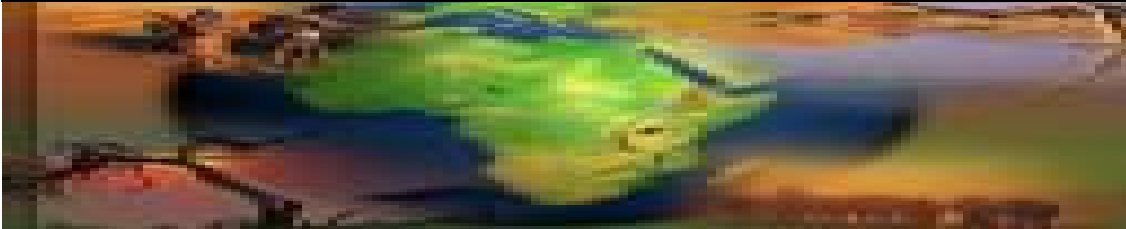


CLIMATE CHANGE AND AFRICAN AGRICULTURE

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The economic impacts of climate change on agriculture in Kenya¹

This study uses a cross-sectional approach to measure the relationship between net revenue from crop agriculture and climate in Kenya by correlating variations in key climate attributes and corresponding variations in net revenue observed across the country. The data for the analysis is based on 816 cross-sectional farm household surveys conducted in six of the eight provinces across the country.

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

¹ This Policy Note is prepared by M De Wit based on Kabubo-Mariara & Karanja (2006), The economic impact of climate change on Kenyan crop agriculture: A Ricardian approach, *CEEPA Discussion Paper No. 12, CEEPA, University of Pretoria*.

optimum. However, while the Ricardian model takes into account the costs associated with various adaptation alternatives, it suffers some limitations.

The value of crop agriculture

Agriculture continues to be the leading sector in the Kenyan economy in terms of its contribution to real GDP. It contributed 36.6% of GDP in the period 1964–74, 33.2% in 1974–79, 29.8% in 1980–89, 26.5% in 1990–95 and 24.5% in 1996–2000. Only 12% of Kenya is considered high potential for farming or intensive livestock production. A further 5.5%, which is classified as medium potential, mainly supports livestock, especially sheep and goats. Only 60% of this high and medium potential land is devoted to crops (maize, coffee, tea, horticultural crops, etc.) and the rest is used for grazing and forests.

Net revenue is defined as gross revenue less all total variable costs, costs of hired labor, farm tools, machinery, fertilizers and pesticides. Costs of household labor are not netted due to difficulties of accurate measurement. Household wage rates for adults and children have been added as independent variables. On average about 90% of all Kenyans are engaged in farming.

Most of the household level variables have a significant impact on crop

revenue. Large farm size may be associated with higher productivity. Main and secondary occupation of household head, religion of household head and average number of years of education of the household members are positively correlated with net crop revenue. Household size, introduced as a proxy for household labor, has a positive and significant impact on net crop revenue. Irrigation has a large positive impact on crop revenue.

Sensitivity to warming and precipitation

Table 1 shows that the marginal impacts for winter temperatures are positive, but summer temperatures have larger negative impacts on net crop revenue. High summer temperatures are harmful to crop production while high winter temperatures are beneficial. This is because summer (March–May) is the planting period followed by formative crop growth, while winter (June–August) is the period for crop ripening and maturing. Increased precipitation increases productivity. A 1% increase in rainfall would lead to a 3.25% increase in net crop revenue, though a similar change in temperature would lead to only a 0.07% decrease in revenue.

Agriculture and climate change

The results in Table 2 show that, with precipitation remaining the same, a 3.5° C increase in temperature would result in a 1% (US\$3.54 per hectare) gain in high potential zones but a 24% (US\$80 per hectare) loss in medium and low potential zones. The results further suggest that medium and low potential zones will bear the brunt of global warming in Kenya. Losses are estimated

to be up to US\$178 per hectare by the year 2030 for these zones compared to losses of only US\$32 for high potential zones and US\$117 for the whole country.

Table 1: Marginal impacts of climate on crop revenue (US\$/ha)

Marginal impacts	Climate variable model	All variables model
Summer temperature	-94.77**	-59.35
Winter temperature	84.87***	58.35
Overall temperature	-9.90	-1.35
Temperature elasticity	-0.55	-0.07
Fall rainfall	7.11***	8.75***
Summer rainfall	5.95**	4.59
Overall rainfall	13.06***	13.34***
Precipitation elasticity	3.18	3.25

*** significant at 1% level ** significant at 5% level

Table 2: Climate change impacts from uniform climate scenarios (in US\$)

Climate change scenario	Medium & low potential	High potential	All zones
+3.5°C	-80.05 (24%)	3.54 (-1%)	- 68.45 (20%)
+4.0°C	-108.79 (32%)	11.91 (3%)	- 93.04 (27%)
20% reduction rainfall	- 69.54 (21%)	-20.14 (6%)	-24.39 (7%)
+3.5°C+ 20% reduction in rainfall	-149.59 (44%)	-16.60 (5%)	-92.84 (27%)
+4°C+ 20% reduction in rainfall	-178.33 (53%)	-32.05 (9%)	-117.43 (34%)

High potential zones are located in the highlands where temperatures are quite low and so a rise in temperature may have a lower impact than a fall in

precipitation. The whole country is also expected to suffer more from decreases in rainfall than from rising temperatures, just as in medium and low potential zones.

Perceptions of adaptation to climate change

Households do already practice a range of adaptation measures, the most popular being crop diversification or mixed cropping, adopted by 37% of all households, and tree planting, adopted by 16%. But 13% of households did not do anything to counter the impact of short-term variations in weather. Only

about 10% of households reported having used any irrigation at all.

Table 3 shows the constraints on adaptations to climate change. About 60% of all households are hindered from adapting by lack of credit and savings (poverty). Another 19% fail to adopt any measure because of lack of knowledge about appropriate adaptations. The other constraints are reported by a relatively small proportion of households. Only 8% of households reported that there were no barriers to adaptation. Poverty and lack of knowledge seem to be more critical constraints in medium and low potential zones than in high potential zones.

Table 3: Constraints on short-term adaptation (% of households)

Constraint faced	All regions	High potential	Med-low potential
Lack of information about short-term climate variation	8% (0.27)	7% (0.26)	10% (0.29)
Lack of knowledge of appropriate adaptations	19% (0.39)	16% (0.36)	25% (0.43)
Lack of credit or savings	59% (0.49)	56% (0.50)	64% (0.48)
No access to water	8% (0.27)	12% (0.32)	3% (0.16)
Lack of appropriate seed	5% (0.21)	4% (0.19)	6% (0.24)
Other constraints	13% (0.33)	12% (0.32)	14% (0.35)
No barriers to adaptation	8% (0.28)	9% (0.28)	8% (0.27)

More than 80% of households have implemented various adaptation mechanisms to counter short-term climate variations, compared to 60% and 78% that have implemented them to counter long-term temperature and precipitation changes respectively.

Conclusions and policy implications

The results suggest that a change in climate affects agricultural productivity. Increased winter temperatures increase net crop revenue, while increased summer temperatures decrease it. Increased precipitation increases net crop revenue.

The predictions show that long-term changes in temperatures and precipitation will have a substantial impact on net revenue, and that the

impact will be more pronounced in medium and low potential zones than in high potential zones. The latter are expected to receive some marginal gains from mild temperature increases, holding precipitation constant.

Diversification (changing the crop mix) is the most common adaptation measure, particularly in high potential zones, while water conservation, irrigation and shading/sheltering of crops are the main adaptation measures in drier regions.

These results imply that adaptation to climate change in Kenya is important if households are to counter the expected impacts of long-term climate change. Monitoring of climate change and disseminating information to farmers would be a critical intervention, while knowing about adaptation measures could encourage both short- and long-term adaptations to climate change. Using this knowledge, farmers and local leaders should be sensitized, through an extension network, to the implications of climate change, including the vulnerability of crop production and the necessity for adaptation strategies.

Management of the scarce water resources in the country could generate more water for irrigation purposes, especially in the drier zones. Given the dwindling and fluctuating water resources in the country, the government needs to embark on recycling of waste water, which can then be used to save on available water. It also needs to introduce water harvesting techniques to farmers and encourage them to adopt these, particularly in drier areas, to supplement any available water. In addition, protection, conservation and rehabilitation of water catchment areas and river basins are critical to ensure

sustainable water supply. Policies that improve household welfare as well as access to credit are also a priority for both short- and long-term adaptation measures.

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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