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

The Impact of Climate Variability and Climate Change on Water and Food Outcomes

A Framework for Analysis

Claudia Ringler

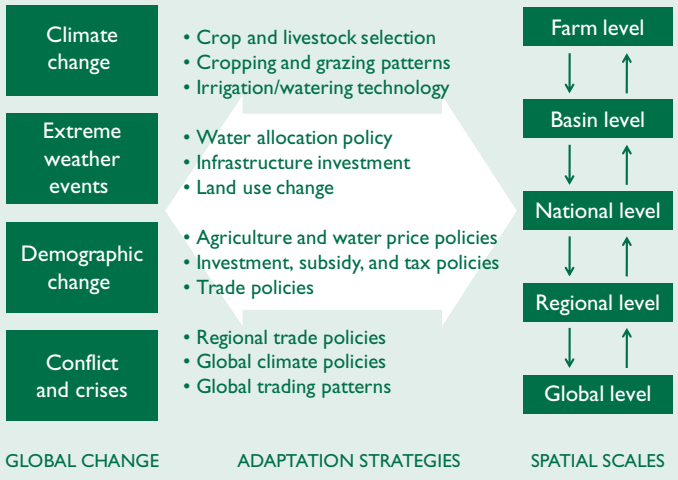
Over the coming decades, global change will have an impact on food and water security in significant and highly uncertain ways, and there are strong indications that developing countries will bear the brunt of the adverse consequences, particularly from climate change. This is largely because poverty levels are high, and developing-country capacity to adapt to global change is weak. Furthermore, the rural populations of developing countries—for whom agricultural production is the primary source of direct and indirect employment and income—will be most affected due agriculture's vulnerability to global change processes. The agricultural sector is the largest consumer of water resources, and variability in water supply has a major influence on health and welfare in poor areas. With water scarcity and extreme weather events expected to increase under climate change, water security could decline significantly in rural areas. Consequently, it is important to understand the impacts of global change (in terms of climate, demography, technology, and so on) on agriculture and natural resources in developing countries and to develop adaptive capacity to respond to these impacts. Moreover, there is a need to develop informed and effective adaptation measures and investment options that can be taken now to alleviate adverse impacts of global change in the future.

FRAMEWORK FOR ANALYSIS

While food and water security are largely determined by actions taken at the local or national levels, global factors—such as world food trade, global climate and climate change, and competition for water—also affect food and water security locally. Moreover, human alteration of land use patterns, urbanization, elimination of wetlands, nutrient overloading in water systems, and other biophysical changes could dramatically affect the ability of the global water cycle to support needed food production. The development of policies that mitigate adverse impacts, enhance positive impacts, and support adaptation to climate and global change, together with enhancing local food and water security, therefore requires an understanding of the interactions among local, basin-level, national, and global factors.

Thus, analysis of strategies for increased food and water security must take into account relevant hydrologic, agronomic, economic, social, and environmental processes at global, regional, national, basin, and local levels (Figure 1). This could be done following the paradigm of "strategic cyclical scaling" devised by Root and Schneider (see further reading), which incorporates large- and small-scale research studies to improve our understanding of complex environmental systems and allow more reliable projections of the ecological, economic, and social consequences of global change. Process-based, bottom-up relationships are used to predict larger scale behavior, which is then tested against large-scale data for a top-down evaluation. Cycling between large and small scales should thus produce more credible overall results.

Figure 1 Global Change, Spatial Scales, and Adaptation Strategies



SOURCE: C. Ringler, The impact of climate variability and climate change on water and food outcomes: A framework for analysis, in C. van Bers, D. Petry, and C. Pahl-Wostl, eds., *Global assessments: Bridging scales and linking to policy*, GWSP Issues in Global Water System Research No. 2, http://www.gwsp.org/downloads/gwsp_issues_no2.pdf, 2007.

RESEARCH ACTIVITIES

A project supported by Germany's Federal Ministry for Economic Cooperation and Development, entitled "Food and Water Security

under Global Change: Developing Adaptive Capacity with a Focus on Rural Africa," has conducted research on adaptation to climate change at various scales. This project, which is associated with the Challenge Program on Water and Food under the Consultative Group on International Agricultural Research (CGIAR), involved close collaboration with researchers at the Center for Environmental Economics and Policy in Africa, the Ethiopian Development Research Institute, the Ethiopian Economics Association, and the University of Hamburg.

At the local level, farm household surveys were implemented in the Nile River Basin of Ethiopia and the Limpopo River Basin of South Africa to examine vulnerability to shocks, perceptions of long-term changes in climate (precipitation and temperature), and the determinants of adaptation to long-term global warming. Policymakers are generally more interested in the development of adaptation measures following political rather than hydrologic boundaries. Consequently, vulnerability and adaptation measures were also developed at the province and state levels for these two countries. In parallel, stakeholder forums were held in Ethiopia and South Africa to discuss measures of vulnerability, adaptation options and constraints, and the role of information and various actors—that is, the State, private sector, and civil society—in shaping adaptation to climate change. Finally, the impact of climate change on crop production in the survey sites was simulated based on crop yield and production function models to assess the implications of climate change for local food security.

At the basin level, the impact of climate change on water availability, water demands, and irrigation was simulated to identify basin-level adaptation strategies. Moreover, alternative investment strategies at the basin level were identified for Ethiopia taking into account climate variability and change, and broader impacts on the economy. A different but similar approach was used to study the impact of climate change and adaptation strategies on river basin units in South Africa. To capture the interactions of climate change and adaptation at the national and regional (Sub-Saharan Africa) levels, a water and food projections model was updated to take into account the impacts of climate change in addition to other drivers of global change. Using the integrated analysis tool, the impact of global change on poverty and water and food security was assessed for case study countries and Sub-Saharan Africa. Alternative adaptation strategies developed at workshops were assessed using the modeling framework, taking into account the local-level constraints and basin-level challenges identified.

These sets of analyses were complemented with papers on the role of climate change mitigation for the region, the importance of taking risk into account in devising adaptation options, and the role of collective action and property rights in community adaptation. The outcomes of the analyses can be used to guide appropriate response options to reduce rural vulnerability to global change.

CONCLUSIONS

The development of adaptive capacity to reduce adverse impacts of global change in rural areas of developing countries requires analyses at various spatial scales and an understanding of the linkages across the various scales. At the farm level, households adjust to global change by changing farm practices or abandoning farming. These local actions, in turn, influence climate and global change. At the basin level, basin authorities influence both land and water allocation, and carry out purposeful adaptations to global change. Purposeful adaptation can be either tactical, in response to climate or other global changes, or strategic, in anticipation of future global change. At the national level, governments and authorities influence ecosystem services and human well-being. They also carry out purposeful adaptations, including changes in price, trade, and investment policies to anticipate or respond to global change. At the regional level, organizations and institutions have the potential to mitigate global change impacts through changes in trading regimes, and the development of regional transportation and communications infrastructure. Important global factors also affect water and food security at the local level, such as world food trade and competition for water generated by the world economy.

This series of briefs describes the results of research in all these areas. While these results reflect only one round of research using the "strategic cyclical scaling" framework, it is hoped that future research will lead to even greater integration of bottom-up and top-down approaches.

FOR FURTHER READING

Ringler, C., The impact of climate variability and climate change on water and food outcomes: A framework for analysis, in C. van Bers, D. Petry, and C. Pahl-Wostl, eds., Global assessments: Bridging scales and linking to policy, GWSP Issues in Global Water System Research No. 2, http://www.gwsp.org/downloads/gwsp_issues_no2.pdf, 2007.

Root, T. L., and S. H. Schneider, Ecology and climate: Research strategies and implications. *Science* 269 (5222: 334–341, 1995).

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