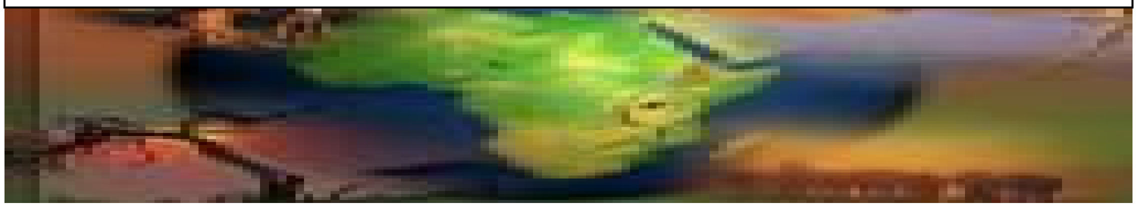
CLIMATE CHANGE AND AFRICAN AGRICULTURE
Policy Note No. 27, August 2006, CEEPA



The economic impacts of climate change on agriculture in Zambia[1]

Over the last two decades, the frequency of extreme climate events such as high surface temperatures, floods and droughts has increased over the entire globe. Although such extreme events are attributed to climate variability, they also signal that the earth is going through long-term climate changes in mean temperature and rainfall norms. Zambia has experienced an increase in drought frequency and intensity in the last 20 years. The droughts of 1991/92, 1994/95 and 1997/98 worsened the quality of life for vulnerable groups such as subsistence farmers.

This study attempted to assess the economic impacts of long-term climate change such as the increase in mean surface temperature and the decrease in mean seasonal rainfall and mean annual runoff on farming activities in Zambia, in order to provide information for appropriate adaptation policies at national level so as to minimize the adverse impacts of climate change on agriculture.

[1] This Policy Note is prepared by M de Wit based on Jain (2006), An empirical economic assessment of impacts of climate change on agriculture in Zambia, *CEEPA Discussion Paper No. 27, CEEPA, University of Pretoria.*

The study used a cross-sectional approach to measure the relationship between net revenue from agriculture and climate in Zambia by correlating variations in key climate attributes and corresponding variations in net revenue observed across the country. The data for the analysis was based on 1015 cross-sectional farm household surveys.

Cross-sectional observations across different climates can reveal the climate sensitivity of agriculture. The advantage of this empirical approach is that it does not only capture the direct effect of climate on productivity but also reflects farmers' adaptation to local climate. This farmer behavior is important as it mitigates problems associated with deviations from optimal environmental conditions. Analyses that do not include adaptation (such as the early agronomic studies) overestimate the damages associated with any deviation from the optimum. However, while the Ricardian model takes into account the costs associated with various adaptation alternatives, it suffers some limitations.

The value of agriculture in Zambia

Agriculture is becoming an increasingly important sector in the Zambian economy since the mineral sector, which was the backbone of the economy from post-independence times (1964) till the late 1980s, has declined. The agriculture sector generates about 18% to 20% of the country's GDP and provides a livelihood for more than 60% of the population. It employs about two-thirds of the labor force.

Zambia has an estimated nine million hectares of land (12% of its total land area) suitable for cultivation and 16 million hectares suitable for rangeland grazing. The country is divided into three agro-ecological zones with rainfall as the dominant distinguishing climatic factor (Figure 1).

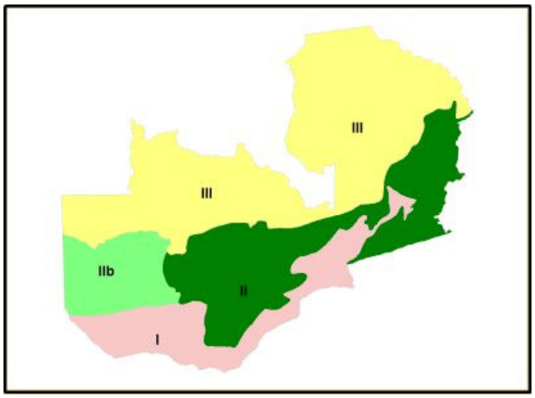


Figure 1: Agro-ecological zones of Zambia

Zone I lies in the western and southern part of the country and accounts for about 15% of the land area. It receives less than 800mm of rain annually. It used to be considered the bread basket of the nation but for the last 20 years it has been experiencing low, unpredictable and poorly distributed rainfall. The observed meteorological data suggest that it is currently the driest zone, very prone to drought and with limited potential for crop production.

Zone II covers the central part of the country, extending from the east through to the west. It is the most populous zone, with over four million inhabitants, and has the highest agricultural potential. The soils here are relatively fertile. It receives about 800–1000mm of rainfall annually, which is evenly distributed throughout the crop growing season.

Zone III spans the northern part of the country and has a population of over 3.5 million. It receives over 1000mm of rainfall annually. The high rainfall in this region has resulted in the soils becoming leached. It is suitable for late maturing varieties of crop. About 65% of the region in this zone has yet to be exploited.

Observed climate trends in Zambia

The observed temperature from 32 meteorological stations in Zambia was analyzed to detect trends in temperature change over last 30 years. The mean temperatures computed for the agro-ecological zones for three time periods, November to December, January to February and March to April, indicate that the summer temperature in Zambia is increasing at the rate of about 0.6°C per decade, which is ten times higher than the global or southern African rate of increase in temperature (Figures 4 to12). The rate of increase is highest in November–December as compared to other periods across all agro-ecological zones.

The major cropping season in Zambia runs from November through April. Agriculture in this season depends on the rains to a very large extent. There is a minor cropping season from June through September. The major crops grown are maize, sorghum, millet, rice (paddy), wheat, cassava, groundnuts, sunflower, cotton, soya beans, mixed beans and tobacco. Most of these are summer crops which depend almost entirely on the rains. Wheat is a minor winter crop and is grown by large-scale farmers using irrigation. This minor season is not included in the analysis.

Figure 2: trends in mean seasonal temperature in Zambia

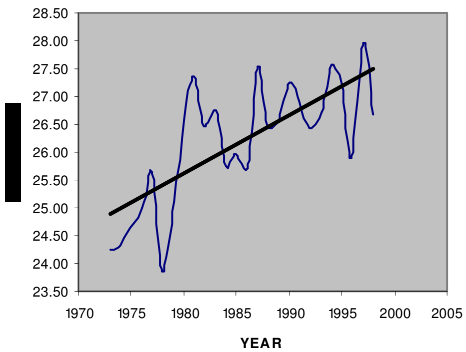


Figure 2a: Nov–Dec temperature in Zone I

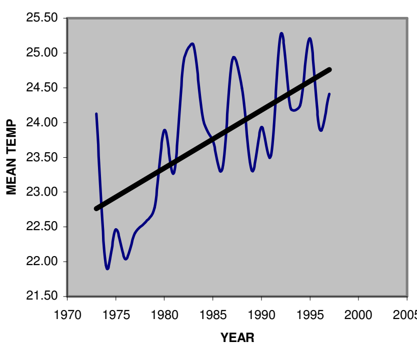


Figure 2b: Mar–Apr temperature in Zone I

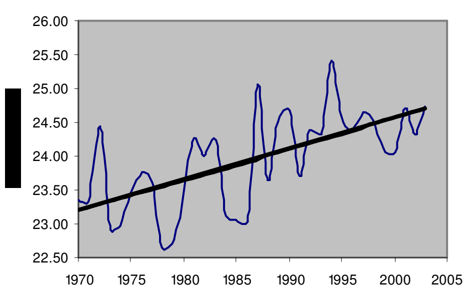


Figure 2c: Nov–Dec temperature in Zone II

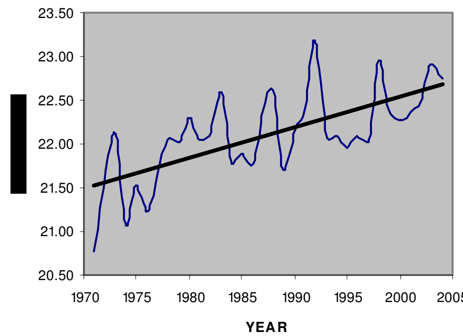


Figure 2d: Jan–Feb temperature in Zone III

The annual rainfall anomalies from the 1970–2000 annual averages were computed using observed data from all 32 meteorological stations in Zambia for the agro-ecological zones. The data show that of the 14 years from 1990/1991 to 2003/2004, at least ten years in each agro-ecological zone had below normal rainfall. The southern zone (Zone I) has experienced more severe dry seasons than the central zone (Zone II) in the last 20 years.

Agriculture in Zambia depends on rainfall to a very large extent. Since the 1990s, crop production in the country has faced the negative impacts of extreme climate events which are believed to be manifestations of long-term climate change. Zambia has experienced some of its worst droughts and floods in the last two decades. Significant rainfall deficits at critical stages of crop growth have frequently led to a serious shortfall in crop production. Maize is a staple grain in Zambian meals. As may be noted from Figures 17 and 18, the maize yield in the Southern, Central and Eastern Provinces shows a high positive correlation with the total seasonal rainfall.

Net farm revenue per hectare was defined as the total revenue from the farm produce minus the cost of seeds and fertilizer. The mean net revenue over 955 surveyed households is US$132.77 with a standard deviation of US$212.20.

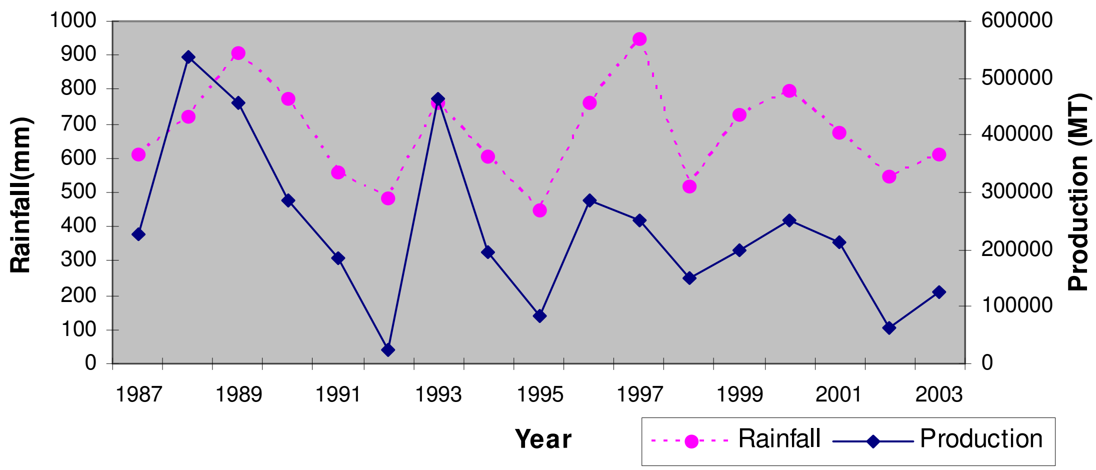


Figure 3: Rainfall and maize production for Southern Province

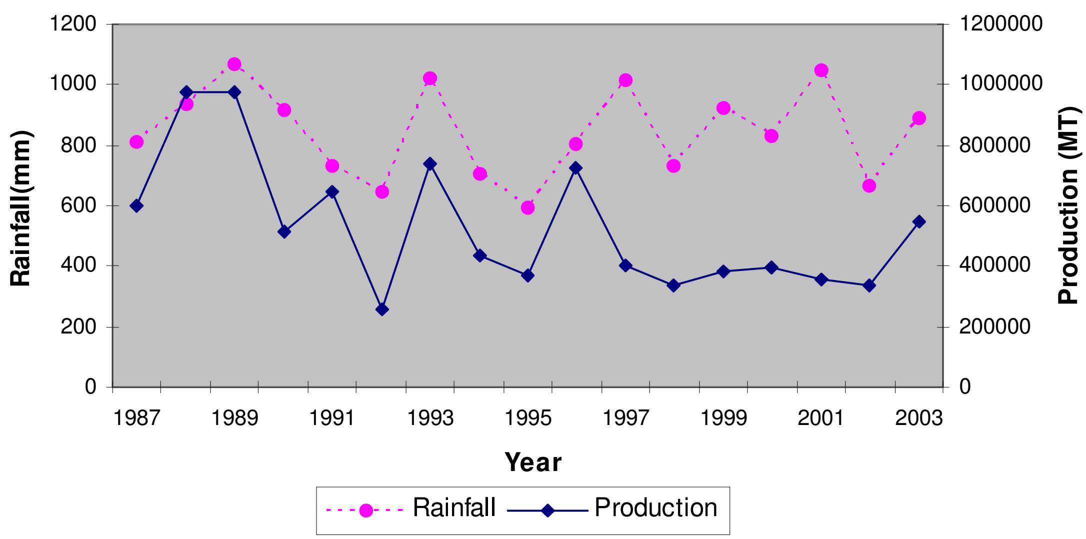


Figure 4: Rainfall and maize production for Central and Eastern Provinces

Sensitivity to warming and precipitation

Marginal net revenue per hectare for an increase of 1℃ in the mean temperature of November and December is US$322.628, indicating that if the temperature rises at the beginning of the cropping season, when plants are germinating, this may have a negative effect on the crop. The marginal net revenue per hectare for an increase of

1°C in the mean temperature of January and February is US$315.70, indicating that if the temperature rises during the growing stage of the plant, this may have a positive effect on the crop.

The marginal net revenue per hectare for a unit increase in the mean wetness index (around 20% of precipitation in Zambia) for January and February is US$334.67.

The marginal revenue for a 1cm increase in runoff from the long-term annual average is US$3.39. The net revenue will increase per cm increase in mean runoff until the optimum level of 32.5 cm is reached.

Table 1: Change in net revenue from uniform climate change scenarios (US$/ha)

Climate scenario	Change in net revenue	% change
1°C increase in mean temperature (Nov–Dec)	-322.62	- 243%
1°C increase in mean temperature (Jan–Feb)	315.70	+ 237%
20% reduction in mean precipitation (Jan–Feb)	-334.67	- 252 %
1cm increase in mean annual runoff	3.39	+ 2.5 %

Adaptation to climate change

Some recommended farm and national level adaptations are listed below.

Farm level adaptations

- Development of new varieties of crops which mature faster and are heat resistant.
- Diversification from traditional crops to other types of crops which can withstand drought and higher temperatures, such as millet and sorghum.
- Rotation of land use between crops and livestock to replenish soil nutrients.
- A shift to more productive new lands, for example moving farming from the Southern to Central Province.

National level adaptations

- Provision of rural credit facility to enable subsistence farmers to buy new varieties of seeds and fertilizer.
- Dissemination of information to farmers on various adaptation options through extension services.
- Removal of subsidies on crops which do not perform well in a changing climate.
- Formulation of appropriate policies for marketing agricultural input and output products which are advantageous to subsistence farmers in particular, as this group makes up almost 80% of the entire farming community in the country and is most vulnerable to the negative impacts of climate.
- Investment in research into agricultural issues such as climate resistant crop varieties, water harvesting, irrigation schemes, water rights, etc.
- Investment in technological innovations, seed banks, etc.
- A feasibility study to migrate farmers to agro-ecological zones which have more potential for agriculture.
- Provision of opportunities for alternative employment in non-

farming activities to enable rural farmers to make a livelihood.

- Allocation of adequate funding to the National Meteorological Department to procure measuring equipment and build capacity in climate data collection, storage, analysis and forecasting.
- Dissemination of climate forecasts in everyday language, not in scientific terms.
- Formulation of policies to encourage the NGOs, private sector and civil societies to complement the government's efforts to implement adaptation policies.

Conclusions and policy implications

This study attempted to estimate the economic impact of climate change on rain dependent agriculture in Zambia by regressing the net farm revenue on the climate, soil, hydrological and socio-economic variables. The results indicate that an increase in mean temperature in November and December and a reduction in mean precipitation in January and February have negative impacts on net farm revenue, whereas an increase in mean temperature in January and February and an increase in mean annual runoff have positive impacts on net farm revenue. The national government and all other stakeholders should respond to climate change by formulating and implementing adaptive measures (of which several have been listed) to minimize the negative effects of climate on agriculture which may pose a serious threat to food security.

The agricultural sector in sub-Saharan Africa is predicted to be especially vulnerable to climate change because this region already endures high heat and low precipitation, provides the livelihoods of large segments of the population, and relies on relatively basic technologies, which limit its capacity to adapt. This series of Policy Notes reports on the methods and results of the first continent-wide study of this kind assessing how the economic well-being of African farming communities is currently affected by climate, predicts how future climate change effects may unfold under various possible global warming scenarios, and evaluates the roles adaptation to climate change could play. The study is based on collaborative research efforts conducted in 11 countries: Burkina Faso, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Niger, Senegal, South Africa, Zambia and Zimbabwe. The sampled districts used as the unit of analysis cover all key agro-climatic zones and farming systems in Africa. This is the first analysis of climate impacts and adaptation in Africa on such a scale and the first in the world to combine cross-country, spatially referenced survey and climatic data for conducting an analysis that uses economic impact assessment methods, river-basin hydrological modeling and crop growth simulation techniques.

All the reports produced under this GEF/WB/CEEPA funded project, *Regional Climate, Water and Agriculture: Impacts on and Adaptation of Agro-ecological Systems in Africa*, are found on CEEPA e-Library at its website link (www.ceepa.co.za/discussionp2006.html) and can also be accessed directly through the project link (www.ceepa.co.za/Climange_Change/project.html)

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