East African Agriculture and Climate Change:

A COMPREHENSIVE ANALYSIS — SUDAN*

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DECEMBER 2012

CURRENT CONDITIONS

Sudan's[*] economy relies mainly on rainfed agriculture. Key cereal crops are sorghum, millet, and wheat. Livestock numbers are estimated at more than 140 million cattle, sheep, goats, and camels. Sudan's population is about 39 million, with annual growth rates of 2.1–2.6 percent. The share of the population living in cities is projected to increase from around 40 percent in 2005 to 60.7 percent by 2030, which would mean that 94 percent of population growth will occur in urban areas. Within Sudan, an estimated six million people have been displaced, mostly by drought, desertification, and famine in the north, and by conflict, famine, and flood-induced epidemics in the south.

Income-based poverty rates computed by the World Bank and UNDP are thought to be as high as 90 percent in southern Sudan, and around 60 to 75 percent in the north. The official poverty line differs from the one used by the World Bank / UNDP. Using that, only around 50 percent are in poverty, with the poverty rate in rural areas (55.4 percent) being more than twice that in urban areas (24.4 percent). Thirty-one percent of children under five years of age are moderately or severely underweight, and 32.5 percent suffer from moderate or severe chronic malnutrition. In fact, the national level of acute malnutrition is just below the international standard indicating a nutrition emergency.

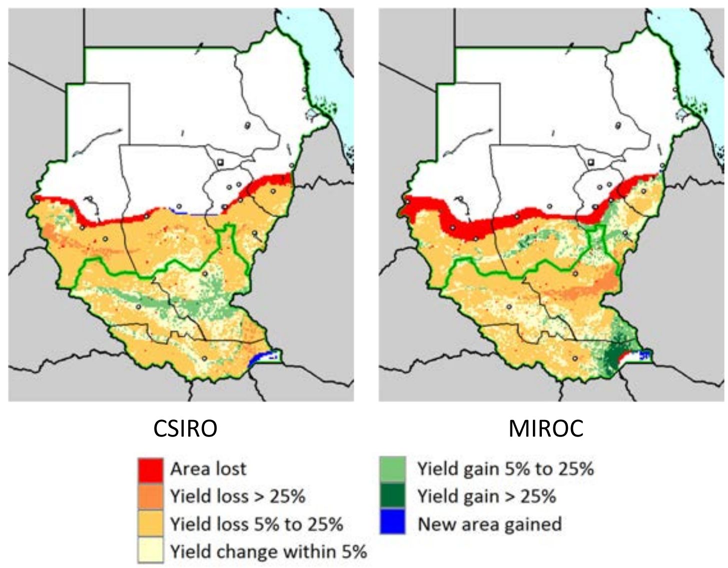
Enrollment in basic education increased in Sudan (the northern country) from 65 percent in 2004 to 71 percent in 2009. The national literacy rate for both north and south together for people aged 15–24 increased from 27 percent in 1990 to 69 percent in 2009, reaching 72.5 percent in 2010. The incidence of malaria and morbidity rates have also declined significantly.

CLIMATE CHANGE SCENARIOS & THEIR POTENTIAL EFFECTS ON YIELDS

As a basis for our analysis, we used four downscaled global climate models (GCMs) from the IPCC AR4. The CSIRO model projects that annual rainfall will remain unchanged through 2050, while the MIROC model indicates that most of the southern part of Sudan will get wetter, a very favorable outcome, particularly for the semiarid regions.

While changes in annual precipitation are negligible or positive, the story for temperature change is different. The results of all models indicated that Sudan is getting warmer (within a range of 0.5–3^{0}C). The CSIRO model projected only moderate increases in temperature for the whole country, with all but very small patches in the 1–1.5^{0}C range. The MIROC model, on the other hand, showed significant spatial variation, with only modest temperature increases in the south, but very large temperature increases in the north. Higher temperatures would increase evaporation and reduce soil moisture, increasing plant water requirements—an unfavorable trend, particularly if associated with a lower level of precipitation and insufficient irrigation water.

CHANGES IN YIELD WITH CLIMATE CHANGE: RAINFED SORGHUM



The maps above depict the results of the Decision Support System for Agrotechnology Transfer (DSSAT) crop modeling software projections for rainfed sorghum, comparing crop yields for 2050 with climate change to yields with 2000 climate. The climate effects from both models result in a yield loss of 5–25

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percent between 2000 and 2050 over most of the country's sorghum harvest area, and, in the marginal cultivated areas of the semi-dry zone, some loss of baseline area. These results would have serious implications for food security, as sorghum is the main staple cereal grain of the rural population. Those same climate models show some limited gain in baseline area that could potentially offset part of the yield loss in the rest of the cropped land.

For irrigated wheat, both climate models predict very negative impacts, ranging from a complete loss of baseline area to a yield loss of 5–25 percent of baseline or more. The most heavily affected areas will be central Sudan (the Gezira scheme and along the White and Blue Niles) and part of the River Nile state. While these areas produce 75 percent of Sudan's wheat, they are marginal areas for wheat production, with current temperatures already warmer than optimal for wheat. The research challenge will be to develop wheat strains and other production technologies to counter the effects of climate change, or to determine economically viable alternative crops.

CLIMATE CHANGE & FOOD SECURITY SCENARIOS

The research used the IMPACT global model for food and agriculture to estimate the impact of future GDP and population scenarios on crop production and staple consumption, which can be used to derive commodity prices, agricultural trade patterns, food prices, calorie consumption, and child malnutrition. Three GDP-per-capita scenarios were used – an "optimistic scenario" with high per capita income growth and low population growth, a pessimistic scenario with low per capita income growth and high population growth, and an intermediate scenario.

Generally, assumptions about population and GDP have a greater impact on future agriculture and malnutrition than does climate change. Yet climate change significantly impacts these areas when compared to a future without climate change.

The IMPACT model predicts that sorghum yield will increase by around 30 percent between 2010 and 2050, while harvested area will increase by around 20 percent over the same period. Together, these changes will result in a production increase of about 60 percent. The international price for sorghum averaged over all scenarios is projected to increase by 25 percent between 2010 and 2050. Exports of sorghum are likely to remain constant under the pessimistic scenario but they double under the intermediate and optimistic scenarios.

For wheat, the outcomes of the model had two main features: (1) greater variability across GCMs in production and yield and (2) decreases in both production and harvested area, with area decreasing more rapidly, even with the world market price assumed to rise by 23 percent. Higher temperatures cause losses in area and yield in the main wheat-producing areas of central Sudan. As a result of climate change, Sudan is likely to become more dependent on imports to meet its wheat demand over time.

Millet yields are projected to increase by almost 70 percent, and with area increasing by more than 20 percent, production should more than double. The production boost outpaces any rise in consumer demand, resulting in a rise in exports. World millet prices are projected to hold steady through 2030 before falling gradually to produce a decline of about 13 percent for the period between 2010 and 2050.

The IMPACT model predicts a decrease in the number of malnourished children in the optimistic and intermediate scenarios, but a slight increase under the pessimistic scenario. Nonetheless, with population increases, the proportion of malnourished children declines in all three scenarios.

Calorie consumption rises in all three scenarios, although the increase is much larger in the optimistic scenario than in the other two: in the optimistic scenario calorie consumption will increase by around 30 percent between 2010 and 2050; in the intermediate and pessimistic scenarios, calorie consumption will rise by 10 percent over the same period.

RECOMMENDATIONS

To facilitate adaptation of agriculture to climate change, policymakers should:

- promote the development and testing of new agricultural technologies (such as drought- and heat stress-resistant high-yield varieties and hybrids) and improved water harvesting and management techniques to enhance productivity;
- promote an active agricultural extension service that is integrated with agricultural research institutions to communicate these developments to farmers;
- establish early warning systems to collect and communicate weather data in a timely manner;
- improve institutional partnerships, coordination, and collaboration for effective long-term adaptation strategies; and
- work with vulnerable communities at the local level, applying a bottom-up approach to project planning.

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This is an excerpt from the chapter on Sudan that will appear in the forthcoming peer-reviewed IFPRI monograph, *East African Agriculture and Climate Change: A Comprehensive Analysis*. For more information, contact g.nelson@ifpri.org. The authors would like to acknowledge financial support from the European Union and the Canadian International Development Agency through their support of the CGIAR Research Program on Climate Change, Agriculture, and Food Security, the German Federal Ministry for Economic Cooperation and Development, and the Bill and Melinda Gates Foundation.