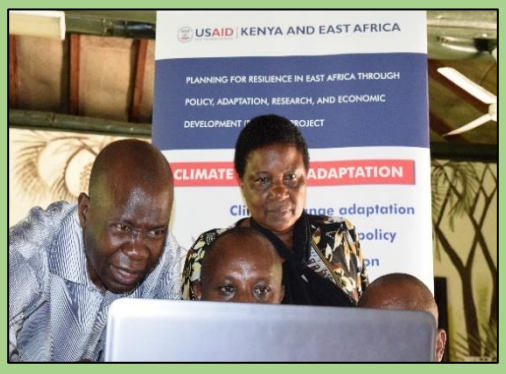
Climate Change Vulnerability, Impacts and Adaptation Assessment for East Africa



SUMMARY REPORT FOR POLICY MAKERS

NOVEMBER 2017

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DISCLAIMER

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ACRONYMS

ASAL	Arid and Semi-Arid Lands
C3A2	Community Climate Change Adaptation Assessment
CCASAP	Climate Change Adaptation Strategy and Action Plan
CCCU	EAC Climate Change Coordination Unit
CCIN	Climate Change Information Network
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station Data
CMIP5	Coupled Model Inter-comparison Project Phase 5
CSA	Climate Smart Agriculture
EAC	East African Community
GDP	Gross Domestic Product
ICPAC	IGAD Climate Prediction and Applications Centre
IDSR	Improve Integrated Disease Surveillance
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
LLIN	Long-lasting insecticidal net
LVB	Lake Victoria Basin
LVBC	Lake Victoria Basin Commission
LVBCCASAP	Lake Victoria Basin Climate Change Adaptation Strategy and Action Plan
MAMJ	March-June
MDG	Millennium Development Goal
NDVI	Normalized Differential Vegetation Index
PREPARED	Planning for Resilience in East Africa through Policy, Adaptation, Research, and Economic Development Project
RCA	Rossby Centre Regional Atmospheric
RCMRD	Regional Center for Mapping of Resources for Development
RCP	Representative Concentration Pathway
SMART	Specific, Measurable, Achievable, Relevant and Time-Bound
SGR	Standard Gage Railroad
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
UNFPA	United Nations Population Fund
USAID	United States Agency for International Development
VIA	Vulnerability, Impacts and Adaptation Assessment

INTRODUCTION

The objective of this report is to provide brief and succinct climate vulnerability information for decision and policy makers in the East Africa region to support their programs and development plans. The report draws from studies carried out by local climate scientists as part of the vulnerability, impacts and adaptation assessment (VIA) of the East African region with a special focus on the Lake Victoria Basin (LVB).

The study undertaken by the East African Community (EAC) with the support of the USAID/Kenya and East Africa Planning for Resilience in East Africa through Policy, Adaptation, Research, and Economic Development (PREPARED) Project adopted the Intergovernmental Panel on Climate Change (IPCC) vulnerability assessment framework and used both locally observed climate data and socio-economic information for the last 30 years (1981-2010) coupled with future modelling results. The VIA team, working through strategic regional and institutional partnerships, applied innovative approaches to determine the local impacts of climate variability and change and the region's vulnerability to the current and expected future climate. What unfolds is evidence of dramatic and unprecedented changes in EAC's climatic patterns at regional, national and community scale, with adverse impacts already being felt on social, physical, ecological and economic systems. The impacts are more severe than earlier reported by IPCC in 2013 and 2016. It is noted that these earlier IPCC projections have been used to inform the current EAC and Partner States climate change strategic plans and visions.

A historical analysis of surface temperature trends of Nairobi and its environs shows steady warming of more than 2.50 C in the recent 50 years (Box 1a). Similarly, warming trends are currently evident in East African highlands, gradually reducing its suitability for coffee cultivation and explaining the region's increasing susceptibility to highland malaria.

Apart from the region getting hotter, it is also becoming drier at an alarming rate; with rainfall declining by 20 – 100 mm/decade, unreliable rainfall patterns, longer dry-spells, and shortened length of staple food growing periods, mostly in marginal agricultural and pastoral zones.

Box 1a:

Dramatic and unprecedented warming trends

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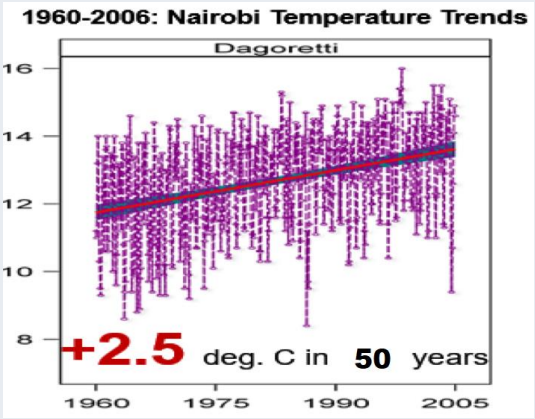
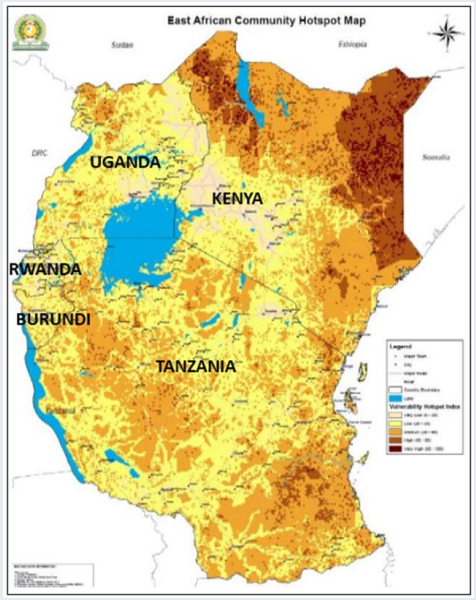


*Box 1.b. Increasing vulnerability to climate change among **pastoralists and marginal agricultural communities***



With the increasing population of **5-6 million people every year** in EAC region, there is an increasing burden to respond to humanitarian crisis related to current recurrent extreme climatic events.

Box 1: Climate change vulnerability in East Africa

This has resulted in deteriorating food production systems and increasing vulnerability to current climatic shocks that are likely to become worse with increasing frequency of extreme climate events. These emerging adverse climatic patterns, coupled with the rapidly increasing population growth rates (3 - 3.5% per year), limited basic services, and low adaptive capacities at community level have resulted in increasing vulnerability to present climatic shocks. Most likely, future climates are expected to become worse because of more extreme climate events, as projected in the detailed future climate scenarios conducted for this study.

Impacts from these potential extremes could be dramatic, especially if no pragmatic and proactive actions are taken to support the most vulnerable in the region, particularly the pastoral and marginal agricultural communities in EAC Partner States. Besides climate and population pressure, environmental degradation and low investment in agriculture by the majority of small – scale farmers are key drivers for increasing vulnerability in the region; underscoring the inherent linkages between increasing structural poverty and worsening climatic trends. The most affected areas are illustrated in a regional vulnerability map (Box 1b).

These issues are discussed in detail in subsequent sections of the report. This report recognizes and highlights these vulnerabilities and the inherent climate and socioeconomic information gaps. These climate information gaps were addressed using locally generated climate datasets geospatially integrated with corresponding socioeconomic information. It therefore provides summarized climate information for policy and decision – makers; information which is both evidence – based and highlights current and future opportunities and challenges in five key socioeconomic sectors within the EAC region.

The report, has four main sections:

- Background, which provides a brief EAC context and the rationale and approach used for the study;
- Baseline and future climate scenarios for five key economic sectors;
- Provision of key adaptation responses for the East African Community; and
- Recommendations for policy considerations and formulation.

In the conclusion, the report makes a deliberate effort to review and draw synergies between these new findings and EAC Partner States' climate change strategies and action plans, which were largely informed previously by the IPCC assessment reports.

BACKGROUND

East Africa is regarded as one of the most vulnerable regions to climate variability and change, a situation aggravated by the interaction of 'multiple stressors', occurring at various levels and populations' low adaptive capacity. This is partly because of human factors, but climate also makes it one of the most vulnerable regions in the world, with most of its countries classified as least developed.

The opportunities and challenges posed by the recent extreme and recurrent climatic events (droughts, floods, etc.) and their impacts on key socio-economic sectors in the region form a strong basis and a good primer on how the region deals with future climate change and further contributes to the work on attribution, interpretation, and assessment of their potential impacts of the future climate change scenarios in 2030 and 2050 within a local EAC context, paying close attention to transboundary issues whilst incorporating local livelihood vulnerabilities.

The latest statistics by the World Bank reveal that the East African region is emerging as one of the world's fastest growing, due to its rapidly increasing population growth rates. The data show that the region had a total 2016 population of 183 million, thus having advanced into one of the most populated regions in

Africa. The average population growth is estimated at 2.6 percent annually and the United National Population Fund (UNFPA) estimates the region's population is likely to more than double by 2050! Among other factors, population growth could be one of the drivers behind the high rate of poverty among local populations. With agriculture employing 80% of the population, the demographic pressure has contributed to extensive land use and land cover changes to provide for farmlands and areas of pasture.

Recent socioeconomic impacts of severe and prolonged droughts (2000/1, 2010/11 and 2016/17) in EAC countries demonstrate the sensitivity and vulnerabilities of local populations. Over 10%, of the region's population is gradually becoming chronically food insecure, requiring both short-term emergency food relief and sustainable long-term development programs. To address the current challenges from the increased frequency of severe droughts occurring every 2 – 3 years and, at times, back-to-back droughts interspersed with extreme flooding and no significant recovery periods will be challenging. For livestock and wildlife herds, the recurrent extreme climatic events, with insufficient recovery periods are pushing pastoral economies and livelihoods to the brink of collapse. Within the EAC, Kenya and South Sudan recently declared National Drought Emergency and Hunger Disasters respectively, owing to the extent and severity of the recent droughts and the overwhelming resources required to adequately respond to the ongoing humanitarian crises.

Recognizing the adverse impacts of climate change and particularly their vulnerability, the EAC Partner States became Parties to the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and the Paris Agreement, in effect stating their commitment to address global warming. They have in place national adaptation plans and strategies, and their commitment to act is demonstrated in their national reports to the UNFCCC, which includes their respective national communications and Nationally Determined Commitments (NDCs).

At the regional level, the EAC Secretariat has focused on improving regional cooperation on climate change through the development of a variety of policy instruments, plans and strategies. These include a regional Climate Change Policy, a Climate Change Strategy, a Climate Change Master Plan, a Summit Declaration on Food Security and Climate, and a Food Security Action Plan, which includes discussion of the relationship between climate change and food security. The EAC Treaty, in Article 100 on Meteorological Services also provides for harmonization in the collection, management, and dissemination of meteorological information to facilitate early warning efforts.

In recognition of the IPCC's predictions for adverse impacts of climate change on the region, and to support its planning processes, the EAC and its Partner States called for a regional VIA aimed at analyzing the expected impacts, risks and the adaptive capacity of the region and its critical productive sectors due to climate variability and change. This VIA study intended to:

- Establish a baseline against which system changes and protective measures can be monitored;
- Determine possible consequences of climate change;
- Determine which populations and sectors are most vulnerable or at risk from the adverse effects of climate change;
- Identify weaknesses and gaps in existing adaptation strategies and policies and recommend adaptation measures that could assist the region to respond to these impacts and build resilience; and

- Build capacity of the EAC and its Partner States in carrying out VIA studies and in the process improve the understanding on key inter – sectoral linkages while strengthening the case for investment in the sectors of priority to the EAC.

Although the VIA covers the entire region, there is particular focus on the Lake Victoria Basin due to the socio-economic importance of Lake Victoria to the East Africa region. Lake Victoria is the largest inland water fishing sanctuary; a major inland water transport linkage for the East African Community Partner States; a source of water for domestic, industrial and commercial purposes; a major reservoir for hydro-electric power generation; a major climate modulator in the region; and a rich biodiversity sanctuary. The basin has also been declared a '***Regional Economic Growth Zone***' and an '***Area of Common Economic Interest***' to optimize its economic and social benefits while addressing any environmental concerns and issues. Climate change has been identified as a serious threat to the basin's economic prosperity and livelihoods.

VIA Approach and Methodology

The IPCC's framework for assessing climate change vulnerability, impacts and adaptation was used to identify vulnerable areas in the East African Community (Figure 1). The VIA integrated climate and socioeconomic information layers and used indicators from these thematic layers for its analyses of vulnerability:

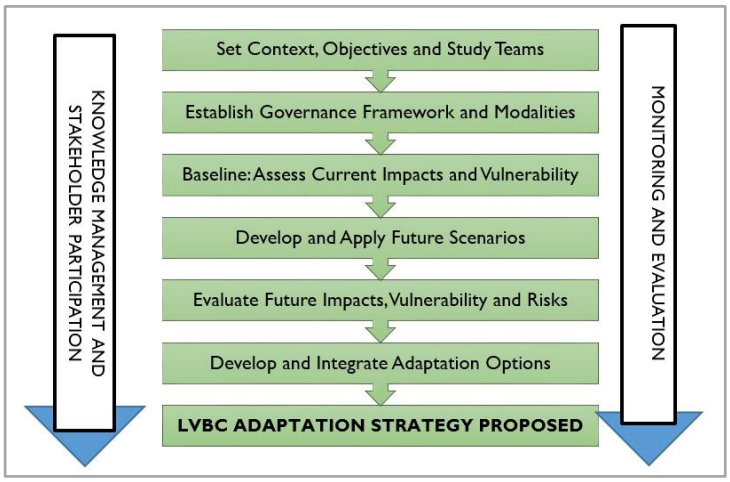


Figure 1: EAC VIA Approach and Phases

- Climate exposure indicators - (e.g. droughts, floods, rainfall variability) and future exposure (ensemble including climate model for rainfall and temperature changes),
- Sensitivity indicators, for example, sensitivity of irrigated lands, human, livestock, and wildlife populations, soil organic carbon, and ecosystems to exposure; and
- Adaptive capacity, or the ability of the biophysical or human system to adapt to exposure and sensitivity.

The EAC study team established strategic institutional partnerships within EAC Partner States to generate the required and enhanced climate datasets and socioeconomic information. Below are examples of the indicators that were used in the one part of the VIA (Table 1).

Table 1: Baseline assessment using IPCC definition of vulnerability and additive approach

COMPONENT	INDICATOR	GEOSPATIAL DATA LAYER	INCLUDE	TYPE
Exposure	pptav	Average Annual Rainfall Totals	Y	Raster
Exposure	pptcv	Inter-Annual Coefficient of Variation of Rainfall	Y	Raster

Exposure	ttrend	Long-Term Surface Temp Annual & Seasonal Trends	Y	Raster
Exposure	flood	Flood Frequency and polygons (1997-2007)	Y	Raster
Exposure	spi15dgt	Drought Index SPI less than -1.5 standard deviations	Y	Raster
Exposure	spi15fld	Flood Index SPI greater than 1.5 standard deviations	Y	Raster
Sensitivity	imr	Infant Mortality Rate (2006)	Y	Vector
Sensitivity	mala	Malaria Stability Index	Y	Raster
Sensitivity	carb	Soil organic carbon/soil quality (1950- 2005)	Y	Raster
Lack of Adaptive Capacity	mark	Market Accessibility (Distance from Markets)	Y	Raster
Lack of Adaptive Capacity	anth	Anthropogenic Biomes (2000)	Y	Raster
Lack of Adaptive Capacity	irri	Irrigated Areas (1990 – 2000)	Y	Raster
Lack of Adaptive Capacity	hhwl	Household Wealth (2006)	Y	Vector

Through a strategic partnership, the EAC Climate Change Coordination Unit (EAC – CCCU) and regional and international climate centers developed and adapted a suite of geospatial analytical tools (GeoTools) with United States Agency for International Development (USAID) funding. These tools and datasets are now locally available at the IGAD Climate Predictions and Applications Centre (ICPAC), the Regional Centre for Mapping of Resources for Development (RCMRD) and the respective meteorological services for each Partner State, providing new capacities for these national and regional institutions to:

- Generate and update locally enhanced climate datasets and analyze current and future climate risks and opportunities at every 5 km by 5 km grid (GeoCLIM and GeoMOD);
- Conduct regular seasonal climate monitoring and early warning systems (GeoCOF);
- Implement regular agriculture monitoring, early warning, risk, and options mapping (GeoWRSI);
- Support dynamic vulnerability index mapping for diverse socioeconomic sectors; and
- Support communities in identifying climate risks, options and develop community based adaptation strategy.

A climate change hotspots map (Figure 2) was developed combining indicators for exposure, sensitivity and adaptive capacity. This was used to identify vulnerable communities for the completion of a Community Climate Change Adaptation Assessment (C3A2), the results of which provided community perceptions of climate variability and adaptive behavior. Using the data and information generated, the C3A2 teams worked with 17 communities to implement community climate change adaptation projects.

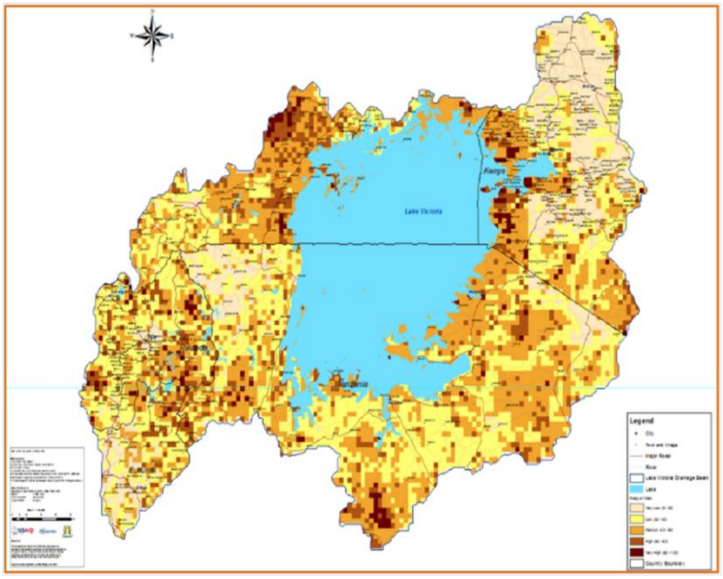


Figure 2: Community hotspots (vulnerability map) for the Lake Victoria Basin

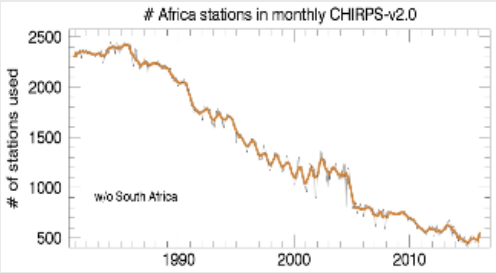
The VIA team examined the current conditions and identified key sectors. Future climatic and non-climatic scenarios were used to examine the possible effects of climate on the various sectors. These then formed the basis for identifying possible adaptation response measures recommended for the East African region, and the Lake Victoria Basin. The study results were also used in the development of the 2017 – 2022 Lake Victoria Basin Climate Change Adaptation Strategy and Action Plan (LVB CCASAP).

BASELINES AND FUTURE CLIMATE CHANGE SCENARIOS

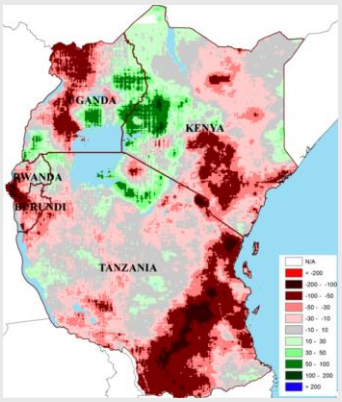
In recent years, East Africa has been characterized by frequent episodes of either excessive or deficient rainfall which has negatively impacted the economy. Comprehensive understanding of climate change and variability has also been hampered by lack of sufficient long – term historical observed data points as the number of stations providing data continue to decline (Box 2a). However, analysis of observed station data blended with satellite data allows for interpretation of historical climate trends and variability. To conduct these analyses of historical and future climate, the VIA team developed a regional gridded database by combining local station data with that from the Climate Hazards Group Infra-Red Precipitation with Station (CHIRPS) dataset.

In general, results indicate average annual rainfall variability of between 6% and 50% across EAC countries for the 1981–2010 period. The long rains depict relatively higher variability, ranging between 40–50% over most of Kenya and Tanzania. This means that the seasonal rains most important for agricultural production are becoming more erratic and unreliable for most farmers, making it difficult for them to predict and plan. Meanwhile, in the recent past the southeastern marginal agricultural areas of Kenya experienced successive rainfall failures, emphasizing the plight of farmers facing increased variability of seasonal rains and unpredictable crop yields.

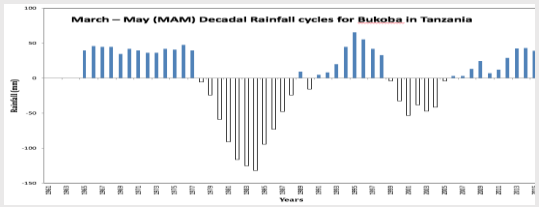
a. *Declining climate observational data*



b. *Declining MAMJ rainfall trends (mm/decade) in most parts of EAC member countries*



c. *10-year climate cycles dominant in station rainfall in some EAC countries*



Box 2: Use of gridded data sets to determine historical trends and variability

Annual precipitation trends for 1981–2016 for the EAC region show significant areas with declining rainfall (Box 2b). Distinct 10-year cycles of dry and wet periods have appeared over East Africa, with wet periods in the 1960s, 1970s, and 1990s and dry periods in the 1980s, 1980s, and 2000 to 2010s (Box 2c).

Drier periods are getting longer and more pronounced during the long-rains of March-June (MAMJ). Precipitation patterns for the long rains exhibit decreasing rainfall trends (20 – 100 mm/decade) over Burundi and Rwanda, northern and eastern parts of the Kenya, and Uganda's Lake Victoria Basin (LVB) region. Increased rainfall trends have also been experienced in the southern and eastern portions of the Tanzania LVB regions (Box 2b).

Analysis of surface temperatures for the 1930–2016 period, using CHIRPs and GeoCLIM datasets indicates significant increases within the five LVB countries, ranging between +0.7°C and +1.2°C for average monthly maximum temperature and between +1.0°C and +1.1°C for the average monthly minimum temperature.

Modeled climate scenarios also indicate substantial warming and drying trends. Analysis of EAC future climate scenarios using outputs from 50 km by 50 km resolution Rossby Centre Regional Atmospheric (RCA) model downscaled Coupled Model Inter-comparison Project Phase 5 (CMIP5) global circulation models paint an equally unfavorable scenario of EAC's future climate. The analysis is based on available historical and downscaled future scenarios for maximum and minimum temperature data (1951 – 2005) and projection (2006 – 2100) periods for the RCP2.6, RCP4.5 and RCP8.5 scenarios. The projected rainfall changes and mean surface temperature for 2030, 2050, and 2070 under different emission scenarios are summarized in Table 2.

Table 2: Future Climate Change Projections for East Africa

Future Climate Change Scenarios in EAC					
Climate Variable		Future Years	RCP 2.6	RCP 4.5	RCP 8.5
Rainfall	MAM	2030	Long rains to decrease over northern parts but increase over south-eastern parts of EAC		
	JJAS	2050	To decrease over most parts of EAC basin and coastal areas (25-50% by 2020 and 2030, 50-75% by 2050 and 2070)		
	OND	2070	To increase over most parts of EAC (10-25% by 2020 and 2030, 25-50% by 2050 and 2070).		
Mean Maximum Surface Temperature		2020	0.5^0 to 1.0^{0}C higher	0.5^0 to 1.0^{0}C higher	0.5^0 to 1.0^{0}C higher
	MAM	2030	Through out the year, annual increase by 1.0^{0}C to 2.0^{0}C over most parts of EAC. The projected warming extent will be greatest in MAM and JJAS but least in OND		
	JJAS	2030			
	OND	2030			
	Annual	2050	1.0^0 to 2.0^{0}C higher	1.5^0 to 2.5^{0}C higher	2.5^0 to 3.5^{0}C higher
			These will be over most parts of EAC, with slightly less warming projected over coastal. Greatest potential warming projected for MAM and JJAS seasons		
		2070	0.5^0 to 1.5^{0}C higher	1.5^0 to 2.5^{0}C higher	3.5^0 to 4.5^{0}C higher, with far greater warming projected during JJAS
Mean Minimum Surface Temperature		2020	0.5^0 to 1.5^{0}C higher	0.5^0 to 1.5^{0}C higher	1.0^0 to 2.0^{0}C higher
		2030	1.0^0 to 2.5^{0}C warmer than the base period, with the greater warming projected for JJAS under the RCP8.5 scenario		
		2050	1.0^0 to 2.0^{0}C higher	1.5^0 to 2.0^{0}C higher	2.0^0 to 2.5^{0}C higher
		2070	The projected annual maximum temperature will likely be 0.5 to 1.5^0 C higher under the RCP2.6, which is notably smaller than the changes anticipated by 2050. This is due to the reduction in radiative forcing expected towards the end of the century due to mitigation measures under RCP2.6. In contrast, under the RCP8.5, the expected annual warming will likely result in temperatures 3.5 to 4.50C higher than the reference period, with far greater warming expected during the dry season (JJAS)		

Generally, it appears that rainfall will increase over East Africa under all the future emission scenarios except for June – September (JJAS) period in 2020. Mean annual maximum surface temperature projections showed an increase of 1^{0}C to 2^{0}C over most parts of the EAC by 2030. The projected warming extent will be greatest in MAMJ and JJAS and least in OND. Maximum daily temperatures are expected to increase 2.5^{0}C to 3.5^{0}C by 2050 and even by 2^{0}C to 2.5^{0}C by 2020 under the business as usual scenario (RCP8.5). East Africa can also expect that rainfall events will become more extreme, episodic, and intense.

AGRICULTURE AND FOOD SECURITY

Agricultural production and food security, including access to food in many of the EAC member countries is severely compromised by climate change and climate variability with small-scale farmers being the most affected. Although farmers in the region have developed several adaptation options to cope with current climate variability, such adaptations may not be sufficient for future changes of climate. Most parts of the region already face semi-arid conditions that make agriculture challenging, and climate change has already reduced the length of growing seasons, possibly forcing large areas of marginal agriculture out of production. Pastoralist communities that predominantly dwell in these areas are threatened by recurring drought, with their only source of livelihood being pushed to the brink of collapse. Rain-fed agriculture accounts for approximately 80% of subsistence food production, yet it is dominated by small holder farmers who overly rely on rainfall. These

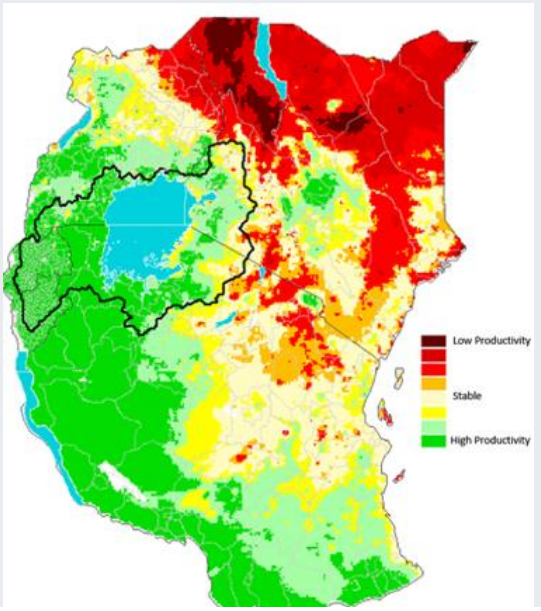
The EAC agricultural production sector plays an important economic strategic role and contributes between 20-40% of the regions GDP's. However, its contribution has largely stagnated and is showing declining trends at national levels, due to its increasing vulnerability to climate variability and change trends, insufficient decision/policy support information systems, exacerbated by low political commitment and under-investment in the sector. This report, recommends specific actions for policy considerations to ensure sustainable growth in sector in tandem with its rapidly increasing food consumption demands and recurrent food insecurity crisis.

farmers have limited or no resources to improve their agricultural production systems, making them extremely sensitive to climatic variability. This sector accounts for 34%, 29%, 32%, 25%, and 23% of the national GDP in Burundi, Kenya, Rwanda, Tanzania, and Uganda respectively. On average the livestock sector contributes about 9% (Burundi), 8% (Uganda), 9% (Kenya), 10% (Rwanda) and 8% (Tanzania), to the GDP of the region (EAC, 2011[1]). The fisheries industry contributes relatively less to GDP, on average about 2.6%, 0.8%, 1.3%, 1.0%, and 3.0% to the economy of Uganda, Kenya, Tanzania, Burundi, and Rwanda respectively.

In the EAC, surface temperatures have in some instances increased by 2^0 to 3^0 C in the past five decades. This is well above the predictions provided by the IPCC and above the thresholds captured in the 2015 Paris Agreement. The consistent warming trends, coupled with the declining rainfall rates of 20-100 mm per decade (1981-2016), have resulted in adverse implications for agriculture and livestock sectors in Arid and Semi-Arid Lands (ASAL) and marginal agricultural areas in the region. The drying trends have even more adverse implications for the pastoral and marginal agricultural areas, which on average receive the lowest rainfall amounts. These current declining trends are causing the shrinking of maize growing zones, especially over northeastern Tanzania and the bordering regions of southern, southeastern, and central lowlands of Kenya. The southwestern regions of Uganda and northern Rwanda are also showing signs of continued decline in maize yield, associated with declining seasonal rainfall amounts and increasing temperatures, as shown in the EAC map of key maize growing areas (Box 3).

A 1.5°C warming by the 2030s could lead to about 40% of present maize cropping areas being no longer suitable for current cultivars. Under warming of less than 2°C by the 2050s, total crop production could be reduced by 10%. For higher levels of warming there are indications that yields may decrease by around 15–20% across all crops and regions. Heat and drought would also result in severe losses of livestock and associated impacts on rural communities.

Shrinking of maize growing areas due to exceptional warming and drying trends in eastern and central marginal agricultural areas



Box 3: Declining productive maize areas

Increasing burden to feed chronically food insecure population with additional projected increase of 5 – 6 million people every year *under challenging climatic conditions*

High inter-seasonal rainfall variability, reduction of arable land, shifts in agro-ecological zones, and increasing natural resources – based conflicts can be expected in the future. The current low yields of maize (1.6 tons/ha), dry beans (2 tons/ha), cassava (8.3 tons/ha) and sorghum (1 ton/ha), and export crops like tea (1.5 – 3 tons/ha) and coffee will decline even more. Climate change related loss of pasture and unfavorable breeding temperatures will affect livestock and fish. The current average dairy cattle productivity of 410 kg/animal is already lower than the global 2,197 kg/animal and could decline even more.

[1] East African Community (EAC), 2011: East African Community Climate Change Master Plan. Arusha, Tanzania.

Current warming trends of more than +2°C above optimal levels (10 – 30°C) for all livestock are expected to adversely impact production, resulting in lower livestock feed intake by 3 – 5% and poor livestock health, with adverse impacts on overall milk and beef production. The current warming and drying trends have negatively impacted the quantity and quality of pastures, fodder crops and grains, water availability, and severity and distribution of diseases and parasites.

Warmer than normal surface water temperatures and variability in rainfall patterns could affect fish physiological processes, thereby impacting spawning, survival of juveniles, and recruitment into the exploitable phase of population size, production and yield.

Overall vulnerability in agriculture to projected climate change is expected to increase under the projected most likely (RCP4.5) and worst case scenarios (RCP 8.5) for the next 20 – 50 years (2030, 2050, and 2070). There is therefore increased likelihood that more EAC agricultural lands will become more vulnerable and unsuitable for growing long-cycle staple foods, especially maize. Under these scenarios, with a rapidly increasing population of 5-6 million every year and declining agricultural productivity in the region, the burden of responding to humanitarian food insecurity crises is likely to increase by more than 4%, with recurrent severe droughts. EAC Partner States will be required to invest heavily in agriculture, from applied research to scaling up viable options to mitigate current and foreseen food insecurity crisis in the region.

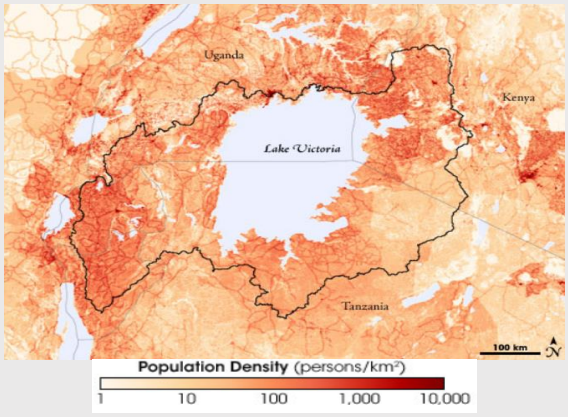
WATER, AQUATIC ECOSYSTEMS AND INFRASTRUCTURE

Climate change, climate variability and socio-economic conditions have imposed additional pressures on water availability, water accessibility, and water demand in the EAC region. It is projected that this will aggravate the water stress currently faced by some countries, while those that currently do not experience water stress will become at risk.

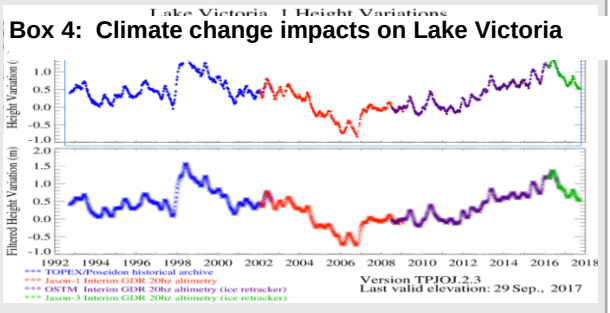
Rainfall is one of the climatic variables that will be most affected by climate change and/or climate variability in EAC region. Arid and semi-arid parts will experience rainfall of below 300 mm annually under the best case scenario of RCP2.6. With an unprecedented increase in temperature of about 2.5⁰ C to 3.5⁰ C, both the quantity and quality of water will be affected. Over extraction of ground water resources, increased competition and conflicts over water may become common in parts of East Africa where per capita water storage is already low. Under such warming trends, the existing differences in water availability across the region could become more pronounced causing serious threat to economic growth, social cohesion and political

Box 4: Climate change impacts on Lake Victoria

a. High population density and rapidly increasing by 3 – 4 % per year within the Lake Victoria Basin



b. Lake Victoria water levels are highly variable and sensitive to prevailing climatic trends



stability. IPCC (2007)[2] projects that 90 to 220 million people in Africa would be exposed to increased water stress due to climate change.

The water resources of the world, and thus of East Africa, are finite, yet uses have continued to increase exponentially. The five EAC Partner States combined have a renewable water volume of 187 km^3/yr. Over the last century populations in the EAC have increased to about 183 million people in 2016, meaning available water per capita has been reducing dramatically (Boxes 4a and 4b).

Across the EAC region, 75% of human populations in the rural areas do not have access to safe drinking water. The Lake Victoria Basin contains about 30 million rural inhabitants, the majority of whom are very poor. Projections indicate that this population will more than double by 2020 (68 million) and by 2050 it could increase to about 165 million people, creating great competition for water resources.

The aquatic biodiversity in the region is very rich. Lake Victoria's natural resources support over 100,000 fishermen across its three countries and the lake is a major source of protein to approximately 8 million people. With the changes in climate patterns, variability, and trends; fish reproductive patterns, distribution of macro-invertebrates and amphibians, and migration patterns for migratory water birds have been and will be adversely affected.

Results of a water stress vulnerability assessment, conducted for the three potential future emission scenarios for the Lake Victoria Basin for the years 2030, 2050, and 2070 indicate spatial variations on the magnitude of the impacts, showing a higher vulnerability in Kenya and Tanzania for 2030 and 2050 respectively. In 2050 the threats will impact the western sections of the LVB. In 2050, the impacts will be severe across the entire basin. In 2070, vulnerability will be higher in Kenya, especially the Mau water tower; in Uganda; and parts of northern Rwanda and Tanzania (Figure 3).

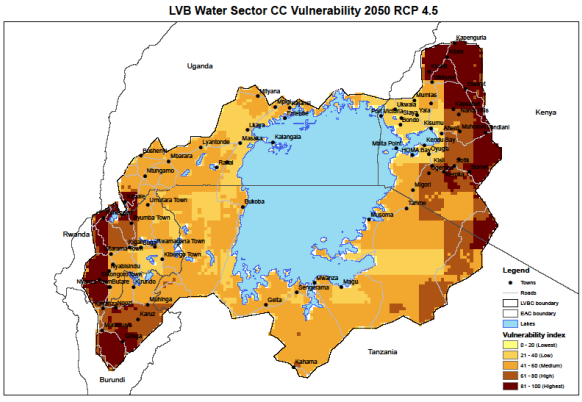


Figure 3: Water stress vulnerability in the Lake Victoria Basin for 2050, RCP4.5

Surface water resources are extremely vulnerable to climate change. Results from dynamical modelling predict that the LVB will experience more rainfall, but that 20 out of its 23 rivers will experience highly variable discharges. Continuous heavy rainfall may simultaneously increase risk by increasing flooding in some low lying areas. The coefficient of variability in these predicted stream flows are high, in some cases above 70%. Groundwater recharge could increase, especially during the short – rains. Where increases in heavy rainfall events are projected, floods could wash away sanitation facilities, spreading wastewater and potentially contaminating groundwater resources. This may lead to increased risk of diseases especially in areas where pit latrines are used. Managers of water resources in the region should prepare for these extremes, through planning and action.

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[2] IPCC, 2007: IPCC Fourth Assessment Report. Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability. IPCC, Geneva.

With continuous climate variability, the region is at risk of biodiversity losses. Changes in the migratory routes (and timings) of species that use seasonal wetlands might lead to increasing human wildlife conflicts. Fish could be severely affected by climate change, as riverine species subjected to climate change and variability tend to react by restricting their range or by colonizing new climatically suitable habitats. A 1° to 2°C increase may led to death of many tropical fish species. Eutrophication due to increased flooding and consequently nutrient inputs from catchments will undoubtedly lead to further pressure, increasing levels of hyacinth, and cause loss of wetland vegetation. Already, the loss of the "spongy-like" effect of wetlands has led to more flooding in Nyando, Kenya.

HEALTH, SANITATION AND HUMAN SETTLEMENTS

Human health has already been compromised by a range of factors and further negatively impacted by climate change and climate variability. Vectors, pathogens, and hosts reproduce within certain optimal climate conditions and changes in these conditions can modify greatly the properties of disease transmission, such as malaria in the East Africa highlands. It appears that the climate change has altered the ecology of some disease vectors in the region, and consequently the spatial and temporal transmission of these diseases. The need exists to examine the vulnerabilities and impacts of future climate change on other infectious diseases such as malaria, dengue fever, meningitis and cholera, among others.

Human health is expected to be significantly affected by climate change. IPCC (2007) predicts a 5-7% potential increase in malaria distribution by the end of the century. Previously malaria-free highland areas in Ethiopia, Kenya, Rwanda, and Burundi could also experience malaria starting from around mid-century, potentially exposing communities with little or no immunity to a debilitating illness.

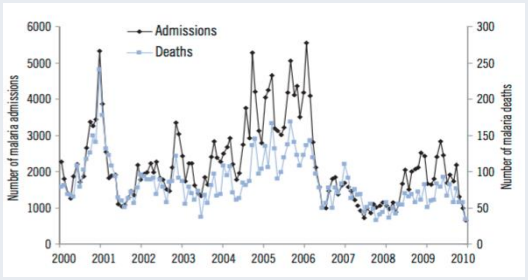
The EAC's climate regime favors the growth, multiplication and transmission of several vector-borne and water-borne diseases. Communicable diseases contribute to the highest morbidity, mortality, and disabilities in this region.

The most common cause of mortality and morbidity is malaria, acute respiratory tract infections, diarrheal diseases, malnutrition, and Human Immunodeficiency Virus/Acquired Immuno-Deficiency Syndrome (HIV/AIDS) (Global Burden of Diseases, 2010). The most common killer diseases in the LVB are malaria, diarrheal illnesses (e.g. cholera), and respiratory tract infections.

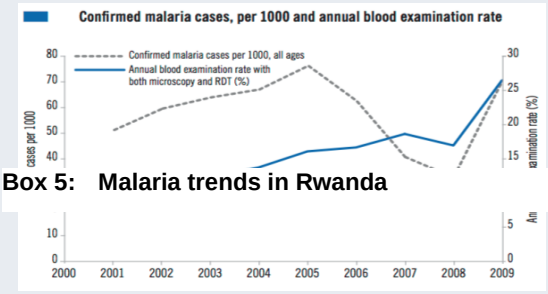
A nationwide seasonal resurgence of malaria cases in Rwanda occurred during both the 2008–2009 and 2009–2010 malaria seasons, which was 2–3 years after the nationwide campaign to provide long lasting insecticidal nets for children less than 5 years of age. The resurgence of uncomplicated outpatient malaria cases was greater than that of severe malaria cases and deaths (Box 5).

The projections into 2030, 2050, and 2070 indicate that there will most likely be an increase in malaria cases reported in the Lake Victoria basin (Box 6). Due to increasing temperatures, the disease will also be prevalent in previously malaria free areas, especially in highland areas. Other projected impacts include

Malaria admissions and deaths, Rwanda, 2000–2010



Trends in malaria morbidity and mortality in Rwanda



(Source: WHO 2016)

Box 5: Malaria trends in Rwanda

burden of endemic and epidemic malaria is estimated at between $61 million and $77 million annually. Initial estimates from a limited number of health facilities in Tanzania indicate that climate change could lead to additional treatment costs of $20 to $100 million by 2030, and $36 to $150 million a year by 2050. In Kabale, Uganda, the cost for treating malaria is estimated to increase from between $0.7 million to $15.8 million in 2010 to between $1.55 million to $41.7million in 2050.

The EAC region has made progress in improving access to safe drinking water and sanitation over the past decade. However, future extreme events, such as floods, could lead to increased contamination of safe water sources and a breakdown of sanitation facilities and sewer systems, while droughts will reduce the availability of safe water to ensure proper hygiene is maintained.

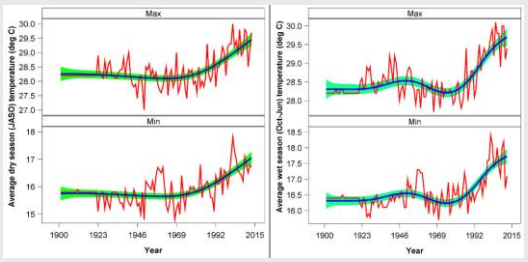
prolonged periods of elevated malaria transmission interspersed by periods of low transmission as malaria is seen as a highly seasonal and cyclic disease.

Studies in EAC region have shown that a mere 0.5°C temperature increase could cause a 30 – 100% increase in mosquito abundance, while air temperatures below 18°C prohibit development of malaria pathogens.

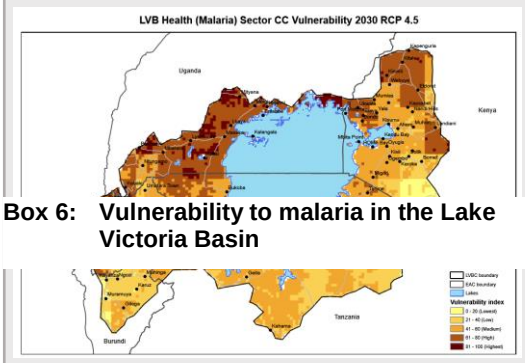
Another feature of the 2030s, 2050s and 2070s could be the infection of other age groups that are not currently considered vulnerable groups, such as the over five years old.

The potential costs of preventing and treating malaria in the LVB will increase due to the expected increase of malaria cases in the future. For example, in Rwanda an estimated 2.5 million people could be affected in the absence of adaptation measures and the additional

Rapid increase in both Maximum and Minimum Temperature within the Lake Victoria Basin



Vulnerability to malaria across Lake Victoria Basin



Box 6: Vulnerability to malaria in the Lake Victoria Basin

Public health expenditure per capita increased in Burundi from $4.9 in 2012 to $10.6 in 2013, in Uganda from $7.8 to $11.7, and in Kenya from $18.5 to $21. This is still well below the estimated $28 per capita spending to achieve the MDG targets.

Rwanda had some improvement in access to safe drinking water from 74 percent in 2012 to 74.2 percent in 2013, while Uganda reported a slight decline from 71 percent to 67 percent. Access to safe drinking water in urban areas remained high throughout the region (above 80 percent).

Increasing episodic and extreme rainfall events will create conditions conducive to the Vibrio cholerae bacterium that causes cholera, as well as to vectors for other diarrheal diseases. V. cholerae lives in aquatic environments and is linked to both abiotic and biotic ecological factors, which are likely to be influenced by global climate changes and the resulting rise in sea levels (Borroto 1997[3]).

Developing countries will be extremely vulnerable to climate changes because they are both susceptible to the change and already at the limits of their capacity to cope with climatic events. These include populations in low-lying coastal regions and islands, subsistence farmers, populations in semiarid grasslands, and the urban poor. Regions already struggling to cope with exploding populations can be expected to be exceptionally vulnerable to climate change, urban growth, and poverty.

The projections for 2030, 2050, and 2070 indicate that stresses on rural populations are likely to sustain or increase the level of rural-urban migration. Meanwhile, increasing temperatures in cities will put additional pressure on available water supplies and could compromise efforts to expand or even maintain current levels of sanitation control, resulting in increased incidence of disease.

ENERGY AND INFRASTRUCTURE

Hydropower accounts for between 35-90% of energy produced in different areas in the EAC region. During prolonged dry spells and drought, the water levels are too low to produce enough energy required by an ever growing population. On the other hand, flooding may provide opportunities for improved storage facilities and infrastructure. However, excessive runoff could increase siltation with possible damage of equipment and destruction of transmission lines. In the recent years, changes in rainfall and temperature patterns have immensely affected the output of power generation due to varying water levels, leading to increased power rationing. Some of the worst affected areas include the Kidatu and Nyumba ya Mungu dams in Tanzania and the Masinga dam in Kenya (Box 7).

Another key source of energy for this region is biomass, which accounts for up to 80-90% of household energy used, with firewood and charcoal being the most consumed products. Prolonged droughts have

[3] Borroto, R., 1997: "Global warming, raising sea level and the growing risk of cholera incidence: a review of literature and evidence." *GeoJournal* 44, 111–120.

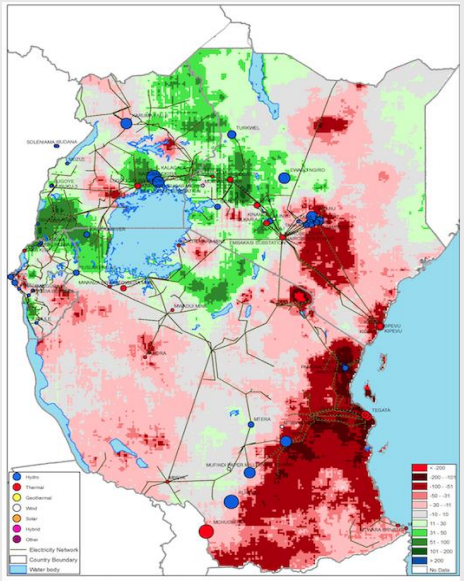
affected biomass availability and regeneration. Extreme temperature leads to bush fires which destroys biomass reserves. The rate of regeneration is low in the region due to generally below average rainfall.

Energy demand is increasing in East Africa. The trend will most likely continue, driven primarily by economic growth and rising populations. A population increase of between 2 – 3% per year will mean the population may double in the next 10 years putting immense pressure on hydropower and biomass, which are already struggling to meet the current population demands.

Climate change and variability present increasing challenges for energy production and transmission. A decline in rainfall levels by approximately 10 mm per year and a continued rise in temperature by more than 2.5^0 C over the next 30 years will lead to increased surface water loss from dams through increased evaporation and exacerbated by declining rainfall trends, which could result in reduced or more intermittent ability to generate electricity.

The transport sector is crucial for developing countries. Tremendous progress have been made to improve on infrastructure in the EAC. Major projects such as the Standard Gauge Railway is meant to open up East Africa markets to Central Africa. Kenya is planning to commence with the Phase 2 of the SGR that will link Mombasa to countries such as Uganda, Rwanda, and South Sudan. Uganda, Rwanda, and Tanzania are planning on linking a SGR that will improve linkages among the EAC countries. Improving sea ports in Tanzania and Kenya will enable the growth of the region by increasing imports and exports markets. Growth in the region's economy has been attributed to the growth of infrastructure, among especially the construction industry, which is linked to transport.

a) *Declining rainfall trends within the National Hydro-Power Stations*



b) *Drought impacts on Masinga dam levels. Just 11% above shut down level in 2017*

Box 7: Most affected hydropower locations in East Africa

Extreme events such as floods lead to destruction of infrastructure. Precipitation, temperatures, and wind play a significant role in the Lake Victoria maritime transport and safety. It is estimated that 5,000 people drown annually in the lake as a result of maritime accidents. Most of these accidents have been attributed to hazardous weather conditions and water currents in the Lake.

With climate variability and populations that are regarded as "poor and underdeveloped" struggle to cope, adjust or bounce back in the face of climate extremes as a result, disaster risk is increased resulting in adverse effects on the economy (East African Climate Change Master Plan, 2011[4]).

TERRESTRIAL ECOSYSTEMS, FORESTRY, WILDLIFE AND TOURISM

Changes in a variety of ecosystems are already being detected at a faster rate than anticipated, particularly in the Lake Victoria Basin. Climate change, interacting with human drivers such as deforestation, is a threat to the region's forest ecosystems. Changes in grasslands and marine ecosystems are also noticeable with additional consequences for pastoralism and fisheries. The impacts on ecosystems already have a negative effect on tourism and according to one study, between 25 and 40% of mammal species in national parks in East Africa have become endangered.

The terrestrial ecosystems thematic sector of the VIA covers forests and woodlands, grassland and savannas, mountains and associated wildlife, and tourism.

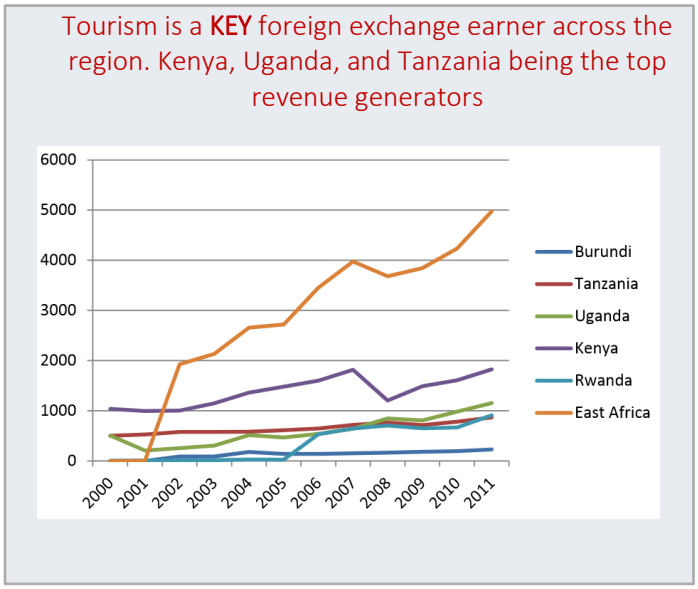


Figure 4: Revenue gained in EAC Partner States

According to recent satellite based vegetation trends indicators, based on eMODIS/Normalized Differential Vegetation Index (eMODIS/NDVI) satellite imagery (2001 to 2009), the area under woody savanna increased, while there was a decrease in natural vegetation, especially land under forests, shrub lands, and grasslands in the Nile Basin areas, in each of the five East Africa countries (UNEP 2013[5]).

Tourism is an important economic sector in the EAC region. In Kenya, Uganda, and Tanzania, the tourism sector is a major foreign exchange earner and much of the sector is wildlife-based and managed within protected areas (Figure 4). These protected areas are mainly in the arid and semi-arid areas which are climate sensitive and characterized by low and erratic rainfall patterns as well as high evapotranspiration rates. This sector is highly vulnerable to current climatic trends, which have led to shifts in wildlife preferences and migration patterns from important tourist destinations such as Serengeti and Mara to less important areas, possibly affecting tourism revenues. Fire risk is also a serious threat to tourism, since frequent fires may result in a loss of endemic biodiversity. Recent prolonged droughts (2000/1, 2010/11, and 2016/17) resulted in the rapid depletion of rangeland resources (pasture and surface water) and change of vegetation and ecological zones, thus affecting the distribution of wildlife in some of these areas.

Changes in hydrological cycles have also been shown to affect the availability, patterns, and distribution of endemic plant and animal species. Increased wildlife losses in East Africa may be due to climate variability

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4 East African Community, 2011: The EAC Climate Change Master Plan, EAC Secretariat, Arusha, Tanzania.

5 United Nations Environment Programme (UNEP), 2013b: Thematic focus: Ecosystem management, Environmental governance, Climate change. Saving the Great Migrations: Declining wildebeest in East Africa? http://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article_id=107.

and change, which impacts forage and its availability, adversely impacting herd sizes (Ogutu J.O, et al. 2011[6]).

Rwanda climate hotspots include the Akagera Park and Rugezi Swamp, where current increased temperature, recurrent droughts and high evapotranspiration has resulted in reduction of water levels of lakes and rivers. The La Nina drought of 1999 – 2000 resulted in the drying of the Gabiro – Akagera valley within the Akagera National Park, affecting the distribution of wildlife (The Republic of Rwanda, 2006[7]).

From ICPAC projections on future climate change, several forested hotspots were consistently projected to have low rainfall and high temperatures in the future (2030, 2050, and 2070). These hotspots include Kilombero Valley Flood Plain Ramsar Site in Tanzania, with a diversity of quality habitats with unique levels of biodiversity of international importance; Mount Kenya, Lake Nakuru, and Meru National Park in Kenya; Volcanoes National Park in Rwanda; and Mgahinga Gorilla National Park in Uganda. Future climate change could exacerbate existing anthropogenic pressures on these important biodiversity sites.

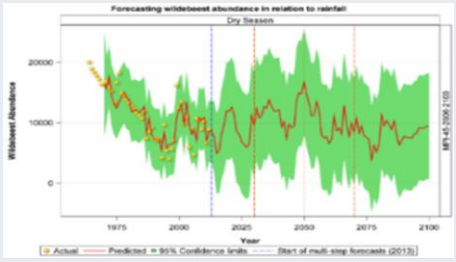
The VIA terrestrial team conducted a study of wildebeest populations for the Ngorongoro ecosystem for both the wet and dry seasons to determine the impact on their populations. The analyses illustrate oscillatory dynamics with extended periods of population increase followed by extended periods of persistent population decline. The projected wildebeest trajectories suggest that the population will continue to fluctuate widely between 5,000 and 15,000 animals under all the scenarios and seasons. It is only under the best case scenarios (low emissions, or RCP 2.6) that the dry season population increases beyond 20,000 animals between 2070 and 2090 (Box 8).

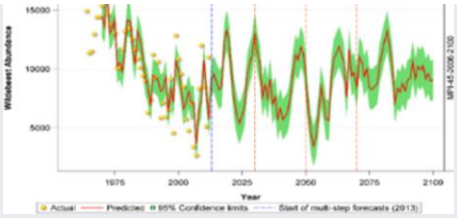
The impacts of combined anthropogenic drivers, such as human population growth and land use changes, may have more far reaching impacts on terrestrial ecosystems than

Box 8: Climate change impacts and wildlife migration

Wildebeest seasonal migration routes within Mara-Serengeti Parks

Strong historical correlation between Wildebeest and seasonal rainfall variability serving as medium to long-term forecasting tool within Ngorongoro Crater Park





[6] Ogutu, J.O., N. Owen-Smith, H-P. Piepho, and M.Y. Said, 2011: "Continuing wildlife population declines and range contraction in the Mara region of Kenya during 1977-2009." *Journal of Zoology*, 285: 99–109.

[7] Rwanda, Republic of, 2006: The National Adaptation Programme of Action to Climate Change. Ministry of Lands, Environment, Forestry, Water and Mines.

climate change. Wildlife populations in the Serengeti have remained stable for many species, including for the wildebeest, with its numbers remaining relatively stable at about 1.3 million. However, in the Maasai Mara National Reserve and in the adjoining conservancies, the population of almost all wildlife species has declined to a third or less of their former numbers. Encroaching farmland and livestock grazing appear to be the main reason for this decline, as wildlife habitats and corridors are shrinking. Future drying and warming trends are likely to continue constraining rangeland resources, with increased human – wildlife conflicts experienced.

EAST AFRICAN RESPONSE TO CLIMATE CHANGE IMPACTS

There are a wide range of existing actions being implemented by key East African and national institutions, as well as individuals that promote adaptive capacity. In addition, adaptation program options, to address these future climate change impacts, have been identified and proposed in numerous forums by regional and national stakeholders from government, nongovernment, and private sector organizations.

AGRICULTURE AND FOOD SECURITY

More investment in agriculture is required, not only by governments to meet their 10% commitments, but also other stakeholders such as the private sector, for this sector to stay resilient and continue being the backbone of the economies in the region.

Based upon the VIA results, East Africa regional and national stakeholders have proposed the following actions to address the impacts of climate change on the agriculture and food security sector.

Program 1: Strengthen regional and national early warning systems to be more responsive to users' needs

- Improve agro-climatic data observation in vulnerable areas within the EAC.
- Train national meteorological services and climate information users in necessary skills to provide required climate products and services.
- Support climate information network platforms and protocols for sharing and exchanging data, products and information.
- Enhance and strengthen private sector participation in early warning systems in the region through public private partnerships.

Program 2: Promote climate – smart agriculture (CSA) approach and risk management programs.

- *Crop/livestock research and improvement*: adaptive research is necessary as climate change is expected to affect the length of growing seasons, increase droughts and periodic water logging, increase temperatures, and potentially cause the introduction of new pests and diseases.
- *Agricultural extension services and outreach*: agricultural extension services are expected to continue to play a key role in agricultural development in East Africa through the diffusion of innovations and the provision of training to farmers in CSA. However, CSA research in regional and other national centers needs to advance beyond just field trials and pilots.

- *Agricultural finance and microfinance*: access to financial capital allows farmers to implement adaptation measures and explore diversified livelihoods.
- *Weather indexed crop insurance*: insuring farmers against climatic risks is a viable way to build their resilience to climate change.
- *Payment for ecosystem services*: paying farmers for ecosystem services can act as an incentive that promotes the adaptation of resources management and agricultural practices to climate change. These include (1) provisioning services such as food, water and forest products (2) regulations of climate, flood, drought, land degradation, and disease (3) supporting services related to soil formation, photosynthesis and nutrient cycling and (4) enhancing cultural services such as recreational, spiritual, religious, aesthetic, and other nonmaterial benefits.
- *Promote small – scale irrigation and water harvesting technologies across the entire value chain through public private partnerships.* Water for crop production may not be available in the future when it is needed. Local solutions for water harvesting can assist farmers with strategic irrigation during times of scarcity.
- *Strategic grain and forage reserves*: Holding Strategic Grain Reserves (SGR) can be a viable measure to address climate – triggered food shortages.
- *International and national policy integration*: Coherence between international and national policies is crucial for planning and implementing adaptation.
- *Limiting agricultural expansion*: As population pressure contributes to agricultural expansion, less suitable soils and climate conditions, combined with declining rainfall and increasing temperatures may contribute to more frequent crop failures. Conversely, increasing yields in productive areas can provide '*more crop per drop*', leveraging limited water resources.

Program 3: Support and strengthen agricultural value chains through Public – Private Partnerships (PPPs).

- Strengthen farmers, associations, organizations and cooperatives for collective action in mitigating climate change vulnerabilities.
- Develop and support management information systems for meteorological services that collect and disseminate useful weather and climate information.
- Develop and support agro-climate advisories and decision support tools for the entire value chain by connecting farmers to climate service providers for timely seasonal forecasting and weather updates.

Program 4: Harmonize and coordinate climate change initiatives for optimal use of limited resources.

- The EAC Secretariat could play a role in identifying and coordinating programs and projects in the region.

WATER, AQUATIC ECOSYSTEMS AND INFRASTRUCTURE

East Africa regional and national stakeholders have proposed the following actions to address the impacts of climate change on the water, aquatic ecosystems and associated infrastructure.

Program 1: Develop and implement community – based climate change resilience programs for on water catchment management

- Develop and implement climate change resilient catchment management plans and promote Trans – boundary Water Resource User Associations (TWRUAs).
- Promote cross – border experience sharing.

Program 2: Develop a decision support system that integrates climate change and Integrated Water Resources Management (IWRM) information,

- Improve the availability and dissemination of climate change and integrated water resources management (IWRM) information in the LVB.
- Develop a comprehensive hydro – meteorological monitoring network.
- Develop best practices on water allocation plans that takes into account climate change that can be scaled up to other sub-basins within LVB.

Program 3: Enhance technological advancement for water resources harvesting, storage, processing and utilization.

- Opportunities exist to mainstream climate change into water resources management by (i) promoting, developing, and implementing water harvesting and storage facilities (e.g. dams and water pans); (ii) promoting groundwater assessment and management technologies to improve aquifer recharge; and (iii) promoting cleaner production technologies that improve water quality and efficiency.

Program 4: Develop sustainable funding mechanisms and regional policy frameworks that support water security.

- Gain access to climate adaptation funds through EAC Secretariat accreditation to the Adaptation Fund and the Green Climate Fund.
- Capitalize the EAC Climate Change Fund.
- Harmonize regional policy frameworks on water security that mainstream climate change.

HEALTH, SANITATION AND HUMAN SETTLEMENTS

East Africa regional and national stakeholders have proposed the following actions to address the impacts of climate change on the health, sanitation, and human settlements.

Program 1: Build the capacity of the health workforce on climate change preparedness and response.

- Conduct climate change and health capacity needs assessments of the healthcare workforce in the EAC.
- Develop a capacity building framework and training guidelines on climate change and health related issues.
- Conduct training programs for health workforce on climate change and health awareness and preparedness and response.

Program 2: Strengthen and institutionalize surveillance, early warning, and communications systems on climate-sensitive diseases.

- Establish a regional platform for data, information, and knowledge sharing on climate change and health.
- Improve Integrated Disease Surveillance (IDSR) systems by integrating climate information.
- Develop and disseminate information, education and communication materials on climate change and health at all levels.
- Implement programs that utilize climate appropriate technologies and approaches to support improved climate resilience for health at community levels.

Program 3: Strengthen research and interventions (prevention, preparedness, response) that address climate-sensitive sanitation and diseases.

- Identify and prioritize key research areas in climate and health at the regional, national and sub-national levels.
- Mobilize resources for research on interventions that address climate-sensitive sanitation and diseases (public, private, donor and global funds).
- Conduct research in prioritized key research areas in climate and health in the LVB, and use findings to inform decision-making and programming.

Program 4: Utilize climate appropriate technologies for health and sanitation infrastructure.

- Identify and invest in climate appropriate technologies and approaches for health and sanitation infrastructure in the region.
- Assess key health and sanitation infrastructure in the LVB to determine its ability to withstand climate – related shocks and stresses and take appropriate action.

ENERGY AND INFRASTRUCTURE

East Africa regional and national stakeholders have proposed the following actions to address the impacts of climate change on the energy and infrastructure.

Program 1: Develop an all-encompassing Specific, Measurable, Achievable, Relevant and Time-Bound (SMART) regional renewable energy policy that reviews and harmonizes existing strategies that support participation of the private sector and NGOs.

Program 2: Research and invest in alternative energy, including the establishment of regional standards and setting up an internationally – accredited energy laboratory.

Program 3: Develop incentives and funding framework for regional energy project incubation and start – ups.

Program 4: Develop and promote community – based biomass reduction and efficient best practice models for the region.

TERRESTRIAL ECOSYSTEMS, FORESTRY, WILDLIFE AND TOURISM

Key elements of the four recommended adaptation options for terrestrial ecosystems are described below:

Program 1: **Application of a climate lens across key trans-boundary ecosystems**, especially biologically significant areas that are transboundary, such as Mara – Serengeti, Mount Elgon, Sango Bay – Minziro, Nyungwe – Kibera, and Greater Virunga – Volcanos.

Program 2: **Provide analysis of options for mitigation and adaptation for various regional and national governments, private sector and local communities**.

Program 3: **Prepare a regional approach in the LVB to address community-based climate change impacts on wildlife, forests and tourism**.

Program 4: **Develop climate change information hubs in the EAC and LVBC secretariats**.

INTEGRATED WATER, ENERGY AND LAND RESOURCES MANAGEMENT

The continuous determination of present and future climate change vulnerabilities in key EAC socioeconomic sectors provides valuable decision – support information for policy considerations in the region. More specifically, there are inherent linkages between these sectors, which require a well-coordinated and integrated approach to address the current and projected risks and opportunities.

Investment in agricultural production requires better water and energy infrastructure and resource management for optimal utilization of limited resources. Figure 5 illustrates the current sectoral vulnerabilities and highlights opportunities for a regional integrated approach in the transboundary regions of the Lake Victoria Basin. The LVB region has high potential for economic growth, but also has its own challenges due to its current high population density and growth rates and high sensitivity to climate vagaries. However, it poses an excellent opportunity to forge regional integration and protocols to overcome potential regional climate change challenges.

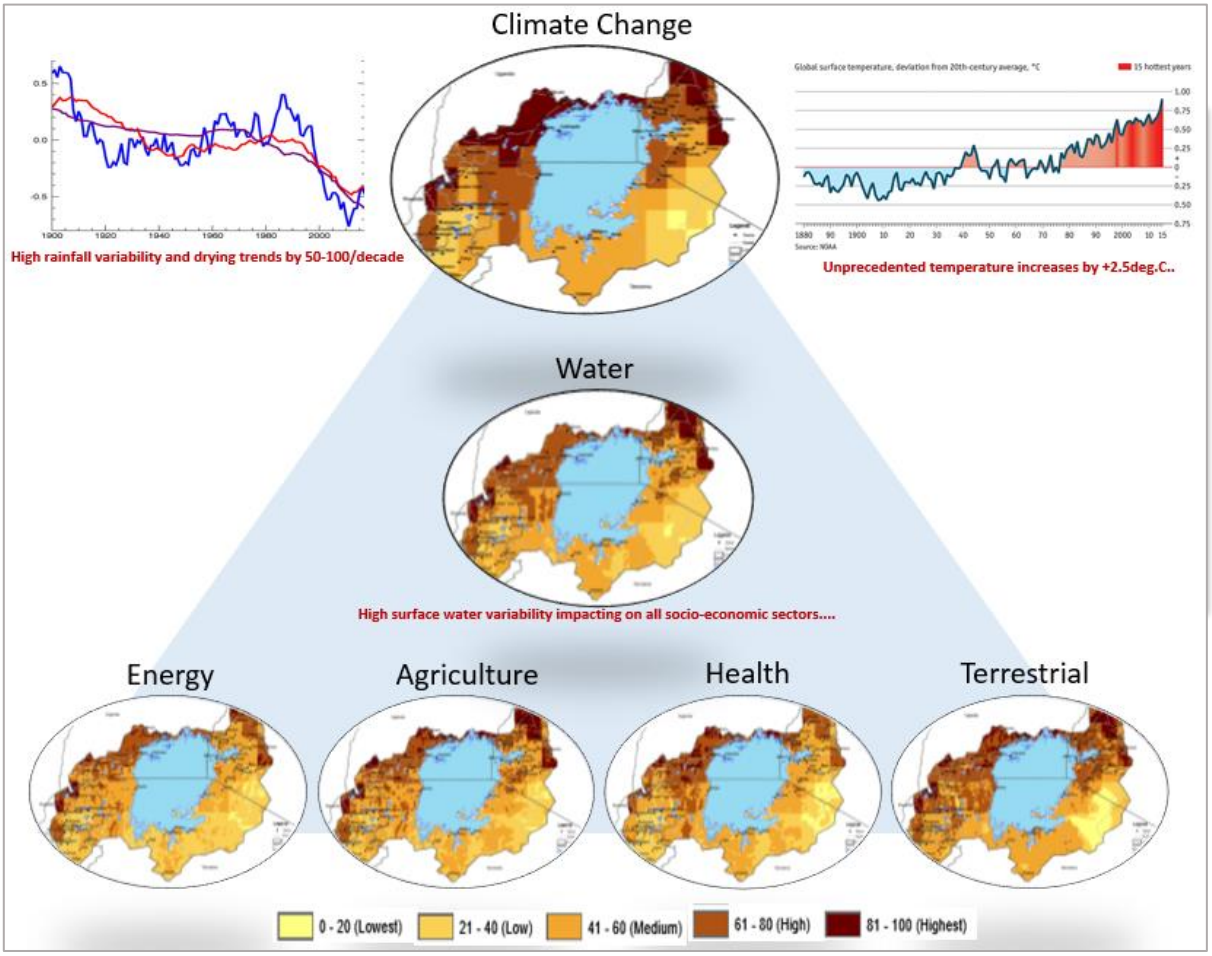


Figure 5: Integrated approach to climate change adaptation

CONCLUSIONS AND NEED FOR ACTION

The EAC Partner States recognize that climate change is real and its adverse impacts are becoming more evident in the region, with increasing vulnerability from recurrent natural disasters affecting local livelihoods as well as health and food insecurity crises**.** The results of the East African VIA strongly indicate that the East African region is already suffering from the adverse impacts of climate variability and change.

Some of the challenges identified for impeding Partner States' effectiveness in dealing with adaptation include:

- Inadequate information on regional scenarios;
- Adequate, accurate, and validated climate and socioeconomic data;
- Insufficient financial resources, including for the development of innovative technologies and their required investments; and

- Need for enhanced awareness creation at all government levels and across communities on impacts of climate variability and change and adaptation options available.

It is against this background that local climate scientists, using innovative approaches and strategic institutional partnerships can provide an in – depth understanding of current and future climate risks and vulnerabilities. The key VIA findings are contextualized for the EAC region and form the basis for policy considerations, focusing on foreseen challenges and opportunities by sector.

Through the continuous capacity building conducted during the VIA, most tools and climate change projections are now quite well understood in the region. However, less understanding of factors impacting socioeconomic systems is evident. While regional studies conducted and data developed have improved because of the VIA, socioeconomic scenarios on the same long – term time scales are more difficult to predict than climate scenarios. Significantly more work is therefore necessary to improve the collection and collation of socioeconomic data for future impact analyses.

In summary, the following VIA products are now available within the region for improved decision – making:

- Improved local climate institutional capacities (National Meteorological Hydrological Services (NMHSs), EAC CCCU, ICPAC, and RCMRD);
- More than 35 years of regional gridded climate datasets and risk maps (1981 – 2017);
- EAC and Lake Victoria Basin current and future climate Vulnerability Index maps;
- Baseline and future climate change scenarios reports for the five key thematic sectors;
- An established EAC Climate Change Information Network (CCIN);
- A C3A2 approach that includes a toolkit, handbook, and trained organizations within the region; and
- The Lake Victoria Basin Climate Change Adaptation Strategy and Action Plan (LVB CCASAP).

In summary, the VIA results indicate compelling evidence of:

- Unprecedented warming trends, of between +2 and +2.5 degrees Celsius over the last 50 years in ASAL and marginal agricultural areas of East Africa. This is well above the Paris Agreement thresholds, and is already within the projected most – likely and worst – case scenarios for 2030 to 2050. Currently, adverse impacts are being felt and are very likely to get worse, with a 3 – 4 degrees Celsius temperature increase expected in the near future.
- Increased seasonal and annual rainfall variability, exacerbated by declining rainfall trends (20–100 mm per decade), mostly in ASAL and marginal agricultural areas. The combined adverse effects of extreme warming and drying trends are already impacting agricultural production, habitats and ecosystems, health, and infrastructure.
- East Africa has become drier over the past three decades, but it is likely to become wetter in the next 30 – 50 years, providing new development opportunities; but risks as well from more extreme, episodic, and erratic rainfall events.
- Recent extreme climatic events, which provide valuable insights of how future climate change scenarios may potentially impact various socioeconomic sectors in business – as – usual scenarios.

One point that emerges from the VIA is the need for the EAC Partner States to review vulnerability scenarios, including the influences of El Niño and La Niña, relevant to their respective climate change planning documents. These two phenomena, influenced by climate change, will alter expected outputs in the agriculture, water, and energy sectors, among others.

There is need to review current sectoral policies to ensure that the real magnitude of the expected impacts of climate change are factored in and that climate change adaptation is mainstreamed related to all thematic sectors. The EAC and its Partner States climate change strategies and visions were developed on the basis of coarse global climate analyses and future projected scenarios from the IPCC, UNFCC, and UNISDR reports. Considering that new information is now available from the EAC VIA, there is an urgent need to review these strategies and action plans based on this recent local climate analysis and validated vulnerability studies in the region.

Through a strategic partnership formed of regional organizations to conduct the VIA, the region now has a suite of geospatial analytical tools (e.g. GeoTools) that are now locally available to departments of meteorological services, IGAD Climate Predictions and Applications Centre (ICPAC), and the Regional Center for Mapping of Resources for Development (RCMRD). New capacities and capabilities exist for these national and regional institutions to:

- Generate and update locally enhanced climate datasets and analyze current and future climate risks and opportunities (e,g, GeoCLIM and GeoMOD);
- Support continuous seasonal climate forecasting, monitoring, and early warning (e.g. GeoCOF);
- Support agriculture monitoring, crop modeling, risk assessment, and options mapping (e.g. GeoWRSI);
- Support dynamic vulnerability mapping for diverse socioeconomic sectors (e.g. Vulnerability Index mapping); and
- Support communities in identifying climate risks and adaptation options and developing community based adaptation strategy (e.g. C3A2).

Numerous activities are ongoing on adaptation but a lot more needs to be done especially in accessing financial resources, improving regional cooperation, and sharing of knowledge and best practices. The wide range of projected and current impacts of climate change means that at the very least the policies in place should:

- Have broad socioeconomic benefits and rationale, essentially supporting good practice and sustainable development pathways and ensuring resilience to shocks whether they be due to climate change or other causes;
- Be flexible and scalable – the direction and magnitude of change cannot be known with certainty – but we do expect that significant change will occur. It is important that communities can deal with change regardless of how it manifests itself and can rapidly scale – up the response as change becomes more evident and severe;
- Promote and enhance improved governance and strengthened institutions that allow for participatory approaches and improved decision – making capacity for individuals and communities;

- Support diversification of income sources and livelihoods wherever possible, so that people have options at times when they really need them; and
- Provide monitoring and early – warning information and build capacity, which is essential to making good decisions at all levels of government and community.

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