Research Note

Drought and Rainfall Variability: Costs and Resiliency Pathways for Rural African Households[1]

This Research Note presents monetary estimates of the costs that drought, and rainfall variability more generally, impose on rural households in sub-Saharan Africa (SSA).

The Note characterizes rainfall environments faced by rural households in SSA. Crop production variability and the costs that drought and rainfall shortfalls generate for maize, wheat, and sorghum are then simulated using historical data from Ethiopia and Zambia. The analysis also explores the effectiveness of alternative resiliency strategies in reducing household costs from variable rainfall.

The Research finds that off-farm employment and public transfers are effective strategies in terms of stabilizing household income and reducing the costs of rainfall induced income variability. But these strategies do not fully protect households. Going forward there is urgent need for robust integrated policies at continental, national, and local levels to assist smallholder farmers in adapting to climatic variability and change.

Drought and Rainfall Variability

Rural households in SSA continue to rely heavily on rain-fed agriculture and face considerable rainfall variability across years. For example, figure 1 shows the distribution of the coefficient of variation (CV) for seasonal rainfall in major maize growing areas across SSA.

Focusing on the two countries in this study, average growing season CVs of annual rainfall from 1980 to 2010 in major crop growing areas are 0.38 in Ethiopia, and 0.21 in Zambia, respectively. This variability translates into a severe drought roughly once every **four** years in at least one zone in Ethiopia, and roughly once every **six** years in at least one district in Zambia.[2] Rainfall variation clearly has a major impact on rural livelihoods and livelihood strategies.

Production Variability

Since most rural households engage in rain-fed agriculture, rainfall variability also translates directly into variability in agricultural production. Average yields and the CVs associated with variations in maize yields for 1980 to 2010 in

1 A summary of findings from collaborative research by Bradford Mills and Jianfeng Gao of Virginia Tech, Genti Kostandini of University of Georgia, Joseph Rusike of AGRA, and Anthony Murray of the USDA Economic Research Service on the welfare costs that exposure to rainfall shocks generate for rural households in Ethiopia and Zambia.

2 Severe drought is defined as at least one month with a standard precipitation index of –2 or below.

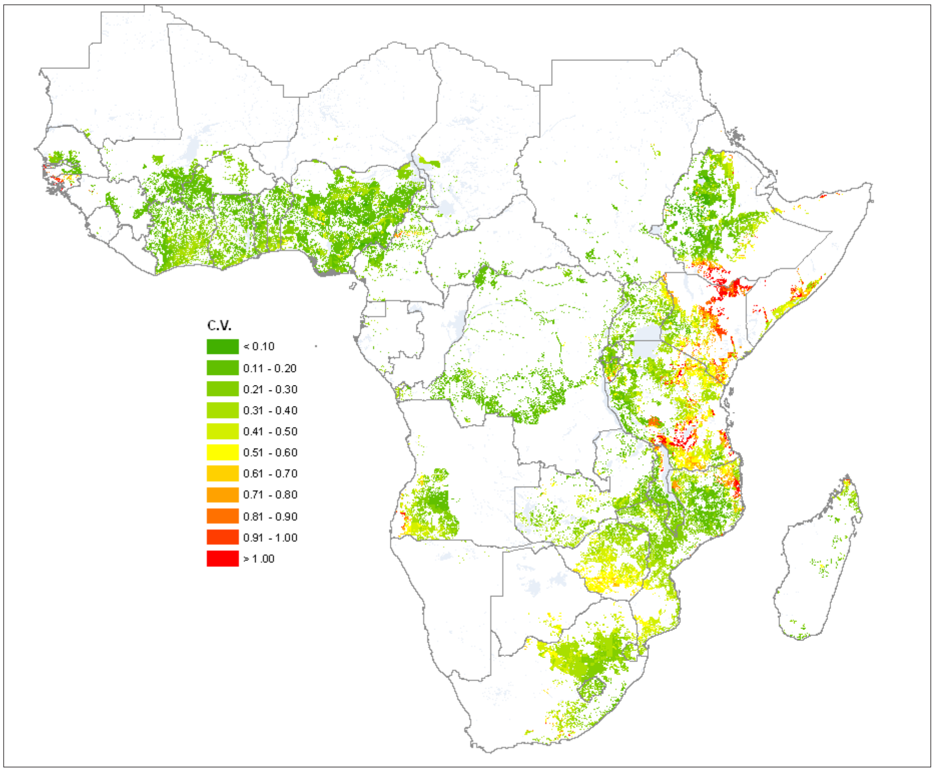

Figure 1. Map of sub-Saharan Africa showing the coefficient of variation (CV) of seasonal rainfall at major maize growing areas during 1955-2004. Source: Harvest Choice

The total cost of rainfall induced income variability is defined and measured as the amount a household would be willing to pay to eliminate rainfall induced income variability without having to employ other coping strategies.

Ethiopia and Zambia are presented in table 1 for maize mega-environments (MME) using historical weather data and crop yields based on simulations by the International Food Policy Research Institute (IFPRI) with the Decision Support System for Agrotechnology Transfer (DSSAT) crop model. These simulations can be viewed as the upper bounds on household yield variability, with observed yield variability often lower due to household efforts to buffer against and adapt to rainfall shocks. As expected, mean yields vary considerably across MMEs in both countries. However, most striking are the large simulated yield CVs due to weather variability. **CVs are high** in all MMEs, ranging from 0.38 in the wet lowlands of Zambia to 0.79 in the dry mid-altitude zone of Ethiopia.

Cost of drought and rainfall variability

Rainfall induced crop yield variability generates two types of costs for households. The first is lost income from average crop yield losses due to drought (or flooding) and other low rainfall events. The second cost stems from household income variability associated with variability in agricultural production. Uncertainty over future income streams will cause risk averse households to make more conservative decisions, lowering both household production and consumption levels. It is again worth noting that simulated levels of income variability may be higher than actually observed levels because households employ a number of coping strategies to mitigate exposure to rainfall variability. But these coping strategies come at a cost.

Simulations of the costs of household mean yield losses from drought and of the costs from household agricultural income variability are presented in table 2. In Ethiopia maize and sorghum losses from drought are equivalent on average (across drought and non-drought years) to a little under one percent of household income for each crop, while losses from wheat are a little over one percent of household income. For Zambia drought losses from Maize and Groundnut are quite small and represent only 0.2 percent and 0.6 percent of household income, respectively.

By contrast, exposure to rainfall variability and associated crop variability generates significant economic costs for rural households in both countries. The costs borne by households from income variability associated with maize

Table 1: Maize production variability in Ethiopia and Zambia by maize mega-environment (MME)

	Dry lowlands (DL)	Dry mid altitude (DMA)	Highlands (HI)	Wet lowlands (WL)	Wet lower mid altitude (WLM)	Wet upper mid altitude (WUM)
Zambia Maize from 1980-2010						
Yield/ha.	1,747	-	825	1,430	1,542	1,330
CV	0.42	-	0.70	0.38	0.43	0.47
Ethiopia Maize from 1980-2010						
Yield/ha.	1,531	1,306	1,632	2,200	1,351	1,424
CV	0.70	0.79	0.65	0.47	0.67	0.69

Table 2: Household costs of drought and yield variability

	Ethiopia ($)	Household Income (%)	Zambia ($)	Household Income (%)
Mean yield losses from drought				
	$1-$10	0.72	$0.2-$0.7	0.15
Maize	$1-$10	0.72	$0.2-$0.7	0.15
Sorghum	$4.47	0.65	N.A.	N.A.
Wheat	$8.05	1.17	N.A.	N.A.
Groundnuts			$4.19	0.6
Costs of yield variability				
Maize	$14-$150	8.6	$52-$89	8.3
Sorghum	$66	9.6	N.A.	N.A.
Wheat	$174	25.5	N.A.	N.A.
Groundnuts	N.A.	N.A.	$25	3.8

production are equivalent to 8.6 percent and 8.3 percent of total rural household income in Ethiopia and Zambia, respectively.[3] Estimates of the cost of rainfall induced variability in sorghum and wheat production are equivalent to 9.6 and 25.5 percent of rural household income, respectively, for Ethiopian households engaged in rain-fed agriculture. The costs of rainfall induced variability in groundnuts are equivalent to 3.8 percent of rural household income in Zambia. Since these costs are additive across crops, rainfall variability clearly generates very significant economic costs for rural SSA households.

Household resiliency strategies

Rural SSA households employ a number of strategies to reduce their exposure to income variability stemming from drought and rainfall shortfalls. Agricultural strategies include changing crop mix to more drought tolerant crops. For instance, in Zambia we find evidence of movements out of maize and into cassava with decreases in rainfall. Households also adopt drought tolerant varieties and water conservation techniques, and modify input use. However these responses do not fully buffer against low rainfall, and we find empirical evidence of farm-level yield decreases with negative rainfall shocks.

Non-agricultural strategies to mitigate the costs of drought and rainfall variability include migration, off-farm employment, use of public social protection programs, and transfers from friends and family. These strategies are frequently employed to diversify and stabilize income in the face of rainfall shocks. In Ethiopia 14 percent of rural households have adult members who migrated for employment purposes in the past 5 years. Further, 33 percent of households have at least one adult member engaged in off-farm employment and the average off-farm earnings across all households is $40. Correspondingly, 21 percent of households received transfers through public social protection programs in the past year and the average received across all households is $20. For informal transfers, 17 percent of households received transfers from family and friends, with an average transfer of $9 across all households.[4]

The effectiveness of these resiliency strategies in reducing household costs of rainfall variability is simulated for Ethiopia by first calculating the average stream of steady income associated with each strategy. An equivalent portion of the variable income stream from maize is then replaced with the fixed amount of income associated with each strategy and the reduced costs of income variability associated with the new more stable income stream is calculated.

The results in table 3 show that off-farm employment and public transfers are effective strategies in terms of stabilizing household income and reducing the costs that rain-fed induced income variability impose on households. In fact, the impact of off-farm employment in terms of reducing the costs of income variability to the household is equivalent to 2.7 percent of household income across all of Ethiopia, and ranges from 1.5 to 5.1 percent of household income within the specific MMEs examined. Public social protection transfers show the second greatest benefit in terms of income stabilization, equivalent to 1.8 percent of household income. Migration remittances and transfers from family and friends are less effective in reducing the costs of household exposure to income variability because income streams from these strategies are smaller.

Resiliency strategies are effective. But our results also indicate that these resiliency strategies do not fully protect households. Ethiopian households continue show lower per-capita consumption in response to rainfall shocks even after employing these resiliency strategies. The accompanying note **'Policies to Support Household Resilience to Drought'** discusses additional policy options to support effective household resiliency strategies.

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Table 3. Simulated Reductions in Costs of Rainfall Variability from Resiliency Strategies in Ethiopia ($US)

	Ethiopia ($)	% HH Income	Lowest %	Highest %
Migration & Remittances	1.79	0.25	0.17	0.68
Off-farm Employment	20.60	2.72	1.54	5.14
Public Assistance	13.16	1.81	1.40	4.22
ISSN Transfers	4.26	0.60	0.41	1.63

3 A conservative relative risk aversion coefficient of 1.2 is employed in these estimates and adjustments are made for market level price changes. See Kostandini, Mills, Mykerezi (2011) for details on methods.

4 All these monetary values are in 2015 U.S. dollars.

Further reading

Details on the research synthesized in these notes can be found in two working papers on the AGRA website.

Rainfall Variability, Migration, Off-farm Activities, and Transfers: Evidence from Rural Ethiopia

Weather Shocks, Diversification Strategies and Consumption in Rural Ethiopia

References

Kostandini, G., Mills, B., Mykerezi, E. 2011. “Ex-Ante Evaluation of Drought Tolerant Varieties in Eastern and Central Africa.” Journal of Agricultural Economics, 62(1): 172-206.

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