East African Agriculture and Climate Change:

A COMPREHENSIVE ANALYSIS — MADAGASCAR

MIREILLE RAHAINGO VOLOLONA[1], MIRIAM KYOTALIMYE[2], TIMOTHY S. THOMAS[3], AND MICHAEL WAITHAKA[2]

DECEMBER 2012

CURRENT CONDITIONS

Madagascar is an island in the southwestern Indian Ocean off the coast of Mozambique. The topography of the country is varied and uneven, with some regions dominated by plains and plateaus extending into vast delta areas.

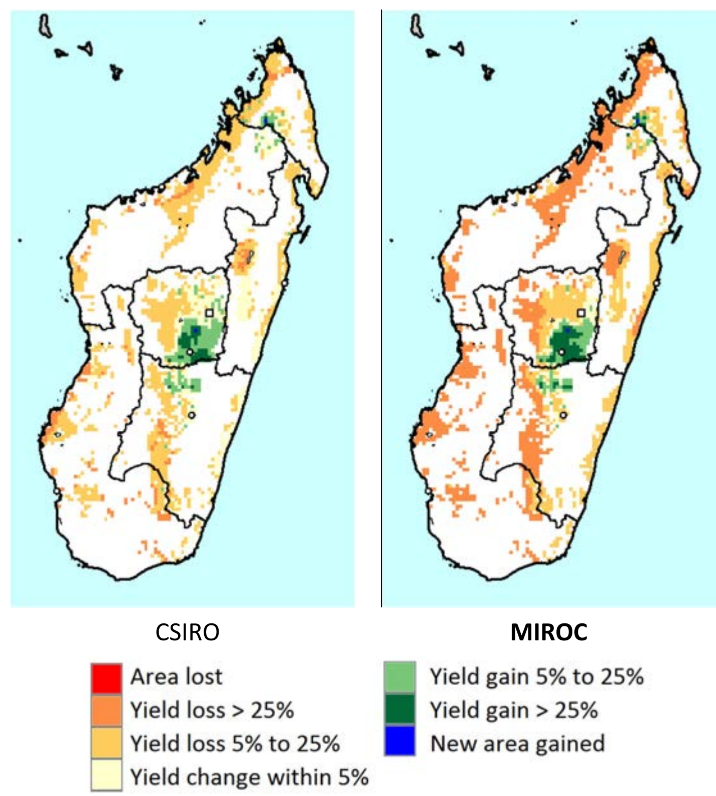
Average annual temperatures range between 23˚C and 27˚C. The eastern and northwestern coasts are dominated by southeasterly trade winds, which produce annual precipitation ranging from 2,000 mm to 3,700 mm. The central plateau and the western coast receive rain from the monsoon winds, with precipitation ranging from 1,000 mm to 1,500 mm per year. The south receives as little as 350 mm of rain in a year.

Only about 5 percent of the land area is cultivated at any given time, of which 16 percent is irrigated. In addition to providing livelihoods for two-thirds of the population, agriculture contributes 29 percent of Madagascar's GDP.

Most farmers practice subsistence agriculture, growing rice, cassava, bananas, maize, and sweet potatoes. Yields are generally low and not keeping up with population growth. For example, per capita rice production declined from 1.2 tons in 1975 to 0.9 tons in 2006, despite a 15 percent growth in rice area and and 35 percent increase in rice yield over the same period. Slash-and-burn (shifting) agriculture is a common practice, resulting in environmental degradation and loss of forest area.

Extreme weather events threaten agricultural productivity. For example, in early 2000, a series of three particularly devastating cyclones affected more than a million people and caused nearly $85 million in damage to agricultural infrastructure.

CHANGES IN YIELD WITH CLIMATE CHANGE: IRRIGATED RICE



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. For the northern part of the country, the models projected either no change or an increase in annual precipitation. In the south, rainfall either remains relatively unchanged or decreases (the range of increase or decrease in both regions falls within 50–200 mm). Because most of the country's key crops are rainfed, reduced rainfall has negative consequences for agricultural production. More irrigation investment is required or farmers may need to switch to crops that are suitable with less rainfall. Less rainfall would mean more cassava mosaic disease, which would reduce yield. In short, without adaptation or technological improvements, food insecurity may increase. Since the south already receives much less rain than the north, this reduction could be a significant blow to the cultivation of many of that region's crops.

The climate models also project increased temperatures of 0.5–3°C. The CSIRO model predicts a median temperature increase of 1.3°C, which is considerably cooler than the increase of 2.1°C projected by the MIROC model. Furthermore, the results differ in

---

[1]Ministry of Agriculture; [2]Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA); [3]International Food Policy Research Institute (IFPRI).

their geographic variation. High temperatures promote evapotranspiration, thus reducing soil moisture and increasing soil degradation. High temperatures may also foster more pests and disease, as in the case of cassava mosaic disease.

The Decision Support System for Agrotechnology Transfer (DSSAT) crop modeling software was used to compute yields for six crops in rainfed and irrigated systems under current temperature and precipitation regimes, and then again for the 2050 climate projections. The maps illustrate projected yield changes for rainfed rice. The results indicate remarkably similar changes across all GCMs. Each shows losses throughout the island. In the CSIRO model, most of the losses appear to be less than 25 percent, while in the MIROC model most losses are greater than 25 percent. But there is a noticeable area of yield gain near Antananarivo, which other maps suggest is devoted to irrigated rice. There is also a much smaller patch in the north that shows yield gain. Both of these patches are in high elevations with colder temperatures. Rice yields are hampered by the cold. These maps illustrate that with climate change rice yields could increase in selected locations. While it is difficult to determine whether the yield gains in these high-production areas will offset the losses, many of which occur in low-production areas, we can see that there will likely be winners and losers among rice growers as a result of climate change, and there may be pressure for new settlements or more intensive cultivation in those areas where productivity is expected to rise.

For rainfed maize, the DSSAT results show climate change resulting in scattered areas of yield increase but with overall yield declines.

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. Per capita GDP increases in all scenarios, with the pessimistic scenario predicting a gradual rise to $650 by 2050, while the optimistic scenario projects that per capita GDP will increase to $1,740.

The results indicate that rice yields will more than double between 2010 and 2050 as technology advance outweighs the negative effects of climate change. With harvested area projected to increase only slightly through that period, production is projected to more than double. Rising internal demand for the crop will lead to increased imports in the intermediate and optimistic scenarios despite increases in international prices of rice (by 55 percent – averaged across all scenarios and climate models – between 2010 and 2050); maize (by 101 percent) and cassava (5 percent.)

For cassava, the analysis showed increased production, harvest area, and yields, as well as rising cassava prices. However, there is also a clear trend of increased imports between 2010 and 2050.

For maize, yields rise by around 60 percent but the area under cultivation is projected to drop by around 40 percent. Both of these changes are true regardless of scenario and regardless of climate model, since there is virtually no variation between the results for any of these. This leads to a slight increase in production until 2020, and then a decline, leaving production in 2050 around 10 percent lower than in 2010. As in the case of cassava and rice, the country will experience declining net exports and face higher prices by 2050. As a result, Madagascar is projected to go from being an exporter to an importer of maize.

A projected rise in available calories per capita will increasingly come from trade rather than domestic production.

The IMPACT model projects that the number of malnourished children will rise slightly before it declines in both the optimistic and baseline scenarios. The numbers increase more dramatically in the pessimistic scenario and do not return to the 2010 levels by 2050.

RECOMMENDATIONS

To enable farmers to adapt to the impacts of climate change, policymakers should:

- fund agricultural research and extension institutions' development and promulgation of crop varieties better suited to a range of potential future climate conditions;
- develop new varieties and substitutes for maize (including grains that are more resilient in hot, dry conditions, possibly sorghum or millet); and
- improve existing weather forecasting systems and international cooperation on meteorological issues.

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
2033 K Street, NW • Washington, DC 20006-1002 USA
T: +1.202.862.5600 • F: +1.202.467.4439
Skype: ifprihomeoffice • Email: ifpri@cgiar.org

This is an excerpt from the chapter on Madagascar 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.