

HOW CAN AFRICAN AGRICULTURE ADAPT TO CLIMATE CHANGE? INSIGHTS FROM ETHIOPIA AND SOUTH AFRICA

Are Soil and Water Conservation Technologies a Buffer Against Production Risk in the Face of Climate Change? Insights from Ethiopia's Nile Basin

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The agricultural sector in developing countries is particularly vulnerable to the adverse impacts of climate change. Given Ethiopia's dependence on agriculture and natural resources, any adverse agricultural effects will pose serious risks to economic growth and livelihoods across the country. Soil and water conservation technologies have been suggested as a key adaptation strategy for developing countries, particularly those in Sub-Saharan Africa, in light of increased water shortages, drought, desertification, and worsening soil conditions. According to a survey of 1,000 households in the Nile Basin of Ethiopia, more than 30 percent of farmers adopted soil and water conservation measures in response to perceived long-term changes in temperature and rainfall. Although soil and water conservation technologies are generally considered low-cost, they still engender risk for very low-income, risk-averse households, which are prevalent in rural Ethiopia. Thus, it is important to consider the impacts not only on crop yields, but also on risk levels.

This brief is based on a study that investigates the risk implications of various soil and water conservation technologies for crop production in Ethiopia's Nile River Basin. The analysis identifies technologies that increase and decrease crop production risk—with risk defined as the degree of yield variability—for the purpose of isolating which technologies are best suited to particular regions and agroecological zones. These results could be used to improve the geographical targeting of soil conservation techniques as part of efforts to promote farm-level adaptation to climate change.

THE USE OF SOIL AND WATER CONSERVATION TECHNOLOGIES IN ETHIOPIA

Soil and stone bunds are structures commonly built to control runoff and thus increase soil moisture and reduce soil erosion. However, constructing continuous bunds to protect broad tracts of land is costly and often difficult, so alternative methods of erosion control are also employed. These include grass strips and contour leveling, sometimes incorporating trees or hedgerows, to reduce runoff velocity and allow water to infiltrate and trap sediments. In addition, waterways help direct precipitation flows along specified pathways in farm fields; and water-harvesting structures, including dams, ponds, and diversions, ensure water availability in the dry season.

Using historical rainfall data from 1951 to 2000, Ethiopia's woredas (districts) were categorized as having either high or low

rainfall. All of the woredas in Tigray and the Southern Nations, Nationalities and Peoples Region (SNNPR) fell into the low-rainfall category, whereas those in the Amhara, Oromiya, and Benishangul-Gumuz regions fell into a combination of both categories. Tigray appears to be the driest region of the five, and Oromiya had the highest average rainfall during 1951–2000.

Overall, the most commonly used soil and water conservation technologies by region are: soil bunds and stone bunds in Tigray, waterways and stone bunds in Amhara, soil bunds and waterways in Oromiya, waterways in Benishangul-Gumuz, and shade trees in SNNPR. Plots in low-rainfall areas have disproportionately more stone and soil bunds than plots in high-rainfall areas, and plots in high-rainfall areas have more waterways and irrigation. The results show clear spatial heterogeneity in the use of soil and water conservation technologies, suggesting that such technologies perform differently according to region and agroecological zone.

THE EFFECTS OF SOIL AND WATER CONSERVATION TECHNOLOGIES ON CROP YIELDS AND PRODUCTION RISK IN AREAS OF LOW AND HIGH RAINFALL

All soil and water conservation technologies considered in this study (that is, stone and soil bunds, grass strips, waterways, trees, and contours) show positive and highly significant impacts on crop output in the low-rainfall areas, but only waterways and trees show strong and significant positive effects in high-rainfall areas. Grass strips show the largest effect on crop yields among the technologies used in low-rainfall areas.

Although most of the technologies show significant positive effects on crop yields in low-rainfall areas, surprisingly, only soil bunds have a risk-reducing effect. This explains why almost 30 percent of the plots employ these techniques, and why other interventions that also have high positive impacts on yields are less common. In areas of high rainfall and high agricultural potential, most of the technologies considered in this study have risk-reducing effects, including soil and stone bunds, grass strips, waterways, and contours. Although both traditional and improved seeds increase average crop production in both low- and high-rainfall areas, they have different effects on production risk. Traditional seed is risk-reducing in both low- and high-rainfall areas, whereas improved seed

Table 1 Risk effects of soil and water conservation technologies on crop production by region and category of rainfall

Technology employed	Tigray		Amhara		Oromiya		Benishangul-Gumuz		Southern Nations, Nationalities and Peoples Region
	Low rainfall	Low rainfall	High rainfall	Low rainfall	High rainfall	Low rainfall	High rainfall	Low rainfall	
	Soil bunds		-		-	-			
Stone bunds			-		-			-	
Grass strips			-		-	+	-	-	
Waterway			-		-		-	-	
Shade trees	+		-		-		-	-	
Contour			-		-		-	-	
Traditional seed	-		-		-		-	-	
Improved seed			-		-		-	-	
Irrigation	+						-		
A combination of fertilizer, improved seed, and irrigation	-								

NOTE: A plus sign indicates significantly increased risk, whereas a minus sign indicates significantly reduced risk. Only results that are statistically significant at the 10 percent level are reported.

is only significantly risk-reducing in high-rainfall areas. These results suggest that, in attempting to adapt to climate change in low-rainfall areas, the choices of soil bunds and traditional seed are appropriate. Improved and traditional seed, stone and soil bunds, grass strips, waterways, and contours all appear to be promising adaptation strategies in high-rainfall areas.

THE EFFECTS OF SOIL AND WATER CONSERVATION TECHNOLOGIES ON CROP YIELDS AND PRODUCTION RISK BY REGION

The effects of soil and water conservation technologies within Ethiopia's Nile Basin vary not only by high- and low-rainfall area, but also by region (Table 1). The results for low-rainfall areas show that soil bunds are risk-reducing in Amhara and Oromiya, and that stone bunds are risk-reducing in the low-rainfall areas of SNNPR. Grass strips, waterways, and trees are only risk-reducing in SNNPR. Irrigation has no significant risk-reducing effect in any of the low-rainfall areas but shows a significant risk-increasing effect in the

Benishangul-Gumuz; contours are risk-reducing in Amhara; and irrigation is risk-reducing in Benishangul-Gumuz.”

CONCLUSIONS AND POLICY IMPLICATIONS

The results show that soil and water conservation technologies have significant impacts in reducing production risk in Ethiopia and could be part of the country's climate-proofing strategy. The results also show that one-size-fits-all recommendations are inappropriate given the differences in agroecologies and other factors. The performance of these technologies is location specific; therefore, programs aimed at promoting soil and water conservation measures as part of a climate change adaptation strategy should take these important differences into account.

FOR FURTHER READING

Kato, E., C. Ringler, M. Yesuf, and E. Bryan. 2009. *Soil and Water Conservation Technologies: A Buffer against Production Risk in the Face of Climate Change? Insights from the Nile Basin in Ethiopia*. Washington, DC: IFPRI Discussion Paper No. 871.

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low-rainfall areas of Tigray. The risk-increasing aspect of irrigation in low-rainfall areas seems counterintuitive considering irrigation is intended to mitigate the adverse effects of low rainfall. Nevertheless, other studies have suggested reasons for failure of irrigation and water harvesting structures including poor technical design; lack of water, which could be stored in dry years; inappropriate and costly placement; and lack of community sensitization.

The results show that all technologies tend to reduce production risk in high-rainfall areas. Soil bunds are risk-reducing in Oromiya and Benishangul-Gumuz; stone bunds are risk-reducing in Amhara and Oromiya; grass strips are risk-reducing in Amhara, Oromiya, and Benishangul-Gumuz; waterways are risk-reducing in Amhara and Benishangul-Gumuz; trees are risk-reducing in Amhara and