Healthy Soils, Strong Roots

Water Smart Agriculture for Climate Resilience in Rural Mesoamerica

EVIDENCE FROM THE FIELD

CLIMATE CHANGE IS CREATING A GROWING HUMANITARIAN CRISIS IN RURAL CENTRAL AMERICA AND SOUTHERN MEXICO. WATER SMART AGRICULTURE PROVIDES A PATHWAY TO RESILIENCE, ECONOMIC OPPORTUNITY, AND ROOTEDNESS FOR MILLIONS OF MESOAMERICANS.

An increasingly extreme and variable climate threatens the food security and livelihoods of millions of rural farm families in Central America and southern Mexico. Current trends of increasingly irregular rainfall, more frequent and intense drought, and intermittent extreme precipitation events and storms are predicted to worsen over the next decades as the region becomes significantly hotter and drier.[1] Cumulative climate-related shocks over the last decade, including severe droughts (2014, **2015**, 2016, **2018**) and tropical storms and hurricanes (2011, **2020**) have caused devastating crop loss and widespread food insecurity in many rural communities.[2]

The effects are especially grave in the Dry Corridor, a large region of dry tropical forest running north to south along the Pacific side of Central America and into southern Mexico. Most of the region's estimated 2.3 million smallholder farmers live in or adjacent to the Dry Corridor, which has been defined as one of the world's most susceptible areas to increasing climate variability.[3] Over the last decade, as many as 3 million Central Americans have required emergency food aid at one time or another due to climate shock-induced crop loss.[4]

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[1]Harvey et al. *Climate change impacts and adaptation among smallholder farmers in Central America*. Agriculture and Food Security (2018); Hannah et al. *Regional modeling of climate change impacts on smallholder agriculture and ecosystems in Central America*. Climatic Change 141, 29–45 (2017).

[2]FAO. *Chronology of the Dry Corridor: The impetus for resilience in Central America. Agronoticias: Agriculture News from Latin America and the Caribbean*. http://www.fao.org/in-action/agronoticias/detail/en/c/1024539/ (2017); FAO. *Drought causes crop losses in "Dry Corridor" in Central America - Global Information and Early Warning System Update*. http://www.fao.org/3/CA1321EN/ca1321en.pdf (2018); FEWS NET. *Central America and the Caribbean Special Report.* https://fews.net/central-america-and-caribbean/special-report/march-2021 (2021).

[3]FAO. *Small Family Farms Data Portrait*. http://www.fao.org/family-farming/data-sources/dataportrait/farm-size/en/ (2020); van der Zee Arias et al. *Caracterización del Corredor Seco Centroamericano - Países CA-4. Tomo I*. ACF, FAO, y ECHO (2012)

[4]WFP. *Erratic weather patterns in the Central American Dry Corridor leave 1.4 million people in urgent need of food assistance*. https://www.wfp.org/news/erratic-weather-patterns-central-american-dry-corridor-leave-14-million-people-urgent-need (2019).

Mounting evidence links a surge in Central American migration, beginning as early as 2010, to these increasingly frequent climate shocks and the subsequent escalation of poverty and food insecurity.[5] The economic consequences of the COVID-19 pandemic and a global fertilizer supply crisis that has steeply increased the cost of agricultural inputs have exacerbated many of the causes that were already pushing rural people to migrate north.

EXPANDING GREEN ECONOMIC OPPORTUNITIES THROUGH RESILIENT AGRICULTURE

The search for economic opportunity and security is driving increased migration from rural Central America. To help rural Central Americans to stay and thrive in their communities, Catholic Relief Services is working to strengthen rural market systems and accelerate job creation and income-generating opportunities to benefit more of the population. This is especially important for the large number of rural young people who aspire to something better than persistent poverty, chronic crisis, and vulnerability. It is crucial that any economic opportunities be built on restoration of the region's land resources, especially soil and water. Regional vulnerability to climate variability and weather shocks is greatly exacerbated by high levels of deforestation on the region's steep hillsides and severely degraded soil and water resources. An estimated 75% of agricultural land in Central America suffers from human-induced soil degradation, among the highest in the world.[6] Bare hillsides and degraded soils diminish ecosystem capacity to protect and regulate itself in the face of climate variability and extremes. In the context of climate change in rural Mesoamerica, a resilient rural economy requires increased ecological resilience through the restoration of the region's soil and water resources.

Since 2015, Catholic Relief Services (CRS) has been building, validating and scaling Water Smart Agriculture (WSA) to simultaneously confront the challenges of land degradation, drought and erratic rainfall, low agricultural productivity, and poverty in Central America and southern Mexico. CRS´ WSA projects and programs in Guatemala, El Salvador, Honduras, Nicaragua and Oaxaca, Mexico have built solid evidence that the restoration of soil and water resources to increase water and agricultural productivity is a viable short and long-term solution to the economic and environmental problems associated with agriculture in the region. **For every $1 invested by WSA, farmer income increased by $2.46, an almost 250% return on investment.[7] These economic benefits were amplified in the ecosystem with an estimated $7.70 per hectare worth of economic value in carbon sequestered, rainfall infiltrated and stored, and nutrients captured for crop use.[8]** This on-the-ground evidence, generated together with thousands of farm families across the region, is a source of hope that resilient, productive, thriving agriculture is not only essential for Mesoamerica, but possible.

"Nobody wants to leave – it's so risky. They do it out of necessity because there are no harvests. They just want to stay on their land and take care of their families. What we need is to invest in ways to make it possible for us to stay and earn a dignified living. On my farm, I had a better harvest just by planting wild beans for cover and using the 4Rs [improved fertilizer management]."

Alirio Martinez, Jocotán, Chiquimula, Guatemala

[5] Masters, Jeff. *Fifth Straight Year of Central American Drought Helping Drive Migration*. https://blogs.scientificamerican.com/eye-of-the-storm/fifth-straight-year-of-central-american-drought-helping-drive-migration/. Scientific American (2019); Bermeo and Leblang. Honduras Migration, Climate change, Violence and Assistance. DCID (2021); Bermeo et al. *Policy Brief Root Causes of Migration from Guatemala*. DCID (2022).

[6] Oldeman, LR. *Global Extent of Soil Degradation*. ISRIC (1991).

[7] Wier et al. *Cost-effectiveness of Water-Smart Agriculture implementation in Central America*. CRS (2022).

[8] Ibid.

WSA – MANAGE SOIL TO MANAGE WATER AND PRODUCE MORE

In the Dry Corridor, where the poor distribution of rainfall rather than the overall amount is the biggest limiting factor, improved soil and water management offers potential for substantial yield and resilience gains, enabling farmers to produce more food with the same amount of water. WSA integrates soil management practices such as plant residue retention on the soil surface (mulching) and minimal to zero tillage to keep soil permanently covered. Permanent soil cover protects soils from erosion, reduces unproductive evaporation, and moderates soil temperature. Cover crops (rotations/ intercropping) build soil organic matter and supplement soil nitrogen. Integrated soil fertility and plant nutrient management increase biomass production and yields, and work in synergy with the other practices to increase rainwater productivity – producing more crop per drop of rainfall. A well-fertilized and pest- and disease-free plant will produce more biomass per unit of water used, increasing efficiency. The relatively simple and low-cost WSA practices have proven highly attractive to farmers – over 95% of basic grains demonstration farmers and over 80% of coffee farmers reported highly positive reactions and satisfaction with the WSA practices, noting improvements in production, livelihoods, food security, soil quality and drought resilience.

EVIDENCE GENERATED BY 3,000 FARMERS

From 2016 to 2020, WSA used an evidence-based approach to participatory, on-farm research to validate and adapt water-smart practices to local conditions in the main Mesoamerican agricultural systems, including basic grains (maize, beans), coffee agroforestry and pastures. Over 3,000 farmers in Central America and Oaxaca planted demonstrations, and through a continuous and iterative learning process, helped WSA refine field recommendations for nutrient management, cover cropping, residue management, diversification, and agroforestry. This contrasts with conventional practices like poor nutrient management, tillage, burning, removing residues, or complete grazing of crop residues that leave the soil bare. WSA agronomic practices are tailored to available resources that improve system management and increase productivity, profitability, and resilience. Participatory on-farm demonstrations provide proof of concept from the farmer's perspective and serve as living classrooms for capacity building through Farm Field Schools and outreach activities to a wider audience of decisionmakers.

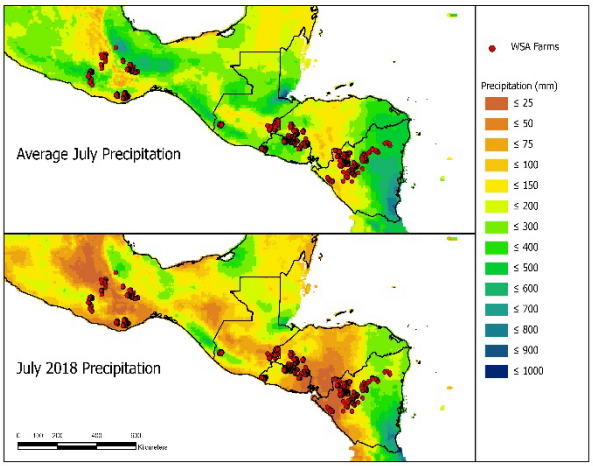

Figure 1: July average precipitation vs. July 2018 precipitation (mm), location of the WSA plots identified by red points (Map prepared by M.-S. Turmel; Map data source, Funk et al., 2014 *U.S. Geological Survey Data Series 832*).

WSA PRACTICES BOOSTED RESILIENCE DURING THE 2018 DROUGHT

In 2018, the Central American Dry Corridor suffered a severe drought in the main *(primera*) maize growing season. A prolonged *canícula* (mid-season dry spell) started in early July and continued into August, causing yield reductions and crop loss on over 300,000 ha of maize and bean production in the region.[9] July rainfall was only 80 mm, less than half the average July rainfall

[9]FAO. *Drought causes crop losses in "Dry Corridor" in Central America - Global Information and Early Warning System Update*. http://www.fao.org/3/CA1321EN/ca1321en.pdf (2018).

of 222 mm (*Figure 1*). Some areas where WSA demonstration plots were located went 20 to 45 days without rain. The 2018 rainy season was characterized by abundant rainfall during maize planting in the last week of May, followed by a significant drop in precipitation in July and early August. This created drought conditions during important stages of maize crop growth.

In regions where the drought was less than 30 days, and farmers were able to obtain a harvest, results from the WSA plots in all five countries show that maize under WSA management was more tolerant to drought and produced significantly greater yields (*Figure 2*). WSA maize yields were on average 41% higher, and 80% of all farmers produced at least 15% more on WSA plots compared to conventional practice. The World Food Program estimated that as a result of the 2018 drought, 2.2 million Central Americans were affected by yield loss and 1.4 million were left food insecure.[14] **Based on 2018 data, at least 25% more farmers in the Dry Corridor will meet their basic maize production needs[10] in a drought year if they implement WSA management practices**.

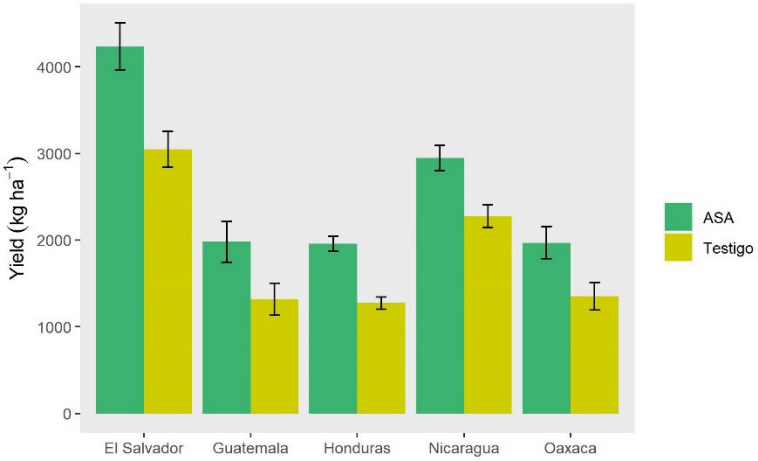

Figure 2: Average maize yield in 2018 from 1065 on-farm WSA vs. comparison plots (*Testigo*) (CRS 2018)

SOIL FERTILITY MANAGEMENT IS FUNDAMENTAL TO RESILIENCE

In addition to rainfall variability, soil fertility is one of the main factors limiting crop production in Central America. According to the baseline soil analysis of WSA plots, 66% of farmers had at least one severely limiting soil fertility problem: soil acidity, low soil organic matter, low inherent fertility, or low nutrient concentration. **For example, 37**% of farms had very low phosphorus (P) content, one of the main nutrients that can limit crop production in tropical soils. Improved plant nutrition not only increases root growth and the drought tolerance of the crop but also contributes to the production of more plant biomass. When left as residue, the plant biomass protects the soil and conserves moisture for the next cropping cycle. An integrated approach to soil management that involves soil fertility management and practices to improve water capture and retention is essential to improve productivity and drought resilience.

WSA results from the 2018 drought showed that farmers limited by both water (<600 mm of rainfall) and soil fertility conditions (low phosphorus) could not meet a minimum production level for food security with their current production practices. Water-smart practices provided the greatest relative yield improvements (over 50% increase) on farms where both soil fertility and water were limiting. **For smallholder farmers facing drought, water-smart practices can make the difference between resilience and crisis.**

LOCAL LEADERSHIP AND CAPACITY FOR RESILIENT RURAL PROSPERITY

The WSA Program has been working since 2015 with key agricultural institutions in the region to build local capacity and improve support systems for smallholder agriculture with investment in water-smart approaches, methodologies, and services. Together with local leaders, ministries of agriculture, and other public and private agricultural service providers and farmers, WSA aims to transform Mesoamerican agriculture – reaching 500,000 farm families and putting 500,000 hectares under restoration practices by 2030 - for thriving and resilient rural prosperity that allows Central American and Oaxacan farm families to build their future at home.

[10] Based on a 2 t/ha maize food security threshold.