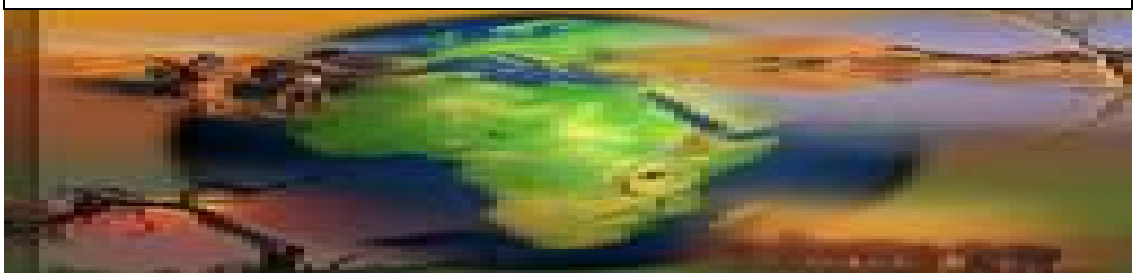
CLIMATE CHANGE AND AFRICAN AGRICULTURE

Policy Note No. 17, August 2006, CEEPA



Impacts of climate change on crop farming in Cameroon[1]

About 80% of the poor in Cameroon live in rural areas and work primarily in agriculture. About 35% of the country's GDP comes from agriculture and related activities and close to 70% of the national labor force is employed in agriculture. Cameroon's economy is therefore predominantly agrarian and agriculture remains the driving force for the country's economic development. Its agriculture is moderately productive, extensively managed, and semi market-based. However, while it is on a long march to productivity, the agricultural system is still highly dependent on climate, because temperature, light, and water are the main drivers of crop growth. Plant diseases and pest infestations, as well as the supply of and demand for irrigation water, are also influenced by climate. The key uncertainty, therefore, for agricultural outlook in the country is future climate, despite relative improvements in technology and yield potential. Given the increasing evidence of global warming, there is now concern that climatic impacts on food production will be significant in Cameroon as well as other parts of the African continent.

Current climate variation is already altering the types, frequencies, and intensities of crop and livestock pests and diseases, the availability and timing of irrigation water supplies, and the severity of soil erosion. Low rainfall in 1997 in northern Cameroon directly affected crop yields and caused livestock deaths, leading to hunger and triggering the need for food aid. In March 2005 northern Cameroon was again hit by food shortages, requiring external intervention from international aid agencies. In addition to directly affecting crop yields, drought has triggered an increased migration of pastoralists and nomads from the northern part of the country to the south. The observed decline in rainfall in the region is thought to contribute to the increasing desertification in northern Cameroon, leading to shifts in the ecological zones and an increasing exploitation of marginal ecosystems. Global climate change may therefore be one of the major challenges that will confront agricultural policy makers in Cameroon.

This study attempts to measure the economic impacts of predicted future climate on agriculture in Cameroon, with

[1] This Policy Note is prepared by R Hassan based on Molua & Lambi (2006), The economic impact of climate change on agriculture in Cameroon, *CEEPA Discussion Paper No. 17, CEEPA, University of Pretoria.*

the following specific objectives: (i) to estimate how climate affects the current agricultural systems, and (ii) to project how climate change might affect these systems in the future. The study also looks at the options for adaptation to climate change in Cameroon's agriculture. It adopts the cross-sectional (Ricardian) approach to measuring climate change damages and examines the implications of future climate scenarios.

The Ricardian model

The Ricardian method is a cross-sectional approach to measuring determinants of land value. The principle follows Ricardo's original observation that land rents would reflect the present value of future net productivity of farmland (Ricardo 1817). The model uses actual observations of farm performance in various climatic regions to measure how long-term farm profitability varies with local climate while controlling for other factors. By regressing farm values on climate and other control variables we are able to measure the marginal contribution of each variable to land value.

The data and variables included

Because land markets are imperfect and agricultural farm values in the developing world are weakly documented, net farm revenue per hectare is commonly used as the response variable instead of land values. In this study the focus is on crop net revenues.

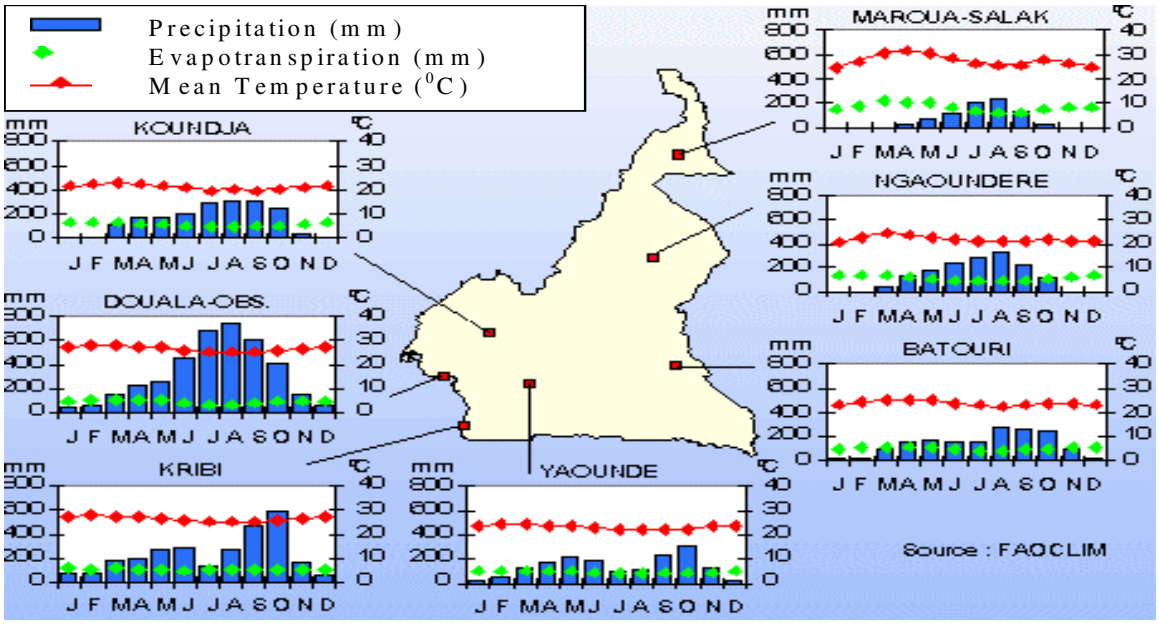
The analysis uses cross-sectional data at the household and district levels on farm activities, climate, soils and hydrology.

The data was obtained from the nationwide field survey conducted between January and April 2005 covering all the agro-ecological zones in the country, as well as the major and minor crops, rainfed and irrigated agriculture, small- and large-scale production, and traditional and improved technology-based agriculture. All the selected divisions and villages/towns were covered during the survey in eight agro-ecological zones. A sample comprising 800 households was interviewed from 50 of the 58 administrative divisions in Cameroon. The farm-level and household information collected was for the 2002/2003 farming season.

The study relied on monthly temperature data collected from US Department of Defense satellites. The monthly precipitation data came from the Africa Rainfall and Temperature Evaluation System (ARTES) (World Bank 2003) Soil data was obtained from FAO (2003). Hydrological data was predicted from a hydrological model for Africa (Strzepek & McCluskey 2006) which model calculated the water flow through each district in the surveyed countries.

The dependent variable is measured as crop net revenue per hectare of cropland calculated as gross revenue from crops less total variable cost of production. The cost of household labor is not deducted but its effect is controlled for by including household size as a proxy for household labor as a regressor in the model.

Figure 1: Temperature and precipitation distribution across Cameroon



Sensitivity of farm revenue to climate

The results of estimating Cameroon's net farm revenue response function show that spring and summer temperatures are moderately significant. Winter and spring precipitations are strongly significant. Both linear and squared terms are significant in certain seasons, implying that climate has a non-linear effect on net revenues. Surface water runoff appears to have a strongly significant influence on farm returns.

The results for the socio-economic variables (e.g. farmer's age, education, access to subsidies and extension services, adaptation, etc.) provide important information about the influence of farm values in Cameroon. Cameroon's farmers adapt the agricultural systems and practices to changing economic and physical conditions by adopting new technologies and changing crop mixes and cultivated acreage (captured in an adaptation dummy). The economic significance of such flexibility is revealed by the econometric estimates which reveal that the adaptation dummy is significant and dummies for various groups of adaptation (crop and soil management options) are moderately significant.[2] The dummy variable for irrigation though positive is not statistically significant. Few farmers in the country can afford the costs of modern irrigation systems. However, a plethora of rainwater harvesting strategies is employed to cushion the negative impacts of short

[2] In addition to adaptation in general, we specifically identified clusters of farmers who relied predominantly on crop management techniques or soil management strategies as their primary mode for adapting to changing climate, and tested the statistical significance of these options.

rainy seasons and long dry seasons in some parts of the country.

The study also revealed that climatic, hydrological and agronomic variables explain about 19% of variation in farm value. Statistical tests indicate that the model is well behaved.

Table 1 displays the results of the marginal impact analysis. The marginal effect of temperature and precipitation is evaluated at the mean for each sample. Relying on the sample results evaluated at the national mean climate (23.5℃ and 283.44mm/mo), the marginal temperature effect ranges from -$25/℃ to -$5/℃ and the marginal precipitation effect ranges from $5.3 to $9.4/mm/mo.

Table 1: Marginal impacts of climate net revenue (US$/ha)

Variable	Estimate
Temperature	-15.4 (-2.77)**
Precipitation	5.65(3.39)***

** Significant at 5% level and *** significant at 1% level

Impacts of future climate projections

Using the estimated regression coefficients, the study examines how changes in climate change net revenue per hectare in each province in Cameroon. We multiply the change in net revenue per hectare by the number of hectares of cropland in each province to get an aggregate impact in each province. This value is summed across all the provinces to get a total impact for the country. The results of the uniform climate scenarios are presented in Table 2. Four uniform climate scenarios are tested: changes of +2.5℃ and +5℃ in temperature, and -7% and -14% changes in precipitation.

The 2.5℃ warming results in predicted losses of $0.65 billion and doubling warming to 5℃ increases the losses to $1.8 billion. Reducing precipitation by 7% reduces net revenue by 6.5% on a per hectare basis. Without doubt, 14% reduction in precipitation is predicted to cause much larger losses of about $4.56 billion. This significantly demonstrates Cameroon's dependence on rainfed agriculture.

Table 2: Impacts from Uniform Climate Scenarios

Impacts	2.5℃ warming	5℃ warming	7% decreased precipitation	14% decreased precipitation
ΔNet revenue (USD per ha)	-7.3 *(-5.5%)*	-19.5 *(-11.3%)*	-26.8 *(-6.5%)*	-45.3 *(-15.3%)*
ΔTotal net revenue (billion USD)	-0.65	-1.82	-2.95	-4.56

Note: Using coefficients in Table 1 for nr1_3 (gross revenue less the total costs incurred per farmland). The numbers in brackets represent the percentage change in net revenue per hectare relative to the mean of the sample.

The study also employs 15 scenarios derived from five different well tested models (CSIRO2, HadCM3, CGCM2, ECHAM and PCM) in conjunction with two different emission scenarios (A2, B2) provided by

Strzepek & McCluskey (2006). Table 3 summarizes the results of analyzing the climate change scenarios for Cameroon. The consequences of these country level climate change scenarios on farm income in 2020, 2050 and 2100 are shown in Table 4.

Table 3: Summary results of analyses of Climate Change Scenarios

	CGCM2 (cg)		CSIRO2 (cs)		ECHAM (ec)		HadCM3 (ha)		PCM (pc)	
	2050	2100	2050	2100	2050	2100	2050	2100	2050	2100
Precipitation										
A2-Scenario	100%	99%	99%	96%	106%	116%	101%	104%	104%	110%
B2-Scenario	100%	99%	99%	96%	106%	116%	101%	104%	104%	110%
Temperature										
A2-Scenario	3.4	8.3	3.4	8.3	3.1	7.9	3.7	9.2	2.2	5.2
B2-Scenario	2.9	5.1	3.5	6.3	3.1	5.6	3.7	6.5	2.2	3.8
Streamflow										
A2-Scenario	89%	77%	89%	76%	110%	127%	93%	88%	99%	99%
B2-Scenario	91%	85%	87%	79%	115%	128%	93%	90%	102%	104%

Source: Strzepek & McCluskey (2006)

Table 4: Climate change impacts on agriculture in Cameroon

	CGCM2 (cg)		CSIRO2 (cs)		ECHAM (ec)		HadCM3 (ha)		PCM (pc)	
Impacts	2020	2100	2020	2100	2020	2100	2020	2100	2020	2100
A2-Scenario										
ΔNet revenue (% in $/ha)	5.8	20.5	*-23*	*-45*	10.7	22.6	*11.3*	-35	25.5	40.2
ΔTotal net revenue (billion $)	1.2	-1.5	-5.4	-12.6	2.4	1.3	1.2	-3.7	1.6	2.9
B2-Scenario										
ΔNet revenue (% in$/ha)	9.3	28	-26	-50	17.3	27.4	15.5	-48	19.3	30.2
ΔTotal net revenue (billion US$)	0.9	-2.5	-13.5	-20.3	1.6	0.5	0.5	-5.8	0.3	2.2

Note: Using coefficients in Table 1. The numbers in brackets represent the percentage change in net revenue per hectare relative to the mean of the sample.

Conclusions

This study examines the impact of climate change on crop farming in Cameroon. It is based on a farm-level survey of over 800 farms. We employ a Ricardian cross-sectional approach to measure the relationship between climate and the net revenue from crops. Net revenue is regressed on climate, water flow, soil and economic variables. The resulting regression explains the role that each variable plays today. We find that net revenues fall as precipitation decreases or temperatures increase across all the surveyed farms. We also examined some simple climate scenarios to see how Cameroon would respond to climate change. These 'uniform' scenarios assume that only one aspect of climate changes and that the change is uniform across the whole country. The empirical analysis reveals that a 2.5°C increase in temperatures would cause net revenues from farming in Cameroon to fall by $0.5 billion. We also examined a 5°C increase and found that it would cause net revenues to fall by $1.7 billion. A 7% decrease in precipitation would cause net revenues from crops to fall by $1.96 billion and a 14% decrease in precipitation would cause them to fall by $3.8 billion. Increases in precipitation would have the opposite effect on net revenues.

In addition to the uniform scenarios, we also examined 15 climate change scenarios. These reveal that net revenues could rise by up to $2.9 billion if future climates are mild and wet but could fall by up to $12.6 billion if they are hot and dry. This study reaffirms that agriculture in Cameroon is often limited by the seasonality and amount of moisture availability. Although the other physical factors such as soil and relief have an important influence on agriculture, climate remains the dominant influence on the variety of crops cultivated and the types of agriculture practiced. Climate cannot be dissociated from agriculture since its various elements (rainfall, sunshine, humidity and temperature) are essential for the survival of crops and of man. The climate problems that plague agriculture in Cameroon must be factored into production plans and catered for, if agricultural output is to be maximized.

References

FAO (Food and Agriculture Organization), 2003. The digital soil map of the world: Version 3.6 (January), Rome, Italy.

Ricardo D, 1817. *On the Principles of Political Economy and Taxation*. London: John Murray.

Strzepek K & McCluskey A, 2006. District level hydroclimatic time series and scenario analyses to assess the impacts of climate change on regional water resources and agriculture in Africa. CEEPA Discussion Paper No. 13, Centre for Environmental Economics and Policy in Africa, University of Pretoria.

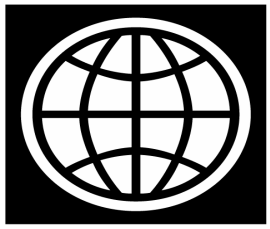
World Bank, 2003. Africa rainfall and temperature evaluation system (ARTES). World Bank, Washington DC.

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)

***Centre for Environmental Economics and Policy in Africa (CEEPA)**, University of Pretoria, Room 2-7, Agricultural Annex, 0002 PRETORIA, South Africa. Tel: +27 (0)12 420 4105, Fax: +27 (0)12 420 4958, Web address: www.ceepa.co.za*

Core funding from the GEF and supplementary funding from TFESSD, Finnish TF, NOAA-OPG, and CEEPA in support of this project's activities are all gratefully acknowledged. The project was coordinated by CEEPA and managed in the World Bank by the Agricultural and Rural Development Department and World Bank Institute.



THE WORLD BANK