East African Agriculture and Climate Change:
A COMPREHENSIVE ANALYSIS — SENEGAL

MAMADOU KHOUMA[1], ABDULAI JALLOH[2] AND TIMOTHY S. THOMAS[3]   DECEMBER 2012

CURRENT CONDITIONS

The agricultural sector employs 77 percent of Senegal's workforce. Rice is the country's staple crop, but millet is the most widely grown crop, largely because of low rainfall in most of the country. The severe drought in the late 1960s and early 1970s contributed to migration into cities. The share of GDP from agriculture has been declining since the mid-1980s, despite noticeable improvements over the last decade, reflecting the growing dominance of the service sector. The malnutrition rate for children under five years (14.5 percent) is decreasing. The increase in life expectancy from 40 years in 1960 to more than 50 years in 2008 has been driven by improvements in health care, including efforts to reduce the mortality rate of children under five years. The proportion of the population living on less than US$2 a day is lower in urban areas, areas where irrigation is developed, and areas where important industries are located.
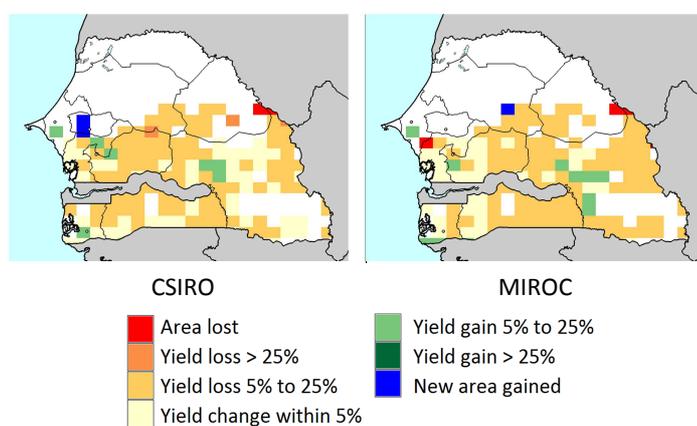
CLIMATE CHANGE SCENARIOS & THEIR POTENTIAL EFFECTS ON YIELDS

As a basis for our analysis, we used four downscaled global climate models (GCMs) from the IPCC AR4. All models project that rainfall will be more or less unchanged in most of Senegal. However, both the CNRM and MIROC models project that rainfall will increase by 50–100 mm in the Casamance region. In contrast, the ECHAM model predicts a reduction of 50–200 mm in eastern Senegal.

The models predict an increase in the average daily maximum temperature during the warmest month of at least 1–1.5^{0}C across the country. The CNRM, CSIRO, and ECHAM models project that smaller temperature increases will be experienced in the west with higher in the east. The MIROC models has similar temperature patterns, but the smaller increases will be in the south, with higher increases further north. The CNRM model predicts that temperatures will rise by 1.5–2.5^{0}C and the ECHAM model predicts an increase of 1.5–3^{0}C. The CSIRO and MIROC models predict the lowest increases in temperature, with the CSIRO ranging from 0.8–1.8^{0}C, and the MIROC ranging from 1.2–2.1^{0}C.

The maps above depict the results of the Decision Support System for Agrotechnology Transfer (DSSAT) crop modeling

CHANGES IN YIELD WITH CLIMATE CHANGE: RAINFED GROUNDNUTS

CSIRO   MIROC

■ Area lost
■ Yield loss > 25%
■ Yield loss 5% to 25%
□ Yield change within 5%
■ Yield gain 5% to 25%
■ Yield gain > 25%
■ New area gained

software projections for rainfed groundnuts, comparing crop yields for 2050 with climate change to yields with 2000 climate. Both the CSIRO and MIROC models show a general yield loss of 5–25 percent, with varying loss in harvested area in the northern fringes of the groundnut basin. Both models also project a few small areas of yield gain.

For maize, all models project yield gains of 5–25 percent for the areas where maize currently grows. In addition, all models predict some areas of yield loss. The CNRM and ECHAM models predict a larger decline in maize yields than the CSIRO and MIROC models. The ECHAM also predicts relatively greater loss in harvested area than the CSIRO and MIROC models.

The projections for rainfed rice are very similar to those for maize, but project a relatively greater increase in yield. In Senegal, the data indicate that climate change will have more adverse impact on groundnuts than on maize or rice.

_____

[1] Consultant, Agronomist, and Climate Change Expert; [2] Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles/West and Central African Council for Agricultural Research and Development (CORAF/WECARD); [3] IFPRI.

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.

In the pessimistic scenario, the change in per capita GDP between 2010 and 2050 is relatively small. In the optimistic scenario, per capita GDP is projected to rise from almost $750 in 2010 to $1,866 in 2030, reaching more than $5,600 in 2050. However, realizing these optimistic conditions would require sound public and private investments in productive sectors that can provide employment and generate wealth. The baseline scenario, which seems more realistic, projects moderate GDP growth, but still assumes a quadrupling of income between 2010 and 2050.

IMPACT predicts a 60 percent yield increase between 2010 and 2050 for groundnuts. There is only a slight difference between scenarios in yield prediction, with the pessimistic scenario averaging about 4 percent higher than the optimistic scenario. There is a little greater variation between climate models for any given scenario, with the high yield being about 7 percent higher than the low yield. Harvested area is projected to grow by 87 percent. Together with yield growth, this suggests a tripling of production. Despite such a large increase, consumer demand grows rapidly, as well, resulting in projections ranging between no change to an increase in net imports. In the pessimistic scenario, global prices of groundnuts increase by 24 percent, while in the optimistic scenario, the declined by 13 percent.

Similar to groundnuts, sorghum yield is projected to increase, though for sorghum, it is by 120 percent. However, there is virtually no variation in yield between scenarios or climate models. Area is projected to increase by 68 percent, resulting in production increasing by 270 percent. All the models also predict an increase in the world price for sorghum, but only around 25 percent. However, for the optimistic and baseline scenarios, net imports are predicted to rise after 2020, while the pessimistic scenario predicts an increase in exports.

Maize yields are expected to rise by a more modest 40 percent when compared to groundnuts and sorghum, and the area expansion is projected to be a modest 12 percent. Production, therefore, will increase only by 60 percent. All scenarios predict a doubling of the world price of maize, as well as an increase in net exports from about 120,000 metric tons (MT) in 2010 to around 200,000 MT in 2025, declining thereafter. The optimistic scenario projects the lowest range.

The number of malnourished children under the age of five is projected to not change much in the pessimistic scenario over the entire 2010 to 2050 period. However, there will likely be more than a 50 percent reduction in malnourished children in the intermediate and optimistic scenarios. Furthermore, population growth suggest that the share of malnourished children under five years will decline substantially in the latter two scenarios, and will decline even in the pessimistic scenario.

Average calorie consumption projections were nearly identical. In the pessimistic scenario, per capita availability of calories does not improve. Only the baseline and optimistic scenarios result in an increase. Together, these figures point to the importance of raising income levels to alleviate malnutrition.

RECOMMENDATIONS

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

- improve meteorological data collection;
- establish early warning systems to help farmers plan cropping systems before the onset of the rainy season; and
- invest in research and extension so that appropriate technologies can be developed and employed.