Two factors critical to assuring food security, whether at the local or the global level, are increasing crop productivity and increasing access to sustainable water supplies. These factors are also vital to the economic success of agriculture, which is particularly important in Ethiopia given that the sector accounts for about 41 percent of the country’s gross domestic product (GDP), produces 80 percent of its exports, employs 80 percent of the labor force, and is a major source of income and subsistence for the nation’s poor.

Extreme hydrological variability and seasonality have constrained Ethiopia’s past economic development by negatively affecting crop production—chiefly through droughts—and by destroying roads and other infrastructure due to flooding. As climate change unfolds, average climatic variables will shift, and weather variability will intensify, exposing Ethiopian agriculture to higher levels of risk and jeopardizing economic growth, food security, and poverty reduction. Most of the studies that have helped clarify the strong relationship between climate variability and Ethiopia’s GDP have been based on historical data, but future projections of climatic changes are critical to our understanding of the evolution of hydrological conditions in Ethiopia and our ability to extrapolate their associated effects on economic growth.

This brief is based on a paper that models the effects of three climate change–driven factors on the Ethiopian agricultural sector and overall economy. The model investigates the economic impact of water constraints on rainfed food production, changes in CO\textsubscript{2} fertilization due to increased atmospheric CO\textsubscript{2}, and losses due to floods.

OVERVIEW OF THE MODEL
The study assesses selected global circulation models from the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007) to project changes in water stress and flood events to 2050, together with changes in CO\textsubscript{2} concentration. The projections are compared with a 1990–2000 baseline period for three different emission scenarios. Outputs from the projections are then translated into impacts on crop yield due to water constraints, flood damage, and fertilization effects. The study then uses a multimarket model simulating the period 2003–50 to analyze the effects of changes in water constraints, flood damage, and fertilization on economic indicators such as agricultural GDP growth, overall GDP growth, and the poverty rate.

In order to compare projections with baseline conditions in the absence of climate change, the model incorporates new economic parameters for projected population growth and baseline economic growth to reflect recently updated observations. Importantly, the study examines the potential of the irrigation expansion recently proposed by the Ethiopian Ministry of Water Resources to buffer the effects of climate change.

NEGATIVE EFFECT ON GDP GROWTH
Although CO\textsubscript{2} can increase vegetative growth and biomass, a number of other factors like fertilizer availability must be in place for this potential to be realized. Results using the multimarket model show that CO\textsubscript{2} fertilization is expected to increase the rate of agricultural GDP growth and that this may be further enhanced by the Ethiopian Ministry of Water Resources’ proposed irrigation development.

Projections from the global circulation modeling show increased annual mean rainfall and an increase in evapotranspiration to the year 2050, although the magnitude of the variability in these parameters is larger than the change in mean values. The incremental variability of precipitation, which translates as fluctuating rainfall, reduces the availability of a stable water supply and increases the risk of floods. The frequency of low-probability extreme events is expected to increase as well. When these projections are translated into impacts on crop yields due to water constraints and flood damage, results from multimarket modeling indicate that flood damage—mainly influenced by weather variability rather than changes in the means—has a larger depressing effect on agricultural and overall GDP growth.

These results demonstrate that the negative impact on GDP growth actually stems from hydrological variability rather than water supply constraints. When the effects of all three climate factors are evaluated together, flood damage still drives the overall impacts. The difference between the three climate scenarios is minimal, with the worst conditions occurring for the scenario that embodies the most extreme climatic changes (Scenario A2). Implementation of the proposed irrigation development has a positive, but limited, buffering effect on agriculture GDP growth under climate change conditions for all three scenarios. The improvement is visible, but it does not change the main adverse impact of climate change on growth (Figure 1).
Analysis of climate change impacts on five agriculture subsectors that are important for smallholder subsistence farmers and pastoralists shows that climate change increases poverty, even with increased irrigation development.

POLICY IMPLICATIONS
In Ethiopia, climate change is expected to intensify the already high hydrological variability and frequency of extreme events. More than changes in mean annual rainfall, these two factors may have a significant negative effect on the development of the agricultural sector and on the Ethiopian economy as a whole. Droughts impair agricultural productivity and may lock subsistence farmers into poverty traps, whereas recurrent flooding can have long-term negative effects on agricultural GDP by directly damaging crops and by destroying roads, thereby exacerbating the inadequacy of transport infrastructure and consequently limiting access to markets. Omitting climate change impacts from future investment analyses will lead to suboptimal investment decisions. Our analysis can therefore support decisionmaking by identifying development strategies that offer the highest resilience to future climate change.

Based on the analysis, it appears that investments in multipurpose water infrastructure, such as reservoirs, detention ponds, and small dams, have a high potential to address increased hydrologic variability by increasing water storage and regulating water flows, while at the same time providing water for irrigation. The benefit of the Ethiopian government’s proposed irrigation development could thus be further enhanced through a focus on multipurpose storage infrastructure in high-risk flood areas.

Over time, the nonagricultural sector will increasingly dominate Ethiopia’s GDP growth, but most of the population will continue to depend on agriculture for survival. Given important concerns about the country’s wealth distribution and poverty levels—and given that agriculture is highly vulnerable to climate variability and change—Ethiopia should start to invest in agriculture and rural water today.

FOR FURTHER READING

Figure 1  Simulations of GDP growth based on changes in water constraints, flood damage, and fertilization

<table>
<thead>
<tr>
<th>GDP level under different scenarios (log of million U.S. dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a. Without proposed irrigation development</strong></td>
</tr>
<tr>
<td>2003</td>
</tr>
<tr>
<td>Baseline</td>
</tr>
<tr>
<td>5.00</td>
</tr>
</tbody>
</table>

| **b. With proposed irrigation development**                   |
| 2003  | 2008  | 2013  | 2018  | 2023  | 2028  | 2033  | 2038  | 2043  | 2048  |
| Baseline| Scenario A1B | Scenario A2 | Scenario B1 |
| 5.00  | 4.80  | 4.60  | 4.40  | 4.20  | 4.00  | 3.80  |       |       |       |

NOTE: The baseline scenario provides GDP projections without climate change. The worst effect on GDP growth is observed under Scenario A2, which corresponds to the most extreme climatic changes.

Gene J.-Y. You (geneju@ntu.edu.tw) is an assistant professor in the Department of Civil Engineering at National Taiwan University. Claudia Ringler (c.ringler@cgiar.org) is a senior research fellow in the Environment and Production Technology Division of the International Food Policy Research Institute.

This series of IFPRI Research Briefs is based on research supported by the Federal Ministry for Economic Cooperation and Development, Germany, under the project “Food and Water Security under Global Change: Developing Adaptive Capacity with a Focus on Rural Africa,” which forms part of the CGIAR Challenge Program on Water and Food. Through collaboration with the Center for Environmental Economics and Policy in Africa, the Ethiopian Development Research Institute, the Ethiopian Economics Association, and the University of Hamburg, the project aims to provide policymakers and stakeholders in Ethiopia and South Africa with tools to better understand and analyze the consequences of global change—in particular climate change—and to form policy decisions that facilitate adaptation in these countries and beyond.

Financial Contributors and Partners
IFPRI’s research, capacity strengthening, and communications work is made possible by its financial contributors and partners. IFPRI receives its principal funding from governments, private foundations, and international and regional organizations, most of which are members of the Consultative Group on International Agricultural Research (CGIAR). IFPRI gratefully acknowledges the generous unrestricted funding from Australia, Canada, China, Denmark, Finland, France, Germany, India, Ireland, Italy, Japan, the Netherlands, Norway, the Philippines, South Africa, Sweden, Switzerland, the United Kingdom, the United States, and the World Bank.

Printed on alternative-fiber paper manufactured from agriculturally sustainable resources that are processed chlorine-free (PCF).

Copyright © 2011 International Food Policy Research Institute. All rights reserved. Sections of this document may be reproduced without the permission of but with acknowledgment to IFPRI. Contact ifpri-copyright@cgiar.org for permission to reprint.