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

Climate Variability and Maize Yield in South Africa

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Maize is the primary food staple in southern Africa, and 50 percent of the total maize output in the area is produced in South Africa, where maize constitutes approximately 70 percent of grain production and covers 60 percent of the country's cropping area. Climate change could have a significant impact on South African maize production. The scientific community has established that the temperature in South Africa increased significantly between 1960 and 2003 (by 0.13 degrees Celsius), and further temperature increases and changes in the quantity and pattern of rainfall are expected despite any attempts by the international community to reduce greenhouse gas emissions. Although the maize plant is quite hardy and adaptable to harsh conditions, warmer temperatures and lower levels of precipitation could have detrimental effects on yields, thereby increasing food insecurity in the region.

This brief is based on a paper that uses household survey data to explore the direct impact of climate variability, measured by changes in temperature and precipitation, on maize yields in the Limpopo Basin of South Africa.

MAIZE PRODUCTION IN SOUTH AFRICA

Sampled farms in the Limpopo Basin of South Africa produced 1,237 kilograms per hectare of maize using an average of 449 hours of labor per hectare, 26 kilograms of seed per hectare, and 159 kilograms of fertilizer per hectare during the 2004/05 growing season. A majority of the farms were rainfed; only 7 of the 25 farms in the survey sample (28 percent) used supplementary irrigation during the 2004/05 growing period (Table 1). Temperature and precipitation data were obtained from weather services in South Africa and were matched with farms within the neighborhood of each climate station. The mean temperature for the months of the 2004/05 farming season was 21.4 degrees Celsius, and the mean monthly precipitation was 71 millimeters (Table 1).

Table 1 Maize Production in the Limpopo Basin of South Africa, October 2004–May 2005

Indicator	Mean
Yield (kg/ha)	1,237
Labor (hrs/ha)	449
Seed (kg/ha)	26
Fertilizer (kg/ha)	159
Mean temperature (°C/month, October–May)	21
Mean precipitation (mm/month, October–May)	71
Irrigation (=1)	0.28

THE IMPACT OF CLIMATE VARIABILITY AND CHANGE ON MAIZE PRODUCTION IN SOUTH AFRICA

Under the study on which this brief is based, mathematical models were applied to estimate the direct impact of climate variability on maize yields. As was expected, an increase in production inputs—including labor, seed, fertilizer, and irrigation—raises maize yields substantially. Consistent with previous findings on the impact of climate change and crops in South Africa, the results suggest that a change in the amount of precipitation is the most important driver of maize yields. A 10 percent reduction in mean precipitation reduces the mean maize yield by approximately 4 percent. Correspondingly, an increase in mean precipitation increases mean maize yields; however, as rainfall continues to increase, the additional gain in maize yield begins to diminish (Figure 1). Also consistent with previous studies, the results suggest that changes in temperature affect maize yields. As the mean temperature increases from 21.4 to 21.6 degrees Celsius, the average maize yield increases by 0.4 percent. However, like increased precipitation, the gain in maize yields prompted by increased temperature begins to diminish as temperature increases further.

Figures 1 and 2 show that an increase in either precipitation or temperature from the 2004/05 mean values would increase maize yields at a decreasing rate. The combined effect of changes in temperature and rainfall on maize yields depends on the magnitude and direction of each of the changes. As predicted by climate models, the overall impact on yields of a marginal decrease in mean precipitation simultaneous with a marginal increase in mean temperature will be negative because the effect of reduced precipitation on maize yields is stronger than the effect of increased temperature. The figures also show that yields from

Figure 1 Diminishing Marginal Yield Benefit from Increasing Monthly Precipitation

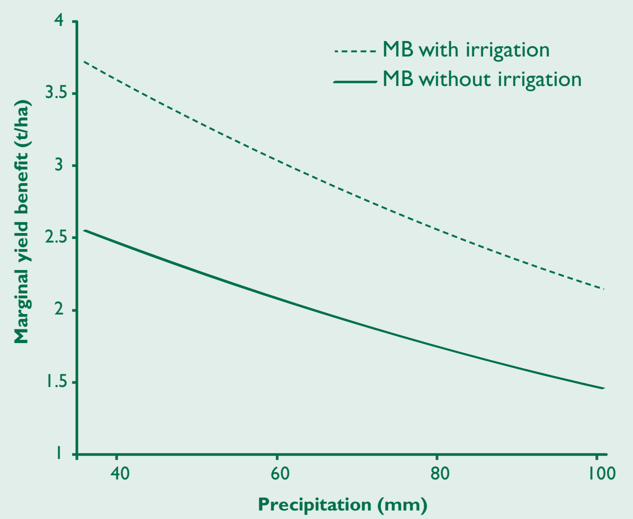
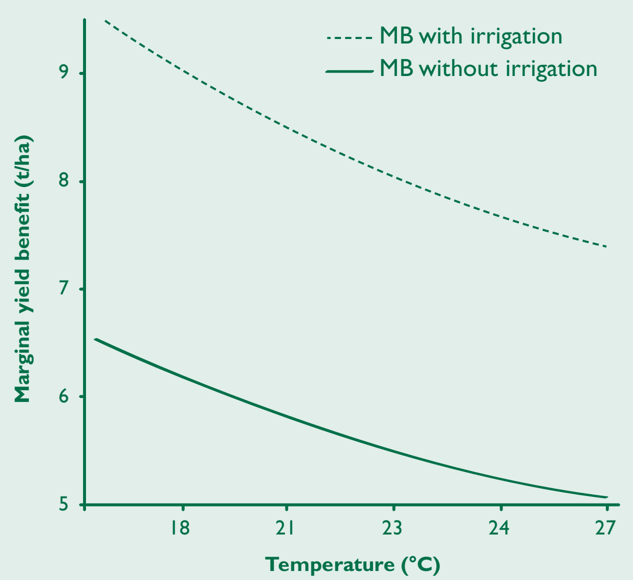


Figure 2 Diminishing Marginal Yield Benefit from Rising Temperature



irrigated farms are higher than from non-irrigated farms, irrespective of the temperature and level of precipitation.

POLICY IMPLICATIONS

The scientific evidence shows that mean temperature in South Africa has increased and is expected to increase further in the future. At the same time, mean rainfall is expected to decrease by 5 to 10 percent, and rainfall variability is expected to increase over the next 50 years. The results of this study indicate that such effects would have a significant negative impact on maize yields and consequently pose a serious threat to food security in South Africa as well as other countries in the southern African region that depend on maize imports from South Africa.

The results also suggest that one way to mitigate potential yield loss due to climate change is to encourage irrigation. The findings show that irrigated farms had higher maize yields than did dryland farms; however, maize yields are determined more by the level of precipitation than by the presence of irrigation, indicating that irrigation practices partially mitigate the impact of decreased precipitation on yields.

Additional observations and data on temperature and precipitation at the farm level, rather than from nearby climate stations, would increase the robustness of these results. Nevertheless, while the study on which this brief is based could be improved with better data, this research provides an important starting point for further studies in South Africa and other developing countries on the impact of climate variability and climate change on crop yields and the resulting implications for food security.

FOR FURTHER READING

Akpalu, W., R. M. Hassan, and C. Ringler, *Climate Variability and Maize Yield in South Africa: Results from GME and MELE Methods*, IFPRI Discussion Paper No. 843 (Washington, DC, 2009).

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