Facilitating, Enabling, and Triggering Sectoral Transitions: the Sahel

Case Study 11. Improving Water Availability and Restoring Soil Fertility in the Sahel

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Context

Soils are the dominant terrestrial sink for carbon, containing three times as much CO_2 as plant biomass above the ground (Manning 2008). They also act as a host for both organic and inorganic CO_2—as soil organic matter and pedogenic carbonates, respectively—by sequestering CO_2 through photosynthesis. As such, soils have an important role to play as passive agents in removing atmospheric CO_2, similar to the role of reed beds in cleaning contaminated waters. Agroecosystems can degrade and deplete soil organic matter levels, but this carbon deficit opens up the opportunity to store carbon through new land management practices, and in turn, mitigate climate change (Lal 2004).

This is particularly important in the Sahel, where agriculture is a large source of employment and economic activity (table 3.2). The sector represents 40 percent of GDP for Burkina Faso, Chad, Mali, Mauritania, and Niger combined, and employs almost three-quarters of the workforce. Many households—particularly poorer ones—depend on farming for their livelihoods and food security. Agriculture is mainly smallholder subsistence dryland farming and is extremely dependent on highly variable seasonal rainfall due to limited irrigation.

TABLE 3.2 Selected Indicators for Countries in the Sahel, 2021

	Income classification	GDP per capita (current $)	Population (millions)	Land area (millions km²)	Agriculture employment (% of total employment)	International poverty rate (% living on > $1.90 a day)	Human Development Index (0–1)
Burkina Faso	LIC	953.1	21.5	0.3	76.2	30.8	0.452
Chad	LIC	666.4	16.9	1.3	75.1	37.8	0.398
Mali	LIC	885.2	20.9	1.2	62.4	17.6	0.434
Mauritania	LMIC	1735.8	4.8	1.0	30.8	6.0	0.546
Niger	LIC	569.8	23.3	1.3	72.5	41.8	0.394

Sources: World Bank 2022f; UNDP 2020.

Note: Population and agriculture employment (modeled International Labor Organization estimate) show most recent available values (2018). Estimated poverty rate is based on the most recent value using 2011 purchasing power parity. Human Development Index ranks are from the 2020 Human Development Report with 2019 data from 189 countries. The index is the geometric mean of health, education, and income index with a value between 0 and 1, where a value above 0.800 = very high, 0.700–0.799 = high, 0.550–0.699 = medium, and under 0.550 = low. GDP = gross domestic product; km² = square kilometer; LIC = low-income country; LMIC = lower-middle-income county.

Although structural transformation is required to diversify household income sources, reducing poverty will also require improved agricultural productivity. Due to the dominance of agriculture as a source of income for rural households and the slow pace of structural transformation, short- and medium-term opportunities for growth and poverty alleviation are primarily in the agricultural sector. Yet, productivity in agriculture remains low. For example, in Burkina Faso, where most farmers produce food crops, productivity remains low despite the relatively large average land and livestock holdings. This could be a result of poor access to domestic and international markets, low rates of commercialization, credit and liquidity constraints, frictions in the labor and land markets, or information gaps (De Janvry, Sadoulet, and Suri 2017; Udry 1996).

Access to productive soil and water are two of the main barriers to increasing and ensuring more equal distribution of agricultural productivity in the Sahel. In Burkina Faso, 97 percent of farmers have access to land, and the average size of land holdings is relatively large and equally distributed, although formal ownership is limited. This distribution and the unequal level of agricultural productivity suggest that the size of landholdings is not the primary driver of income inequality. Instead, factors such as soil quality and access to water and markets are more critical. Households have limited access to irrigation, so rainfall conditions are strong predictors of yield, and low and irregular precipitation patterns mean income risk is high (Hill et al. 2019).

Climate change will exacerbate income risk if agricultural productivity does not increase. The latest Intergovernmental Panel on Climate Change (IPCC) report warns that drought frequency, duration, and intensity will likely increase in Africa, particularly in the Sahel (IPCC 2022). In 2030, researchers estimate that 250 million people could live in an African region with high water stress. In turn, climate change will impact yields. One study estimates that sorghum and maize yields in the western Sahel will decline by 1.5 percent on average at 1.5°C global warming and by 4 percent at 2°C global warming (Faye et al. 2018). Although irrigation, which currently represents less than 1 percent of cultivated land, could be a solution, labor market failures may limit adoption in the medium run (Jones et al. 2022), and eventual adoption may increase competition and tensions over scarce water. Indeed, the Sahel is one of the most water-stressed regions in the world, with an unevenly distributed water supply that crosses national boundaries.

Policies

Policies to improve agricultural productivity do not always lead to long-term sustainable solutions to low productivity. For example, current policy mixes often include significant spending on fertilizer subsidies. The impacts of fertilizer subsidies are not straightforward. Indeed, although subsidies are often targeted to poor households, the usual fertilizer mix has negative crop returns if unsubsidized. The benefits of using fertilizer are also compromised by extreme weather conditions, such as floods or

droughts, making fertilizer use nonprofitable in bad weather years (Dercon and Christiaensen 2011). As a result, fertilizer subsidies could amplify, rather than reduce, households' income risk. Subsidies also do not address the long-run challenge of poor-quality soils and can lead to emissions of significant amounts of nitrogen dioxide.

To address low agricultural productivity, in the Sahel, farmers use low-cost, efficient traditional practices, such as agroforestry and conventional rainwater harvesting techniques, to capture rainfall, reduce runoff, and restore soils, as well as some of the following interventions.

- Stone bunds: an innovation developed from traditional farming practices. In the late 1970s, farmers in Burkina Faso's Yatenga Province built stone contour bunds following imaginary lines of equal elevation to harvest rainwater. These walls slow water runoff and increase water infiltration in the soil, trapping sediments and organic matter and allowing soils to regenerate. In the 1980s, the development of a simple cost-effective tool to measure water levels made designing the contours accessible to those with no or little education.
- Zaï holes: originating in the same region as stone bunds, farmers traditionally dug a grid of planting pits to reclaim severely degraded land that the water could not penetrate. In the 1980s, farmers perfected this technique by optimizing the depth and diameter of the holes and adding organic matter to the bottom. The resulting planting pits retain water for extended periods and concentrate nutrients where the plants' roots are, allowing crops to survive dry spells and soil quality to improve.
- Half-moon structures: similar to zaï holes, but large and shaped as a semicircle. This shape makes them appropriate for sloped land with severely degraded soil in Niger (Aker and Kelsey 2021).
- Farmer-managed natural regeneration: a low-cost practice for growing trees and shrubs developed in Niger in the 1980s. Tony Rinaudo, a member of an international missionary organization, and local farmers developed an effective way to regenerate selected tree roots that lay underneath cleared fields, selecting the best stems and protecting them by removing competing stems. The resulting trees produce fodder, fuelwood, or food, protect neighboring crops by reducing wind speeds and evaporation, and sometimes enhance soil fertility by adding nitrogen in the soil (Reij, Tappan, and Smale 2009).

Information and training help expand the adoption of low-cost, efficient solutions. Despite the efficiency of the zaï hole and stone bund practices, only one-third of Burkina Faso's farmers practice such anti-erosion measures on their land. Evidence shows that knowledge building is critical to increasing the adoption rate of traditional techniques. In Burkina Faso, the use of zaï holes has expanded thanks to the engagement of a few influential farmers who organized market days, created a "zaï school," or developed a network of trained farmers in their region. A study in Niger using a randomized control trial shows that informational barriers are a major constraint to adopting half-moon

techniques, and that training farmers increases the share of adopters by 90 percent on average, with the addition of cash transfers making no difference to the rate of adoption. The study also finds that trained farmers continue to transmit this knowledge to their neighbors up to three years after the initial training and are 50 percent more likely to have neighbors adopting the technique than farmers who were not trained. This evidence suggests that information campaigns and training are cost-effective ways to boost the adoption of profitable and accessible technologies.

Results and Impacts

Not only do traditional agricultural practices significantly increase agricultural productivity, they also improve soil quality. In Niger, farmer-managed natural regeneration increases yields by 16 to 30 percent (Matlon 1985), and adopting this practice increased tree cover by nearly 5 million hectares between 2003 and 2008. Similarly, in Burkina Faso, adopting the zaï holes technique increases yields by 300 to 400 kilograms per hectare in low rainfall years and by up to 1,500 kilograms per hectare in good rainfall years. Over the past three decades, 200,000 to 300,000 hectares of land have been rehabilitated thanks to this technique. Adopting stone bunds also increases yields by around 300 kilograms per hectare, and farmers can get even higher returns by combining zaï holes, stone bunds, and fertilizer use. In Niger, adopting the half-moon techniques has been found to increase yields and reduce land turnover. Trained households cultivated an additional 0.3 hectares of rehabilitated land by the third year after training.

These traditional land management practices contribute to climate change mitigation and improved resilience. Rainwater harvesting, crop rotations, and agroforestry increase soil carbon sequestration at the respective estimated rates of 839, 378, and 1,359 per kilogram per hectare per year in Africa (World Bank 2012). Not only does this mitigate climate change, but the resulting higher soil organic content improves the resilience of crops, which is crucial for climate adaptation and food security. The associated increase in productivity also allows farmers to reduce their use of chemical fertilizers, further contributing to climate mitigation. Indeed, chemical fertilizers are the third most significant contributor to total non-CO_2 agricultural emissions after enteric fermentation and livestock manure (FAO 2018).

Supporting traditional agricultural practices can alleviate poverty, reduce income risk, increase climate resilience, and empower women. Given agriculture is the primary source of income for many poor households, the increased agricultural productivity associated with traditional farming practices could improve welfare and, in turn, lift people out of poverty. For example, a study in Niger estimates that farmer-managed natural regeneration increased cereal production by 500,000 tons a year, covering the needs of 2.5 million people, or 10 percent of the population. Traditional agricultural practices also weaken household reliance on precipitation, allowing them to harvest rainfall and improve soil quality. This reduces their income risk to weather shocks, which is even

more critical as climate change and extreme weather events become more severe and frequent. Some agricultural practices can also contribute to women's empowerment—for example, farmer-managed natural regeneration of firewood-producing trees lifts the burden of collecting firewood, which traditionally falls on women.

Key Takeaways

Low-cost technologies and practices can improve soil quality and agricultural household incomes, reduce risk, and contribute to climate change mitigation. Such interventions, which support the productivity of a wide variety of crops, are increasingly used, but a large share of households still do not use them, suggesting there are constraints to adoption that need to be overcome. One of these is the lack of information and knowledge, which appears to be a small constraint to overcome, given the large potential benefits.

Providing high-quality extension services at scale can be challenging and is not as easy as subsidizing inputs. Scaling up depends on a combination of awareness building, providing technical information, social learning, and motivation, underlining the importance of implementation partners. Stakeholders who benefit from current input subsidy schemes are also resistant to reform, challenging a shift from a model of production support via input subsidies to one based on extension.