Climate Change: What it means for agriculture in Eastern Africa?

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Farmers in Mutomo preparing for planting ahead of the season

There is a growing realization that climate change is real and is happening. In fact, more recent studies indicate that climate change is happening faster than that envisaged by the IPCC and that the impacts are overshooting even the worst case scenarios that were predicted. The 2007 IPCC assessment, the most comprehensive and respected analysis of climate change and its impacts involving thousands of scientists from about 130 countries, has provided sufficient evidence to conclude that the current global mean surface temperature was about 0.42°C to 0.54°C above the 1961-1990 annual average. The report further ranked eleven of the last twelve years (1995-2006) among the 12 warmest years ever on record and more recent assessments indicate that the decade 2000-09 has been warmer than any other decade in the previous 150 years. Perhaps the most convincing and clear evidence of climate change comes from the dramatic changes observed in the extent of ice sheets and mountain glaciers, the most sensitive natural systems to global warming. After an extensive review of all the available evidence about climate change, IPCC report concluded that "the warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average temperature". Even if the global community agree on limiting and /or cutting back on GHG emissions and the emissions are reduced to zero, the planet would continue to warm until the energy stored in the system equilibrates.

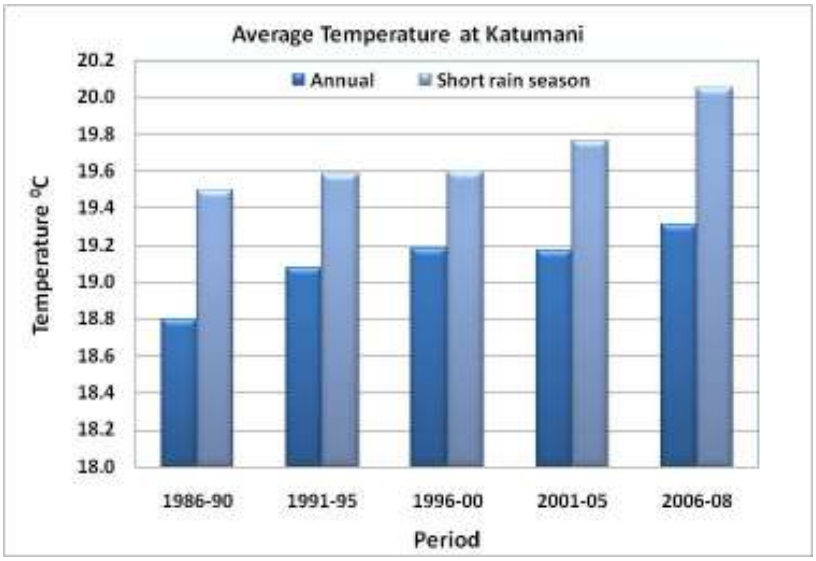

Figure: Observed trend in average temperature at Katumani

The fact that we are going to live in an increasingly warmer climate raises several questions. Important amongst them are - what changes will climate change bring to Eastern Africa? What impact these changes will have on agriculture in the region? How can we mitigate and adapt to the negative impacts of climate change? The objective of this article is to provide a brief account of our current understanding about climate change and its impacts on agriculture and highlight some of the options available to mitigate and adapt to climate change impacts.

What the future climate of East Africa will be?

Despite the availability of overwhelming evidence in support of climate change, uncertainty prevails over the precise nature of these changes especially at local level, making it difficult to plan and develop appropriate adaptation strategies, programs, and technologies. Global level predictions become less clear as to the magnitude and timing of the changes at national and local levels, and according to the IPCC difficulties remain in reliably simulating changes at smaller scales. Even at the global scale, there will always be uncertainty in predicting future climates partly due to uncertain levels of future greenhouse gas emissions and partly due to inadequacies in our understanding of the global climate system. Hence, it is not surprising that the scientific community is unable to tell with any amount of certainty what the climate would be in 20, 50 or 100 years from now at a given location.

Existing analyses summed up by IPCC indicate that the global average temperatures will increase by about 1.1-2.9^{0}C under low emission scenario and by 2.4-6.4^{0}C under high emission scenario by the end of the present century. For Eastern Africa, the predicted changes under a medium emission scenario (A1B) are summarized in Table 1. The median predictions show an increase in both temperature and rainfall. Annual temperature of the region is projected to increase by about 3.2^{0}C and rainfall by about 7% towards the end of this century.

Table 1: Temperature and rainfall projections for Eastern Africa (120S and 220E to 180N and 520E) from a set of 21 global models in the CMIP3 for the A1B scenario by 2100 (IPCC, 2007)

Season	Temperature response (oC)					Precipitation Response (%)					Extreme Seasons (%)		
	Min	25	50	75	Max	Min	25	50	75	Max	Warm	Wet	Dry
DJF	2.0	2.6	3.1	3.4	4.2	-3	6	13	16	33	100	25	1
MAM	1.7	2.7	3.3	3.7	4.5	-9	2	6	9	20	100	15	4
JJA	1.6	2.7	3.4	3.6	4.7	-18	-2	4	7	16	100		
SON	1.9	2.6	3.1	3.6	4.3	-10	3	7	13	38	100	21	3
Annual	1.8	2.5	3.2	3.4	4.3	-3	2	7	11	25	100	30	1

Notes: The table shows the minimum, maximum, median (50 %), and 25 and 75 % quartile values among the 21 models for temperature (°C) and precipitation (%) change. Numbers in the Extreme Seasons columns indicate a change in frequency of extreme seasons the increase is positive.

For shorter time scales, analysis by ICPAC indicates that the mean annual temperatures in the region increase by about 0.8-1.1^{0}C by year 2030 and by 1.5-2.1^{0}C by 2050 for the mid-range emission scenario. At the same time, the rainfall in the region is expected to increase by 0.6-9.7% by 2030 and 1.1-18.8% by 2050. To place these changes in perspective, a 3^{0}C rise in average temperature will make Kampala climate look like that of current climate in Jinja, Nairobi climate similar to that of Embu and Addis Ababa climate to that currently experienced at Aksum.

Though there are problems in predicting accurately where, when, and how climate changes, the following can be expected based on our current understanding and available information. The magnitude and direction of these changes need to be reviewed and modified as and when new scientific information becomes available.

1. The region will be warmer by about 1^{0}C by 2030 and by about 2^{0}C by 2050
2. The region is expected to receive slightly higher rainfall, especially during the period September to February
3. The region will also experience an increase in the frequency of both extreme wet and dry seasons
4. There are indications that the variability in rainfall between and across the seasons will increase

What impacts these changes in climate will have on agriculture in the region?

For a region, where agriculture is mainly rainfed and is the main source of livelihood for nearly 85% of the population, impacts of climate change on agriculture are a major concern since it can only make the fragile situation worse. The ten countries in the region regularly experience negative climate-related outcomes such as food crises, water shortages and disease outbreaks due to a combination of climate variability and vulnerability to climate-related hazards. Prolonged and highly destructive droughts were recorded in 1973-74, 1984-85, 1987, 1992-94, 1999-2000 and more recently in 2005-06. Most countries in the region are threatened by famine at least once in each decade while localized and nationwide droughts especially in Eritrea, Ethiopia, Somalia and Sudan have now become more frequent. The negative impacts of climate are not limited to the years with extreme climatic conditions. Even with normal rainfall, the countries in the region do not produce enough food to meet their people's needs. The projected changes in climate are expected make agriculture in the region even more difficult.

Rainfall and temperature regimes are perhaps the most important factors in determining the potential productivity of various agricultural enterprises either directly or indirectly. The direct effects of rainfall and temperature determine the suitability, rate of growth and potential yield of crops while the indirect effects influence the supply of nutrients and water through their effect on nutrient and hydrological cycles. Annual crops with short production cycles are much more sensitive to changes in seasonal climatic conditions compared to perennials with growth cycles covering several seasons or years. Further, the impacts of climate change are not going to be uniform across the region and differ from location to location depending on a number of biophysical and socio-economic conditions. Semi-arid tropics, which are marginal environments for crop production with high inter and intra seasonal variability in rainfall, will be affected more severely than humid and sub-humid regions. This makes arid and semi-arid areas within the region more vulnerable compared to sub-humid and humid areas.

There are several major pathways by which climate change will affect the performance of crops. Firstly, changes in temperature and precipitation lead to changes in evaporation from the soil and evapo-transpiration from vegetation. Hence, higher temperatures will lead to increased demand for water by plants which is difficult to meet, especially when rainfall is expected to decline and become more variable. Secondly, different crops have different optimal growing conditions and high temperatures can make the crops unsuitable for growing in some areas where the current climatic conditions are already close to the maximum tolerable limits. For example, assessments indicate that some areas in the region will no longer be able to support tea and coffee production if the temperatures increase by 2^0C or more from the current levels. Thirdly, crops grow faster and mature earlier under warmer temperatures compared to cooler temperatures. The available data indicate that duration of several crops will be reduced by about one-two weeks with every degree increase in temperature. This reduction in the time that a crop takes to mature will also reduce the productive potential of these crops. Studies using crop simulation models broadly indicate that potential for biomass production will decline by about 500 kg/ha with every one week reduction in the duration of the crop. Fourthly, increased concentration of CO_2 in the atmosphere may have some beneficial effect on some crops. This response of crops to increased CO_2 concentration, often referred to as "CO_2 fertilization effect", varies among plant species. Plants with "C-3" photosynthetic pathway, which include potato, beans, rice, wheat and many weed species, can benefit from this phenomenon but no significant benefit is expected in case of crops like maize, sorghum and millet with "C-4" photosynthetic pathway. Further, attaining these benefits requires high levels of management including use of fertilizer, optimum conditions for root growth, and control of weeds, pests and diseases. Under the prevailing low input management scenario, it is very unlikely that the region will be able to benefit from this phenomenon.

In addition to these direct effects, climate change will also impact crop production indirectly by reducing the capacity of natural resources to support productive agriculture. These effects include decline in soil fertility from increased mineralization, nutrient leaching and erosion, reduced availability of water, and changes in the distribution and incidence of pests and diseases including weeds. All these changes will have significant impact on productivity, food security, and profitability both at household and national level.

What is needed to mitigate and adapt to the adverse impacts of climate change?

The scientific evidence leaves little room for doubt that our climate is changing and it will have a significant impact on agriculture. This makes adapting agriculture to climate variability and change an essential component of agricultural

research and development programs. Some of the available options that are relevant to the region in adapting to climate change impacts are outlined here.

Address the current challenges: While climate change brings new challenges, it also highlights the need to address more comprehensively the same old problems that agriculture in the region is struggling to cope with. Current variability in the climate across many parts in the region is very high and often ignored in developing and promoting new technologies. Managing vulnerabilities associated with current variability in climate provides a good starting point to deal with future changes. The need is to assess the climate sensitivity of both indigenous and recommended technologies and develop options to make them work under a range of situations.

Create awareness and promote strategic and tactical decision making: To some extent the issue of climate change is over dramatized and over sold. Any extreme event now is considered as a result of climate change, even though events of similar and or of bigger magnitude have happened in the past when climate change is not on agenda. There is a need to improve the understanding of extension and other service providers on issues related to climate variability and change and on the range of possible responses that farmers should consider when making management decisions. Farmer decision making can be greatly enhanced through proper use and application of climate information. While the historical trends in climate can be used to enhance the strategic planning, information on current conditions including seasonal climate forecasts can make farmers take more tactical decisions regarding land and input use and management.

Strengthen and promote sustainable management of natural resources: Some of the recommendations that are aimed at addressing climate change are simply good management practices such as improved agricultural water management, efficient use of fertilizer and manure, and linking and improving the market access. Such practices, while enhancing the productivity and profitability of the systems, have the potential to sequester atmospheric CO_2 in biomass and soils, decrease the rate of land clearing for agriculture, increase efficiency of farm inputs such as fertilizers, and pesticides, and decrease N_2O and methane emissions.

Promote risk management strategies: Adaptation to climate change is characterized by uncertainty and decision making under uncertainty requires a thorough assessments of risks and opportunities associated with the decision under a range of conditions. Risk management offers a practicable approach for prioritizing and selecting optimal strategy

Strengthen early warning systems: One of the predicted impacts of climate change is increased intensity and frequency of occurrence of extreme events such as drought, floods, heat waves, and cyclones. At the same the ability of the meteorological institutions to predict and forecast such events has also increased. The challenge is timely communication of this information to users in a format that can easily be understood by them.

Risk covering options: Pilot studies were conducted in several countries to examine the use of insurance to help reduce vulnerability and adapt to climate change. However, there are several issues that need to be addressed to make it a viable program. The region should explore the opportunities to use this to help people adapt to some of the unavoidable risks associated with climate.

Strengthen the capacity to make better assessments using new science tools: Understanding how systems perform under a changing climate and how the negative impacts can be mitigated is an important prerequisite for formulating effective adaptation options. A number of tools such as crop simulation models were developed and are being used in conjunction with historical climate data to explore the long-term implications of the results from short-term experimental research both with and without climate change. The region has very limited capacity to use such tools and there is an urgent need to strengthen the formal and informal education to include them in the curricula.

Conclusion:

Though climate change is real and happening, uncertainty prevails over the exact nature and consequences of climate change especially at local level, making it difficult to plan and develop appropriate adaptation strategies, programs, and technologies. The predicted impacts of climate change on agriculture are largely negative but the same can be effectively addressed by integrating climate change issues into the general agricultural and risk mitigation strategies.