a tree. Foresters typically extorted cash from farmers after accusing them of 'breaking the law'.

But when these 'enforcement' practices were suppressed, FMNR landscapes began to spread rapidly. In 2004, the Government of Niger formally recognized the trend by revising the national forestry laws to eliminate the onerous restrictions on the freedom of farmers to manage the trees that they regenerated and managed on their own land.

Tree densities and tree cover in Niger have increase dramatically in recent decades[18]. Analysis of high-resolution images acquired during 2003 to 2008 shows that in the Maradi and Zinder Regions of Niger alone, about 4.8 million hectares of farmlands were regenerated by 2008 through FMNR[12]. An estimated 1.2 million households were engaged in managing these FMNR systems through their own independent efforts. Many villages now have 10–20 times more trees than 20 years ago and the agricultural landscapes of southern Niger have more than 200 million more trees than they did 30 years ago. Reij and colleagues[12] estimated that this transformation has resulted in an average of at least 500,000 additional tons of additional food produced per year which covers the requirements of 2.5 million people. More recent satellite image analysis has revealed that FMNR is being practiced on over 7 m ha in Niger[19].

The further scaling-up of farmer-managed natural regeneration has been spreading to other countries in the Sahel, inspired by the Niger experience. The US Geological Survey recently mapped 450,000 hectares of young, contiguous FMNR on the Seno Plains of eastern Mali[20]. This had evolved through a similar process as in Niger, and was accelerated during the past 15 years as the enforcement of forestry laws prohibiting FMNR was relaxed. FMNR is also now locally-prominent in northern Burkina Faso. Interestingly, some farmers there are managing FMNR in more standard row patterns, in order to avoid interference with ploughing operations[21].

In Senegal, the Serere people have sustained a dense cover of mature *Faidherbia albida* parklands on about 150,000 hectares of farmlands for at least the past few generations. But

degradation of the tree and land resources prevailed in much of the rest of the country. The Government recently has revised its agricultural strategy to promote FMNR for land regeneration. This has led to over a dozen FMNR pilot projects that are providing the technical and institutional experience to enable the widespread renewal of regreening[22,23,24]. World Vision's FMNR project in the Kaffrine region has enabled the adoption of 70,000 hectares of new FMNR.

What has happened since 1994 on Mali's Seno Plains illustrates the importance of forestry legislation. In 1991, Mali's president was toppled by a popular uprising. During that period many forest agents were thrown out of the villages and some were even killed. They had managed to make themselves very unpopular, for instance, by starting bushfires themselves, while later accusing the villagers that they had done so. Since this practice was against the law, the forest agents were subsequently able to impose unjustified fines on the people[25]. In 1994, a new forest law was adopted, which specifically mentioned on-farm trees and the farmers' rights to these trees, on the condition that the land was not left fallow for more than 10 years. This policy encourages farmers to reduce the number of years that they leave their land fallow and to protect on-farm trees. Due to the high and rapidly growing population densities on the Seno Plains, most farmers have to cultivate their land permanently, in any event.

A radio station in the small town of Bankass on the Seno Plains, which was funded by the NGO SahelEco, decided to broadcast the contents and implications of the new forest law. The reaction of villagers was "does this mean we can refuse access to those who cut our trees with a permit of the forestry service?" The answer was yes, and it was also broadcast by the radio station. From that day farmers refused access to woodcutters arbitrarily contracted by the Forestry Department to harvest farmers' own trees without compensation. Farmers now had the incentive to begin protecting their on-farm trees[25].

It took until 2011 before the scale of the new agroforestry systems on the Seno Plains was fully uncovered. Local staff estimated the scale to be on the order of 16,000 hectares. However, Gray Tappan of the US Geological Survey's EROS Data Center in South Dakota, used satellite images and mapped the area under medium and high-density agroforestry to be almost 500,000 ha. Until 2011, no one had the slightest idea of the scale of this re-greening process. Field visits have showed that 90 percent of the trees are less than 20 years old.

Projects in Niger have invested less than $100 million since 1985 in the promotion of re-greening by farmers. Part of the 5 million ha is the result of project intervention, but a substantial part is the result of farmers spontaneously adopting the practice because they have observed the benefits and do not wait for external support. One key activity was the organisation of farmer-to-farmer study visits. Letting farmers (men and women) who don't yet use the practice visit with those who have gained experience with it is one of the most effective ways of spreading the practice widely.

If an investment of less than US$100 million has led to 5 million hectares of new agroforestry parklands, then the average costs of adoption per hectare were less than 20 US $/ha. The annual labour costs per hectare for pruning and protection are also quite low. The International Fund for Agricultural Development recently calculated the costs of farmer-managed regreening in the Maradi Region. The costs amounted to 9000 CFA/ha, which is US$14 per hectare at current exchange levels (1 $ = 607 CFA)[26].

Reij and colleagues[12] conservatively estimated that the 5 million ha of new agroforestry parkland had increased average grain yields by 100 kg/ha. They postulated that the yield increases are higher in areas dominated by *Faidherbia albida*, but it may be less elsewhere. In this way, regreening by farmers was calculated to contribute an estimated annual increase in grain production of 500,000 tons. This is enough grain to feed 2,500,000 people.

Not all smallholder farmers practice agroforestry. In the Southern part of the Zinder Region, the agroforestry parklands are fairly contiguous, but in the Maradi Region one can find villages with and without agroforestry adjacent to each other. The reason behind this difference seems to be that internal conflicts in some villages have prevented them from engaging effectively in the protection and management of natural regeneration, which requires community efforts and organization, particularly in grazing management.

What are the consequences of the spread of FMNR?

Global temperatures are significantly increasing as a result of climate change. Average temperatures in the Sahel have increased by about one degree Celsius during the past 40 years[27]. Periods of extreme day-time temperatures are also more frequent and severe. Most annual crops experience a reduction in their yield potential as a result of higher temperatures due to two processes: they have higher respiration rates, which burns up more of their energy, making less available for grain filling; and they shorten of the crop maturity period (fewer days between flowering and maturity) which reduces the size and weight of the grain[28].

Trees in crop fields significantly reduce temperatures in the crop canopy and at the soil surface, thus reducing the crop exposure to high temperature shock, particularly at mid-day[9,11]. The aggregate effect across the growing season is to reduce the shock of a shortened crop maturity period, thus enabling the crop to photosynthesize longer during the daytime, and to increase the amount grain filling and the ultimate yield[29]. The sum of these effects is a more stable crop yield in drought years in fields with tree populations, than in fields without them. Surveys in Niger comparing the crop performance in drought years between villages and households with and without the practice of farmer-managed natural regeneration of trees, have also provided farm-level evidence of this[12]. The research data are consistent with farmer observations that higher tree populations reduce the drought effects on their crops.

Trees in crop fields directly and significantly ameliorate the severity of drought effects on annual crop performance by modifying the humidity. Crops in the vicinity of trees experience a more favourable microclimate, with significantly higher humidity in the crop canopy, causing a lower vapor pressure deficit. Trees also slightly lower solar radiation stress. They also dramatically increase the infiltration and storage of rainfall in the soil by reducing surface runoff[30]. The additional biomass that they provide increases soil organic matter, which enhances both soil moisture storage capacity and nutrient availability to the crops[31]. Moreover, there are circumstances under which some species of trees effectively transfer water from deeper depths, bringing it up to near the soil surface through their root systems, thus making such water available to nearby crops ("hydraulic lift")[32,33,34]. These phenomena reduce the rate of onset of crop water stress, enabling the crop to more successfully withstand periods of drought during the growing season.

A diverse portfolio of trees on the farm can enhance a household's ability to cope with stresses, because the fruits or edible leaves are available at different times during the year. The leaves from several species of trees are used as vegetable protein throughout the year for human or livestock nutrition (e.g. baobab, moringa, and others).

Trees are assets that can be cut and sold for cash or exchanged for goods in times of need. In the Maradi and Zinder Regions of Niger, and where 1.2 million households now sustain medium-to-high densities of tree populations on their farms, tree branches are cut on a continuous cycle for household fuelwood supplies and for sale. Some of the mature trees are also cut down and sold in local wood markets for poles and construction materials. Export markets are now active in buying and shipping wood south to Nigeria. During prolonged drought periods, these tree assets may be gradually liquidated to supply the household with cash for food purchases. This process is an important source of coping capacity for households during prolonged drought[12].

In Niger, Faidherbia trees help to increase crop yields. Photo: World Agroforestry

Trees are important to the livelihoods of dryland households, and they can contribute in many ways to resilience. Income from wood and non-wood tree products can make a significant contribution to rural households' budgets and their food security. The services that trees provide for crop and livestock systems are in many cases even more important, and of higher value, than their direct products alone. Building resilience and improving livelihoods requires an integrated approach. Investment in scaling-up FMNR is now widely seen as an essential component of a basic set of technological options for supporting dryland livelihoods.

Trees of all types have some properties that are beneficial for soil conservation and fertility, chiefly through their root systems, which help to hold soils in place, the litter that falls as mulch, and the organic matter that the roots and litter provide to nourish micro and macro fauna in the soil[9]. Many farmers have known and appreciated these properties for

generations[34]. At the same time, trees can compete with crops in terms of nutrients, water and light. So, farmers weigh the benefits and costs in associating trees with crops and they make decisions on the appropriate tree species, and the optimum densities of these trees to establish in their crop fields. Trees in crop fields may also compete with animal ploughing operations, by imposing additional time and costs. Cultivation with 'clean' fields is often the message that extension agents have conventionally conveyed to farmers[35], a message that needs to be actively disputed based on the positive evidence and experience that now exists in favour of sustaining a more productive tree-crop-livestock system.

Quite a number of tree species have been found to offer significant benefits to soils with relatively little competition with crops. *Faidherbia albida* (formerly *Acacia albida*) is popular in many parts of the Sahel and throughout eastern and southern Africa[36,37]. It fixes atmospheric nitrogen, has a deep rooting system, has a light, open canopy, and it drops its nitrogen-rich leaves onto the soils right as the rainy season begins, and remains dormant during the crop-growth period. This means that it throws minimum shade onto the crop. There are many other useful species for soils as well. These are often the same species that are beneficial as livestock fodder (such as many of the acacia species).

Studies on the effects of fertilizer trees on maize yields found that they often have significant positive effects[37,38,38]. The effects of FMNR on millet and sorghum yields, the major food crops in the Sahel, were found to be between 16% - 30% in Mali, Burkina Faso and Niger, controlling for other inputs and conditions[13]. The limited evidence suggests that while the fertilizer tree systems cannot completely shield crops from some yield losses in droughts, they provide higher yields than when trees are absent[39].

Tree vegetation cover in the drylands may also reduce wind speeds and dust loads. African drylands contribute over 50% of total global atmospheric dust circulation. They have dust concentrations considerably higher than any other region of the world[40]. High child mortality is associated with respiratory illnesses, especially in Africa; this has been partly attributed to exposure to dust[41,42].

How can FMNR be scaled up most effectively?

Empowerment of village communities

Individual farmers can protect and manage trees, but it is more effective if village communities organize themselves to do so, and develop enforceable by-laws for managing the trees. This is what was done by an IFAD-funded project in the Maradi Region, which supported the building of village institutions. Men and women farmers, but also representatives of the herders, are members of the management committee. The committee holds meetings with surrounding villages (inter-village organisation) to foster cooperation in tree protection. They have developed rules and set fines for the illegal cutting of trees. And these rules are enforced. The village of Dan Saga receives many national and international visitors, who come to learn from their experience in landscape management of their village-wide FMNR success. They feel empowered by this outside attention to their technical and institutional innovations.

Forest Policy Reform

The issue of forest regulations which create disincentives for farmers is one that is widespread in the developing world. These include the banning of felling or cutting of a number of species without obtaining a prior permit, at a fee. Violation of such regulations entails a hefty fine, and so farmers will often remove young trees from their land to avoid having to adhere to these rules in the future. Among such regulations, the adverse effects of the Sahelian forest codes have long been recognized[43]. There have been many policy dialogues in the region to try and move reforms forward. Although not initially backed by formal policy change, the recent regreening in Niger and Mali has been attributed to a significant extent by the relaxation of enforcement of such policies[12]. A recent analysis of the forest codes[44] led to recommendations for action[45,46].

There are several institutional-related factors that have been identified as limiting the potential for FMNR, such as fire setting, free grazing and rights and regulations over trees[47]. The use of fire and free grazing systems generate benefits to some local people - in terms of grass regeneration, clearing of debris, catching wild rodents for food, and in the case of free grazing, offering a cheap mechanism for feeding livestock. Thus, it is challenging to deploy institutional reforms that can accommodate the interests of FMNR with these other benefits. However, practices such as controlled fires, rotational grazing areas, and the promotion of livestock corridors are all options that have been successfully implemented in the drylands to facilitate the scaling-up of FMNR.

Market Development for Dryland Tree Products

The existence (or not) of markets for tree products is another factor that impacts on incentives to manage trees. The development of tree product markets will have a positive effect on encouraging tree-based systems in general. For FMNR in particular, market development may have different effects. In general, as tree product markets develop, there is more incentive to maintain trees on farms, as the case of shea in Burkina Faso has demonstrated. There may be further incentives that influence the selection of tree species to retain in the crop fields, based on market signals, but only if market signals -persist for a long enough period of time, since changes in tree species composition is a long-term evolutionary proposition in the drylands. Furthermore, in the semi-arid and dry sub-humid zones where tree planting opportunities are greater, certain types of market development may favour tree planting by farmers and, as a result, may also reduce farmer interest in FMNR.

Continental Recommendations

Recently, there has been a resurgence of interest by the Heads of State of the Sahelian countries in the creation of a Great Green Wall across the continent. At the 1st African Drylands Conference (Dakar, June 2011), scientists presented evidence underpinning the value of an approach based on a grass-roots, participatory engagement of the local rural populations to expand the farmer-to-farmer dissemination of FMNR region-wide. This was supported by the World Bank and the Global Environment Facility, which are now collaborating with each of the Sahelian countries to invest a pool of $1.8 billion dollars to implement land regeneration projects based on these community-based natural resource

management systems and other restoration methods. The declaration of the 2nd African Drylands Week, convened by the African Union in August, 2014, urged that the drylands development community commit seriously to achieving the goal of enabling every farm family and every village across the drylands of Africa to be practicing Farmer-Managed Natural Regeneration and Assisted Natural Regeneration by the year 2025.

At a coarse scale, FMNR should be considered as a recommendation in all geographical regions, and particularly in the semi-arid and dry sub-humid drylands. FMNR will continue to support the largest number of established trees on farms in the drylands. Place and Binam[13] found that over 90% of trees on farms in the Sahelian countries were established by farmer-managed natural regeneration.

Within a particular dryland zone, there may be further nuances on recommendations for how to practice FMNR. For example, certain institutional arrangements, such as improved grazing management may be an important complementary action in some places, while not in others. The types of trees that will be desirable for farmers to retain, as well as the densities of trees, may also differ across locations. For example, where fertilizer use is extremely low, promoting the regeneration of trees which have known positive soil fertility properties will be more important.

Due to the continued expansion of agricultural land in the drylands, FMNR is all but assured to play an ever-important role in overall tree management. It can be considered a 'foundational practice' that is relevant for virtually all farming systems in the semi-arid and dry subhumid dryland zones. It has such a wide recommendation domain because establishment costs are very low. Regeneration has high success rate due to growth from rootstock, and it involves species that are well-adapted to each site environmentally and climatically. The practice can be integrated with the full range of traditional and improved crop and management systems. Other tree-based systems that involve the planting of trees can then be built around the basic FMNR practice, further enriching the species portfolio on the farm. Tony Rinaudo refers to this process as FMNR+.

By contrast, tree planting has more limited niches in the drylands. It is more suited to the semi-arid and sub-humid and humid zones, where rainfall is higher, where there is access to dry season water to be used in tree nurseries (e.g. proximity to low lying wetland areas). Tree planting is further induced where there are attractive commercial opportunities for specific tree species suitable to the drylands.

How to massively scale-up FMNR?

There is growing political support for massively scaling-up FMNR. The African Restoration Initiative (AFR100) of the African Union is now supporting a process of engaging many countries in Africa to restore 100 million hectares of degraded landscapes by 2030. This AFR100 initiative has an audacious level of ambition that can only be achieved if FMNR, led by farmers and their communities will be a dominant component of the effort. No other set of practices could possibly accomplish the job – given the enormous areas of land involved and the limited investment funds available.

Six Steps to Success

The World Resources Institute recently published a report[48] about how to scale up regreening successes. This report builds on and distils the regreening experiences observed in the West African Sahel that was discussed above. The scaling strategy has 6 steps, and some activities under each of the steps.

Step 1 Identify and analyse re-greening successes

There are many smaller and bigger re-greening successes in Africa's drylands. As the examples from Niger and Mali show, re-greening by farmers is often overlooked. Each country should make an effort to identify its re-greening successes, because these can be used as sources of inspiration and as training grounds for farmers who do not yet protect and manage their naturally regenerating trees. It is interesting to note here that farmer-managed natural regeneration occurs in the Sahel, but is also extensively practiced in Ethiopia, and under the higher rainfall sub-humid conditions and the different farming systems practiced in Malawi.

Step 2 Build a grassroots movement

In most countries, donor-funded projects are already promoting some forms of participatory natural resource management, but they are not always working together. The challenge is to get them around the table to create synergies and stronger political leverage in discussions with government about enabling policies and legislation.

Farmer-to-farmer study visits are a very effective way of scaling-up FMNR. In some regions, farmers (men and women) have gained so much experience with the practices that they have become the experts who train other farmers. If it is true that practice precedes policy, then it is important to inform government about the successes, and about the existing dynamics that can accelerate the process on-the-ground.

Step 3 Address policy and legal issues and improve the enabling conditions

Working at the grassroots level only is not sufficient to accelerate the scaling-up of FMNR. The role of national governments is to create forestry legislation and agricultural development policies that induce land users to invest in trees. Current forest legislation tends to show some weaknesses. One of these is that they often do not recognize farmers' right to own, manage and harvest the trees that are established on their land. For instance, in most Sahelian countries, farmers are allowed to exploit and also cut the trees that they have planted, but if they have protected and managed natural regeneration they may need a permit from the forestry service in order to manage or to prune or harvest the tree.

A major weakness that needs to be addressed is that Ministries of Environment tend to be interested in natural forests and in planting trees, but not in the protection and management of natural regeneration; whereas Ministries of Agriculture usually concentrate their extension efforts only on annual crops. However, as soon as funding for agroforestry projects becomes available, turf fights often emerge between both Ministries. The Ministries of Environment then claim that agroforestry is about trees, which is their domain, while the Ministries of Agriculture, which have much stronger extension services, usually have a much greater

capacity to implement such projects, claiming that it is all about farming systems. The solution is the development of inter-sectoral platforms that combine the strengths of both Ministries in the accelerated scaling-up of agroforestry.

Step 4 Develop and implement an effective communications strategy

It is possible to reach out to tens of millions of smallholders by using rural and regional radio stations to spread the messages about regreening, and by linking mobile phones with radio and ICT to make the web more accessible to rural people. The process can be enhanced by inviting national and international journalists to visit re-greening successes. However, at this moment most regreening projects don't have a communication strategy, or if they have one, it is seriously underfunded. The challenge is to inform all land users in a country about what has been achieved, and about what they and their communities can do to participate. Land users themselves should be at the heart of FMNR communication strategies.

Step 5 Develop or strengthen FMNR tree product value chains

This is where the private sector has a major role to play. They can support the development of value chains around the agroforestry products from FMNR. This will put more cash into the pockets of smallholder farmers.

Step 6 Design research activities to fill gaps in knowledge about FMNR

We know enough to move into accelerated action on FMNR scaling-up, but at the same time it is important to fill some important gaps in our knowledge. For instance, too little is known, about the impact of landscape-level FMNR on surface and groundwater hydrology, or about the impact of re-greening on rainfall, on carbon sequestration in biomass and in soils, and on nutrition and food security.

What are the 'next generation' issues and how can they be addressed?

Tree-based systems provide regenerative or restoration effects that are realized at a landscape scale. They cover a wide range of practices that enrich the quality of the land resource, and they provide additional environmental benefits such as watershed protection and enhanced biodiversity. The natural regeneration of trees may be applied across the range of land use types, including farmlands, forests, woodlands, and rangelands. Restoration at scale has been achieved through the efforts of large numbers of rural residents,

Besides environmental conditions, other factors may limit the technical potential of FMNR. There are several other institutional related factors that have been identified as limiting the potential for FMNR, such as fire setting, free grazing, and the rights and regulations over trees. Place and Binam[13] found a large percentage of Sahelian farmers identifying unreasonable forest codes as still a limiting factor (44%), heavy-handedness on the part of forest officers (38%), uncontrolled cutting of trees by outsiders (31%), and animal damage (28%).

Although the scaling up of FMNR in the Sahel has been labelled as farmer-driven with little external support, a number of programs are now investing in the scaling-up of FMNR. These programs are spending resources on enhancing farmer awareness of the benefits of FMNR, building farmer tree management skills, organizing landscape management of grazing and

fire, developing tree product markets, and identifying workable solutions to forest code regulations. The increased rural population, coupled with dwindling woodland, also suggests that woodland management is not an alternative to FMNR, but rather it is a highly complementary activity[49,50].

Policy recommendations for scaling up

FMNR has great potential to reduce vulnerability and increase resilience of households living in the dryland regions of sub-Saharan Africa. This potential is not always appreciated, however, so work remains to be done to change the mindsets of policy makers, development professionals, and even technical specialists such as researchers and extension agents. For many, mixing trees with crops is considered unconventional and to be avoided, yet a growing body of evidence suggests that successfully integrating trees into farming and livestock keeping activities can be extremely profitable, provided the appropriate species and management practices are used.

Key policy factors and proposed action for the mass scaling-up of FMNR are discussed below[25]. They cover aspects of production, value chain development and policies/institutions. Each of the factors is equally relevant whether trees are established through regeneration or through planting.

1. Changing attitudes/mindsets towards the integration of trees in agriculture

The benefits of trees have been well-appreciated by generations of farmers. However, there remain some obstacles towards the better integration of trees on farm, for which there is increasing need given the continued conversion of woodlands into agriculture in the drylands. First, there is renewed interest from agricultural programs to promote conventional crop agronomy --- good seeds, mineral fertilizer and having 'clean' fields using animal traction – where mixing trees with crops has not been typically recommended due to the perception that they compete with crops. This, of course, ignores the positive synergies that trees can have with crops and it also ignores the fact that some trees can provide products of higher unit area value than crops. Second, foresters in most countries continue to implement policies which have adverse incentives on farmers to grow trees on their land. The most common one is the protection of certain indigenous species meaning that they cannot be cut or sold without license and fines are issued for violations. This legacy of being 'forest policemen' instead of tree extensionists continues today.

The conventional mindset permeates the formulation of development programs by governments, and even some NGOs, who then neglect to include trees as part of agricultural development programs, or even discourage the practice. Therefore, this issue is mostly about changing attitudes among organizations that interface with farmers. There is as well the need to alter the mindsets of higher-level policy makers. Many see trees serving only environmental purposes and they fail to recognize the large income-generating roles that trees can play in sustainable agricultural intensification, increased crop production, and livelihood improvement.

Farmers themselves are generally very open and receptive to managing trees on their farms, as they all tend to use trees as part of their farming system. One key issue here relates to attitudes towards women's rights to trees, which are not very progressive in many

communities. If both women and men were able to influence tree management decisions, trees could play a more beneficial role on farms. Lastly, there are other resource users whose main objectives may come into conflict with those managing trees. These include herders and charcoal burners, whose actions regarding grazing/browsing, fire-setting and felling can conflict with successful tree regeneration and management.

Proposed actions include:

(1) Expand the documentation and dissemination of the benefits of FMNR, notably systems that are integrated with crops and livestock.

(2) Increase the documentation and dissemination of the costs associated with onerous forestry regulations.

(3) Intensify advocacy for and implementation of pilots of new approaches for agriculture and forestry that can be jointly monitored.

(4) Deepen the technical support to the designers of all agricultural development programs to be able to better include FMNR among their interventions.

2. Spreading awareness and knowledge of improved or new practices

While farmers have been managing trees for generations, in the drylands more than anywhere else, they are accustomed to the performance of native species which have locally regenerated without significant management. This means that most farmers are unaware of the potential improvement in the productivity of native trees that can be achieved under improved management. They need to be exposed to the different propagation techniques, improved tree germplasm, and using better management techniques for which growth and productivity can be significantly greater than what is observed in the typical landscape.

There are in addition, a range of management options available for soil fertility regeneration, fodders, fruits and timber in the semi-arid and dry sub-humid zones that relatively few farmers are aware of. Extensionists and development organizations (including farmer organizations) themselves are poorly trained in these new techniques, and building this technical capacity should be a focal emphasis of a scaling up program.

Proposed actions include:

(1) Expand the documentation of promising FMNR/agroforestry options and dissemination for awareness creation via many different media.

(2) Regionally, intensify the promotion of FMNR in large development initiatives, like the Great Green Wall of the Sahel.

(3) Broaden the technical training of agricultural and forestry extension agents and development staff to cover FMNR.

(4) Locally, promote FMNR through demonstrations on farmers' fields.

(5) Promote field visits for opinion leaders & farmer leaders to successful FMNR practices on farms.

3. Improving local landscape management – especially grazing management and fire control

In the drylands, a number of resource users apart from farmers have effects on the success of tree-based systems, both on farms and in the woodlands. These include herders, charcoal makers and mammal and rodent hunters. Trees and shrubs are essential sources of feed during the long period of time when there is no fresh pasture or crop stover. While browsing can often be a mutual benefit to the herder and tree owner, it is also recognized by many farmers as a key threat to natural regeneration.

Charcoal makers do negotiate the use of trees, but not all stakeholders are involved in the final decisions, and thus the resulting felling of trees may not be in the community's interest. Hunters use fire as an aid for catching rodents and small mammals with the externality of destroying some vegetation. These practices provide many benefits, and therefore will need to continue. But more progress can be made to protect mature or young trees temporarily from grazing through local enclosures, or to create more incentives for herders to manage livestock away from young fragile trees. This requires investments in dialogues on landscape management among different interest groups.

Proposed actions include:

(1) Expand support for landscape stakeholder meetings to diagnose problems and jointly identify solutions at the landscape level that can benefit communities and manage trade-offs,

(2) Disseminate successful landscape management experiences and models,

(3) Promote the creation or strengthening of local environmental management institutions to undertake improved landscape management programs, and

(4) Develop and enforce local bylaws that influence the behaviour of all land users for the common good.

4. Increasing tenure security

Devolution of ownership of woodlands is least-advanced in Africa compared to other continents. Moving forward on co-management models could enhance both the productivity and sustainability of woodlands in Africa. Tenure on farms is also not well clarified or secure for farmers in the drylands. Many of these lands have not been formally adjudicated either at the community or household levels. This not only creates uncertainty among communities and households, but it also creates conflicts between the state and communities. Dryland areas are often seen as unutilized or underutilized by outsiders, and thus prone to large-scale investments that take little cognizance of local rights and circumstances.

More settled dryland areas normally do offer secure tenure for long term investments, but even there, tree ownership and rights are less clear. This is because of the predominance of natural regeneration, the shifting of fields in and out of fallow, and the fact that some trees have been present for more than 100 years, and thus have entrenched use rights to them. Forest departments in most countries protect many indigenous species which means that they cannot be pruned, felled or marketed without license. These are always indigenous trees, which are among those that regenerate on farmers' fields. This discourages farmers from allowing the trees to grow. And where feasible, farmers will choose not to plant such trees but rather opt for exotic trees that are exempt from such regulations.

Proposed actions include:

(1) Identify tenure insecurities and support negotiations to alleviate them

(2) Support the piloting and eventual change towards smart forest policies that do not create disincentives for farmers to manage trees on their farms and also provide forest departments with new mandates and funding sources

5. Strengthening markets for tree products

Many trends within and outside Africa are favorable for the commercialization of tree products: the new generation of farmers who are much better connected with urban areas and with ICT than their forefathers; urbanization that raises demand for wood, fruits and other products; growing health concerns that increase markets for natural products like gum arabic, baobab, and moringa; more interest in sustainable sourcing of products, more value being now given to farm than forest harvesting of tree products.

At the same a number of obstacles remain in Africa for meeting such increased demand. These include: (1) poor market information systems for tree products, (2) poor rural infrastructure (and particularly in low populated areas such as drylands), (3) a growing but low level of collective action by farmers, (4) low numbers of farmers participating in outgrower schemes, (5) very little investment in basic tree product processing at scale (much done by individual farmers/collectors), and (6) little final finishing of products in-country (and continued imports of furniture and fruit juice ingredients, when raw products are available).

Proposed actions include:

(1) Fund the inclusion of key tree products in market information systems,

(2) Support the development of outgrower schemes between processors/buyers and farmers,

(3) Provide venture capital and support services (e.g. to gain information on preferences of consumers for processed products) for the tree product processing industry.

These policy recommendations are the most common ones needed for FMNR in dryland areas. But the priorities may vary across different geographical locations within a country as market connectivity and local institutions vary[51]. There will be need for much more diagnostic work to identify the most appropriate actions to take. There is no blueprint for promoting FMNR that applies in all dryland areas.

Investments in these areas do not need to be borne primarily by the public sector. Helping to strengthen markets for tree products through engagement with the private sector has been shown to attract and leverage additional finance and awareness generation for FMNR from the private sector in some countries.

The practice of FMNR is not confined to Niger, but it is ubiquitous across the region. In the next phase of supporting the further massive scaling up of FMNR we ought hone in on two things: Encouraging a more optimum age and species distribution of trees on farmlands where FMNR is already being practiced, and focusing our FMNR scaling-up efforts more intensively on those areas where tree cover is still unusually low compared to the average.

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