Southern African Agriculture and Climate Change:

A COMPREHENSIVE ANALYSIS — ZAMBIA

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CURRENT CONDITIONS

Zambia's climate is characterized by a dry period, which runs from May to October, and a wet period that runs from November to April. Because most of the country's agriculture is rainfed, rainfall variability poses challenges for food security and planning. Agriculture accounts for about 20 percent of Gross Domestic Product (GDP), with maize as the dominant crop (the other main crops are wheat, sorghum, cassava, rice, millet, groundnuts, soybeans, mixed beans, peanuts, sunflower seed, vegetables, coffee, flowers, tobacco, cotton, and sugarcane). Agricultural jobs account for 71.6 percent of employment in Zambia. During the period between 1960 and 2008, the population increased by more than 50 percent. The urbanization rate in Zambia has averaged 4.3 percent over the past 50 years.

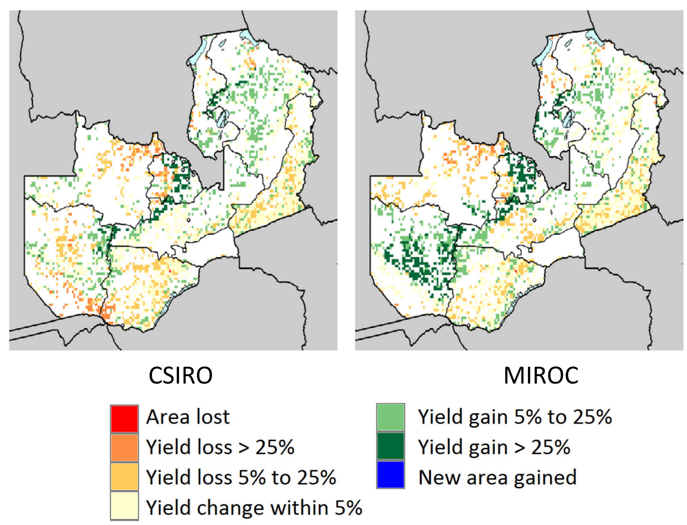
CLIMATE CHANGE SCENARIOS & THEIR POTENTIAL EFFECTS ON YIELDS

Of the four downscaled global climate models (GCMs) used in our study, all of which are from the IPCC AR4, the models project dramatically different results. The CSIRO model shows no significant change in annual rainfall between 2010 and 2050 over most of the country, but an increase of 50–100 mm for parts of Western Province (currently low to medium rainfall) and a decrease of 50–100 mm for parts of Northwestern and Copperbelt Provinces (high rainfall areas). In contrast, the MIROC model shows an increase (averaging 120 mm) for most parts of the country, but little change for extreme southern Zambia.

The CSIRO and MIROC models both predict an increase in temperature, but they differ regarding the magnitude of the increase, along with geographic differences within each model. All four models show an increase in temperatures for the average daily maximum during the warmest month, but they differ regarding the magnitude of the increase. The CNRM model shows an increase of 2–3.5^{0}C for Zambia, with the upper value of that range being among the highest in Africa. The CSIRO and MIROC models project more moderate increases of 1–2^{0}C.

The maps above depict the results of the Decision Support System for Agrotechnology Transfer (DSSAT) crop modeling software projections for rainfed maize, comparing crop yields for

CHANGES IN YIELD WITH CLIMATE CHANGE: RAINFED MAIZE



2050 with climate change to yields with 2000 climate. The MIROC model predicts yield gains in Western Province, the eastern half of North-Western Province, Copperbelt Province and most of Northern and Luapula Provinces. While some of these gains are more than 25 percent, there are also yield losses predicted in Southern Province, parts of Eastern Province, and elsewhere. A small portion of these losses are more than 25 percent in all of the models used. The CSIRO model predicts yield losses in Western Province, but the results are very similar to those of the MIROC model for the other provinces.

The data suggest that the current distribution of maize is concentrated in areas where yields will likely decrease with climate change. This suggests that farmers may increase pressure for expanding agriculture into lands that are not currently being used, and farmers may abandon other areas or substitute other crops for maize.

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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 (or baseline) scenario.

All scenarios seem to show a much brighter future for Zambia. The pessimistic scenario shows per capita GDP increasing by 260 percent. The intermediate scenario predicts a near five-fold increase, and the optimistic scenario predicts a near ten-fold increase.

The IMPACT model projects that maize yield will increase by about 50 percent between 2010 and 2050, while harvested area will not change by much, resulting in a production increase of about 50 percent. For maize, yield changes did not differ between scenarios, nor did it differ between climate models, suggesting that changes are primarily driven by technological change and consumer demand. With population and incomes rising, the result will be increased maize imports.

For cassava, the IMPACT model predicts that yields will rise by about 50 percent. However, the decrease in harvested area by almost half will offset the yield gains, resulting in little overall change in total production (small initial gains over the first half of the timeframe will be followed by a slightly larger decrease). As a result, cassava imports will increase by about a million metric tons over the period. The world price of cassava is projected to increase very slightly, and in the optimistic scenario, not at all.

For cotton, the IMPACT model shows increases in production and yield in all three scenarios. The harvested area declines slightly. Net cotton exports rise through 2030, and then seem to decline thereafter (the models give mixed results about whether they fall below 2010 levels). The world price of cotton is projected to increase by about 80 percent between 2010 and 2050.

Malnutrition levels for children under five years are predicted to rise through 2025, and then fall. With population growth, the increase in the absolute number of malnourished children through 2025 represents a decline in the rate of childhood malnutrition. The optimistic scenario predicts a very steep decline after 2025 (from about 600,000 malnourished children in 2025 to less than 200,000 in 2050). The pessimistic scenario predicts a slow rate of decrease (from 600,000 in 2025 to 450,000 in 2050). The baseline scenario predicts an intermediate rate of decrease (from 600,000 in 2025 to 400,000 in 2025).

In all three scenarios, the model predicts a decrease in availability of kilocalories per capita between 2010 and 2025, which is followed by an increase thereafter. The increase is greatest under the optimistic scenario, and is only moderate under the baseline and pessimistic scenarios. Overall, the increasing availability of kilocalories per capita mirrors the declining trend for levels of malnourished children under five years.

RECOMMENDATIONS

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

- invest in research on water harvesting, irrigation schemes, and water rights;
- examine potential climate impacts on additional crop varieties and livestock;
- introduce incentives to promote adoption of new crop varieties in non-traditional farming areas (maize in high rainfall areas like Northwestern, Luapula, and Northern Provinces, as well as cassava, sorghum, and millet in the drought-prone central and southern parts of Zambia);
- provide rural credit facilities to enable subsistence farmers to buy new varieties of seeds and other inputs;
- remove subsidies on crops that do not perform well in a changing climate;
- invest in technological innovations like seed banks;
- include civil society and the private sector in implementation;
- promote an integrated approach to supporting agriculture that involves allied service providers, including the Department of Water Affairs, Meteorological Department, local authorities, roads departments, and social service providers; and
- base decision-making on a range of scenarios, given the uncertainties in climate forecasting.

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