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

Impacts of Considering Climate Variability on Investment Decisions in Ethiopia

Paul J. Block, Kenneth Strzepek, Mark Rosegrant, and Xinshen Diao

Numerous studies indicate that agricultural production is sensitive to climate variability, and lack of infrastructure in developing countries increases vulnerability to extreme climate events. In Ethiopia, the historical climate record indicates frequent droughts and floods, which can devastate agricultural production and existing infrastructure. Too much precipitation can flood crops, rot or suffocate roots, and wash out roads, creating similar economic conditions to those resulting from drought. With 85 percent of the population living in rural areas, and most people depending on rainfed agriculture, Ethiopia's social and economic welfare depends heavily on climatic conditions.

This brief is based on a paper that uses an economywide, multi-sector, and multi-regional model to assess the impact of climate variability on the outcomes of prospective investment strategies for Ethiopia, as well as on the country's gross domestic product growth rates and poverty rates.

INVESTMENT STRATEGIES AND SIMULATIONS

The model brings agricultural supply, demand, and market opportunity issues together to assess different investment strategies. The analysis gives a broad picture of agricultural growth and poverty reduction and reveals some important economic linkages among agricultural sectors and between demand and supply, exports and domestic markets, and production and farmer income. Additionally, the analysis reveals the complexity of economic linkages and trade-offs among different investment goals. Model results are limited to four economic indicators: the poverty rate and growth rates for gross domestic product (GDP), agricultural GDP, and nonagricultural GDP.

Two major investment strategies are simulated in the model: investments in irrigation, which focus on providing sufficient water to crops, and investments in road construction and maintenance, which focus on ensuring that farmers are able to transport their agricultural products to local markets and for export. A third simulation simultaneously incorporates investments in both irrigation and roads.

For irrigation, the model simulates the effects of investment by incorporating the country's Irrigation Development Program under the Ethiopian Ministry of Water Resources' Water Sector Development Plan (WSDP 2002). Approximately 200,000 hectares of crop area are currently being irrigated in Ethiopia, accounting for just over 2 percent of all cropland. The new program details the addition of 274,000 hectares of irrigated cropland, more than doubling the current irrigated area. For roads, the model simulates the effects of investment based on Ethiopia's 10-year Road Sector Development Program (RSDP 1997–2007). Prior to the implementation of RSDP, Ethiopia's road network consisted of approximately 3,800 kilometers of paved roads and 29,000 kilometers of unpaved roads. The first half of the program (1997–2002) focused on rehabilitating the existing roadways, while the second half aimed both to continue rehabilitation and to increase the network of all types of roads by 5,000 to 8,000 kilometers.

The results of the three simulations are compared against a baseline simulation, which predicts future conditions if current practices remain unchanged—that is, with no infrastructure investments or major policy changes. The baseline scenario stays within the confines of historical growth rates under mean climate conditions for each year, resulting in a smooth growth trend.

THE EFFECTS OF MODELING CLIMATE VARIABILITY

The economic and poverty-reducing effects of investing in irrigation and roads under average climate conditions for a single model run (a deterministic model) are compared with the effects of variable climate conditions for numerous model runs (a stochastic model), including year-to-year changes and extreme climate events. In the deterministic model, the effects of drought and flood are ignored through the use of average climate parameters, whereas the effects of both drought and flood are included in the stochastic model.

The analysis suggests that climate variability results in lower economic welfare; in particular, it highlights the difficulty of returning to a state of constant growth after a shock. Average climate parameters, as used in the deterministic model, can underestimate the negative effects of climate variability and do not clearly represent the difficulties of recovering from extreme climate events. The inclusion of drought and flood impacts in this study results not only in expected declines in agricultural yields, but also in potential damage to roads and infrastructure, which exacerbates declines in agricultural production, trade, and other nonagricultural activities. Failure to include these factors may well result in misleading insights and an overestimation of the welfare benefits to the economy (Table 1). Stochastic modeling, including climate variability, thus appears to be essential and warranted when modeling investment in sectors that are responsive to climate extremes. Including climate variability in the model offers more prudent predictions based on realistic ranges of economic values from which Ethiopian planners may make strategic decisions.

The simulations of increased investment in irrigated agriculture, roads, and a combination of the two showed improved economic outcomes compared with the baseline case. The results of the simulations indicate that benefits from investments in irrigation and roads are manifested differently; investments in irrigation provide benefits within the agricultural sector, while investments in roads predominantly benefit the nonagricultural sector, but they allow for some agricultural feedbacks. The results also show that investments in irrigation are slightly more effective in boosting the Ethiopian economy and reducing poverty than are investments in roads, in part because additional irrigation ameliorates the negative effects of drought and therefore has a particularly strong impact on production and farm income. Because drought has a persistent impact on income and food security, preventing or reducing the severity of drought has long-term benefits. As expected, the welfare of the country is best under the combined investment strategy.

Finally, considering climate variability when predicting the outcome of investment decisions can also provide some sense of probabilistic risk. No investment strategy can ensure economic success, so planners need to know the probability that the economy will fall within some acceptable range of economic values for a given investment strategy.

FOR FURTHER READING

Block, P. J., K. Strzepek, M. Rosegrant, and X. Diao, *Impacts of Considering Climate Variability on Investment Decisions in Ethiopia,* Environment and Production Technology Division Discussion Paper No. 150 (Washington, DC: IFPRI, 2006).

Table 1 Simulated effects of investments on poverty and GDP growth rates

	GDP growth rate		Poverty rate 2015	
Simulation	**Average climate conditions for a single model run (deterministic model)**	**Range for variable climate conditions for numerous model runs (stochastic model)**	**Average climate conditions for a single model run (deterministic model)**	**Range for variable climate conditions for numerous model runs (stochastic model)**
Baseline	2.82	2.34–3.03	42.98	40.59–52.22
Irrigation	3.68	2.25–3.22	39.27	42.70–61.36
Roads	3.58	2.00–3.08	39.82	43.37–62.96
Combination of irrigation and roads	4.40	2.95–3.92	36.15	39.77–58.77

SOURCE: Block, P. J., Kenneth Strzepek, Mark Rosegrant, and Xinshen Diao, *Impacts of Considering Climate Variability on Investment Decisions in Ethiopia*, Environment and Production Technology Division Discussion Paper No. 150 (Washington, DC: IFPRI, 2006).

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