Re-Greening the Sahel

Farmer-led innovation in Burkina Faso and Niger

Chris Reij, Gray Tappan, and Melinda Smale

The Sahel—the belt of land that stretches across Africa on the southern edge of the Sahara—has always been a tough place to farm. Rainfall is low and droughts are frequent. The crust of hard soil is, at times, almost impermeable, and harsh winds threaten to sweep away everything in their path. Over the past three decades, however, hundreds of thousands of farmers in Burkina Faso and Niger have transformed large swaths of the region's arid landscape into productive agricultural land, improving food security for about 3 million people. Once-denuded landscapes are now home to abundant trees, crops, and livestock. Although rainfall has improved slightly from the mid-1990s relative to earlier decades, indications are that farmer management is a stronger determinant of land and agroforestry regeneration.

Sahelian farmers achieved their success by ingeniously modifying traditional agroforestry, water, and soil-management practices. To improve water availability and soil fertility in Burkina Faso's Central Plateau, farmers have sown crops in planting pits and built stone contour bunds, which are stones piled up in long narrow rows that follow the contours of the land in order to capture rainwater runoff and soil. These practices have helped rehabilitate between 200,000 and 300,000 hectares of land and produce an additional 80,000 tons of food per year. In southern Niger, farmers have developed innovative ways of regenerating and multiplying valuable trees whose roots already lay underneath their land, thus improving about 5 million hectares of land and producing more than 500,000 additional tons of food per year. While the specific calculations of farm-level benefits are subject to various methodological and data limitations, the order of magnitude of these benefits is high, as evidenced by the wide-scale adoption of the improved practices by large numbers of farmers. Today, the agricultural landscapes of southern Niger have considerably more tree cover than they did 30 years ago. These findings suggest a human and environmental success story at a scale not seen anywhere else in Africa.

The re-greening of the Sahel began when local farmers' practices were rediscovered and enhanced in simple, low-cost ways by innovative farmers and nongovernmental organizations. An evolving coalition of local, national, and international actors then enabled large-scale diffusion and continued use of these improved practices where they benefited farmers.

A History of Drought and Land Degradation

The Sahel, one of the poorest regions in the world, has long been plagued by droughts. The 1968–73 drought caused the deaths of not only many people but also large numbers of animals and trees—a human, economic, and environmental crisis with effects that lasted for years. Groundwater levels plummeted, yields for staple crops—sorghum and millet—declined, and families began leaving the region *en masse*. Most farm households were unable to satisfy half of their annual food needs through their own production nor could they meet the deficit through food purchases.[1]

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Zai techniques improve soil fertility

During the 1960s and 1970s, foreign aid donors carried out two major projects in Burkina Faso's Yatenga Province—the heart of the country's densely populated Central Plateau—to build earthen bunds designed to reduce soil erosion over thousands of hectares. Conceived without the involvement of local people, however, the projects did not meet farmers' needs. Indeed, farmers failed to maintain the bunds or deliberately destroyed them, and the bunds soon disappeared. Meanwhile, the surface of barren land on the Central Plateau expanded inexorably, and empty, encrusted fields extended across significant parts of the region. Useful tree species were lost, and little natural regeneration occurred. As the landscape was denuded and exposed to severe water erosion, the land and the people became increasingly vulnerable to drought.

The devastating agroenvironmental trends in the Sahel were also weakening the social fabric. Entire families left the region to settle elsewhere, or husbands migrated to coastal countries to earn income, leaving their families behind during increasingly long periods. By 1980, for many farmers, the choice was simple: claim back their land from the encroaching desert or lay down their tools and leave.

Planting Pits and Stone Bunds in Burkina Faso

Around 1980, several farmers close to Ouahigouya, the capital of Yatenga Province, began experimenting with traditional planting pits. To reclaim severely degraded farmland that water could not penetrate, farmers would dig a grid of planting pits (also known as *zaï*) across the rock-hard plots. Their innovation was to increase the depth and diameter of the pits and then add organic matter, such as manure, to the bottom of the basins.

Planting pits improve soil fertility and agricultural production in several ways. They concentrate both nutrients and water precisely where they are needed. Farmers add manure to the pits, which also capture windblown soil, leaves, and litter. Termites are attracted to the organic matter, digging channels that enhance soil architecture as well as water infiltration and retention. By digesting the organic matter, the termites also make nutrients more easily available to the plant roots. The planting pits retain water for long periods of time, allowing crops to survive dry spells. And because farmers can dig the pits during the dry season, they do not have to wait until the rains come to prepare the land for planting. The technique allowed farmers to effectively raise their yields from virtually nothing to 300 to 400 kilograms per hectare in a year of low rainfall, and up to 1,500 kilograms or more per hectare in a good year.[2]

The use of new and improved planting pits spread rapidly, even though the government's agricultural extension service had been crippled by economic reforms and refocused to the country's cotton-growing regions. Several farmer-innovators were central to this process. In 1984, for example, a farmer named Yacouba Sawadogo began organizing semiannual market days to promote planting pits. At the market days, farmers brought a sample of the crop varieties they had cultivated in their *zaï*, deposited seeds with Yacouba, and then later selected the seeds they wanted to plant that season. Initially small, by 2000 Yacouba's market days involved farmers from more than 100 villages. In 1992, a farmer named Ousseni Zoromé began a "*zaï* school," training local farmers on a gravelly site next to the road. When the crop grew, the effort attracted the attention of the minister of agriculture. By 2001, Zoromé's network consisted of more than 20 schools and 1,000 members, with each group charged with rehabilitating its own piece of degraded land. Another farmer, Ali Ouedraogo, trained individual farmers in villages around Gourcy and visited regularly to work with them in their fields and exchange ideas. His students trained other farmers in improved *zaï* techniques and some of the students then experimented with their own techniques.

Over time, and because of these knowledge exchanges, farmers improved and adapted the pits to their own needs. Some farmers used the pits to intensify cereal production, others to produce trees, and others to combine cereal and tree production. Farmers vary the number of pits per hectare and pit dimensions as well as the quantity of organic matter added to the planting pits.

Another innovation based on a traditional farming practice was taking place in this region in the late-1970s and early-1980s. Farmers in Yatenga Province, with support from Oxfam, a nongovernmental organization, began building stone contour bunds to harvest rainwater. For optimum results, the lines of stone had to follow an imaginary line running along land of equal elevation. Around 1980, the development of a simple tool for measuring water levels ensured correct alignment of the contours, something that farmers had been unable to do in the past. The level cost US$6 to make and could be mastered in a day or two by farmers with no reading or writing skills.[3]

The new design allowed runoff to spread evenly through the field and trickle though the small holes in the stones, slowing runoff and causing water to infiltrate the soil. The practice improved the soil by trapping sediments and organic matter within the plots instead of allowing them to wash away with the rain.

These techniques for rehabilitating farmland spread widely among farmers: the total area rehabilitated over the past three decades is estimated to be between 200,000 and 300,000 hectares. The additional food produced on this land helps feed about 500,000 people.[4] A recent study shows that in villages where these soil and water-conservation techniques have long been present, 72 to 94 percent of the cultivated land has been rehabilitated with one or more conservation techniques.[5]

Increasing the Number of On-Farm Trees in Niger

At about the same time, in neighboring Niger, farmers were also putting new twists on old techniques. For centuries, farmers in Sahelian Niger had managed their woodlands to produce continuous harvests of trees. In the 1970s and 1980s, however, they faced significant tree losses from drought and human population pressures. In the early-1980s, they started experimenting with a process known as farmer-managed natural regeneration (FMNR)—a low-cost way of growing and reproducing trees and shrubs that provides useful food, fuel, or fodder.

The original model for FMNR was developed by Tony Rinaudo of Serving in Mission, an international missionary organization. The model grew out of his observation that underneath farmers' cleared fields lay extensive webs of living tree roots and stumps that were continually throwing up new shoots and stems. Here was an invaluable source of new tree stock—a virtual nursery.

Rinaudo and local farmers developed an effective way of regenerating these trees. First, from among the mature root systems in the field, farmers would choose tree stumps based on the usefulness of the species. They would then select the tallest and straightest stems to protect on each stump and remove the rest. Thereafter, they would regularly prune the selected stems to promote their growth and the production of food, fuel, or fodder, while removing new, competing stems as needed. Periodically, they would harvest one of the original stems and choose a newly sprouting stem as a replacement. Farmers could then grow other crops between and around the trees. The techniques were flexible, and farmers adapted them to their own situations and objectives.

Rinaudo, knowing the value of trees to farmers, offered food to farmers during the droughts of 1984 and 1985 in return for protecting on-farm natural regeneration. Many farmers immediately did so, but when food aid stopped, few continued to protect and manage their trees. Those who had cut their trees soon observed the benefits of FMNR, however, and the technique spread.

The trees generated a range of benefits. They reduced wind speed and evaporation. In the 1980s, crops had to be replanted three or four times as they were covered by windblown sand, but today farmers typically plant only once. The trees produce at least a six-month supply of fodder for livestock, and they provide firewood, fruit, and medicinal products that farm households can consume or sell. Moreover, certain tree species, such as the winter thorn acacia (*Faidherbia albida*), enhance fertility by adding nitrogen in the soil.[6]

Many villages now have 10 to 20 times more trees than 20 years ago.[7] In the area where the Serving in Mission project took place, 88 percent of farmers practiced FMNR in their fields, adding an estimated 1.25 million trees each year.[8] Surprisingly, the highest tree densities were found

in areas of high rural population density, where one might expect denuded landscapes. Moreover, many of the trees are young and, thus, still increasing in density and cover.

Boosting Crop Production and Improving Food Security

Because these practices were driven primarily by farmer innovation over three decades, involved many dimensions of impact, and included numerous interventions by nongovernmental organizations and donors, assessing their impacts quantitatively is more difficult than would be the case for single, formal agricultural development projects or programs. Nonetheless, on-the-ground studies, supported by aerial photography and satellite imagery, attest to the magnitude of their success.

Researchers examining the impacts of contour stone bunds and *zaï* have found increases in cereal yields, varying from 40 percent to more than 100 percent.[9] One study of 17 sites rehabilitated with stone bunds found that cereal yields averaged almost 800 kilograms per hectare—325 kilograms per hectare higher than the average yield on control plots.[10]

Zaï alone usually have a greater impact on yields than stone bunds alone, but farmers reap the greatest returns from using both together. And farmers who also used at least five tons of manure per hectare achieved even higher yields, harvesting 1,000 to 1,250 kilograms per hectare.[11]

Farmers in the Central Plateau of Burkina Faso have rehabilitated at least 200,000 hectares of land using these techniques. If cereal production increased by an average of 400 kilograms per hectare—a conservative estimate—farmers have increased their annual harvest there by 80,000 tons, or enough to feed about 500,000 people. With these increases, farm households that suffered from food deficits of six months or more during the early-1980s have been able to reduce their deficit periods from six months to two or three months, or to zero in some cases.

Using satellite imagery, researchers at the United States Geological Survey have been able to identify where tree densities and tree cover in Niger have increased over time and where these changes are likely attributable to FMNR. Estimates from high-resolution images acquired during 2003 to 2008 peg FMNR at nearly 5 million hectares.

Improving soil fertility through rehabilitation of degraded lands

Because of FMNR, farmers in Niger are producing an estimated additional 500,000 tons of cereals a year. This additional production covers the requirements of 2.5 million people out of a total population of about 15 million in 2009. FMNR also has an indirect impact on food security through tree crop products, which farmers can harvest and sell in local markets. Moreover, despite a near-doubling of the population since 1980, Niger has been able to maintain per capita production of millet and sorghum, which make up more than 90 percent of the typical villager's diet. Per capita production remained at approximately 285 kilograms between 1980 and 2006.[12]

A New Agricultural Landscape

The land management techniques adopted by farmers in Burkina Faso and Niger have changed barren agricultural landscapes in those countries into complex agricultural systems with more vegetation and more varied vegetation. In the Central Plateau of Burkina Faso, rehabilitated plots have an average of 126 trees per hectare, compared with 103 trees per hectare on control plots. Moreover, the trees on rehabilitated land are larger and represent a wider range of species.[13] The level of water in wells has improved significantly since land rehabilitation started, and farmers have created small vegetable gardens around several

wells, adding to their incomes and improving nutrition. Increased water recharge appears to result from increases in rehabilitated lands and not from increases in rainfall.

Although millet and sorghum remain the dominant crops in Burkina Faso, farmers are also increasingly growing cowpea and sesame. In some villages, they have begun reintroducing small plots of cotton on rehabilitated land. More on-farm trees and more livestock also add to diversity. With their increased supplies of fodder and crop residues, farmers can keep livestock closer to their fields, contributing to more intensive and profitable livestock production. In turn, livestock produce manure that can be used to improve soil fertility. Twenty years ago, most manure was used as a source of domestic energy, but now it is largely returned to the fields. In many places, a market has sprung up for manure, as well as for transporting manure by donkey cart.

These developments have also brought changes in how rural people earn their livelihoods. After the harvest, men once commonly migrated to urban areas for employment, but some indicators suggest that this pattern is changing as more men remain in the villages where they can now earn sufficient incomes from agriculture.

In recent years, the changed landscape has also been critical to managing crises. Between October 2005 and June 2006, when much of Niger was facing a food crisis caused by drought compounded by other factors, including the export of cereals to the urban markets of northern Nigeria, villages that had protected and managed natural regeneration were much less affected by the food shortages than villages that had not.

Sahelian women may have gained the most from the land rehabilitation techniques. The innovations have greatly improved the supply of fuelwood over the past 20 to 30 years, allowing women to reallocate the time once spent on collecting fuelwood to other activities, including producing and preparing food and caring for children. Women in the Zinder Region who own baobab trees also earned substantial annual income (up to $210) from the sale of tree leaves used to make sauce for the daily porridge.[14] Farmers report that women involved in FMNR have a stronger economic position and better capacity to feed their families a nutritious, diverse diet.

Lessons for Policy and Practice

These stories are among the first examples of the success of poor farmers in enhancing food security while adapting to climate change. Therefore, they carry important lessons about effective partnerships for agricultural development.

First, innovation by local people ("barefoot science") is as important as cutting-edge research. The most successful innovations are often simple, low-cost improvements on practices that are already locally available and known to farmers.

Second, a single technique or practice alone is generally not enough to achieve meaningful environmental and economic impacts but can act as a trigger for other innovations. Where farmers undertook multiple innovations simultaneously, they accomplished more rapid environmental improvements because soil, water, and vegetative regeneration proved to be mutually reinforcing.

Third, a single menu of technical options can be adopted on a large scale, but to achieve this, the menu must be flexible, adaptable, and testable by farmers under their own social, economic, and environmental conditions. Farmers can then choose the practices that best meet their needs.

Fourth, in resource conservation, individual farmers adopting innovations on single fields or farms can achieve impacts, but when communities work together collectively, they will produce more sustainable benefits.

Fifth, farmers are more likely to adopt resource conservation innovations if at least one innovation or component provides significant benefits in the first or second year.

Finally, spreading technical innovations requires coordinated, flexible configurations of actors. In Burkina Faso and Niger, the widespread dissemination of innovations resulted from long-term collaboration between individual farmers, farmer groups, local and international nongovernmental organizations, bilateral and multilateral donors, and national governments. In the Sahel, the projects that became successes tended to start fairly small in scale and to closely involve local farmers in designing technical solutions. Charismatic leaders, both local and from outside the community, stimulated change through their own choices and actions and provided personal role models for others. In a number of the stories

recounted, leaders were willing to take socially risky actions that diverged from customary behavior. These types of strong local leaders will need to play a large role in tackling tough conservation problems.

Conclusion

In 1980, no one would have predicted the extent of re-greening in the Sahel today. Farmers in Burkina Faso and Niger have found low-cost ways of intensifying agriculture that allow production to grow along with population. Studies of these projects refute the popular perception that because dryland environments are difficult and market infrastructure is often lacking, investing in them does not pay. Moreover, the longevity of these innovations—two to three decades—attests to their social and political sustainability.

These techniques alone will not solve all problems. Some of the techniques require a great deal of labor, and in the case of stone bunds, funding from outside the community is often required to purchase the necessary quantity of stones and cover the high costs of transporting them. They are most effective under specific environmental conditions. *Zaï*, for example, function best in areas with rainfall between 300 and 800 millimeters.[15] Yet these innovations are important tools to help crop production in the Sahel address the needs of a burgeoning population. And the process by which these innovations emerged—through experimentation, exploration, and exchanges by and among farmers themselves—is possibly the most vital lesson learned from the Sahel.[16] ■

NOTES

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