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Southern African Agriculture and Climate Change:

A COMPREHENSIVE ANALYSIS — BOTSWANA

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CURRENT CONDITIONS

Botswana has a semi-arid climate, characterized by warm winters, hot summers, low rainfall, and high evapotranspiration. The country is prone to frequent droughts, lately occurring every two years rather than once every four years, as in the previous decade. Only 5 percent of Botswana's area is suitable for cultivation and less than 1 percent is cultivated. The major staple crops, sorghum and maize, are mostly grown in the eastern region. While the contribution of agriculture to GDP has declined to about 2 percent over the past decade, agriculture remains the mainstay activity for the rural economy, employing 30 percent of the workforce. The small-scale farmers who work 80 percent of the country's planted area produce just 38 percent of the total crop harvest. In addition to being less productive, small farms are more susceptible to the effects of drought, as they lack modern farming technologies and irrigation equipment.

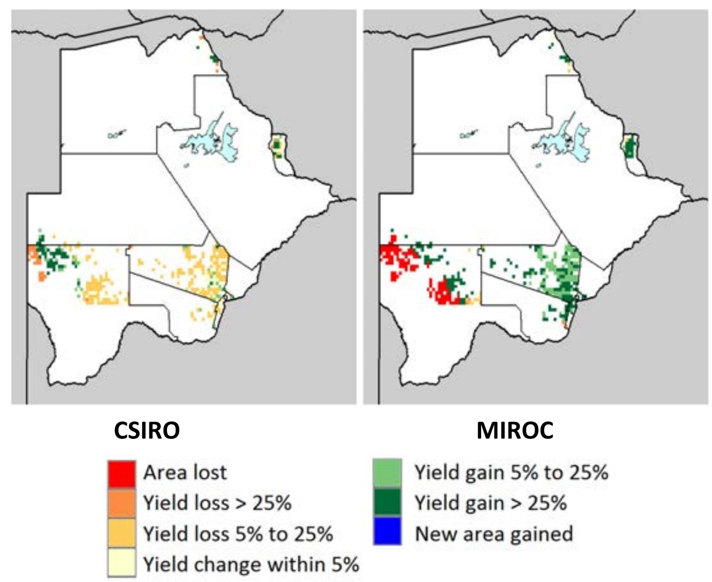
CLIMATE CHANGE SCENARIOS & THEIR POTENTIAL EFFECTS ON YIELDS

Of the four downscaled global climate models (GCMs) used in our study, all of which are from the IPCC AR4, CSIRO and MIROC predict minimal change in annual precipitation in the central, northern, eastern, and western parts of the country between 2000 and 2050. Both suggest a reduction in precipitation of between 100 and 50 mm in the southern and southeastern regions. However, CSIRO predicts an increase in precipitation in the southwestern parts of the north region. The "driest" model shows a decrease in annual precipitation across Botswana of between 50 and 200 mm.

The models were also used to project the likely variation in average daily maximum temperature for the warmest month of the year from 2000 to 2050. The CSIRO and MIROC models suggest an overall increase in the annual maximum temperature ranging from 1.5°C to 2.5°C. Both predict that the east will have smaller temperature increases than the southwest. One model predicts temperature increases of greater than 3°C for 95 percent of the country.

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 2050 with climate change to yields with 2000 climate. Both CSIRO and MIROC climate effects result in a gain in maize yield of more than 25 percent over the 2000 baseline in the North East district and the Pandamatenga area. The MIROC model depicts yield gains ranging from 5 percent to more than 25 percent in one scenario, mostly concentrated in the Kweneng district. For the Kgalagadi district, the GCM models differ, with the CSIRO GCM showing a mix of yield gains and losses, while the MIROC GCM indicates almost total loss of land for maize.

CHANGES IN YIELD WITH CLIMATE CHANGE: RAINFED MAIZE



Modeling of the impact of climate change on yields of rainfed sorghum indicates losses ranging from 5 to 25 percent in the Ghanzi district, the Ngamiland district, and half of the Central district. MIROC projects some yield gains in parts of the Central district, as well as almost all of Kweneng district and Southern district. The GCMs differ regarding the Kgalagadi district. MIROC and CSIRO show losses of land against the baseline for most districts. The areas where most of the yield gains are predicted are dominated by subsistence farms dependent on rainfed agriculture.

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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.

It is not clear that the GDP projections of the optimistic scenario can be realized, since output in the mining sector is expected to decline after 2025. Without significant economic diversification, agricultural production is likely to grow as a share of GDP after 2025–30. The projected increase in GDP per capita, meanwhile, coupled with population growth and continued rural-urban migration, is likely to push up demand for food. If not matched with improvements in agriculture production, the increase could raise food prices or boost demand for imported foods.

The IMPACT simulation suggests that maize yield in Botswana will improve by 67 percent between 2010 and 2050, while area, on average will decline by 10 percent, resulting in a production boost of around 50 percent. There appears to be little variation in yield or area between scenarios, but yield, for example, is 40 percent higher in under the most optimistic climate model compared to the most pessimistic climate model. The global price of maize will double between 2010 and 2050.

For sorghum, yield is expected to increase even more dramatically than that of maize: by 170 percent, on average across climate models and for any given scenario. Area is expected to grow by around 36 percent, leading to production growing by around 260 percent. Production increases far out-pace the growth in consumer demand, leading to a rise in net exports. The IMPACT model estimates that the price of sorghum will rise less sharply and remain relatively stable after 2025. Averaging the results for all scenarios and climate models together, sorghum prices will only be 25 percent higher in 2050 than in 2010.

The IMPACT model also predicted the number of malnourished children under the age of five and the number of available kilocalories per capita as indicators of the impact of climate change on human welfare. The results suggest that the number of malnourished children will continue to rise steadily to 2025 and then decline. The optimistic and intermediate scenarios predict that this downward trend will continue through 2050, when malnutrition levels are expected to be below the 2010 levels. The shorter-term increase is in line with the aforementioned food-price increases. The share of malnourished children will decline further as population growth increases the total number of children.

The IMPACT analysis projects a reduction in available kilocalories per capita through 2025 in the intermediate scenario, followed by an improvement. The optimistic scenario projects a slight increase through 2025 and a much more rapid increase thereafter. The pessimistic scenario depicts a steady decline through 2025 and a slower decline thereafter. In the intermediate scenario, the availability of kilocalories is projected to remain below the normal threshold of about 2,300 per day until 2045.

RECOMMENDATIONS

If it is to be successful in its efforts to fight poverty, diversify the economy, and improve food security, the government should mainstream climate change into its policies, plans, and programs. Policymakers should:

- complement vulnerability assessments with adaptation strategies designed to offset the impacts of climate change;
- undertake pilot adaptation measures, scaling up the most promising among them;
- build capacity within the country to use crop models to assess climate change and other agricultural impacts;
- create a forum for information-sharing to spread awareness of the best adaptation measures;
- deploy a monitoring and evaluation framework to track the achievement of adaptation objectives and to generate feedback for further development planning;
- conduct research in conjunction with regional and international institutions to identify crop and livestock strategies that can help farmers adapt to projected temperature increases;
- take advantage of cost-benefit analysis and lessons learned to guide adaptive measures and strategies.

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