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Can Water Undermine Growth? Evidence from Ethiopia

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Ethiopia has highly variable rainfall, both across the country and over time, and the country experiences regular droughts that devastate parts of the country and ripple through the economy. Such unmitigated hydrological variability[1] currently costs the Ethiopian economy over one-third of its growth potential. The very structure of the Ethiopian economy, with its heavy reliance on rainfed subsistence agriculture, makes it particularly vulnerable to hydrological variability. Currently, the extremely low levels of hydraulic infrastructure and limited water resources management capacity in the country undermine attempts to manage variability. These circumstances leave Ethiopia's economic performance virtually hostage to its hydrology.

Up until now, most policy and macro-economic decisions have been based on growth models that assume rainfall is consistently at historical average levels. These models do not take into account shocks to the economy caused by extreme water events, such as floods and droughts. A World Bank study (World Bank 2006) estimated the magnitude of the impacts of high water variability on growth and poverty so that the government can better manage water and manage other parts of the economy (trade, transport) to reduce the impacts of water shocks. The study found that considering the effects of water variability reduced projected rates of economic growth by 38% per year and increased projected poverty rates by 25% over a twelve year period. Furthermore, the variability of rainfall increased value-added of water investments, such as irrigation, that reduce vulnerability to rainfall. The study also found that transport infrastructure played a major role in the inability of local economies to adjust to localized crop failures, as it allows areas with food surpluses to sell to areas in food deficit. This analysis, undertaken in cooperation with the Ethiopian government, helped to make the issue of water resource management a central focus of the government's national poverty reduction strategy.

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WATER RESOURCES IN ETHIOPIA

Water has always played a central role in Ethiopian society; it is an input, to a greater or lesser extent, to almost all production. Water is also a force for destruction—causing flash flooding, disbursing pollutants, and facilitating the transmission of diseases. In Ethiopia, as in all societies, there has always been a struggle to reduce the destructive impacts of water and increase its productive impacts. This struggle has intensified over the past century as the population has rapidly grown—from 12.5 million in 1905 to 71.2 million in 2005. In fact, the population of Ethiopia is projected to increase by another 64% to 110.5 million by 2030 (HNP Statistics Database). Today, the development of Ethiopia is seriously constrained by a complex water resources legacy and a lack of access to, and management of, these water resources.

Ethiopia's water resources can be characterized by two principal features, a natural legacy and a historical legacy. The natural legacy is one of very high, and apparently intensifying, hydrological variability, coupled with marked rainfall seasonality. At first sight, Ethiopia's water resources endowment appears generous, with a mean total surface water flow of about 122 billion cubic meters per year. The country has several major rivers and lakes, significant groundwater

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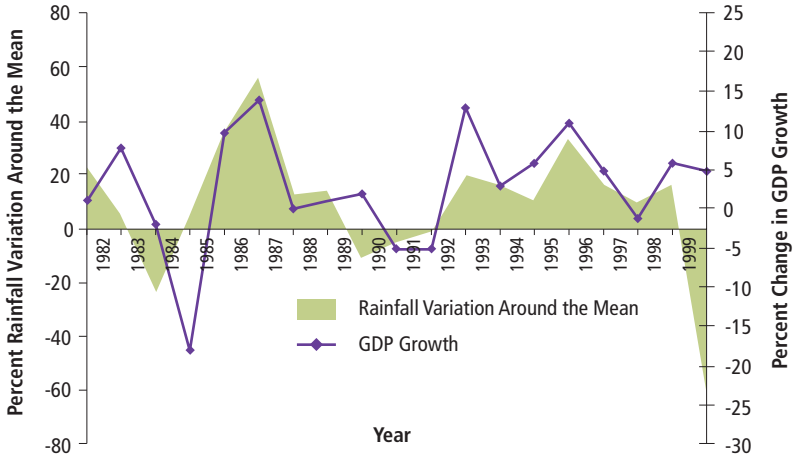
resources and annual rainfall. However, rainfall across much of the country is both highly seasonal—with most of the rain falling in a single, short season from mid-June to mid-September—and exceptionally variable and unpredictable, both in time and space. With poorly protected watersheds and almost no investment in water storage, a consequence of this hydrological variability is endemic and unpredictable drought and flood.

The historical legacy of Ethiopia's water resources is one of several international rivers, of which the Nile is the most important. Ethiopia provides 85 percent of the natural Nile River flow into Egypt. In the Nile River Basin tensions have long been high; without the bold affirmative action for cooperation that Ethiopia is currently adopting, these tensions would likely grow as demand for water grows. Especially in the Nile River Basin, international cooperation on shared waters will be crucial to achieving sustainable water security without international tensions.

Figure 1: Rainfall Variation Around the Mean and GDP Growth



Source: World Bank 2006.

HYDROLOGY AND ECONOMY-WIDE PERFORMANCE

Ethiopia's extreme hydrological variability is echoed in its economic performance. The vast majority (80 percent) of Ethiopia's population subsists on rainfed agriculture, thus their welfare and economic productivity are linked to the volatile rains. The correlation between rainfall and overall GDP is strong, as can be seen in Figure 1. The impact of rainfall variability, unchecked by either physical infrastructure or strong management practices, can be felt not only on agricultural output, but on the environment, electricity (which is 90 percent hydropower), manufactured goods, incomes and consumption, and prices.

Poor market access and costly transportation services have created a highly fragmented economy in which average grain prices differ 30–70 percent across regions. This fragmentation reflects missed opportunities to make both buyers and sellers better off. It also amplifies drought and flood shocks by hampering trade between surplus and deficit regions in the country.

DYNAMIC EFFECTS AND INCENTIVES FOR GROWTH

The fragility of the Ethiopian landscape and the dependence of the Ethiopian population and economy on rainfed agriculture create a web of effects that result—at least in part—from the country's extreme hydrological variability. This variability has economy-wide impacts in good and bad years. Rainfall variability has direct impacts on the landscape, agricultural output, transport passability, and water-intensive industry and power production. These impacts are generally unmitigated because there is little hydraulic infrastructure to regulate or store water. They are often amplified by the fragmented nature of the Ethiopian economy, which does not facilitate trade between affected and non-affected regions of the country; and transmitted through input, price, and income effects onto the broader economy. Many of these dynamics conspire against structural change in the economy. Endemic drought, fragmented and inadequate infrastructure, and expectations that food aid shipments will disrupt transportation and tamp down food price spikes during shortages, all promote a risk-averse subsistence economy and undercut incentives for farmers to produce surplus, marketable crops.

Current policies focus on food aid and other tools for mitigating the impact of drought on the population and the economy, but much of the problem lies in the very structure of the economy, which leaves its people vulnerable to hydrological variability. The majority of the population depends directly upon rainfall for subsistence agriculture, and the broader economy is built on domestic demand that is as unpredictable as the rains. This is compounded by inadequate infrastructure, fragmented national markets, and the current policy environment, which all prove to be disincentives for investments in more weather-resilient activities such as irrigated agriculture, manufacturing, and services. Unless the structure of the economy changes, stable economic progress will continue to be both intensely disrupted by drought and flood, and quietly undermined by risk aversion.

MODELING THE ECONOMIC IMPACTS OF THE WATER RESOURCES OF ETHIOPIA

A model was developed by a team of expert economists for the World Bank's Ethiopia Country Water Resources Assistance Strategy (2006) that sought to quantify the economy-wide impacts of hydrological variability and water resources management in Ethiopia.[2] This model was developed in contrast to standard economic models, which assume average rainfalls over a long period, and thus are inappropriate for Ethiopia as they fail to capture the significant economic impact of the country's hydrological variability. The newly developed model accounts for this variability and projects a much bleaker—but more realistic—picture of the country's economic future. The model is dynamic, running for a period long enough to explore the implications of variability over time, and captures the following key characteristics:

- Highly variable rainfall and endemic droughts and floods
- Fragile and degrading landscapes
- Low levels of infrastructure investment to mitigate hydrologic variability
- Fragmentation of the economy, particularly regional segmentation in agricultural markets
- High transportation and marketing costs

The model was run with three assumptions regarding rainfall variability. Specifically:

1. *Smoothed rainfall:* This variation assumes 1995–2002 average rainfall in all years. Smoothed rainfall is the underlying assumption in virtually all economy-wide modeling.

2. *Stylized drought:* This variation assumes 1995–2002 average rainfall except for a stylized, two-year drought of average severity; it captures the isolated "shock" of a single drought.

3. *Historical variability:* This variation is a stochastic extension (varying within a range of probability) of the model that more fully reflects Ethiopia's historical levels of rainfall variability, and, in addition, captures the negative impacts of excessive rains on the agricultural and non-agricultural sectors.

GROWTH AND POVERTY COSTS OF DROUGHT AND VARIABILITY

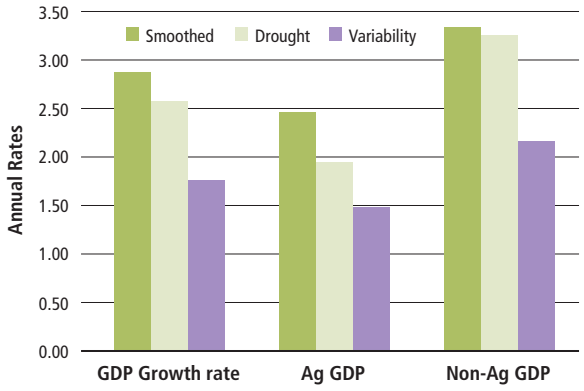
The model showed that historical levels of hydrological variability diminish growth projections for the Ethiopian economy by over one-third and raise poverty rates by some 25 percent—clearly demonstrating the extraordinary impact of drought, and particularly variability, on the Ethiopian economy.

A single drought event in a 12-year period—a very conservative estimate for Ethiopia—will decrease average GDP growth rates by 5–10 percent. If historical levels of variability and the partial impacts of floods are incorporated, GDP growth rates fall 20–40 percent. Figure 2 shows the difference in GDP growth rate projections when rainfall is modeled as a smoothed average, when a single drought event is incorporated, and when historical levels of variability are assumed.

In terms of poverty, the impact of a single drought will increase poverty rates 12–14 percent, causing an additional 5 million Ethiopians to be living in poverty by the year 2015 (relative to the non-drought case)—17 million more than today. With hydrological variability, projected poverty rates rise 25–35 percent and project 51 million people living in poverty—22 million more than today. Figure 3 shows the difference in the number of people projected to live in poverty when rainfall is modeled as a smoothed average, when a single drought event is incorporated, and when historical levels of variability are assumed.

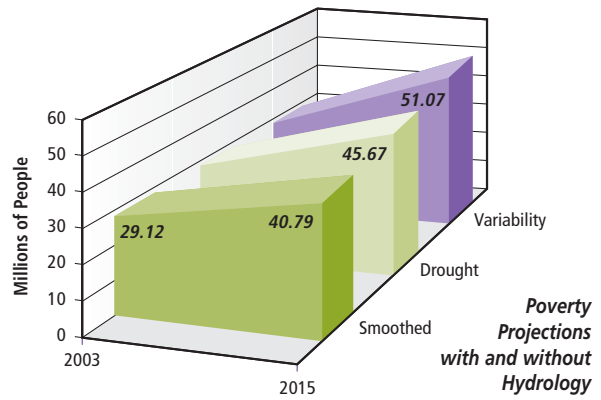
It is important to note that drought shocks, which tend to be a primary focus for weather risk analysis in Ethiopia,

Figure 2: Effects of Hydrology on GDP Growth Rates



Source: World Bank 2006.

Figure 3: Effects of Hydrology on Poverty Rates



Source: World Bank 2006.

represent just part of the story. The historical variability model, while still quite conservative, better reflects the real hydrological impacts endured in Ethiopia. It captures year-on-year stochastic variations, and some of the impacts of floods as well as droughts. These models clearly suggest that variability, rather than a narrow focus on drought, must be the central water resources challenge for development in Ethiopia.

DE-LINKING THE ECONOMY OF ETHIOPIA

In order to de-link economic performance from rainfall and enable sustained growth and development, three strategic shifts appear necessary.

First, Ethiopia must make major investments in water resources infrastructure, institutions, and management capacity. The country's growth will continue to be undermined until it achieves water security by acquiring a minimum platform of infrastructure, institutions, and capacity to manage its water resources. Investment on this scale may initially show low returns—much like a road investment, which shows little return until it joins two cities—but growth will continue to be hindered until water security is achieved.

Second, Ethiopia's investments in water infrastructure should be multipurpose in nature, and should be made in combination with the market infrastructure investments and related reforms needed to fully leverage their growth potential. Particularly given the vast scale of investments needed in water and transport infrastructure, it may be necessary to adopt a "growth pole" strategy (World Bank 2005) ensuring the resilience of the primary engines of economic growth. The combination of water, irrigation, hydropower, roads, and other market infrastructure investments should produce dramatic synergies and provide the incentives and opportunity for farmers to shift out of subsistence agriculture into surplus/commercial agriculture and nonagricultural activities. While it is common practice to spread different types of investment across regions, such isolated investments will not have the same growth impact as coordinated, co-located investments.

Finally, in addition to managing the variability of water resources, the vulnerability of the Ethiopian economy to hydrology must also be managed. Economy-wide, policies and investment decisions need to shift the pattern of development and the structure of the economy away from the country's heavy reliance on rainfed agriculture to make it less vulnerable to its hydrologic legacy.

WATER, POVERTY, AND WEALTH

In Ethiopia the centrality of water is clear. With little water resources infrastructure, relatively weak management institutions and capacity, extreme hydrological variability and seasonality, and a highly vulnerable economy, Ethiopia faces an enormous challenge in building the minimum platform of water infrastructure and management capacity needed to achieve water security. But until water security is achieved, growth will continue to be severely constrained.

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1 *Hydrologic variability* is variation in the distribution of water resources due to fluctuations in rainfall, groundwater levels, river flows, and so on.

2 The model includes 56 climatic zones, 34 agricultural commodities, 2 non-agricultural commodities, and distinguishes between irrigated and non-irrigated areas.

This note was prepared by Sandra Ruckstuhl, Consultant, and Claudia Sadoff, Lead Economist, both of the Water Resources Management team in the Agriculture and Rural Development Department of the World Bank. This note summarizes findings from the Ethiopia Country Water Resources Assistance Strategy (CWRAS) of the World Bank. It is based on findings from *Managing Water Resources to Maximize Sustainable Growth: A World Bank Water Resources Assistance Strategy for Ethiopia.* The core team for the report was led by Claudia Sadoff and included Catherine Revels, Yitbarek Tessema, Mekuria Tafesse, Mulat Demeke, Peter McCornick, Mark Rosegrant, Sherman Robinson, Xinshen Diao, Ken Strzepek, Paul Block, Charles Rogers, Martha Solomon, and Tadesse Kuma. David Grey provided advice and guidance to the core team throughout this work. The full report can be downloaded at www.worldbank.org/cwras. The text of this note can be downloaded at www.worldbank.org/rural or email ard@worldbank.org.