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Famine Early Warning Systems Network—Informing Climate Change Adaptation Series

FEWS NET FAMINE EARLY WARNING SYSTEMS NETWORK

A Climate Trend Analysis of Uganda

Conclusions

- *Both spring and summer rains have decreased in Uganda during the past 25 years.*
- *The magnitude of observed warming, especially since the early 1980s, is large and unprecedented within the past 110 years, representing a large (2+ standard deviations) change from the climatic norm.*
- *Cropping regions in the west and northwest appear most affected by the observed changes in climate.*
- *Rainfall declines in the west and northwest threaten Uganda's future food production prospects.*
- *Warming temperatures may be adversely affecting coffee production.*
- *Rapid population growth and the expansion of farming and pastoralism under a drier and warmer climate regime could dramatically increase the number of at-risk people in Uganda during the next 20 years.*
- *In many cases, areas with changing climate are coincident with zones of substantial conflict, indicating some degree of association; however, the contribution of climate change to these conflicts is not currently understood.*

A Context for Adapting Food Security to Climate Changes in Uganda

This brief report, drawing from a multi-year effort by the U.S. Agency for International Development (USAID) Famine Early Warning Systems Network (FEWS NET), identifies observed changes in rainfall (fig. 1) and temperature in Uganda, based on an analysis of a quality-controlled, long time series of station observations throughout Uganda. Extending recent trends forward, it also provides a current and near-future context for understanding the actual nature of climate change impacts in the country, and a basis for identifying climate adaptations that may protect and improve the country's food security.

Although the general level of food insecurity in Uganda is relatively low compared to its neighbors in the region, Internally Displaced Persons (IDPs), and pastoralists and agropastoralists, in the northern and northeastern parts of the country face chronic and intermittently higher levels of food stress (FEWS NET, 2010). A protracted insurgency by the Lord's Resistance Army is the primary cause of internal displacement of populations in Uganda. The disruption of the IDP's traditional livelihoods and communities, and especially their ability to cultivate crops, has greatly increased the overall vulnerability of these now marginalized groups. Pastoralists in the northeast, especially in Karamoja, face chronic food insecurity. More frequent droughts decrease their resilience, as well as the resilience of pastoralists and agro-pastoralists in the broader "cattle corridor", a dryland area of approximately 84,000 square kilometers (km^2) that stretches from the northeast to the southeastern parts of the country (Stark, 2011).

Observed and Projected Rainfall Trends

Smoothed time series of 1900–2009 rainfall (fig. 2, 10-year running mean), extracted for crop growing regions in Uganda, indicate that 2000–2009 rainfall has been, on average, about 8 percent lower (-0.65 standard deviation) than rainfall between 1920 and 1969. Although the June–September rainfall appears to have been declining for a longer period, the March–June decline has only occurred recently.

These declines have been visualized in figure 1 as a contraction of the regions receiving adequate rainfall for viable agricultural livelihoods. Actual and projected (extending recent patterns forward) changes are mapped across the country in figure 3.

Uganda receives most of its rain between March and June, and rainfall totals of more than 500 millimeters (mm) during this season typically provide enough water for crops and livestock. Between 1960 and 1989, the region receiving this much rain (on average) during March–June is shown in light brown in the left panel of figure 1 and should be understood to lie beneath the dark brown and orange areas. During the past 25 years, this region has contracted (dark brown polygon), exposing populations in the central and western parts of the country to increased rainfall deficits. Cropping areas northeast of Fort Portal, south of Gulu, and northwest of Bombo no longer receive, on average, the bountiful rains that were the norm between 1960 and 1989. If present rainfall trends continue, by 2025 the drying impacts will likely lead to a further contraction (orange polygon in fig. 1).

A similar set of polygons is also shown for the June–September season (right panel, fig. 1). Unimodal rainfall areas across the north of the country are likely to be affected by earlier cessation of summer rains.

Observed rainfall reductions of the 1960–2009 period are projected to the 2010–2039 period in figure 1, assuming a persistence of the observed trends (fig. 2). The projected rainfall declines range from -150 to -50 mm across the northern part of the country, and appear likely to impact the already chronically insecure IDPs and the inhabitants of Kamajora.

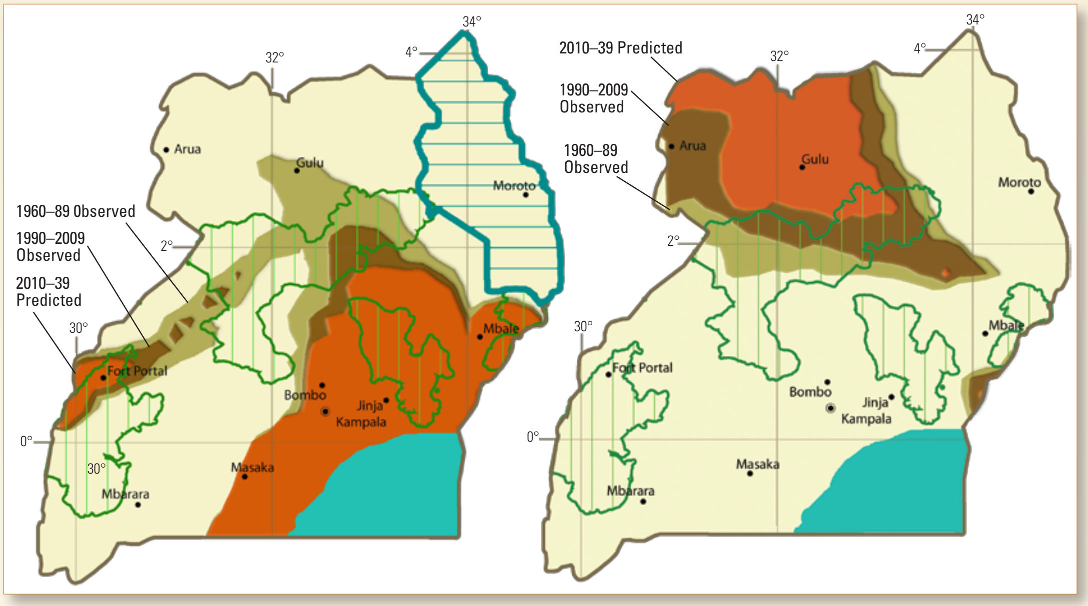

Figure 1. Climate change in Uganda: The left map shows the average location of the March–June 500 mm rainfall isohyets for 1960–1989 (light brown), 1990–2009 (dark brown), and 2010–2039 (predicted, orange). The green polygons in the foreground show the main maize surplus regions; these areas produce most of Uganda's maize. The blue polygon in the upper-right shows the Karamoja region.The right map shows analogous changes for the June–September 500 mm rainfall isohyets.

Observed and Projected Temperature Trends

Time series of air temperature data (fig. 2) indicate that the magnitude of recent warming is large and unprecedented within the past 110 years. It is estimated that the 1975 to 2009 warming has been more than 0.8 degrees Celsius (°C) for Uganda during both the March–June and June–September rainy seasons. Given that the standard deviation of annual air temperatures in these regions is low (approximately 0.3°C), these increases represent a large (2+ standard deviations) change from the climatic norm.

Temperatures have increased by up to 1.5°C across much of Uganda (fig. 3), with typical rates of warming around 0.2°C per decade. This transition to an even warmer climate is likely to amplify the impact of decreasing rainfall and periodic droughts, and will likely reduce crop harvests and pasture availability. Because this area is characterized by repeated conflicts that reduce the overall availability of food, a decrease in locally produced food because of reduced crop harvests and pastures will have a significant impact on food security. Assuming the observed climate trends persist, we can create a composite of observed and anticipated air temperature changes (figs. 3 and 4). The spatial pattern of warming corresponds (broadly) with the areas associated with reduced precipitation. Uganda is becoming drier and hotter, which is consistent with an increase in atmospheric circulation, bringing dry subsiding air during the March–June and June–September rainy seasons.

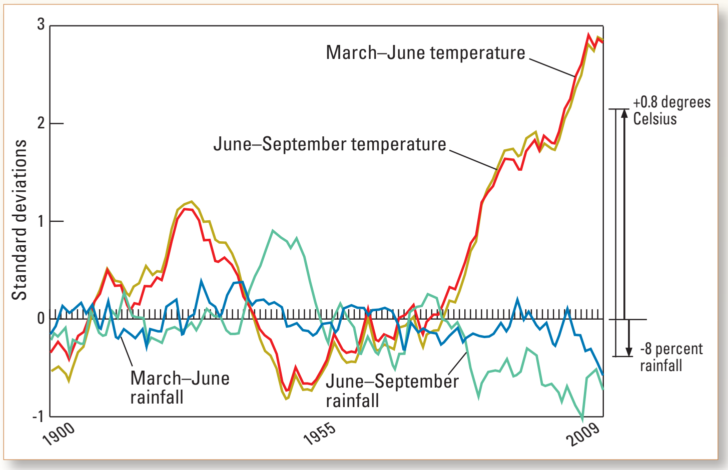

Figure 2. Smoothed 1900–2009 March–June and June–September rainfall and air temperature time series for crop-growing regions.

Such warming in regions with high average air temperatures can amplify the impact of water shortages on agriculture. Warming temperatures may adversely affect coffee production, which is an important cash commodity in Uganda. Temperature sensitivities vary by coffee varieties, but most coffee plants fare poorly in areas with average air temperatures greater than 24°C. During March–June and June–September, these areas have been expanding (fig. 4), and this expansion of warm areas will likely continue during the next century as the earth continues to warm.

Population Pressure and Stagnating Agricultural Growth

In 2011, Uganda's population was 30.6 million, with a rapid population growth rate of 3.6 percent (CIA, 2011). If sustained, this growth rate will result in a doubling of the population every 20 years. According to Gridded Population of the World statistics (CIESIN, 2010), the population increased by 89 percent between 1990 and 2010, adding some 15 million people. Given that Uganda is a landlocked country that depends on agricultural, agro-pastoral, and pastoral livelihoods, this population expansion will place increasing stress on limited natural resources. Crop statistics from the United Nations Food and Agriculture Organization indicate that per capita cereal production in Uganda is low (150 kilograms per person per year). While yields have been improving, the amount of farmland per person has been declining twice as fast. If these trends persist, then per capita cereal production could decline by 35 percent by 2025. This level of food production could leave hundreds of thousands more Ugandans exposed to hunger and undernourishment.

A Convergence of Evidence

There is a consistent set of patterns being displayed between the observed rainfall and temperature data evaluated in this report. Both of these station-based analyses indicate large departures from normal. As well, there is a convergence of evidence between the declines in the observed patterns of rainfall and temperature in Uganda, with those seen in nearby southwestern Ethiopia, South Sudan, and Kenya. FEWS NET analyses from these countries reveal similar trends (see Objectives

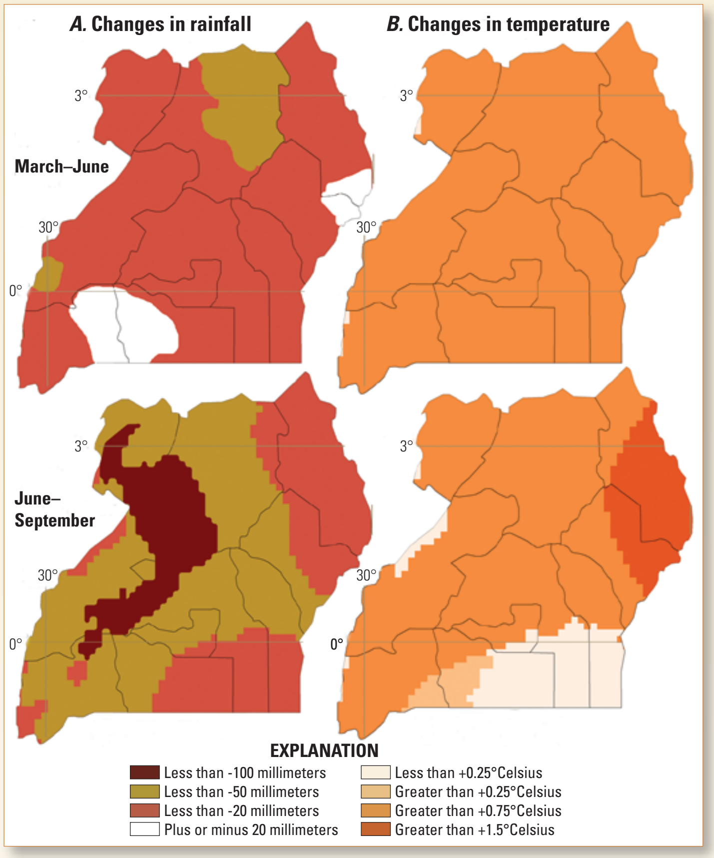

Figure 3. Observed (1960–2009) and projected (2010–2039) changes in March–June and June–September rainfall and temperature.

and Methods section). In addition, recent analyses of climate model output indicate that these trends are associated with the observed warming of the Indian and Western Pacific Oceans (Funk and others, 2008; Williams and Funk, 2011; Williams and others, 2011). Therefore, a persistence of the observed trends might be assumed as the most likely case, against which climate adaptation efforts should be oriented.

Some Implications for Food Security and Adaptation Efforts

Although the results presented here do not depict a massive drying trend, they are potentially large enough to affect the IDPs, agro-pastoralists, and pastoralists across northern Uganda. The 0.6 standard deviation decline in rainfall (close to –8 percent) is sufficient to increase the frequency of poor harvests that would be expected. The increasingly frequent droughts could be offset by adaptation efforts aimed at improving water and agricultural management practices, and raising yields in wetter areas may be a more viable option, for the medium and longer-run, than extending agriculture into more marginal areas. In both cases, however, rapid population growth may make it difficult to slow the process of agricultural extensification into marginal areas.

Given the importance of coffee to the economy of Uganda, the observed drying and warming of Uganda's climate is another priority to examine for potential adaptation efforts. Since 1980, decreasing rainfall has been accompanied by rapid increases in air temperature on the order of +0.8°C. This warming will negatively impact maize and coffee production, and exacerbate the impact of droughts.

Objectives and Methods

The FEWS NET Informing Climate Change Adaptation series seeks to guide adaptation efforts by providing subnational detail on the patterns of climate trends already observed in an appropriately documented record. Whether or not these observed trends are related to natural climate variations, global warming, or some combination of the two is less important than knowing now where to focus adaptation efforts.

These FEWS NET reports rely on rigorous analysis of station data, combined with attribution studies using observed climate data. This brief report examines Ugandan rainfall and temperature trends for the last 110 years (1900–2009) using observations from 57 rain gauges and 5 air temperature stations for the two primary rainy periods, corresponding to March–June and June–September. The data were quality controlled, and the mean 1960–1989 and mean 1990–2009 station values calculated. The difference between these means was converted into 1960–2009 trend observations and interpolated using a rigorous geo-statistical technique (kriging). Kriging produces standard error estimates, and these can be used to assess the relative spatial accuracy of the identified trends. Dividing the trends by the associated errors allows us to identify the relative certainty

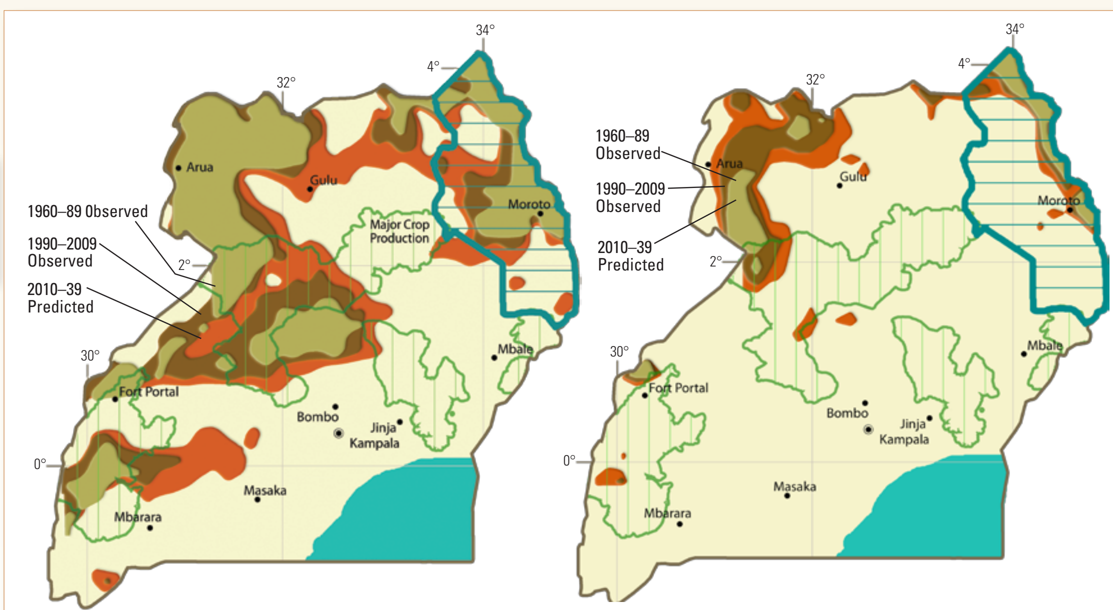

Figure 4. Warm regions expand in Uganda: The left map shows the average location of the March–June 24 degrees Celsius (°C) isotherms for 1960–1989 (light brown), 1990–2009 (dark brown), and 2010–2039 (predicted, orange). The green polygons in the foreground show the main maize surplus regions. The blue polygon in the upper-right shows the Karamoja region. The right map shows analogous changes for the June–September 24°C isotherms.

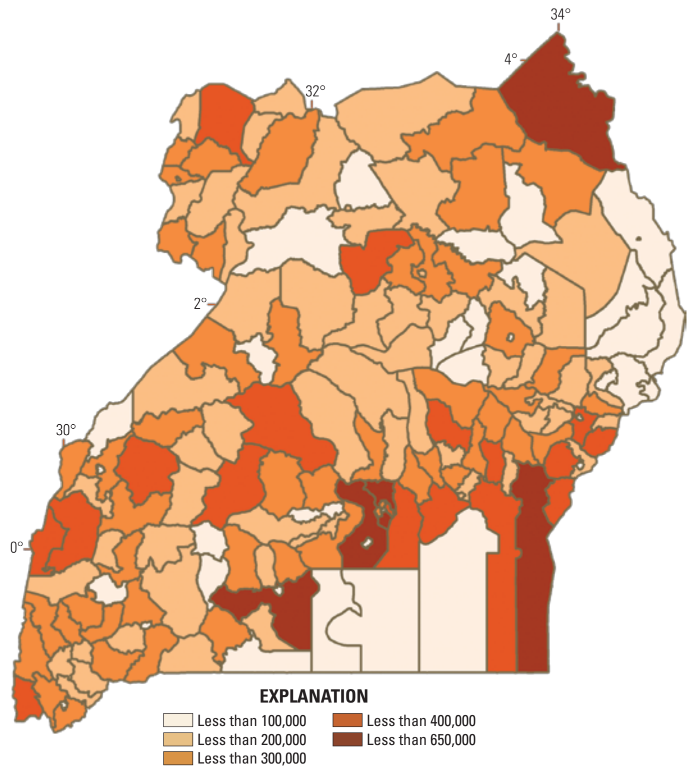

Figure 5. Landscan 2008 population for Uganda.

of our estimates (Funk and others, 2005; Verdin and others, 2005; Brown and Funk, 2008; Funk and Brown, 2009; Funk and Verdin, 2009; Funk and others, 2011). The location of climate changes should be considered in conjunction with population (fig. 5; ORNL, 2010) and other factors affecting food security.

The observed warming trends are more likely to continue in the same direction and rate of change than the rainfall trends. Recent declines in rainfall appear linked to a warming of the Indian and Western Pacific Oceans and are, therefore, likely to persist for at least the next decade. Readers interested in more information can see the reference links below. These publications are available at *http://earlywarning.usgs.gov/fews/reports.php*.

This report was written by Chris Funk and Jim Rowland (both USGS), Gary Eilerts (USAID), and Libby White (UCSB). It builds upon a multi-year research project (see references below) carried out under a USAID-funded FEWS NET agreement with USGS.

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