Adoption of farmer managed natural regeneration in Senegal

Robert Winterbottom, Mike McGahuey & Gray Tappan

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"Successful restoration of agricultural landscapes can be initiated and sustained by smallholders and rural communities."

Introduction

Valuable lessons can be learned from smallholder farmers who have successfully protected and regenerated tree cover across agricultural landscapes in Senegal, with minimal reliance on tree nurseries, seedling distribution or tree planting. In the process, they have restored soil fertility to sustainably increase agricultural production. Analysing how and where this approach has occurred underscores the importance and feasibility of achieving restoration in ways that contribute to improved livelihoods, reduce vulnerability to climate change and other shocks, and restore ecosystem services. This article highlights a relatively low-cost intervention implemented by rural communities with support from development organizations and that could be widely replicated.

Farmer leader practising FMNR in Keur Soce, Kaolack Region. Photo: World Vision, courtesy Chris McMillan

Farmer managed natural regeneration

Farmer managed natural regeneration (FMNR) is transforming the lives of Senegalese farmers, especially in Kaffrine region. Since 2007, instead of cutting back sprouting shrubs and trees while clearing fields for planting, farmers have deliberately pruned coppice shoots, leaving the largest tree stems to grow, and assisting the natural regeneration of trees in their fields.

According to field staff working with World Vision in Senegal, by May 2019, more than 20,000 farmers across 45 communes in Kaffrine, Fatick and Kaolack had been trained in FMNR. Average farm size is about 2 hectares (ha), and most farmers protect and manage some 40 trees per hectare. In 2015, there were 64,000 ha of FMNR in Kaffrine, increasing to 85,000 ha by 2020. The expansion is attributed to farmers' appreciation of the benefits of FMNR, and continued training and extension (pers. comm., C. McMillan, 2020).

A well-adapted response to farmers' problems

Farmers adopted FMNR to increase soil productivity and reduce vulnerability to climatic and other shocks. Population pressure forced many to reduce or abandon fallowing, their traditional means of soil restoration and a safety net in years of crop failure. Table 1 summarizes key soil and climatic threats, and how farmers have used agroforestry to address these challenges.

Table 1. Threats arising from soil degradation, water erosion and drought and the benefits of adopting FMNR and other agroforestry practices as a response.

Threats	Documented benefits from *Faidherbia albida* parklands, FMNR and other forms of agroforestry
Sahelian soils are nutrient poor, with little inherent capacity to retain nutrients and moisture in crop root zones; they are also prone to surface crusting, low infiltration, and high rates of rainfall runoff.	• Increased nutrient recycling from lower horizons to topsoil • Increased soil organic matter that (a) significantly increases the capacity of the soil to retain nutrients and moisture in crops' root zone, thereby increasing fertilizer and rainfall-use efficiencies; and (b) improves soil structure, thereby allowing greater rain infiltration and air flow • Increased populations of soil microbiota that convert complex compounds to nutrients that can be used by crops • Increased nitrogen fixing by leguminous trees
Dry periods of 10-15 days, along with low retention of soil moisture, increase mortality of newly germinated crops, which then require replanting; shortening the growing season and lowering yields.	• Increased soil capacity to retain moisture in crop root zones • Increased shade, which reduces soil temperature and crop transpiration rates • Nightly transfer of water by trees from deeper soil horizons to crop root zones through "hydraulic lifting"
In periods of periodic drought and other shocks (e.g. pests, market changes), rural families face food shortages, whatever farming practices they use.	• Agroforestry products such as fuel wood, fodder, fruits, condiments, poles, fencing and pharmaceuticals are less vulnerable than annual crops to droughts and other shocks; these products are also sold to support domestic necessities, reducing the need for people to migrate in search of work or to sell productive assets (livestock, equipment, land)

Restoration of agroforestry parklands and increasing tree cover across agricultural landscapes clearly help to remedy several critical problems faced by farmers in African drylands.

Benefits and advantages of FMNR

With no reliance on tree nurseries, and no costs for raising, transporting, planting, and fencing planted seedlings, FMNR has many advantages over reforestation through tree planting. The cost of FMNR to increase tree cover on cropland is estimated at US$50 per ha, approximately one-tenth of the cost of planting trees, typically US$500 or more. In addition, there are low survival rates for tree planting. FMNR, on the other hand, takes advantage of existing tree root stocks and vigorous coppicing capacity of native multipurpose trees. Also, investing time and effort in naturally regenerating trees is more attractive for farmers than relying on external assistance for seedling production, transportation, and out-planting, especially as this assistance may no longer be available when projects end. FMNR can also spread following interactions among farmers, with minimal reliance on government forest service agents or other specialists.

FMNR generates tangible and valued benefits for farmers. Pruning rapidly growing shoots and branches from tree stumps provides short-term benefits that are not possible from planted seedlings. In the first year, a farmer can prune and harvest selected branches for fodder and firewood and make green manure from leafy branches to replenish soil organic matter, increasing soil nutrients, soil structure and efficient use of rainfall.

Increased tree cover from FMNR practiced on cropland near Kaffrine. Photo: R. Winterbottom

The most common trees regenerated and managed by farmers practicing FMNR include *Balanites aegyptiaca, Combretum glutinosum, Faidherbia albida, Piliostigma reticulatum* and *Ziziphus mauritiana*. These tree species provide a variety of socioeconomic and environmental benefits, including the production of poles, firewood, fodder, fruit, oil seeds, honey and medicine, improved soil fertility and crop yields. Senegalese researchers measured a 2.5-fold increase in cereal production, from 296 to 767 kg/ha (World Vision 2010). Some farmers have earned an extra CFA100,000–200,000 (US$170–340) annually from selling Balanites oil, Ziziphus fruits, and honey (World Vision 2020).

Increasing smallholder productivity – an important driver of adoption

Research shows that the productivity of Senegal's weathered soils is highly correlated with soil organic matter content (SOM). Traditional soil restoration systems, based on long fallows, allowed farmers to, inter alia, regularly replenish SOM. Population pressure in the 1960s and 1970s, however, forced farmers to reduce or abandon fallows and cultivate continuously. The resulting decline in yields was aggravated by severe droughts in the 1970s that produced a crisis. To increase productivity, the Senegalese government, in collaboration with international partners, increased fertilizer subsidies to encourage fertilizer use as a means to increase productivity. But, over time the yield response to fertilizers declined, demand fell and the continued use of fertilizer, *by itself*, was called into question. Research showed that failure to accompany fertilizer subsidies with ways to increase and maintain SOM levels was a key reason for the failure of fertilizer to be cost-effective (Dancette and Sarr 1984). Absent the multiple services provided by soil organic matter summarized in Table 1, fertilizers will likely perform below their potential on Senegal's weathered soils (Wopereis 2006).

Experience and research show that agroforestry systems provide many of the advantages of fallowing as a soil restoration tool while allowing farmers to continuously cultivate (Felker 1976). This research shows, for example, that the traditional *Faidherbia albida* agroforestry system not only doubled yields and increased the protein content of cereal crops, but significantly increased factors that sustained yield improvements over time.

These factors included more soil organic matter as well as nutrient recycling (Felker 1976).

Researchers also noted that *Faidherbia albida* produced high-quality pods (26–28% seed protein) and leaves for livestock browse (Felker 1976). Pod yields were 105–5,400 kg/ha/year, depending on tree age and density. Farmers feed pods to livestock or sell them in local markets, diversifying household income and reducing vulnerability to shocks.

Until recently, many researchers, agricultural extension agents and government policy makers had largely overlooked the importance of trees and shrubs on cropland in relation to nutrient cycling and other ecosystem functions (Winterbottom et al. 2013). In the past decade, however, researchers have documented how the root system of common shrubs such as *Guiera senegalensis* and *Piliostigma reticulata* move water from deeper soil layers to the crop root zones during the night (Dossa et al. 2012). This "hydraulic redistribution" increases moisture available to crops at critical times in their development cycles (Kizito et al. 2012). Shrubs also add organic matter that contributes significantly to the soil microbial population and stimulates nutrient cycling, helping to drive biogeochemical processes year-round in ways that were not previously recognized by agronomists.

Of the many benefits of agroforestry trees, their role as an efficient delivery system for organic matter may be the most important. Senegal's growing population requires greater yields, which will require more efficient use of fertilizers and rainfall to support the regular replenishment of soil organic matter. Protecting and managing tree regeneration on cropland adds substantial quantities of organic matter in the right place at the right time.

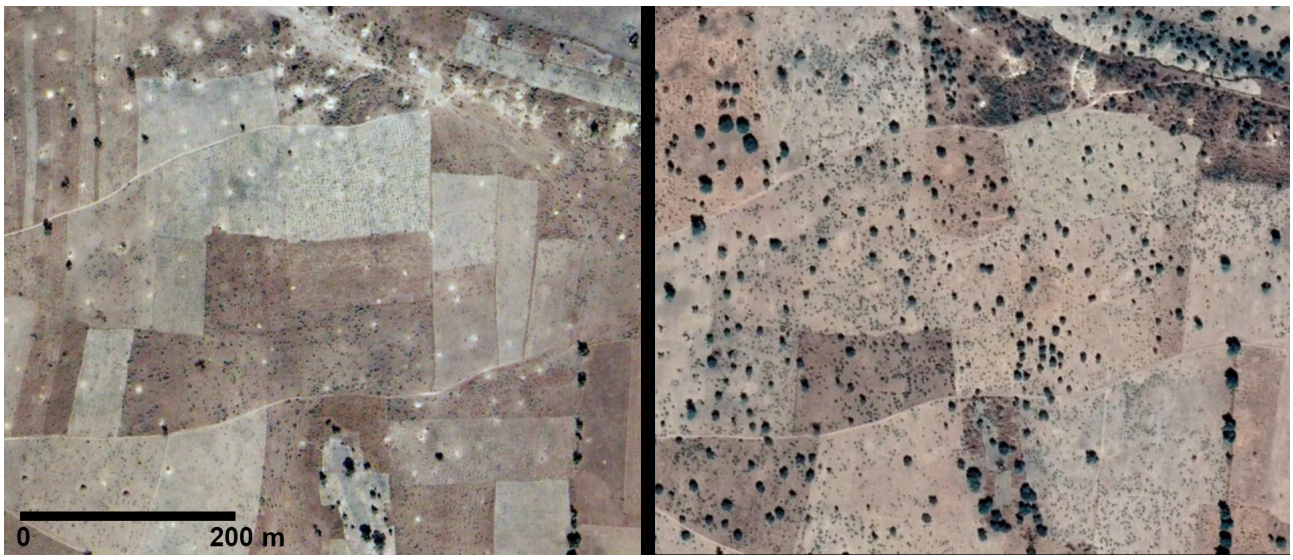
Key interventions to support the adoption of FMNR

For more than a decade, World Vision has supported rural development projects in Senegal to help smallholders increase agricultural production and rural incomes while combatting land degradation and the effects of climate change.

Senegalese farmer excited about describing the benefits of FMNR and keen to share his successful restoration experience with his peers. Photo: R. Winterbottom

These projects initially worked with farmer associations to increase access to fertilizers, and distributed cashew, mango and eucalyptus seedlings. Beginning in 2007, support from World Vision encouraged the adoption of FMNR, including funding for a learning visit that enabled farmers from Kaffrine to talk with those in the Maradi region of Niger and see the extent and benefits of FMNR there. When the Kaffrine farmers returned, they immediately adopted FMNR practices in their fields. When the authors visited several of these farmers in 2011 and 2016, they observed how farmers had enthusiastically embraced the protection and management of natural regeneration in their fields.

National and international development organizations have continued to initiate and accelerate FMNR adoption in Senegal and elsewhere. In addition to international learning visits, key interventions included facilitation of local cross visits between FMNR leader farmers and others in their communities, providing opportunities for farmer leaders to encourage their peers to adopt



A comparative view of farmland east of Korki in December 2002 (left) and January 2019 (right). The dramatic increase in tree cover indicates the active spread of FMNR from farmer to farmer.
Sources: Maxar Technologies with Google Earth

FMNR, and for farmers to learn about and witness the benefits. Peer-to-peer training and awareness raising through community meetings and radio broadcasts also helped to spread the practice, as did periodic field visits with local environmental authorities to monitor and support FMNR adoption. The formulation and adoption of "local conventions" governing the use of land and natural resources encouraged farmers to practice FMNR by addressing problems of uncontrolled grazing, bushfires and wood harvesting. The effective application of decentralization policies and devolution of authority for decentralized natural resource management were critically important for developing local conventions. Support was also provided for training and strengthening of community-based organizations responsible for enforcing local conventions. Mayors and religious leaders also helped to spread FMNR by drawing attention to its benefits and by facilitating the application of local conventions. Finally, institutional reforms within the Senegal Forest Service and changes in forest regulations also played roles in improving the enabling conditions for the adoption of FMNR.

All these activities helped to motivate farmers to adopt FMNR and encourage its spread, seen clearly in time-series remote sensing across Kaffrine and eastern Kaolack regions. The World Vision Senegal programme certainly had a major catalytic role, and an important driver for the continued spread of FMNR has been farmer-to-farmer communication about the tangible benefits that farmers see from parklands of on-farm trees.

Putting FMNR adoption in perspective

The growing adoption of FMNR in Kaffrine, Fatick and Kaolack regions is at the heart of a new and extensive transformation of agricultural land in Senegal that has led to greener, more tree-covered landscapes in the past 10-20 years. This positive development is not unlike the regreening that began in southern Niger in the mid-1980s, a phenomenon that led to the success story that it is today (Reij et al. 2009; Pye-Smith 2013). These regions in Senegal belong to what is called the "new peanut basin" owing to the recent expansion of rainfed cropland from the original peanut basin. Together with a wave of charcoal production from the 1960s to 1990, the cropland expansion severely degraded wooded savannas on the plateaus and the broad valleys (Tappan et al. 2004; Stancioff et al. 1986). At that time, many farmers deplored the loss of trees and the many benefits that they provide. Tree cover began to increase a decade ago when positive results from FMNR became evident in the fields of early adopters. It is instructive to take a closer look at the changes in the FMNR fields and adjacent ones over the past 18 years using time-series imagery.

Images above present cropland that includes the fields of a farmer who actively began practising FMNR in 2008 upon returning from his visit to Niger. His fields are 1 km east of Korki and 16 km west of Kaffrine city. Most neighbouring farmers did not participate in the visit to Niger but heard about it from the few who went. The paired satellite images show the dramatic change in the density of field trees, from 0.4% tree cover in December 2002 (left) to 5.2% in January 2019 (right), a 13-fold increase. This area of farmland in Senegal now has a tree density equivalent to areas where FMNR has been adopted in southern Niger.

Conclusions

Based on experiences in Senegal and elsewhere across the Sahel, successful restoration can be initiated and sustained by smallholder farmers and local communities. Mobilizing support for cross-visits and farmer-to-farmer exchanges has been especially important in motivating behavioural changes. Support for peer-to-peer training about FMNR and other improved natural resource management practices have also been crucial in enabling smallholders to overcome the biophysical constraints of dryland agriculture, including weathered and leached soils, loss of soil organic matter, highly variable rainfall, and high rates of runoff. Additional capacity building and training in institutional development and enterprise management, and support for decentralized land-use planning, participatory forest management and tenure policy modifications have also been important.

The path to success includes taking steps to strengthen local governance and diversify local economies. The full participation of key stakeholders in community-based land-use planning is essential, together with the devolution of authority to local communities to enable the formulation and local enforcement of rules governing access to and use of natural resources. For restoration to be fully successful requires that stakeholders work together to market the products of protected and managed trees across agricultural landscapes, while providing for equitable benefit distribution (Dororetz et al. 2014). Institutional and regulatory reforms are also needed to establish more favourable enabling conditions, and to provide programme support that addresses factors related to community organization, governance and other aspects highlighted in this example of successful restoration. Using such experiences can clearly inform the required changes, shorten the process, and lead to more effective reforms (Reij and Winterbottom 2015).

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Authors: **Robert Winterbottom**, *Fellow, Global Evergreening Alliance; Stoddard, New Hampshire, U.S.*
Mike McGahuey, *Fellow, Global Evergreening Alliance, Arlington, Virginia, U.S.*
Gray Tappan, *Geographer, US Geological Survey, EROS Center, Sioux Falls, U.S.*

Editors: Nick Pasiecznik and Chris Reij
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Cover photo: Senegalese farmer practicing the technique of farmer managed natural regeneration by pruning smaller coppicing shoots of *Piliostigma* shrubs to favour regrowth of the main stem and increase tree cover on his cropland. Photo: R. Winterbottom

ETFRN
c/o Tropenbos International
P .O. Box 232,
6700 AE Wageningen,
the Netherlands
etfrn@etfrn.org
www.etfrn.org