Scoping Study on

VULNERABILITY TO CLIMATE CHANGE AND CLIMATE VARIABILITY IN THE GREATER HORN OF AFRICA

Mapping Impacts and Adaptive Capacity

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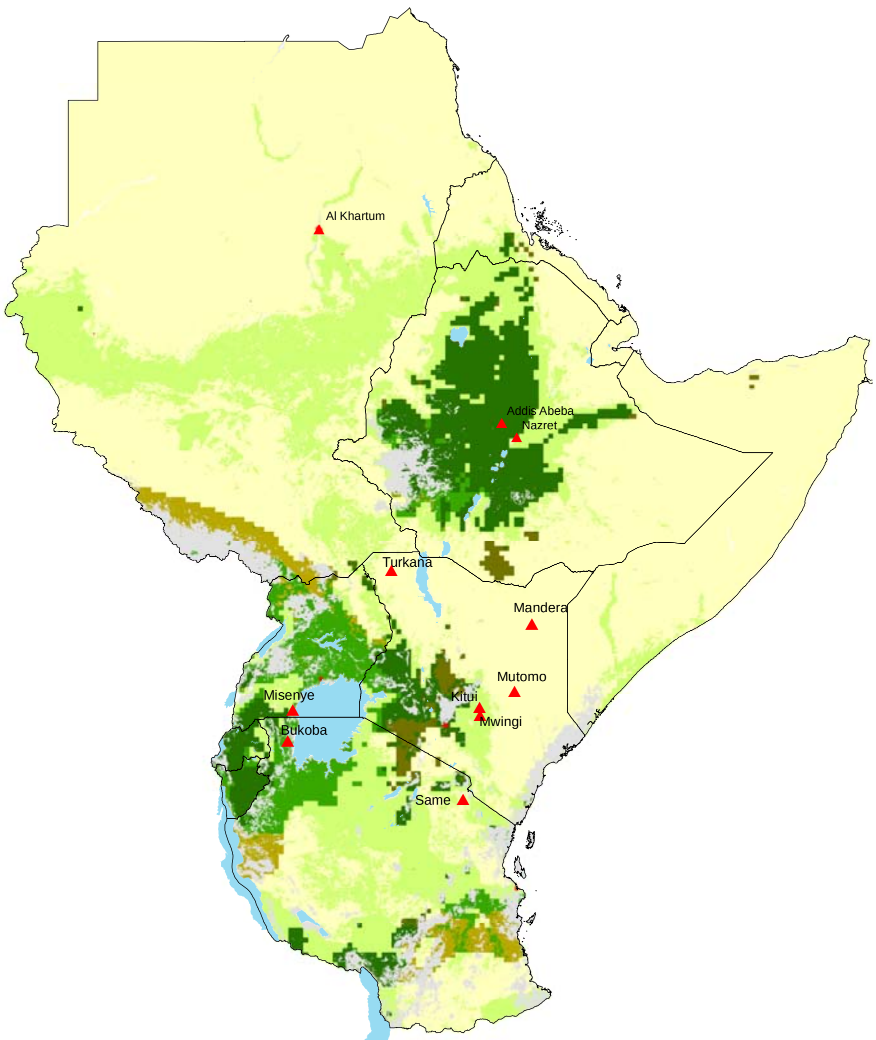

Note: Map shows some of the CCAA programs and related sites where institutional partners are implementing climate change and adaptation science projects

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Table of Contents

1. Introduction 1

1.1. Study objectives 3

1.2 Structure of the report 4

2. Methodology 5

3. Drivers of climate change and variability 7

4. Climate change scenarios 10

4.1. Annual rainfall and rainfall variability 12

4.2. Drought severity 14

4.3. Predicted climate conditions 15

4.4. Changes from predicted climate conditions 16

5. Vulnerability to climate change and climate variability 17

5.1. Defining vulnerability 17

5.2 Exposure to climate variation 19

5.3. Sensitivity to climate change 19

5.3.1. Who is vulnerable? 20

5.3.2. Climate change impacts on social vulnerability 22

5.4. Resilience to climate change impacts 26

5.4.1. Coping mechanisms and risk management 26

5.4.2. Adjustments or adaptations to reduce vulnerability 28

5.5. Regional assessment of sectoral vulnerability 29

5.5.1. Agriculture and food security 29

5.5.2. Health and diseases 30

5.5.3. Water and energy resources 35

5.5.4. Social institutions and governance 36

5.5.5. Technology and infrastructure 37

6. Spatial data analysis and mapping hotspots of change 40
6.1. Hotspots of length of growing period 41
6.2. Hotspots of population distribution 43
6.3. Hotspots of the distribution of crop-livestock production systems 44
7. Institutional adaptive capacity and gap analysis 45
7.1. Climate information sources 46
7.2. Severity of vulnerability distribution 47
7.3. Gaps in regional climate data 49
7.4. Gaps in vulnerability of climate sensitive sectors 50
7.5. Gaps in CCAA ongoing projects 51
8. Policy entry points in the adaptation process 52
8.1 Policy dimensions of climate change 52
8.2. Policy information conduits 54
9. Targeting future CCAA project development 56
9.1. Implications of the regional assessment for existing projects 56
9.2. Framework for assessing regional vulnerability 57
9.3. Priority areas for future project development 59
10. Conclusions and recommendations 60

REFRERENCES 64
APPENDIX 1 – Study terms of reference (ToR) 70
APPENDIX 2 – CCAA program abstract 72
APPENDIX 3 – Summary of CCAA projects in the greater horn of Africa 73
APPENDIX 4 – Scenarios of the Special Report on Emissions Scenarios (SRES), IPCC, 2000 78
APPENDIX 5 – CCAA ongoing programs and map location of project sites 79
APPENDIX 6 – Institutional survey 82

List of figures

Figure 1. Temperature variability under present and model future climate change

Figure. 2. Multi-model global averages of surface warming (relative to 1980-99) for SRES scenarios. IPCC, (2007)

Figure 3. Current conditions (2000) temperature regime and its distribution, from WorldCLIM output (Hijmans et al., 2004)

Figure 4. Annual rainfall and coefficient of variation of annual rainfall from downscaled WorldCLIM output and weather generator MarkSim (Jones and Thornton, 2000)

Figure 5. Occurrence of (a) rainfall, dekedal and (b) monthly severity stress index across the horn of Africa for April 2008

Figure 6. Past, current and future projection of population growth in the horn of Africa

Figure 7. Linkage between climate change, human exposure and health effects

Figure 8. Predicting lead time in vulnerability to malaria

Figure 9. Current (2000) areas of suitability for the transmission of malaria in the horn of Africa (MARA/ARMA atlas), 1998

Figure 10 Current (2000) areas of suitability for tse-tse fly habitat in the horn of Africa

Figure.11 Current (2000) areas of extent of surface water resources from the sub-basins contribution to the overall runoff of the major basin, which is the difference between precipitation and actual evapotranspiration

Figure 12. Predicted changes in the length of growing season 2000 to 2030

Figure 13. Crop-livestock production system changes in the area below or above the critical 180 days LGP by country, 2000 to 2030, scenario EC B1

Figure 14. Changes in livestock population 2000-2030

List of tables

Table 1. CCAA current and proposed projects in the greater horn of Africa

Table 2. Assessing the indicator severity on livelihood capital asset types in the horn of Africa

Table 3. A simple model for households coping with exposure to drought in the Red Sea and Wollo provinces of Sudan and Ethiopia respectively

Table 4. Vector diseases that are sensitive to climate change and variability

Table 5. Changes in technological use through uptake of communications over a 15-yr period in the horn of Africa

Table 6. Human population projections and production system changes for the horn of Africa 2000-2030

Table 7. Information sources on regional climate policy information, horn of Africa

Table 8. Scope and distribution of vulnerability, coping and adaptations from ongoing CCAA projects in the horn of Africa

Table 9. Proposed methodological framework for regional assessment of sectoral vulnerability to climate change

List of acronyms

ASAL	Arid and Semi Arid Lands
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
CCAA	Climate Change Adaptation in Africa
CGIAR	Consultative Group on International Agricultural Research
CORAF	Conférence des responsables africains et français de la recherche agronomique
CSIRO	Commonwealth Scientific and Industrial Research Organization
DFID	Department for International Development
ENSO	El Nino Southern Oscillation
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agricultural Organization Statistics
FEWS-NET	Famine Early Warning System Network
GCM	General Circulation Models
GDP	Gross Domestic Product
GHA	Greater Horn of Africa
GPS	Global Positioning System
GRUMP	Global Rural-Urban Mapping Project
HDR	Human Development Report
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immune Deficiency Virus
ICPAC	Intergovernmental Climate Prediction and Applications Center
IDRC	International Development Research Center
IGADD	Inter-Governmental Authority on Drought and Development
ILRI	International Livestock Research Institute
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
IWMI	International Water Management Institute
KACCAL	Kenya Adaptation to Climate Change in Arid Lands

KEMRI	Kenya Medical Research Institute
KMD	Kenya Meteorological Department
KNMI	Royal Dutch Meteorological Institute (Koninklijk Nederland Meteorologisch Instituut)
LGP	Length of Growing Period
MARA/ARMA	Mapping Malaria Risk in Africa/ Atlas du Risque de la Malaria en Afrique
MET	Meteorological
NARS	National Agricultural Research Systems
NGO	Non Governmental Organization
SRES	Special Report on Emissions Scenarios
SSA	Sub-Saharan Africa
ToR	Terms of Reference
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USGS	United States Geographical Society
WB	World Bank
WHO	World Health Organization
WFP	World Food Program
WRI	World Resources Institute

Executive Summary

Background

Africa is the continent most vulnerable to the adverse impacts of climate change and climate variability. In addition, mechanisms for coping and adapting to these adverse effects of changing climate are weak or lacking. In order to bridge this gap, the IDRC Climate Change Adaptation in Africa program in partnership with DFID (IDRC/DFID-CCAA hereinafter referred to as CCAA) aims to significantly improve the capacity of African people and organizations to adapt to climate change in ways that benefit the most vulnerable sectors of society. It is intended that the project builds on existing initiatives and past experience to establish a self-sustained, skilled body of expertise on climate change and adaptation science in Africa. To better inform current research projects and identify priority areas for future activities and project development, we examine the relationship between projects currently in the CCAA pipeline and their linkage to hotspots of vulnerability, with particular focus on key climate sectors such as agriculture, water and health, as well as social, institutional, and technological sectors.

Key issues

Current model projections show that three quarters of the total horn of Africa population in 2015 will be distributed in the four countries of Ethiopia, Kenya, Sudan and Tanzania. Because these countries are experiencing rapid rates of population growth, current public infrastructure will be overstretched and further exposure might be more likely to translate into impacts that require significant long-term investments in the human and biophysical environment. Most of the region's economies sustain low access to capital assets which is an indicator of weak social structures that exist among poor populations in the horn of Africa. In the vulnerability context, poverty and inequality exacerbate problems caused by exposure to climatic changes. Due to civil conflicts in the greater horn, mobility is increasingly curtailed by clan, ethnic, national and international boundary movement and restrictions. The expansion of agricultural cultivation in the semi-arid regions, growing sedentary livelihoods, and continuing encroachment by other land uses in urban and peri-urban settlements is now forcing people into ever more marginal areas that cannot sustain their livelihoods. In general those populations with the least capacity to adapt are generally the most vulnerable to climate variability and change impacts. This assessment report reveals that:-

Climatic changes associated with variability in the length of growing season will occasion adverse changes to agricultural land suitability in various production systems thereby reducing agricultural productivity. For instance, central, rift Valley and western provinces of Kenya which at the moment mainly produce food crops (maize, beans, potatoes, etc) may shift to cash crop farming producing coffee and tea due to a projected extension of growing period in a few highland areas. Such a major adaptation shift in allocation of crop farmland will likely exacerbate food insecurity under changing climate.

Communities living within medium altitudes beyond 1100 m asl, represented as very low in suitability of malaria transmission will have added risks of exposure to malaria due to increasing long-term average warming. Similarly, communities living along the lake shores are more vulnerable to cholera epidemics. Epidemic livestock diseases, such as rift valley fever, will not only impact livestock production but also have a dramatic negative influence on the livestock trade in the horn of Africa

Habitat modification under land use change is likely to be considerable, and these impacts may be exacerbated or moderated by climate change. Wetlands which are recharged by rainfall, and which represent critical grazing areas for pastoralists in semi-arid regions will severely be affected by higher levels of evapotranspiration as a result of increased temperatures. An example is the Sudd in Sudan which could shrink drastically in size or even disappear altogether. In the arid and semi-arid regions, drought conditions will prevail where surface and groundwater is the main water resource.

Climate change projections of the distribution of length of growing period (LGP) predicts a 5-20% gain in LGP over southern to south eastern Ethiopia, northern Kenya, Somalia and western to northern Sudan. These areas are mostly arid. However, the greatest loss in LGP of > 20% will occur over much of current cropped area along lowland coastal Tanzania and lowland southern Sudan. Given this scenario, arid regions may double in size, the limit of cereal (>90 days LGP) may retreat to higher elevations, and the tea/dairy zone (>330 days) may become drier or disappear in some places. These scenarios indicate a future with increasing vulnerability of rural populations since their capacity to produce adequate food and feed resources will be limited by these changes.

Hotspot analysis reveals that crop-livestock systems are projected to intensify since for all production systems, the population will nearly double by the year 2030. This translates into 80% to 120% change over the current population. A future with greater intensification of crop and livestock production will escalate risks of vector borne disease with increased danger of cross-transmission between humans and livestock as contact increases from higher stocking rates and population density. The density of small ruminants is projected to decrease in the pure livestock systems while that of large ruminants will increase.

For the period reported, 79%, 53% and 47% of the CCAA project pipeline focused on issues of agriculture and food security, health and water resources in marginal arid and semi-arid regions respectively. In order to cope with the magnitude of the impacts caused by climatic changes, the next CCAA pipeline will need to consider strengthening institutional capacity for planning, developing and implementing climate change adaptations and tools across all climate sensitive sectors. Particularly in crop-livestock systems, this approach needs to include support to partners who engage with key players in industry and technology transfer

For climate change and adaptation science, 42% and 53% of respondents among institutional partners reported accessing climate information through online journals or internet searches while 58% and 32% only sometimes, rarely or never procure such information from libraries and subscriptions. Further, 53% to 68% of partners cited four main constraints to climate research in the region as: (i) the lack of climate data (ii) lack of access to climate modelling and its applications and (iii) poor access to literature sources. Nearly all respondents reported little or no access to institutional internet connectivity, much of which was slow or not functional.

Policy entry points were identified as those promoting integration of climate information into development activities, developing community assets and other types of social capital as well as allowing public participation in the adaptation process. Some unique entry points included recommendations of a framework for negotiating and implementing multilateral environmental agreements and targeting through risk management and insurance by helping the public and policy implementers to formulate adaptations to current levels of climate variability.

A knowledge framework is proposed for assessing vulnerability to climate change through the inclusion of mapping of hotspots of change as a key step to targeting adaptation projects to support the most vulnerable populations in the region. Such a framework integrates the identification of issues in the national planning process with a synthesis of existing information, storylines, GIS mapping, statistical tools, economic modeling and development policy analysis**.**

Given high rates of population growth in the region it is recommended that crop-livestock systems, which support the largest populations now and in the future, be given priority in implementing future CCAA climate adaptation projects. In these intensifying agricultural systems potential payoffs are greater for employment and income creation but risks of losses from climate hazards such as droughts, floods and cross transmission of new and emerging diseases are also higher than other production systems. In addition, this report recommends that projects be solicited to address the impacts of labor-related migration, infrastructure, food, and water sanitation systems in hotspots of vulnerable urban and peri-urban settlements.

1. Introduction

The greater horn of Africa (GHA), including Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, Sudan, Tanzania and Uganda, has a population of over 220 million people which is expected to double within the next two decades (World Bank 2006). The region supports one of the highest densities and poorest rural populations in the world (Hoekstra and Corbett, 1995). The horn of Africa is one of the least developed and most vulnerable regions to climate change and variability in Africa. Climate variability creates risks in many climate sensitive sectors such as in agriculture, livestock, water resources and health. Climate variability and extremes also affect the welfare and livelihoods of rural populations. In addition, the horn of Africa is particularly vulnerable because of the dominance of rain-fed rather than irrigated agriculture for food production.

The impacts of increased temperature from global warming and reduced and variable precipitation resulting from climate change is expected to reduce agricultural production, depress crop yields and put further pressure on marginal land that is currently under crop production and livestock grazing . Based on crop modelling (Parry et al, 2004) and climate outlook forecasts (ICPAC, http://www.meteo.go.ke/events/climate_watch.html) more people in the horn of Africa will be at risk of exposure to food insecurity by 2080.

Present recording of an increase in drought, flood, windstorms and other extreme climate phenomena will negatively affect water resources through reduced freshwater availability. For the afflicted populations, competing needs for water from domestic livestock, irrigated crops and industrial uses will further exacerbate access to dwindling supplies from degrading water catchments drying underground reserves and declining precipitation (IPCC, 2001). Increasing drought events and flooding are in turn likely to exacerbate the frequency and magnitude of epidemics from water-borne diseases such as typhoid and cholera (Schneider et al., 2007), as well as to influence the incidence of vector-borne diseases (Githeko et al., 2006).

Planning and implementation of coping and adaptation mechanisms are still lacking and deteriorating physical infrastructure as well as the weak base for socio-economic growth suggests that the capacity for African people and institutions to cope with these structural failures is poorly developed (Orindi and Eriksen, 2005). In order to bridge this gap, the IDRC Climate Change Adaptation in Africa program (CCAA) in partnership with DFID supports climate and adaptation science projects aiming to significantly improve the capacity of African people and organizations to adapt to climate change in ways that benefit the most vulnerable sectors of society. The CCAA program builds on existing initiatives and past experiences to establish a self-sustained, skilled body of expertise on climate change and adaptation science in Africa.

This scoping study is undertaken to better inform current research projects and identify priority areas for future activities and project development. The assessments include mapping regional vulnerability hotspots and identifying current and future vulnerabilities and trends. Questions related to present vulnerability distribution are explored to the extent that helps in identification of possible impacts as well as the corresponding policy interventions in the region as well as strategies and alignments within CCAA program.

1.1. Study objectives

This study aims to deal with the identification and analysis of the multiple drivers of vulnerability in the GHA and the different approaches to improving livelihoods and building adaptive capacity in relation to current CCAA activities. This includes an examination of the factors causing and exacerbating both biophysical and social vulnerability. A synthesis of regional projects is conducted in seeking to identify and target areas for future project development.

The broad objectives are:-

1. to create a regional framework for addressing vulnerability assessment in the horn of Africa
2. to identify policy entry points and conduits to support future planning and adaptation to climate change and to inform CCAA projects, their design and implementation targeting the most vulnerable people and institutions in the region

Specific Objectives

1. (i) Identify and analyze the multiple drivers of vulnerability in the GHA, and the different approaches to improving livelihoods and building adaptive capacity in relation to the current CCAA project pipeline;

2. (ii) Identify and analyze the factors causing and exacerbating both biophysical and social vulnerability;

3. (iii) Map vulnerable hotspots where assumptions, technologies and adaptation strategies can be tested;

4. (iv) Identify and analyze the severity, characteristics and distribution of current vulnerability to climate change in relation to current CCAA's projects;

5. Identify and analyze the implications of the regional assessment for existing projects, and identify priority areas for future project development;

6. Where possible, identify and analyze policy dimensions of social and biophysical vulnerability and how these can be integrated and mainstreamed in national policy planning.

1.2. Structure of the report

The report is organized to respond to the objectives in 1.1 above beginning with a review of climate change scenarios and drivers and linking them to impacts on populations and institutions. We examine trends in future population growth and discusses these changes by casting vulnerability through the ability of social institutions to respond to current and future social risks. Apart from predicted changes in climate and climate variability, we note that growing poverty and inequality are key drivers of exposure with profound effects on production systems in the region. In Chapters 4 and 5 (sections 1-4) we further examine climate change impacts on social vulnerability, resilience through adaptations and provide examples of coping and risk management in the region. In the last section of chapter 5, we review the sensitivity of agricultural, health, water/energy resources and technological sectors to changing climate. Although some of these sectors provide opportunities for investments that would increase regional adaptive capacity, there are still gaps in the knowledge framework not just for assessing regional vulnerability but also for mainstreaming adaptation into the development process. Further on in chapter 6 we perform spatial analyses using national and sub-national data sets with a view to mapping regional vulnerability hotspots and identifying current and future trends in vulnerability. We map impacts of climate change from hotspots of climate change, changing population distribution and shifting crop-livestock production systems. Chapter 7, documents information on the severity of vulnerability distribution, coping and adaptation mechanisms from regional institutions participating in the CCAA program. A summary of their project activities provides the benchmark for assessing existing policy conduits and gaps in the current implementation. These gaps arise from applications of climate data, vulnerability knowledge and focus in current ongoing CCAA projects. In the next chapter 8 we combine knowledge from the review of climate change, sensitivity of development sectors and a summary of the activities of the project partners to scout for policy dimensions and suggest policy actions in the adaptation process. This analysis is followed in chapter 9 with an overview of implications for the existing projects. In this section we also propose a regional framework for vulnerability assessment and suggest some priority areas for consideration in future CCAA project call for proposals. In chapter 10, we summarize the report by offering recommendations for targeting during CCAA project alignment.

2. Methodology

In this study, we scope vulnerability to climate change and variability by assessing a knowledge framework for developing adaptive capacity through regional institutions involved in climate science research and policy interventions. Because this report is exploratory and is intended to guide future CCAA project design, we use a summary of information from project partners to scout for gaps in regional climate data, gaps in assessment of climate sectors and indeed gaps in CCAA ongoing pipeline.

Review of existing information

The desk study synthesized work carried out in the region concerning the likely impacts of climate change in the greater horn of Africa. We examined regional vulnerability, looking at new literature on vulnerability and adaptive capacity, how it may be measured, and hotspot identification from available examples. We also provide a measure of extent to which socio-economic structures are able to support adaptive capacity in vulnerable populations. In order to track impacts on livelihoods, we use social vulnerability indicator scores to rank severity. The color code represents severity, red as extremely severe and green as not severe. If a country has frequent scores of red to yellow, it has low capacity to withstand risks and hazards associated with climate change and variability. As such, exposure might be more likely to translate into impacts that require mitigation of social vulnerability.

Survey of local institutions

Field visits were undertaken to key institutions in the region that are working on climate change and adaptation science. The objective was to survey partner institutions in four of the ten GHA countries; Kenya, Tanzania, Ethiopia and Uganda in order to understand some of the local level vulnerability issues, their sectoral distribution and adaptation strategies. These four countries represent the major crop-livestock production systems as defined in Sere and Steinfeld (1996). For these partners, current ongoing donor funded projects that are shown in Table 1 are designed to strengthen adaptation to climate change and climate variability. The survey structure obtains a summary of progress and records local level adaptation to present vulnerability within the region. The questionnaire design further inquires about the local level severity and vulnerability distribution as well as existing coping mechanisms and anticipated adaptations. By combining regional vulnerability mapping with local-level studies, we capture factors and processes acting at different scales, in order to understand how local-level decisions are informed by climate policy. This approach helps to identify those hotspot locations where policy intervention is most critical—both geographically and thematically. Such information will be combined with information from the desk study to carry out the vulnerability analyses, for providing the regional context within which vulnerability can be characterized and plans made for addressing it

Spatial analysis

In order to map vulnerability to climate change through length of growing period (LGP) we used the production systems classification of Seré and Steinfeld (1996). The system breakdown has four production categories: landless systems (typically found in peri-urban settings), livestock/rangeland-based systems (areas with minimal cropping, often corresponding to livestock grazing or pastoral systems), mixed rainfed systems (mostly rain-fed cropping combined with livestock, i.e. agro-pastoral systems), and other which include urban developments. As described in Herrero et al. (2008) the systems were further disaggregated by agro-ecological potential as defined by the LGP projected to 2030. This period is considered crucial in demonstrating the ability of regional institutions and people to adapt to the magnitude and rate of anticipated climate change impacts over the next 20 to 30 years, which is limited by social, technical, and environmental factors including widespread poverty, fragile ecosystems, weak institutions, and ineffective governance. Prior to this, Thornton et al (2006) present LGP changes for Africa to 2050 under various model projections, showing little differences in projections under A1F1 and B1 scenarios. For this study we present projections from the Inter-governmental Panel on Climate Change (Christensen et al., 2007), B1 storyline and scenario family which describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource efficient technologies. The methodology employed allows us to disaggregate LGP, population and livestock changes by country and by production system. All models to 2030 project less than 1°C temperature change narrow range is good agreement between GCMs. Other IPCC storylines can be found in the appendix 4 section of this report.

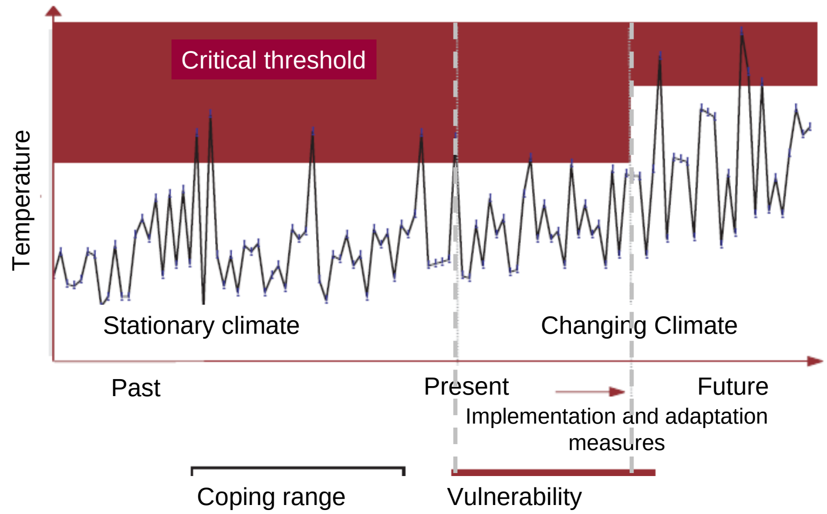
Gap and policy process analyses.

This process involved summarizing the status of climate data, vulnerable knowledge regarding climate sensitive sectors and the portfolio of current CCAA projects in the region, and assessing qualitatively how well the portfolio fits the results of the regional vulnerability assessment. Key gaps were identified that could be used to help align the portfolio of CCAA activities in future calls for proposals. From the gap analyses we examine policy dimensions of vulnerability and develop a set of suggested policy actions to promote adaptations to climate change. We also summarize the involvement of upstream institutions in generating and disseminating climate policy information to downstream user groups and actors thorough existing conduits.

3. Drivers of climate change and variability

Climate change and climate variability are two important characteristics of climatic change. According to UNFCCC, climate change is an adjustment of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural variability observed over comparable time scales. Therefore, climate variability is the departure from normal or the difference in magnitude between climatic occurrences. Thus, climatic variations are attributed mainly to natural processes, while the observed variation of climate change is due largely to anthropogenic sources of intervention. According to figure 1, Jones, (1987) illustrate recorded temperature variations under historical climate have a threshold which is projected to shift under future climate change therefore necessitating implementation of adaptation measures.

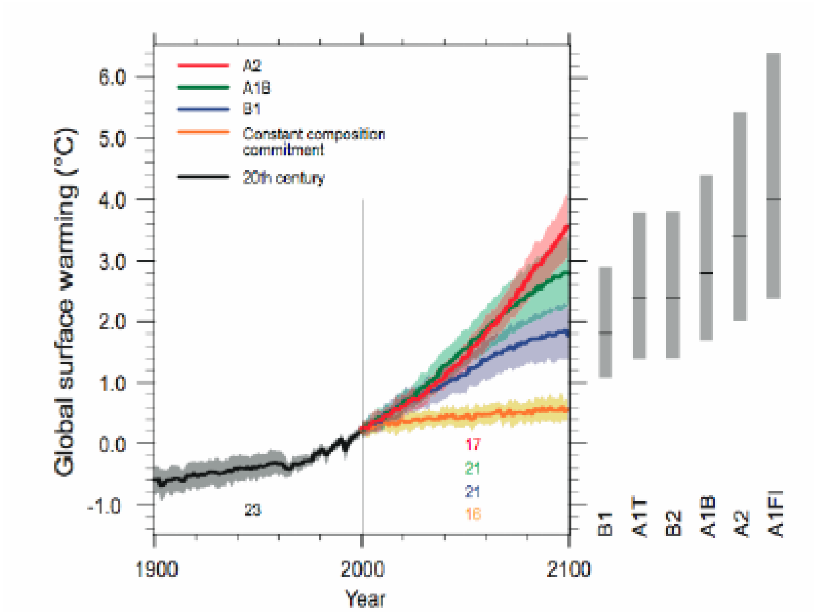
Figure 1. Temperature variability under present and model future climate change



Source: R Jones (CSIRO)

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) has offered significant clarifications regarding climate change. Warming of and alteration to the global climate system is now unequivocal. It is now better understood that global warming is driven through human induced sources of emissions of greenhouse gases (carbon dioxide, methane and nitrous oxide). Figure 2 shows that over the last century, the average global temperature rose by 0.74° C primarily because of an increase in atmospheric concentrations of carbon dioxide from a pre-industrial value of 278 parts per million to 379 parts per million in 2005 (IPCC, 2007). An increasing rate of warming has particularly taken place over the last 25 years, and 11 of the last 12 warmest years on record have occurred in the past 12 years. The IPCC report gives detailed projections for the 21st century and these show that on average, global surface warming is likely to progress at an accelerated rate. In the horn of Africa region, such a trend implies that there will be a shift in length of growing period affecting crop and livestock production areas, including migrations in human populations in order to adapt to changing environmental conditions.

Figure. 2 Multi-model global averages of surface warming (relative to 1980-99) for SRES scenarios. IPCC, 2007



The primary source of the increased atmospheric concentration of carbon dioxide since the pre-industrial period results from fossil fuel use, with land-use change providing another significant but smaller contribution. The IPCC, (2007) concludes that the understanding of anthropogenic warming and cooling influences on climate has improved since The Third Assessment Report (IPCC, 2001) leading to very high confidence that the global average net effect of human activities since 1750 has been one of warming, with a high radiative forcing effect.

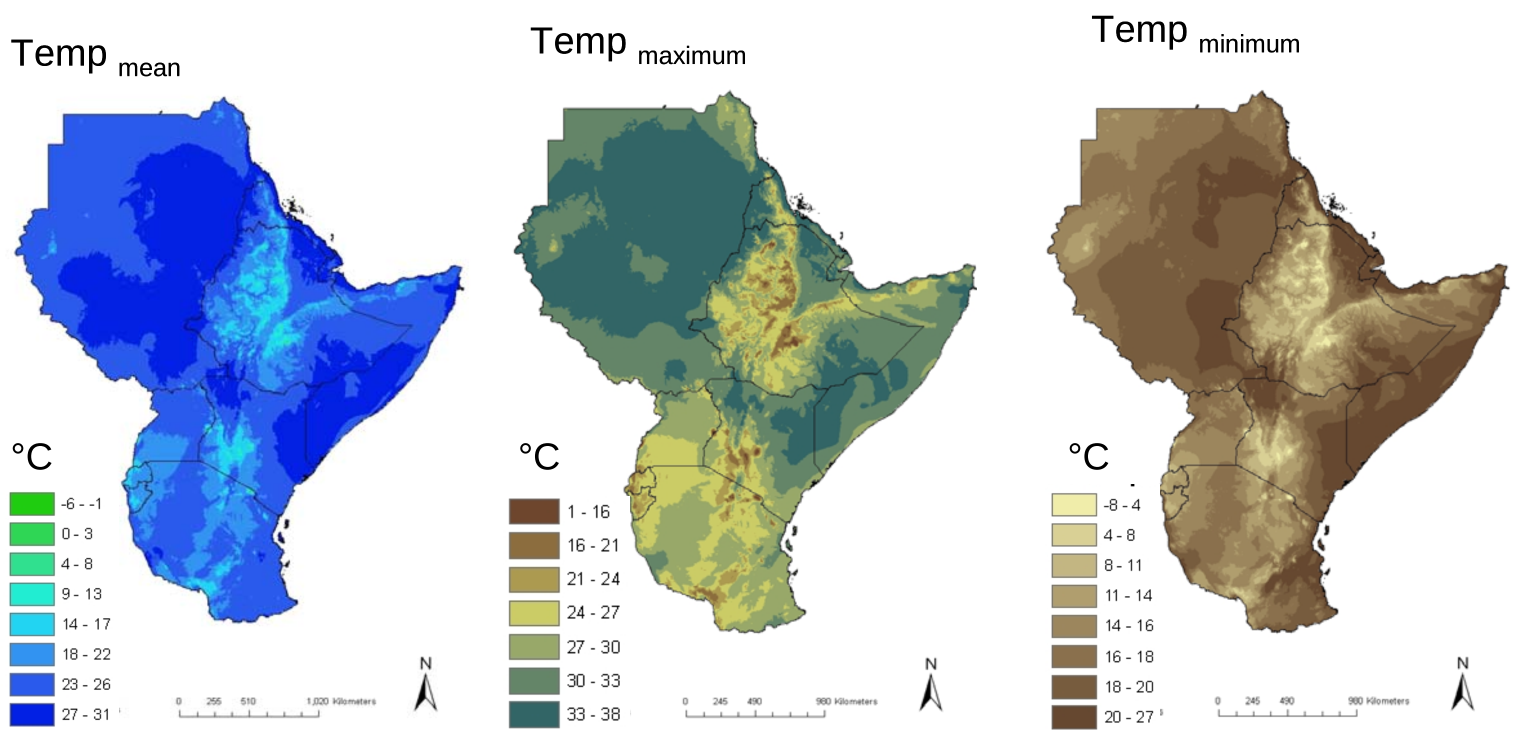
4. Climate change scenarios

Climate change scenarios are most commonly derived from the results of general circulation models (GCMs). These models are parameterized to represent the dynamics of the atmosphere under current conditions. They are then rerun at graduated atmospheric concentrations of carbon-dioxide in order to simulate future conditions (IPCC, 2007). Differences that develop between simulation runs in temperature, rainfall, evapotranspiration and other climatic factors are reported as predictors of climate change (Schlesinger and Mitchell, 1985). The GCM scenario approach has been used in a number of comprehensive studies (Parry et al., 1988; Smith and Tirkpak, 1989).

In the greater horn, large water bodies and varied topography give rise to a range of climatic conditions, from a humid tropical climate along the coastal areas arid low lying inland elevated plateau regions across Tanzania, Kenya, Somalia, Ethiopia and Djibouti. The presence of the Indian Ocean to the east, and Lake Victoria and Lake Tanganyika, as well as high mountains such as Mount Kilimanjaro and Mount Kenya induce localized climatic patterns in the horn of Africa region (KNMI, 2007). Mean temperature varies with elevation. In figure 3 shows that the difference between the lowest minimum and maximum temperatures for highland regions is in the order of 8-10 degrees.

Under changing climate, this difference may increase particularly in relation to long-term average maximum temperatures (ICPAC http://www.meteo.go.ke/events/climate_watch.html). Thornton et al., (2006) argue that highland regions are likely to experience an increase in the length of rowing period, crossing the 9 °C threshold even where the length of growing period is currently projected at zero days. Githeko and Ndegwa, (2001) have reported a correlation between unusually high maximum temperatures and the incidences of in-patient malaria suggesting that malaria epidemics may migrate to highland regions that are experiencing an increase in maximum temperatures.

Figure 3. Current conditions (2000) temperature regime and its distribution, from WorldCLIM output (Hijmans et al., 2004)

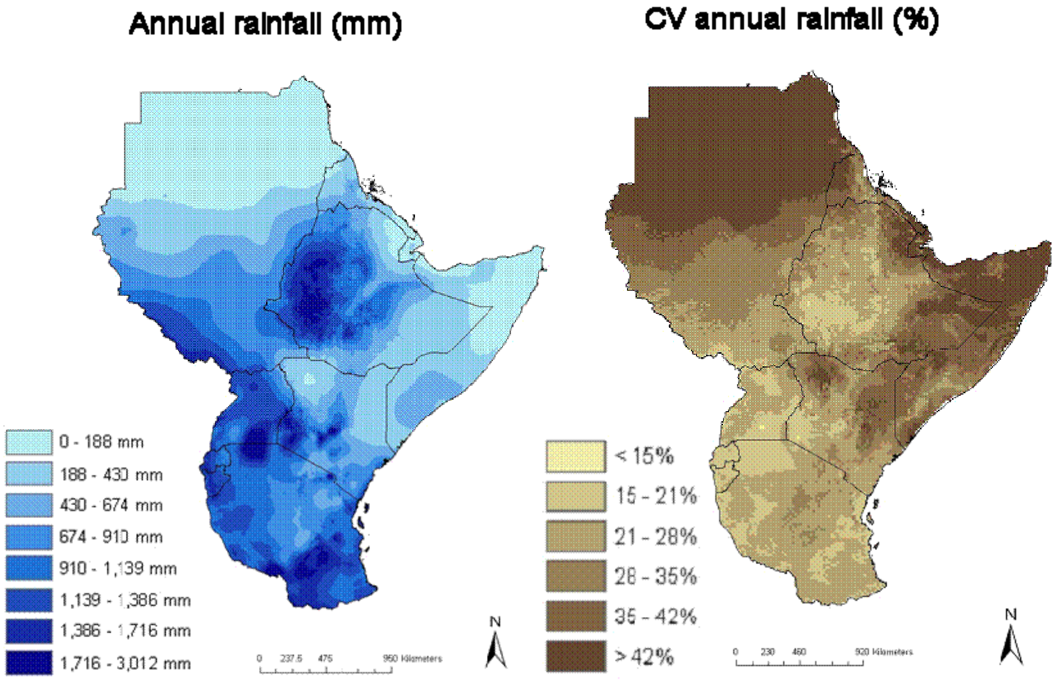


4.1 Annual rainfall and rainfall variability

The horn of Africa region experiences a bimodal seasonal pattern, with two rainy periods: short rains occur in October to December and long rains in March to May (coinciding with the shifting of the Inter-Tropical Convergence Zone). Rainfall is correlated to topography, for example in figure 4, the highest elevation regions indicated with dark blue shade receive over 1139mm per year whilst the low plateau regions appearing in light blue shade receive <674 mm. In most countries, these rainfall amounts support sufficient food crop (maize in Kenya, Uganda and Tanzania; bananas in Uganda and Tanzania; tef in Ethiopia and Eritrea) and cash crop agriculture (Tea, coffee, sugarcane in Kenya, Sudan, Ethiopia, Tanzania and Uganda) in the highlands.

At lower elevation mid-altitude plateaus the main activities are pastoral grazing (livestock sales in Sudan, Ethiopia, Somalia, Djibouti, Eritrea and Kenya) and irrigated agriculture (Sudan). In general, over two-thirds of the horn region receives less than 500 mm of rainfall per year (Osbahr and Viner, 2006). Rainy seasons can be extremely wet and often late or sudden, bringing floods and inundation (Anyah and Semazzi, 2007). Links between El Niño events and climate variability have been suggested, and it is a common perception that high coefficients of variation in rainfall may be attributed to El Niño effects (Anyah and Semazzi, 2007). This means that even for the predicted rainfall, we are less certain to record near average annual events (Fig 4). Currently it is not clear whether a relationship exists between both El Niño or La Niña events and prolonged drought or particularly wet periods over much of the greater Horn of Africa (Thornton et al., 2006; Hanson et al., 2006).

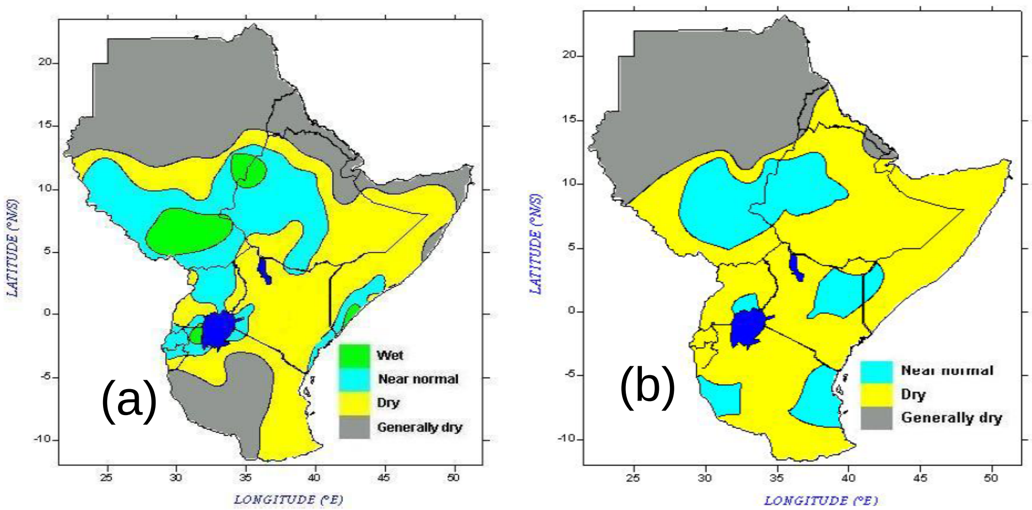
Figure 4. Annual rainfall and coefficient of variation of annual rainfall from downscaled WorldCLIM output and weather generator MarkSim (Jones and Thornton, 2000)



In Kenya, Orindi et al. (2007) indicate that over two thirds of those areas around the northern parts of the country receive less than 500 mm of rainfall per year and are classified as arid or semi-arid. This classification can be extended to characterize large parts of south-central Somalia, southern Ethiopia and south eastern as well as much of northern Sudan. These areas are known to experiences major droughts every decade and minor afflictions in one out of four years with varied consequences. In recent years, the region has experienced drought periods in 1984, 1995, 2000 and 2005/2006 (HDR, 2007). The impact of these droughts on the population is increasingly resulting in vulnerability of agricultural production systems in marginal arid and semi-arid regions

4.2 Drought severity

Figure 5. Occurrence of (a) rainfall, dekedal and (b) monthly severity stress index across the horn of Africa for April 2008



Source: ICPAC (http://www.meteo.go.ke/events/climate_watch.html)

Uncertainty rainfall patterns resulting in severe drought can be assessed from a rainfall stress index. As shown in figure 5, the rainfall severity stress index patterns in the horn for the month of April 2008 which is the peak rainfall month during the long rains season, indicate occurrence of heavy precipitation over many parts of the sub-region with some areas experiencing the wettest month on record. Drought conditions however frequently persist over the marginal areas of the horn with very erratic rainfall being observed during the season. Particularly for north and south-eastern Ethiopia, much of central and northern Somalia, the rift valley region in Tanzania and nearly all of Sudan, the index predicts drought even when many highland regions are recording wet events. Overall, there is a higher likelihood of more frequent future severe drought events occurring in the region.

4.3 Predicted climate conditions

Studies by Hulme et al. (2001) point out that climate change over much of the greater horn of Africa has implications for present and future vulnerability. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) indicates that climate model projections for the period between 2001 and 2100 show an increase in global average surface temperature of between 1.1 and 5.4 °C, with varying model estimates depending on future trends in fossil-fuel emissions for the same period (Thornton et al., 2006). Since IPCC's first report in 1990, model projections have suggested global average temperature increases between about 0.15°C and 0.3°C per decade from 1990 to 2005. Observed values of about 0.2°C per decade, strengthen confidence in near-term projections (IPCC, 2007). The climate model simulations under a range of possible emissions scenarios suggest that for Africa, and in all seasons, the median temperature increase lies between 3°C and 4°C, roughly 1.5 times the global mean response. Half of the models project warming within about 0.5°C of these median values (Christensen et al., 2007). Therefore, there is still some measure of poor agreement between model and observations (IPCC, 2007)

Precipitation is highly variable on spatial and temporal scales, and data are limited in some regions (IPCC, 2007). As indicated by Vincent, (2007), rainfall changes in Africa projected by most Atmosphere-Ocean General Circulation Models (GCMs) are relatively modest, especially when compared with current rainfall variability. Seasonal changes in rainfall are not expected to be large. Great uncertainty exists, however, in relation to regional-scale rainfall changes simulated by GCMs. Much of the highlands of East Africa appear to have a relatively stable rainfall regime, although there is some evidence that the coastal lowlands might on average experience long-term wetting (Hulme et al., 2001). Over much of Kenya, Uganda, Rwanda, Burundi and southern Somalia there are indications for an upward trend in rainfall under global warming (Thornton et al., 2006)

4.4 Changes from predicted climate conditions

For the region, knowledge on changes in climate variability from both model and climate observations is lacking. (Christensen et al., 2007; Sivakumar et al., 2005). However, it can be said that a general increase in the intensity of high-rainfall events, associated in part with the increase in atmospheric water vapor circulation is expected over much of the greater Horn of Africa (Christensen et al., 2007). Rainfall may well become more intense, but whether there will be more tropical cyclones or alteration to the frequency of El Nino events remains speculative (Sivakumar et al., 2005). In the horn of Africa wet extremes of high rainfall events occurring once every 10 years are projected to increase during both the short- and long-rains, respectively (Thornton et al., 2006). There has been a gradual increase in extremely wet seasons of about 20%. This means that close to 1 in 5 seasons will be extremely wet, as compared to 1 in 20 in the preceding period (Christensen et al., 2007). Dry extremes are projected to be relatively less severe during September to December. The net effect is that many parts of the greater Horn of Africa may well present higher probability of season failure to crops where clearly these annual cycles of rainfall are increasingly unpredictable (Thornton et al., 2006)

5. Vulnerability to climate change and climate variability

The horn of Africa is one of the most vulnerable regions to climate change and variability in Africa. In many climate sensitive sectors such as agriculture, livestock, water resources and health climate variability exacerbates the exposure of vulnerable populations to extreme events. Holding that vulnerability determines adaptive capacity (O'brien et al., 2005) we seek to identify multiple interrelated constraints that leave poor households and systems exposed and therefore vulnerable to the negative impacts of climate change

5.1 Defining vulnerability

Vulnerability is the degree to which a system is susceptible to climate stimuli (IPCC, 2007). Turner et al, (2003) propose an enlarged framework for assessment of the composition of vulnerability with application sustainability science. They emphasize that human-natural systems are closely coupled; therefore physical perturbation from climate impacts has a direct influence on the responses that take place within the human systems (Fussel and Klein, 2006). In this study, we define vulnerability in the context of existing mechanisms to adapt to and cope with changing climate and variability. We recognize that there is inherent variability in the distribution characteristics especially whether these emanate from sensitivity to the biophysical environment (Vincent, 2004; Herrero et al., 2007) or from sensitivity to social and technological sources of vulnerability (IPCC, 2007)

Given the geopolitical characteristics of the greater Horn of Africa the magnitude of exposure to risk is high and sustained. The ability to adapt to extreme events is low for many sectors since social inequality and declining technology, as vulnerability drivers are currently not well characterized (Leichenko and O'Brien, 2002). These dynamics are exacerbated by high levels of extreme poverty and are further complicated by eroding traditional support mechanisms. Our present understanding of the role of traditional institutions and folk knowledge in sustaining social structures is limited. Other contributing drivers of vulnerability include the absence of social protection programs and a susceptibility to near loss of alternative livelihood opportunities (Vincent, 2004). Given these structural weaknesses several donors are currently piloting projects across sectors, helping to build capacity among local people and institutions in the region. One such example is the CCAA project pipeline (Table 1), partnering with DFID to support African people and their institutions to adapt to climate change and variability. As shown in table 1, the present scope and coverage of these projects is still at inception but the effort demonstrates an urgent need for a sector-led effort to address vulnerability in the horn of Africa region

Table 1 Distribution of current and proposed CCAA projects in the greater horn of Africa, 2008

Climate sector	Projects	Countries									
		Kenya	Uganda	Tanzania	Ethiopia	Sudan	Eritrea	Djibouti	Rwanda	Somalia	Burundi
Health	1. Transferring the malaria epidemic prediction model to users in East Africa	■	■	■	–	–	–	–	–	–	–
	2. Strengthening community based adaptations to climate sensitive malaria	■	–	–	–	–	–	–	–	–	–
Agriculture	3. Lack of resilience in African smallholder farming	■	■	■	–	–	–	–	–	–	–
	4. Managing risk, reducing vulnerability and enhancing productivity	■	–	■	■	■	■	–	–	–	–
	5. Strengthening local agricultural innovation systems	–	–	■	–	–	–	–	–	–	–
	6. Enhancing adaptation to climate change among pastoralists	■	–	–	–	–	–	–	–	–	–
Water Resources	7. Livelihoods under climate variability and change	■	–	–	–	–	–	–	–	–	–

5.2. Exposure to climate variation

Exposure to climate variations is explicitly included as a determinant of vulnerability. Among vulnerable populations and within climate sectors, adaptation can reduce sensitivity to climate change while mitigation can reduce the exposure to climate change, including the rate and extent of negative shocks. In the face of exposure to climate change, some populations will be able to draw on their entitlements to manage risk, for example through awareness and preparation, insurance from losses, and intensifying as well as diversifying livelihood strategies (Nelson et al., 2007).

Exposure to climate change is not simply a measure of the likelihood of changes in biophysical conditions of a given location over a timescale. Rather, both biophysical and human processes determine exposure (Galvin 1992). As an example, in east Africa, temporary or permanent emigration out of a pastoral system is frequently cited as a response to seasonal and drought-induced nutritional stress among community members. However, the frequency, magnitude and duration of such responses are a function of both, the social organization of the community and available institutional mechanisms to adapt to alternative livelihoods.

5.3. Sensitivity to climate change

According to IPCC, (2001) sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. Climate-related impacts contain all the elements of climate change, including climate variability, and the frequency and magnitude of extreme events. Natural and human systems are sensitive to climate change which exerts a direct influence on water resources; agriculture (especially food security) and forestry; coastal zones and marine systems (fisheries); human settlements, energy, and industry; insurance and other financial services; and human health (IPCC, 2007). The vulnerability of these systems varies with geographic location, time, and social, economic and environmental conditions (Boko et al., 2007). Later in section 5.5 of this study, we shall focus more on understanding climate impacts on the sensitivity of agriculture, health, water, social/institutional and technological sectors and further scope existing adaptations in order to recommend pathways to increase future adaptive capacity in the region.

5.3.1 Who is vulnerable?

The present vulnerability study assesses ways to map and identify the hotspots of change within sectors, populations and production systems in the horn of Africa. Vulnerable people generally have a variety of alternatives to increase their adaptability and decrease their risk in times of stress and shock (Kasperson 2001). In the horn of Africa, new and emerging environmental challenges as well as persistent, political and social pressures can limit choices that have traditionally been available. A better understanding of vulnerability could help to mitigate effects of these events for both human populations and the environment.

Impacts of such emergent changes are usually felt unequally throughout a community or region (Galvin et al. 2001). The future severity of impacts on the human population will depend not only on resource availability, but also on the capacities of individuals and communities to respond to climate variability. It has been observed that although various communities may face similar risks, they may not be equally vulnerable (Corbett, 1988). During flooding events livestock herders may be evacuated with their livestock while field crops cultivated by sedentary farmers are exposed to flood damage and destruction.

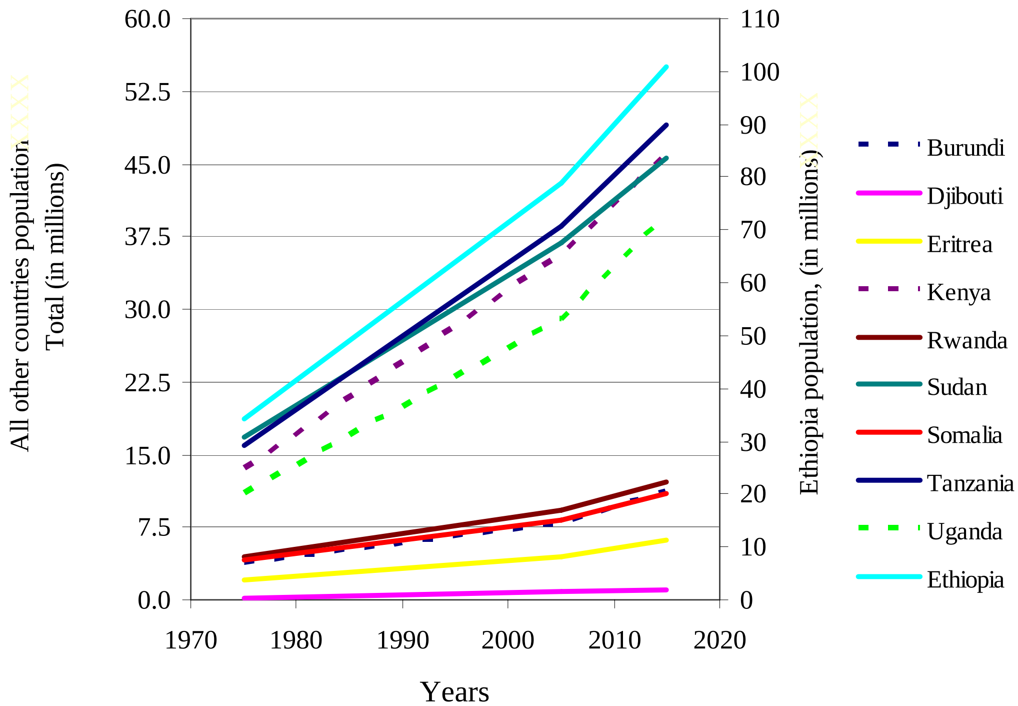
In the horn of Africa, and specifically among the pastoral communities, drought cycles are known to create new livelihood dropouts. When drought cycles persist, many of these poor drop outs move to urban or peri-urban settlements where they mostly depend on relief supplies. For these communities, the ability to cope with subsequent seasons of poor rainfall declines correspondingly. During such events, decisions more vulnerable members of the community such as women and children are left behind as the men herd livestock in search of water and pasture. The more vulnerable members of the household (women, children and the elderly) are therefore exposed to food security risks in a difficult environment and often they have no residual strategies for survival other than to access relief from aid agencies.

Population segments likely to be affected by climate change in Kenya (Downing et al., 1992)

- Nomadic pastoralists practicing little or no agriculture - 85% food risk;
- Agro-pastoralists who often grow some crops - 33% food risk;
- Migrant farmers who have permanent farmlands and keep livestock - 55% food risk;
- Landless poor – farmers with little or no land and are chronically food-insecure;
- Squatters - farmers occupying large absentee-owned estates or public land with no legal claim to the land parcels - 33% food risk;
- Smallholders–farmers on less than 20 hectares of land accounting for 50% of the farming population - 29% food risk;
- Urban-poor – households with low incomes (casual laborers) dwelling in metropolitan areas like Nairobi.

Given that population pressure influences the magnitude of exposure to risk (Cobertt, 1988), projections of population change are necessary when examining the likely scenarios of future trends in vulnerability in the horn of Africa. Figure 6 shows projections (WRI, 2007) of the population, tripling from 106 million in 1975 to 323 million in 2015. While one third of this population (in 1975) was found in Ethiopia, three quarters of the total horn of Africa population in 2015 will be distributed in the four countries of Ethiopia, Kenya, Sudan and Tanzania. It is probable that unless there is urgent development of national and institutional infrastructure to address vulnerability to climate change, the capacity in these four countries will be severely strained. Countries experiencing rapid rates of population growth will overstretch current public infrastructure. With low institutional adaptive capacity we expect the proportion of migrant workers, rural land displacements and urban-poor households to increase, further exacerbating vulnerability.

Figure 6. Past, current and future projection of population growth in the horn of Africa



Source: World Resources Institute, (2007)

Notes: The above population dataset contains estimates for all years and countries from 1950 to 2005. For 2006 to 2050, data are forecasts based on assumptions by the United Nations Population Division (UNPD). Updates to this information is posted every two years; the most recent data are from the 2006 Revision

5.3.2 Climate change impacts on social vulnerability

Characterization of the distribution and severity of social vulnerability provides a measure of the extent to which socio-economic structures are better able to support the adaptive capacity of vulnerable populations. In order to track impacts on livelihood capital assets, we use vulnerability indicator scores to rank severity. As presented in table 2, these indicators have a color code which provides a measure of severity; red as extremely severe and green as not severe. If a country has a large number red to yellow scores, it can be assumed that there exists limited resilience in the face of risks and hazards associated with climate change and variability. As such, exposure might be more likely to translate into impacts that require mitigation of poverty and inequality. In the same table, the severity index of livelihood assets is scored against a mean and variance given by the standard deviation value.

When compared across countries, Kenya, Uganda and Tanzania are least vulnerable to access to physical assets, social capital prevalence and the development of human capital. However, these countries experience a high prevalence of HIV/AIDS (>6%) with close to 200,000 new annual infections where the population exceeds 20 million. Because the mean public expenditure on health as percentage of the GDP is low (2.3), children appear to be at the highest risk of survival as the average infant mortality rate is 9.1% and can be as high as 13.3 % in Somalia.

In relation to social capital the development indicators in table 2 show that Burundi and Rwanda appear most vulnerable to securing human and social capital assets. Overall, a poverty mean index of 36 with a large variation implies that there are high rates of poverty in all countries. Particularly for Ethiopia and Somalia, < 30% of the population has access to improved water sources, meaning there is likelihood that > 70% of the population in both countries is exposed to water-borne diseases. Most of these livelihood capital indicators highlight the magnitude of social vulnerability and poverty. In fact community-level poverty incidences can be explained to a large extent by access to the livelihood capital assets, since these largely define peoples' livelihood options (Kristjanson et al., 2005). For example the human poverty index is low reflecting low life expectancy as well as poor economic well-being and is severe for Ethiopia which also shows poor natural and physical capital endowment.

Overall the region sustains high poverty prevalence with increasing population density and a weakening human capital asset base. Whereas these indicators are aggregated at national level and recognizing that there exists inherent variation among communities and social classes, it is not feasible to speculate on the sub-national distribution of social vulnerability. However, we do observe that low access to capital assets is an indicator of weak social structures that exist among poor populations in the horn of Africa. In the social vulnerability context, poverty and inequality exacerbate exposure to climate change and variability. In order to rank and compare vulnerability across countries, we must consider the quality of the available data, selection and creation of indicators, the assumptions used in weighting of variables and the mathematics of aggregation (Thornton et al., 2006). We exercise caution in the interpretation of indices since there is need to constantly update the resultant vulnerability scores in order to reflect the dynamics of changing vulnerability in the region.

Table 2. Assessing the indicator severity on livelihood capital asset types in the horn of Africa

Vulnerability Indicator Analysis	Kenya	Uganda	Tanzania	Rwanda	Burundi	Ethiopia	Somalia	Djibouti	Eritrea	Sudan	Mean	stdev	+1 stdev	-1 stdev
1. Natural capital														
Internal water resources % access	61	60	62	74	79	22	29	73	60	70	59.0	18.9	77.9	40.1
2. Physical capital														
Access to markets < 2 hrs (% of rural population)	37	47	20	54	58	18	na	na	38	22	36.8	15.6	52.4	21.1
3. Social capital														
Human poverty index	30.8	34.7	32.5	36.5	37.6	54.9	na	28.5	36	34.4	36.2	7.6	43.8	28.6
Population density (2002)	54	104	38	318	236	62	13	30	34	13	90.2	103.7	193.9	-13.5
4. Human capital														
Stunting, children under the age of 5	36	45	44	48	63	51	29	29	44	48	43.7	10.3	54.0	33.4
Rate of infant mortality	79	79	76	118	114	109	133	88	50	62	90.8	26.6	117.4	64.2
Percent children under 5 and underweight	20	23	22	23	45	38	26	27	40	41	30.5	9.4	39.9	21.1
Public health expenditure as (%) of GDP	1.8	2.5	1.7	4.3	0.8	2.7	1.2	4.4	1.8	1.5	2.3	1.2	3.5	1.0
Prevalence of HIV/AIDS (%)	6.1	6.7	6.5	3.1	3.3	0.9	0.9	3.1	2.4	1.6	3.5	2.2	5.7	1.2

Indicator score		
very high ****	red	below mean minus 1 stdev
high ***	yellow	below mean but within 1 stdev
low **	blue	above mean but within 1 stdev
very low *	green	above mean plus 1 stdev

Data sources: FAOSTAT, 2006; Benson, 2003

5.4 Resilience to climate impacts

In vulnerability studies, resilience refers to the degree to which an impacted system rebounds or recovers from a perturbation (Turner et al., 2003). Climate change impacts necessitate responses and adjustments to the biophysical and social conditions which together determine exposure to climate hazards. These responses may occur in form of autonomous action or through public as well as private planned, individual and institutional mechanisms (Turner et al., 2003). Collectively, they constitute the potential capability of the human and social environments to adapt to climate change and variability. Better adaptation and stronger capacity usually translates into higher resilience. For vulnerable groups (such as resource-poor farmers, landless laborers, urban poor, the destitute and displaced or refugee populations), the outcome of strategies to adapt to climate change and climatic hazards may alter their current and future livelihoods. In this report, resilience therefore refers to the present sum of societal actions and assets that can be mobilized within the region, to strengthen the adaptive capacity of vulnerable people and institutions.

5.4.1 Coping mechanisms and risk management

When faced with risk and exposure to climate hazards, the ways in which decision-makers plan strategically determines not just the economic well-being but also the survival of vulnerable populations. For a particular vulnerability source, the coping range is always within the adaptive capacity such that when the long-term ability of a region to expand its adaptive capacity is exceeded, then resulting impacts cannot be avoided (Thornton et al., 2006a). The long-term ability of the region to expand its adaptive capacity through development and capacity installation would signal the avoidance of impacts from climate change. Already some coping mechanisms exist and are currently implemented through autonomous action. For instance pastoralists over much of east Africa know that their ability to move livestock herds rapidly and over long distances improves the chances of foraging and hence survival for the livestock (Mude et al., 2007). Due to civil conflicts in the greater horn, mobility is increasingly curtailed by clan, ethnic, national and international boundaries as long-distance transhumance is progressively less practical.

The expansion of agricultural cultivation in the semi-arid regions, growing sedentary livelihoods, and continuing encroachment by other land uses is now forcing pastoralists into ever more marginal areas that cannot sustain their traditional lifestyle. These changes negate against the rationale of individual herders to keep maximum numbers of livestock as a necessary buffer against the impact of disease or drought (Staal et al., 2001). As total livestock and population numbers increase and compete for ever-diminishing resources, the carrying capacity of land is exceeded and there are fewer resources to support greater and growing numbers of people and livestock (Delgado et al., 1999). We therefore observe that much of the existing coping capacity will instead need to give way to increased adaptive capacity in order to accommodate escalating demands for resources among vulnerable communities and environments

Table 3. A simple model for households coping with exposure to drought in the Red Sea and Wollo provinces of Sudan and Ethiopia respectively

Stage sequence	Coping strategy	Household behavior
One	**Insurance mechanisms**	▪ Changes in cropping and planting practices ▪ Sale of small livestock ▪ Reduction of current consumption levels ▪ Increased petty commodity trade ▪ Migration in search of employment ▪ Collection of wild foods ▪ Use of inter-household transfers and loans
Two	**Disposal of assets**	▪ Sale of livestock ▪ Sale of agricultural tools ▪ Sale or mortgaging of land ▪ Credit from merchants and money lenders ▪ Reduction of current consumption levels
Three	**Destitution**	▪ Distress and migration

Source: Corbett J, 1988. World Development 16:9. 1099-1112

A study by Corbett, (1988) in the Wollo and Red Sea provinces of Ethiopia and Sudan reveal common patterns of coping under food insecurity by focusing on planned actions taken by individuals and households. Table 3 shows that based on these actions the author constructed a simple model describing coping strategies and providing a useful tool for analyzing economic behavior. The model characterizes local insurance mechanisms, productive asset loss and destitution as the main determinants of coping with food scarcity (see Table 3). The use of models to inform adaptation policy is not a well integrated approach among local and national institutions in the region and still by far not sufficiently incorporated into the mainstream development process.

5.4.2 Adjustments or adaptations to reduce vulnerability

Adaptability may be characterized as competency of a system to alter in order to better suit climatic stimuli (IPCC, 2001), whereas adaptation is defined as adjustments in social or economic systems made in response to existing or anticipate climate effects (Smit and Pilifosova 2001; Smith et al., 1996). Adjustments are intended to reduce vulnerability to climate variability (Kates 2000). Adaptive capacity is therefore the ability to cope with resulting impacts of climate variability and change (Smit 2001). In the horn of Africa, we are uncertain regarding the direction and magnitude of such changes; therefore we expect adaptive capacity to vary among geographically contrasting regions and diverse socioeconomic groups. This implies that those with the least capacity to adapt are generally the most vulnerable to climate variability and change impacts. For the horn of Africa region, we explore in chapter 7 of this report whether it would be appropriate to focus long-term on adaptation options depending i) climate change timescale, ii) informational and institutional gaps and iii) risk management approach. The aim is to ensure we create a regional framework that is practical given existing constraints in capacity and implementation.

5.5 Regional assessment of sectoral vulnerability

Assessment of biophysical factors is a necessary but not a sufficient condition for understanding the complex dynamics of vulnerability. Because of the complex nature in organization of human systems, given social order, institutional structures and influences from technological changes, a holistic assessment is required in order to better understand the current impacts of climate change on household livelihoods and coping strategies. For the regional assessment, we highlight predicted impacts of climate change and variability on climate sensitive sectors, providing overview of the vulnerability status.

5.5.1 Agriculture and food security

The prevalence of climate-sensitive livelihood systems, chronically high levels of vulnerability, and a highly variable climate make persistent food insecurity a regular occurrence in the horn of Africa. Since much of the region is subject to rain fed-agriculture, expansion of cultivation and diversification of land-use activities are placing increasing burdens on the ecological, economic and social integrity of rangelands (Hobbs et al. 2007). In terms of potential effects of climate change on crop production, another aspect of importance is the length of growing period (LGP). An analysis by Kassam et al. (1991) estimated that a 4°C increase in temperature in Kenya may result in a dramatic shortening of the LGP. The study shows that arid regions (no growing period) may double in size, the limit of maize cultivation (>90 days LGP) may retreat to higher elevations, and the tea/dairy zone (>330 days) may become drier or disappear in some places. The predicted decrease in the LGP would most likely increase the vulnerable groups since the capacity to produce adequate food and feed resources would also be severely limited.

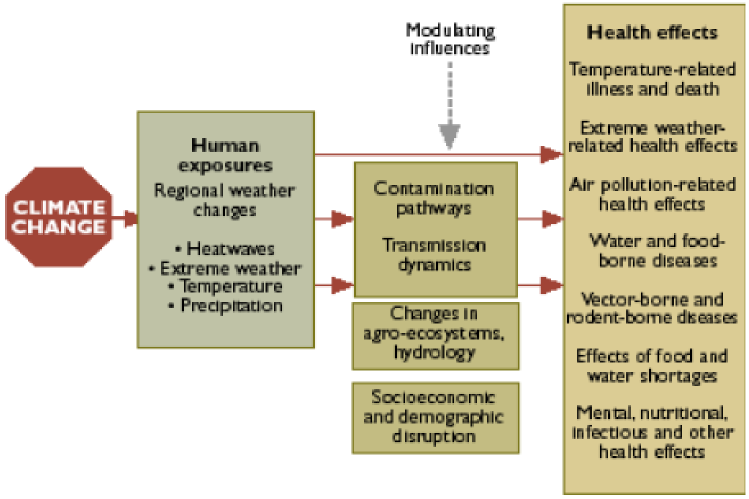
Changes in land suitability to various production systems due to climate change may also reduce agricultural productivity (Thornton et al., 2006a). For instance, some areas in central, rift Valley and western provinces of Kenya which at the moment mainly produce food crops (maize, beans, potatoes, etc) may shift to cash crops such as coffee and tea. Such a major shift would threaten food security. However, the extent of such change and the magnitude of its impact will depend on other factors besides climate change. Additionally, the most significant shift in LGP is likely to affect cereal and legume cropping especially maize, wheat beans and tef production in the highlands of Burundi, Ethiopia, Eritrea, Kenya, Rwanda and Tanzania. Lowland effects of decrease in LGP will likely to be felt along coastal and inland Sudan Somalia, Djibouti and coastal Kenya/Tanzania as well as the banana country of the Lake Victoria and irrigated rice in the lower Nile basin

As in many other regions of the world, demand for livestock products over the next few decades will undoubtedly lead to the intensification of agricultural systems in many places (Delgado et al., 1999; Staal et al. 2001). At the same time, many pastoral communities will be faced with the challenges of shifts in land tenure policy from communal to individual landholdings coupled with high in-migration rates (Galaty 1994; Kristjanson et al. 2002).

5.5.2 Health and diseases

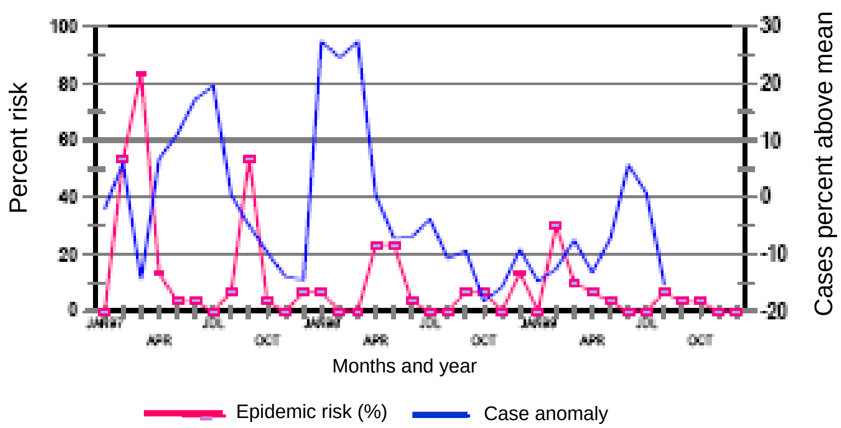
Predicted changes in climate and climate variability will also have direct and indirect impacts on human health. Figure 7 illustrates the linkage between climate and health effects which is a function of contamination and transmission pathways as well as demographic modulating influences which are cause d by changes in agroecosystems. The net effect is that global warming will increase the incidence of vector-borne diseases such as malaria, schistosomiasis and trypanosomiasis. In the horn of Africa increased occurrences of droughts and flooding is in turn likely to exacerbate the frequency and magnitude of epidemics of water-borne diseases such as typhoid and cholera, as well as to influence the incidence of malaria (Githeko and Ndegwa, 2001). There is also a direct relationship between nutritional status and health. Malnutrition and food shortages will increase morbidity and mortality related to infectious diseases. Variation in local environments will aggravate the impacts of air pollution on respiratory illnesses which already kill as many people in Africa as malaria and diarrheal diseases. (IPCC, 2001; Patz et al., 2005)

Figure 7. Linkage between climate change, human exposure and health effects



Source: WHO. 2004. The World Health Report (2003)

Figure 8. Predicting lead time in vulnerability to malaria



Source: Githeko et al., unpublished data

The apparent correlation between disease outbreaks such as malaria, cholera, rift valley fever and meningitis, all of which are sensitive to climate variability (IPCC, 2001) and the strong El Niño events (1982-83 and 1997-98) have been reported to indicate a causal link between climate and health (Githeko and Ndegwa, 2001). Also, figure 8 shows that there is a correlation between epidemic risk and case anomaly counts giving a lead time of between 2 to 3 months between risk detection and the onset of a malaria epidemic. Various other integrated climate disease models show that rates of infections can be affected by climatic anomalies, particularly for vector diseases that are sensitive to climate change and variability (Table 4). Malaria and cholera epidemics have occurred to varying degrees in the east African region in the last decades. As a consequence, health authorities have had a problem in deciding which of these factors are the most important and therefore which policy interventions to institute. For this reason, it is important to anticipate future disease trends in terms of what adaptive measures can be put in place. Equally, it is necessary to establish the population's adaptive capacity in terms of the ability to prevent and treat climate related illnesses.

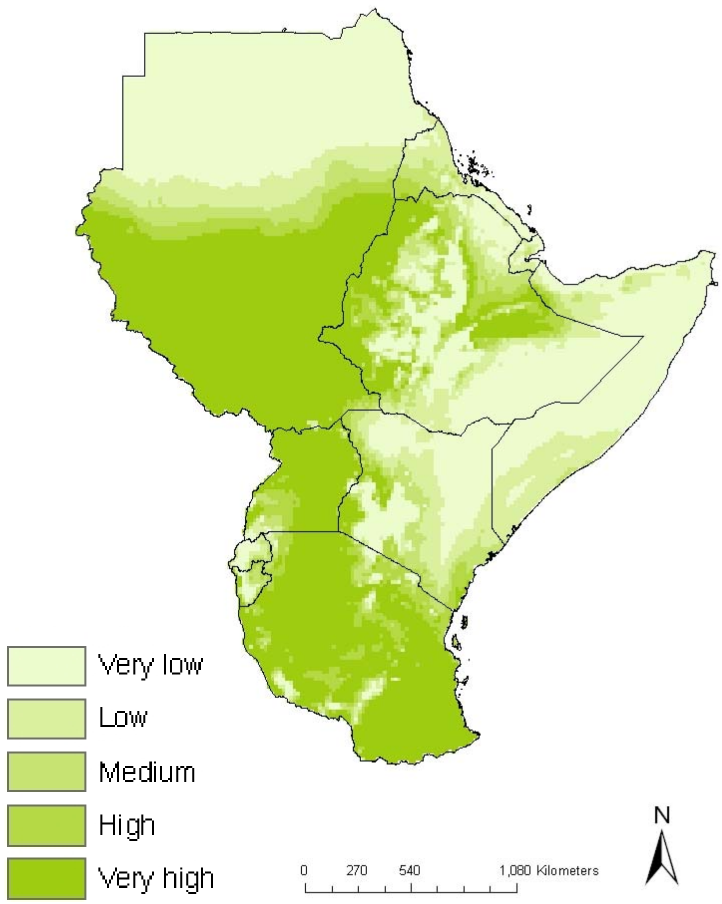
The IPCC (2001) report explains the vulnerability to climate change, impacts and adaptation to malaria and cholera by the local communities in the Lake Victoria Region with specific case studies from Tanzania, Kenya and Uganda. It concludes that communities living at altitudes above 1,100m asl, represented as very low in suitability of malaria transmission in figure 9 have added risks of malaria disease due to climate variability and change, low immunity and poverty. Similarly communities living along the Lake shore are more vulnerable to cholera epidemics

Table 4. Vector diseases that are sensitive to climate change and variability

Diseases	**Vector**
Malaria, filariasis, dengue fever, yellow fever, West Nile Fever	Mosquitoes
Leishmaniasis	Sand flies
Chagas' disease	Triatomines
Lyme disease, tick-borne encephalitis	Ixodes Ticks
African trypanosomiasis	Tsetse flies
Onchocerciasis	Black flies

Source: WHO 2003

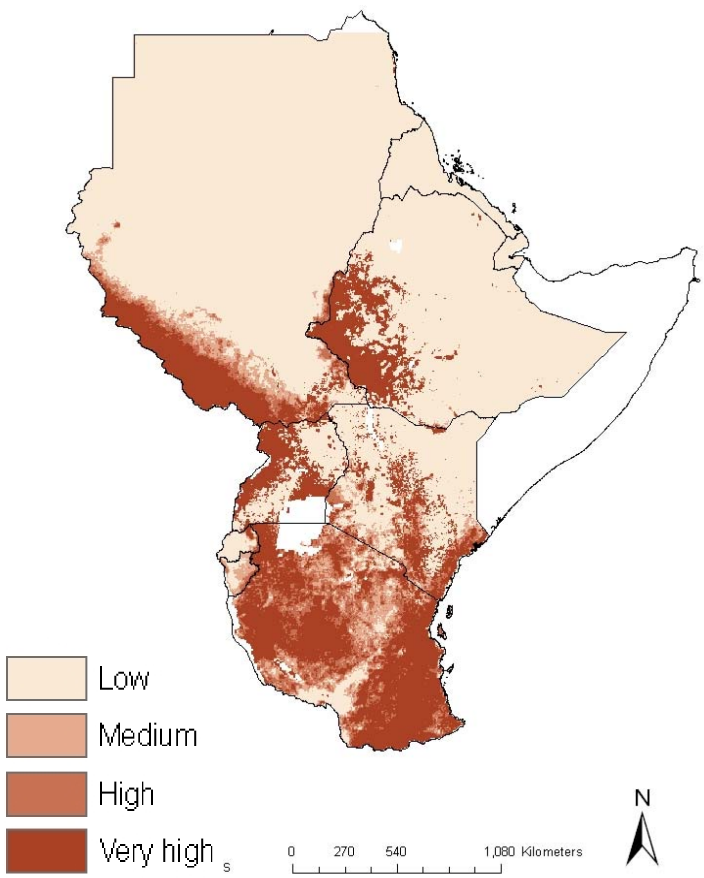
Figure.9 Current (2000) areas of suitability for the transmission of malaria in the horn of Africa (MARA/ARMA atlas), 1998



Several recent studies have pointed in particular to the importance of losses of livestock in explaining household livelihood decline into poverty (Kristjanson, 2005). Epidemic livestock diseases, such as rift valley fever, not only impact livestock production but also have a dramatic influence on the livestock trade in the horn of Africa and the livelihoods of pastoralist communities in livestock (Yuill, 1991) and mixed crop-livestock production systems (Herrero et al., 2008)

In figure 10, we map current demographic impacts on trypanosomiasis risk, as a vector disease. These effects are likely to occur through alteration of generally declining habitat suitability for the tsetse fly as shown in deep the shaded spots in figure 10. Habitat modification under land use change is likely to be considerable, and these impacts may be exacerbated or moderated by climate change (Thornton et al., 2006b) For example, increased rainfall followed by warm temperatures could lead to more frequent outbreaks of rift valley fever. This is already evident in Kenya where outbreaks of the disease in 1998 and more recently in 2006 occurred following El Nino rainfall events. There is need therefore to mainstream climate information and the health impact scenarios in all national as well as local health planning

Figure.10 Current (2000) areas of suitability for tse-tse fly habitat in the horn of Africa



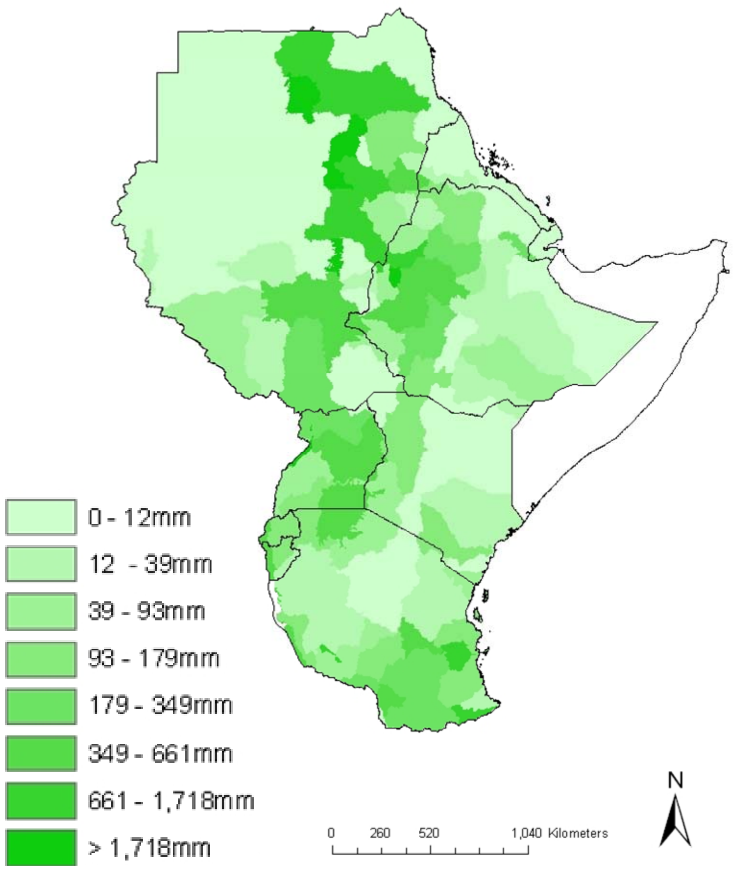
5.5.3 Water and energy resources

Climate is a fundamental driver of the water cycle, helping to determine both availability and demand in the short- and long-term. Understanding current climate variability and future change is essential to infrastructure planning and the development of integrated water resource management systems.

Increased temperatures due to global warming will most likely result in increased evapotranspiration rates leading to increased water losses from open water bodies like lakes, dams, rivers, wetlands and other reservoirs. Ground water recharge capacity is also likely to decrease with lowering of water tables and reduction in borehole yields. For the arid and semi-arid regions a map of surface water in figure 11 shows that and groundwater is the main water resource. The availability of groundwater will be affected by frequent and intense drought conditions that reduce precipitation and instead increase evaporation. Wetlands which are recharged by rainfall, and which represent critical grazing areas for pastoralists in arid regions may be severely affected by increased temperatures as they could shrink drastically in size or disappear altogether.

Like other sectors, the full impacts of the anticipated climate change on the water resources, are yet to be grasped, scientifically, socially or economically (IPCC, 2007). However, we can speculate that the magnitude of the impacts will depend on how the changes are managed and the level of the community's preparedness. Several initiatives are ongoing in relation to utilization of water for irrigated agriculture (Sudan, Ethiopia and Kenya), fish production in the Victoria Nile region (Uganda, Kenya and Tanzania) and energy generation through collaborative investments (Ethiopia, Sudan and Uganda). Although there are difficulties in reaching agreements for the rights of resource use, dialogue is continuing through regional authorities on the integration of these projects into national development plans (Orindi and Eriksen, 2006).

Figure.11 Current (2000) areas of extent of surface water resources from the sub-basins contribution to the overall runoff of the major basin, which is the difference between precipitation and actual evapotranspiration



5.5.4 Social institutions and governance

Evidence of observed impacts of regional climate changes from socioeconomic systems is much less known than from physical and biological systems, and methodologically it is much more difficult to disaggregate climate effects from other factors such as technological change and economic development, given the complexities of these livelihood systems (Vincent, 2004). The adaptive capacity of socioeconomic systems also contributes to the difficulty of documenting effects of regional climate changes; observable effects may be adaptations to a climate change rather than direct impacts. Evidence of observed adaptation of many of these systems to multiple stresses, including climate variability, suggests that complexities inherent in socioeconomic systems could be a source of resilience, with potential for beneficial adaptations in some cases.

Social inequality—or differentiation and marginalization are among the most critical determinants of vulnerability. Different people, groups and places within countries differ in their ability to adapt and divisions between rich and poor translate into differential abilities of individuals and households to adjust to climate hazards. This understanding provides a strong argument for a focus on poor people, as a priority in efforts to facilitate adaptation planning and implementation. At present, there is the lack of effective institutional arrangements to facilitate the generation, analysis and systematic integration of relevant climate data with other pertinent information in a form that planning and operational agencies can use. This raises the question—where should such institutional capacity reside? One option is to have it built within the institutions that serve development in the specific sectors that we review throughout section 5.5 of this report.

5.5.5 Technology and infrastructure

There is considerable debate as to whether modern society is effectively becoming more or less vulnerable as a result of technological innovation and adaptation over time (Meyer et al. 2000). Societies that adapt technologically and couple its application to support social structure are able to effectively reduce the degree of impact from repeated climatic variability of similar magnitude. More recently, some studies have shown how communities develop innovative responses to difficult or changing environmental conditions and introduce technology and management changes to create more sustainable and resilient production systems. More importantly, it has been argued that the magnitude of response to future vulnerability depends on development pathways, which are largely a reflection of technology uptake and use. For instance, better access to public infrastructure such as communication technology is a measure of institutional stability which can extend the coping range for adjustments to climate change impacts (Vincent, 2004).

Technology uptake fuels the information and knowledge economy and as such, a gadget to population ratio of radios or telephones can easily be used as a proxy for economic growth (Vincent, 2004). Table 5 illustrates growth in telephone lines, cellular phones and internet connectivity over a 15-yr period for ten countries in the horn of Africa (WRI, 2007). During this period, there was a significant 2 to 3 times increase in growth over the average of 5 telephone lines per thousand in Somalia and Sudan. This compares to a growth of between 1.5 to 2 times for Ethiopia and Eritrea. For the same period, Kenya recorded a greater shift of 3 times higher than the average subscription resulting in better internet access of 32 users per thousand by 2005. Overall, about 6 countries registered 30-60 cellular subscribers per thousand.

While coverage by communication technology in the region is still low compared to developed economies, we note a steady evolution from fixed telephony to mobile cellular and internet modes of communication. For this communication sector, further future expansion is foreseeable if connectivity costs are contained. In addition, communication technology changes that are highlighted can be associated with changes in some attributes of one or more livelihood capitals, directly related to reducing vulnerability to the negative effects of climatic change on these economies. The direction, magnitude and growth in the communications sector define one of the pathways for addressing future vulnerability. For instance, expansion in network coverage should ease the application of early drought and famine warning systems and enhance the dissemination of climate forecasts to rural populations. Therefore, scientific and technological advances are providing tools and opportunities to enable more effective action for adaptation to climate variability and change. However as we see in the example above, measuring the actual benefits of a technological innovation is generally not possible until years after it has matured in its development.

Table 5. Changes in technological use through uptake of communications over a 15-yr period in the horn of Africa

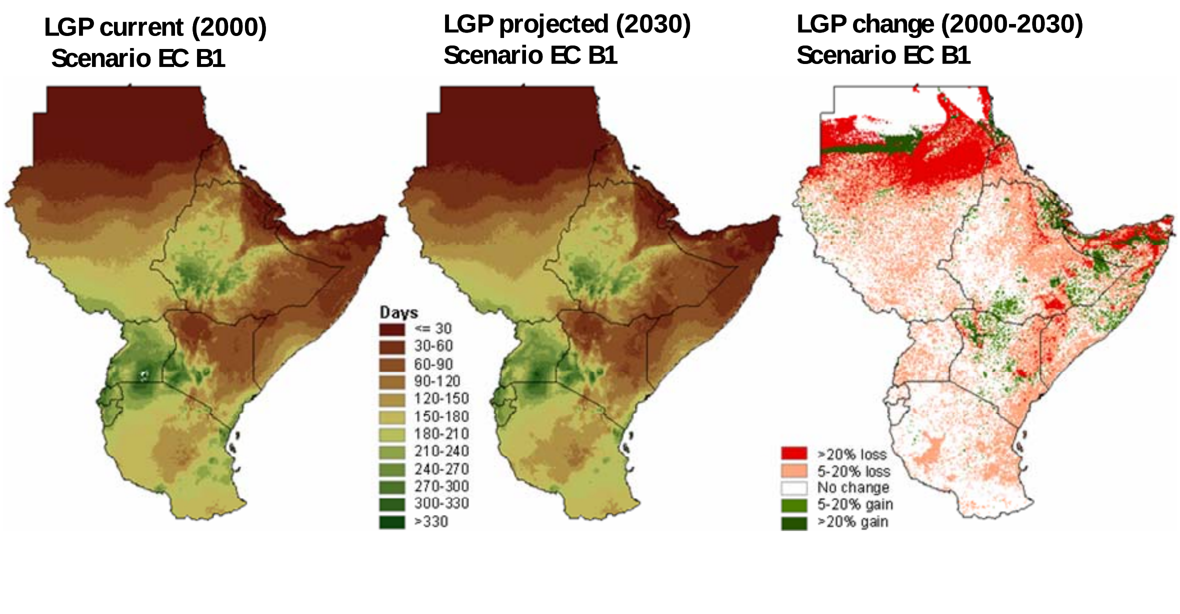
Country	Telephone mainlines (per 1,000), 1990	Telephone mainlines (per 1,000), 2005	Change telephone mainlines (per 1,000), 1990-2005	Cellular subscribers (per 1,000), 1990	Cellular subscribers (per 1,000), 2005	Change cellular subscribers (per 1,000), 1990-2005	Internet users (per 1,000), 1990	Internet users (per 1,000), 2005	Change internet users (per 1,000), 1990-2005
Burundi	1	4	+3	0	20	+20	0	5	+5
Djibouti	10	14	+4	0	56	+56	0	13	+13
Eritrea	0	9	+9	0	9	+9	0	16	+16
Ethiopia	2	9	+7	0	6	+6	0	2	+2
Kenya	7	8	+1	0	135	+135	0	32	+32
Rwanda	1	3	+2	0	32	+32	0	6	+6
Somalia	2	12	+10	0	61	+61	0	11	+11
Sudan	2	18	+16	0	50	+50	0	77	+77
Tanzania	3	4	+1	0	52	+52	0	9	+9
Uganda	2	3	+1	0	53	+53	0	17	+17
Mean	**3.3**	**8.4**	**+5.1**	**0.0**	**47.4**	**+47.4**	**0.0**	**18.8**	**+18.8**
stdev	3.1	5.1	5.0	0.0	36.8	36.8	0.0	22.1	22.1
+1 stdev	6.4	13.5	10.1	0.0	84.2	84.2	0.0	40.9	40.9
-1 stdev	0.2	3.3	0.1	0.0	10.6	10.6	0.0	0.0	0.0

Source: World Resources Institute. 2007. EarthTrends: Environmental Information. Available at http://earthtrends.wri.org. Washington DC: World Resources Institute

6. Spatial data analysis and mapping hotspots of change

From research on vulnerability metrics and indicators, mapping the distribution of vulnerability—either in terms of attributes of sensitivity, exposure or capacity, or in terms of outcomes and impacts—has become a central tool for communicating the results of vulnerability research to other academics, researchers, policy makers, and the public at large. At a regional scale we seek to understand the distribution of vulnerability and identify "hotspots" of change through mapping impacts and outcomes. At a more local scale, case studies of adaptive capacity are able to provide insights into the underlying causes and structures that shape vulnerability (O'Brien et al., 2004), given the inherent capacities that exist across regions to adaptation. For example, in figure 12 the difference between baseline (2000) and projected model LGP presents a change map (2000-2030) which displays hotspots of change in LGP, showing the distribution of areas where there are gains and losses in the growing period. The implication of the change map as indicative of exposure to changing climate is discussed in section 6.1 below.

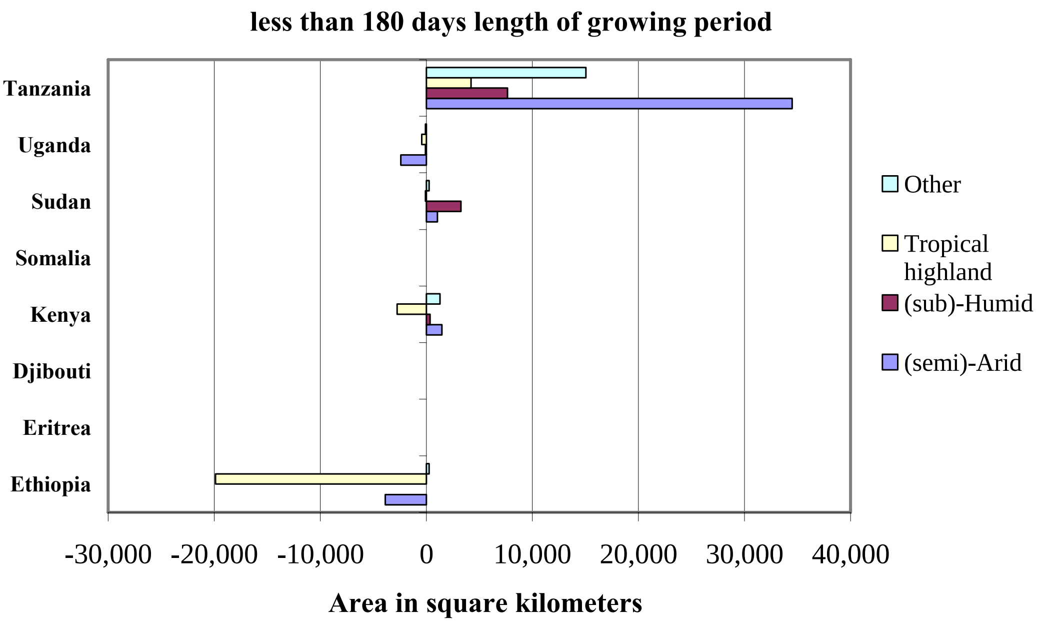
Figure 12 Predicted changes in the length of growing season 2000 to 2030

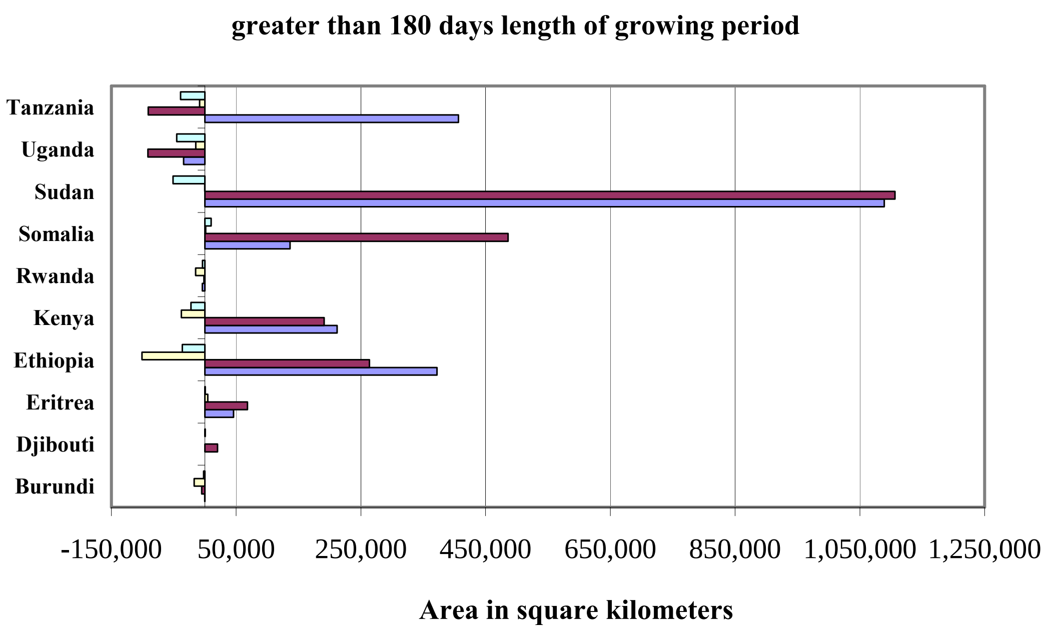


6.1 Hotspots of length of growing period

Since the horn of Africa relies on rain fed agriculture, the most profound climate change and variability impacts will be manifested in projected length of growing period. Figure 12 shows the projected distribution of length of growing period which predicts a 5-20% gain in mostly highland regions of Ethiopia, Eritrea, Kenya, Somalia and western Sudan. The greatest loss in LGP of > 20% will occur over much of lowland coastal Tanzania and lowland inland basins in north and southern Sudan. According to figure 13, there are no significant changes to LGP < 180 days over much of Kenya, Sudan, Ethiopia and Somalia. Tanzania is the hotspot that is at higher risk of gaining areas in arid and semi arid zones. Much of Tanzania will likely be more suitable for pastoral systems rather than rain fed crop agriculture. Changes in LGP outlook under the B1 Scenario are therefore positive for much of the horn of Africa region, predicting a wet and warmer period to 2030. However, caution must be exercised in making these predictions as model results are only indicative at this stage. It should be noted also that some of the large losses and gains occur in areas with less than 60 days LGP which from the scenarios are considered highly marginal for crop production. Secondly the variability and uncertainty associated with the GCM is not yet well understood. For our purpose the main message from these model predictions in Figure 12 and the associated areas shown in figure 13 is that large variability in the change in temperature and rainfall patterns suggests that many parts of the region will experience severe decline in the LGP over the 30-yr period. These same rainfall and temperature patterns combine to suggest that an extension of the LGP will occur in a few highland areas. We would also like to add that in addition to change in LGP, it would be useful to estimate changes in rainfall variability since increases in mean precipitation are associated with increases in variability. For this reason, there are tendencies for inter-annual rainfall variation to increase resulting in more seasonal uncertainty of the rainfall patterns (see chapter 4, section 1)

Figure 13. Crop-livestock production system changes in the area below or above the critical 180 days LGP by country, 2000 to 2030, scenario EC B1





6.2 Hotspots of population distribution

Several adaptation studies indicated that there will be population related adjustments in adapting to the negative impacts and extreme hazards occasioned by climate change and climate variability. In table 6, and for all production systems, the population is projected to nearly double by 2030. This translates into 80% to 120% change over the current population. Consist with the change in LGP, which projects a warmer and wetter future scenario, the highest population increases will be in the humid and sub humid regions of both livestock and mixed crop-livestock production systems. This scenario is indicative of a future with greater intensification of crop and livestock production as demand is expected to soar alongside increasing population. These results begin to indicate that the most vulnerable production systems will likely suffer from land degradation due to increasing human and livestock pressure, particularly in lowland Sudan, Ethiopia, Somalia and Tanzania. In the highland regions, there will likely be increased exposure to malaria and other vector borne disease with increased danger of cross-transmission between humans and livestock as contact increases from higher stock rates and population density.

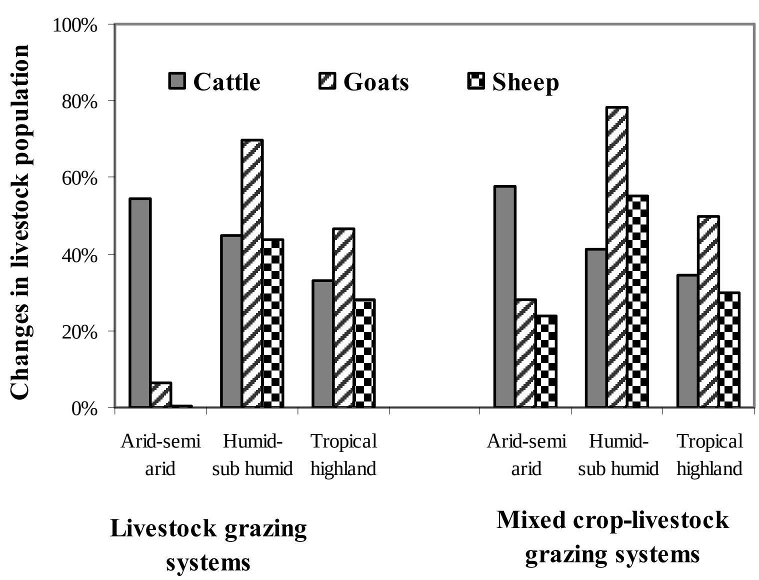
Table. 6. Human population projections and production system changes for the horn of Africa 2000-2030

Production Systems	**2000**	**2030**	**Difference 2030-2000**
	Population (in millions)	Population (in millions)	Population (in millions)
Livestock systems			
Arid and semi arid	39,898,448	75,793,361	35,894,912
Humid and sub humid	1,227,342	2,226,599	999,257
Tropical highlands	1,355,762	2,110,888	755,127
Total	42,481,552	80,130,848	37,649,296
Mixed systems			
Arid and semi arid	48,536,530	87,506,410	38,969,880
Humid and sub humid	25,257,255	55,588,526	30,331,271
Tropical highlands	64,455,076	124,152,144	59,697,068
Total	138,248,861	267,247,080	128,998,219
Other	23,082,079	41,160,521	18,078,441
Urban	4,746,745	9,537,722	4,790,977
Total horn of Africa	**208,559,236**	**398,076,171**	**189,516,934**

6.3 Hotspots of the distribution of crop-livestock production systems

For this report, we disaggregated livestock by cattle sheep and goats in order to examine whether there could be changes in shifting from small to large ruminants as an adaptation strategy. Overall, these dynamics indicate that the density of small ruminants is projected to decrease in the pure livestock systems while that of large ruminants will increase. The combined increase of sheep and goats in the humid and tropical highlands is 3 to 4 times higher than the projected increase in cattle populations. This dynamic may be a reflection of increasing population in addition to better feed availability from a wetter future scenario. It may also reflect changing socio-economic needs as communities become more sedentary. In figure 14, results indicate that the density of small ruminants is projected to increase in the humid and sub humid regions of the mixed crop and livestock systems. Given this increase in stocking density, average contact between livestock and human populations will likely decrease essentially increasing the risk of cross-transmission of livestock diseases. Therefore indicative hotspots for change in livestock will likely be the highlands of Kenya and Ethiopia while the lowlands of Sudan and Somalia, having gained in LGP > 180 days will account for the highest proportion of small ruminants in the emerging production systems

Figure 14. Changes in livestock population 2000-2030



7. Institutional adaptive capacity and gap analysis

In order to understand some of the local level vulnerability issues, their sectoral distribution and adaptation strategies, we carried out consultations with regional stakeholders to identify the policy questions that need to be addressed by the vulnerability assessment.

Surveys were conducted among partner grantees of CCAA in four countries, Kenya, Tanzania, Ethiopia and Uganda. Recent projects designed to strengthen adaptation to climate change and climate variability are currently in progress. We visited partners to discuss a summary of project progress and to record local level adaptations that are being tested in the CCAA framework. Out of 43 survey questionnaires mailed out to CCAA project institutional partners, 19 were returned, 58% from Kenya, 26% and 16% from Tanzania and Uganda respectively. These responses represented 47% research, 37% university, 16% NGO and 5% student participation spread across CGIAR centers, NARS, GOV and NGO development sectors.

All respondents were affiliated to country and regional institutions currently providing meteorological services and information on country climate data and weather reporting. Given that we examine changes in climate sensitive sectors we found that 79%, 53% and 47% of the projects focused on issues of agriculture/food security, health and water resources respectively. Social/governance and technological development foci are receiving much less attention in the current pipeline. Because this report is exploratory and is intended to guide future CCAA project design, we further use the survey information summary from project partners to scout for gaps in regional climate data, gaps in assessment of vulnerability knowledge in climate sectors and indeed gaps in CCAA current pipeline.

7.1 Climate information sources

Because CCAA is interested to support the development of capacity to address negative impacts of climate change and climate variability, we sought to demonstrate the availability of information sources some of which can serve as a basis to construct knowledge networks that could be shared across countries and institutions in the horn of Africa. In table 7, we show results of key partners responding to interview questions related to sources on regional climate policy information. For climate change research, 42% and 53% of respondents source information through online journals or internet searches while 58% and 32% only sometimes, rarely or never procure such information from libraries and subscriptions. Currently the primarily sources of climate information appears to be from internet related sources. Further, 53% to 68% of partners cited four main constraints to climate research in the region as:

- the lack of climate data
- lack of training of climate modeling and its applications
- poor access to literature search/sources

Nearly all respondents reported little or no access to institutional internet connectivity, much of which was slow or not functional.

Table 7. Information sources on regional climate policy information, horn of Africa

Policy information source	Access often (%)	Know about, but rarely access (%)	Never access (%)
Journals Online	32	32	11
Regional Climate Networks	21	37	5
ASARECA/CORAF/SADC	5	16	11
UN agencies	26	26	5
Country government ministries	16	5	11
CGIAR Centers	5	32	11
IGADD Drought Center (ICPAC)	37	21	11
Development & Donor Agencies	16	16	11
FAO and WB Bulletins	21	21	5
Internet sources	63	11	0
Your country MET organizations	42	5	0
Media broadcasts	42	32	5
Universities and state colleges	21	16	5
Country NARS	16		11

7.2 Severity of vulnerability distribution

In combining regional vulnerability mapping with local-level studies, we are able to capture factors and process acting at different scales, and to understand how local-level decisions are shaped by factors at the national and international level. The method applied in this study helps to identify those locations where policy intervention is most critical—both geographically and thematically. In table 8 below, we summarize by each development sector, vulnerability distribution from interviews with the institutional partners together with their current knowledge on coping mechanisms and associated adaptation strategies. In the region the key drivers of vulnerability are those associated with natural capital (water resources), climate hazards (changing LGP and extreme events) biophysical shocks (livestock deaths, diseases), social and livelihood shocks (food insecurity, high prevalence of poverty) and natural variability (rainfall, droughts and flooding). Low level of investments in new and appropriate technologies was also cited as a severely distributed driver of regional vulnerability to climate change.

Coping mechanisms consist largely of planned actions which however require investments through strengthening social structures, institutions and governance. Some of the coping examples cited which can frequently be implemented at the local household level include, planting of alternative crops, crop storage and using crop-livestock mixtures as a means of diversifying livelihoods. Other adaptation measures are more difficult to implement at household-level and require community, government and public participation. These include management of land use in crop and grazing areas, development of health facilities, water sources, wetlands and catchment protection as well as technological investments in labor saving equipment for agricultural production.

Table 8. Scope and distribution of vulnerability, coping and adaptations from ongoing CCAA projects in the horn of Africa

Climate sector	Vulnerability distribution (cited as severe)	Coping mechanisms (cited as frequent)	Adaptation strategies (cited as common/frequent)
Agriculture (crops and livestock) and food security	Food insecurity Crop failure and crop losses Changes in length of growing period Livestock deaths and loss of pasture Drought tolerance to crops Flooding of agricultural land Poor rainfall distribution Crop pests and livestock diseases	Alternative crops Reduction in cultivated area Use of crop-livestock mixtures Crop storage Livestock herd reduction Agricultural processing	Crop and animal resource diversification Intensification of food and fodder production and utilization Shift between pastoral and agro pastoral livelihoods Shift from large to small ruminant husbandry
Population health and well being	Exposure to disease and malnutrition Frequency and magnitude of epidemics Increase in population susceptible to malaria in the highlands	Epidemic prediction Use of bed nets against mosquito vectors Drug administration	Development of health facilities, mobile clinics Early warning for disease prediction
Water resources	Droughts and flooding Access to quality water for domestic use and livestock Degraded groundwater	Water sharing Water catchment protection	Wetland and catchment conservation Digging wells and boreholes to access groundwater
Social & Institutional Governance	Poor response to disasters from government & NGOs High prevalence of poverty	Income diversification Social cultural groups for labor sourcing and efficiency Reduction in food consumption Application of local knowledge for vulnerability support Off-farm remittances	Migration and sedentary settlements of pastoral communities Food aid Deploying family labor/communal labor Mainstreaming gender into adaptation
Technological developments and use	Low level of new investments in appropriate technology	Development of irrigation Mechanization of animal draught power Improved soil water management and rain-water harvesting technologies	Integrated production methods Conservation tillage Mechanization with labor-saving implements Development of indigenous technologies

7.3 Gaps in regional climate data

Responses from project partners were collated in order to provide a baseline of the existing capacity for using regional climate data. From the institutional survey we summarized response on the severity of vulnerability distribution, existing coping mechanisms and related adaptation strategies and identified gaps in-:

Knowledge of basic climatology including gaps in reliable data for establishing baselines and trends. Only a few institutions and mainly universities and the ICPAC were aware of the availability and use of GCMs for modeling and downscaling regional climate data. And even these did not have formal linkages to the global centers such as Hadley in the retrieval and use of climate information.

Providing reliable data for climate monitoring and spatial coverage of some of the highly variable areas of Africa which affects the detection capacity of impacts resulting from long-term climatic changes. This role is currently largely played by the national meteorological agencies. In the Sokoine project, there were discussions on possibilities to link with the USGS in Sioux Falls, SD, USA in order to access satellite information for the region. But it was not clear whether available capacity for remote sensing and satellite image interpretation matches the planned acquisition of data.

Observational climate data in Africa as a major constraint to understanding current and future climate variability. There still is significant potential to use all weather data available from thousands of weather gauging stations across the region. Although mechanisms exist to share regional data through ICPAC, there are constraints to documentation of archived historical records and much of it is currently vulnerable to degradation

Linking current information at seasonal time scales and the information we have at climate-change time scales (2030 and beyond). Information about what is projected over the next 20 years is largely missing. This presents a critical problem, as this time scale is vital not only for assessing vulnerability but also for incorporating climate change adaptation into national development planning. At the moment, few if any of the institutions in the scoping assessment were engaged in national planning for climate change adaptation

7.4 Gaps in vulnerability of climate sensitive sectors

In the agricultural sector, there are gaps in knowledge management in relation to climate forecasting and exotic climate data simulations for yield prediction. This information is needed by small-scale farmers together with predictions provided by meteorological services. Some of the met services such as in Kenya, Tanzania and Ethiopia were providing weather predictions but none of the information was going into secondary simulations for predicting crop yields and pasture availability. Moreover intensification of food and fodder production was cited as necessary adaptation strategy

In the health sector, there are gaps in prediction of epidemics and linking those with climate information. The malaria prediction and modeling project with KEMRI and partners is attempting to provide this link through coupling the model to climate data. So far they are able to demonstrate a 3-month lag in the period before onset of malaria epidemics. This work is commendable and should be extended into a formal disease surveillance program for the region as an adaptation to re-emerging disease challenges

In the water resources sector, an apparent science-policy gap needs to be bridged by defining a new role for science as a determinant of water policy. Since most countries rely on rainfed agriculture, variability in future renewable water resources will further constrain access and lower crop and livestock productivity. Currently there also exist gaps between water development, quality monitoring, and transboundary issues of consumption rights involving particularly Sudan and Ethiopia in the Nile basin. These issues are currently being addressed through the Nile basin Initiative, therefore subsequent climate-related water management policies should be articulated through such regional bodies.

In the climate adaptation process, there are gaps between planning and implementation of adaptation measures. For the scope of this report, we lack sufficient time to synthesize the national adaptation plans but recommend that these plans should incorporate lessons emerging from the work of partners funded under the CCAA. Also the gap between scientific evidence and political response remains large. Due to low levels of technological development there are gaps in understanding its application for climate adaptation. One example is on the evolution of telecommunication technology and discussed in sections 5.5.5 of this report. This example demonstrates the immense potential to convert emerging technology tools for use in remote rural pastoral areas as part of early warning systems for drought coping and disaster preparedness

7.5 Gaps in CCAA ongoing projects

Gaps in training and curriculum development as part of university course instruction. These were suggested in two countries but implementation is pending. For instance Sokoine University and partners have planned as part of their output to design curriculum for university level course instruction in climate science. None of the other projects visited had this output planned and a quick review of the region indicates few institutions such as the University of Nairobi are involved in capacity strengthening for climate research.

Gaps in knowledge sharing across scientists and projects. No institutional mechanisms are available for researchers to share information other than through presentations at conferences or through formal meetings but these were ranking low as sources of information in the surveys. None of the projects reported a pathway for cross-fertilization through sharing of outcomes although some of the scientists involved had collaborated on previous projects such as the Africa NUANCES.

Gaps between adaptation assessment and planning and adaption implementation. Innovative options are needed to close the gap between funding adaptation projects and assessing impacts of climate related hazard to vulnerable sectors. Since methodologies and tools for impact and vulnerability assessment are not readily available there is a danger that the ongoing pipeline may fail to address key capacities not captured in previous outcome assessments. An example is the intensification of crop livestock production systems where thresholds are attained that preclude further investments but where current investment is vulnerable to climatic changes

Gaps in development of decision support tools to bridge the gap between forecast development and end-user application. In this respect, the development and use of indices for monitoring is still only at inception. As an example, we received no responses to a survey question on decision frameworks and decision guides (Appendix 6; Question No. F), indicating that none of these mechanisms for forecasting and disaster preparedness were planned by the projects nor developed through the institutions.

8. Policy entry points in the adaptation process

8.1 Policy dimensions of climate change

Policy action 1. Integration of climate information into development activities In the regional climate centers or national meteorological centers there is need to initiate the routine integration of climate information into development activities, a critical first step is effective and compelling presentation of the existing data, analyses, and distillation of policy options to those who set priorities and allocate resources in the region.

Policy action 2. Develop community assets and other types of social capital that will enhance the capabilities and skills sets of vulnerable groups In addressing community needs and developing adaptation policies, it is important to take a renewed look at community assets and other types of social capital that would enhance the capabilities and skills sets of vulnerable populations and make them more resilient to the adverse impacts of climate change. To start with, vulnerability assessments through regional partners should help to identify and understand current and planned adaptation strategies that revolve around the acquisition and retention of livelihood assets

Policy action 3. Support institutional capacity for negotiating and implementing multilateral environmental agreements The responsibility for negotiating and implementing multilateral environmental agreements such as across border about resource use treaties should be spread among various government authorities and ministries—in view of the weakening of traditional systems of negotiation over access to key resources such as water points. The Nile basin Initiative has been cited for playing a key role in negotiating access to and use of water resources and IGADD for desert locust control. This approach should extend to cross-border disease surveillance, famine, droughts and flood early warning and the development of infrastructure and energy resources.

Policy action 4. A key process is to allow public participation through institutional structures that permit stakeholders to advocate for integrating security considerations into policy. More so where investments in natural resources result in shared benefits across communities. By improving livelihoods and reducing vulnerability, such initiatives provide entry points through integration, intensification and diversification. Dissemination through extension of drought tolerant crop varieties and livestock breeds remains the responsibility of governments but in the adaptation process, private sector participation will likely drive investments such as in building strategic grain reserves and adding value to crop and livestock products through processing. These approaches are intended to reduce conflict but promote entrepreneurship.

Policy action 5. Technical contributions to crop forecasting systems forms an entry point to work with users of the information products to improve information design and dissemination, and foster capacity. Decentralizing of forecasting roles to the communities forms an entry point for broader participation in the implementation process towards increasing adaptive capacity through the use of communication technology. Most early warning systems can be delivered through formal institutions working with community actors.

Policy action 6. Targeting through risk management and insurance by helping policy implementers to deal with current levels of climate variability, whose lessons can be used to improve adaptation strategies. Management of risks and uncertainties provides an entry point to address problems posed by increasing variability in the future and to the adaptation options that may be needed to deal with it. Policies that provide for insurance against economic loss from the adverse effects of weather, floods and drought are necessary for sustaining crop and livestock resources. Whilst crop insurance schemes have been tried in Tanzania and Kenya, the concept is still emerging and data does not exist on how to quantify the risk against which to fix policy coverage. Presently ILRI and insurance partners are piloting a livestock insurance product that is based on a weather generated index. It remains to be seen what key lessons will emerge for livestock insurance in the region.

8.2 Policy information conduits

The availability and distribution of climate change information is becoming common within many government, development and disaster relief agencies. In many cases the policy information is tailored to inform agencies in order to improve disaster preparedness. It seems there may exist opportunities to better share policy information between sources through established service providers. By surveying a range of these institutions we found that most partner institutions are able to access policy information from internet searches (63%), country meteorological institutes (42%) and media broadcasts (42%), IGADD climate applications center (37%), online journals (32%) and UN (26%) as well as World bank/FAO bulletins (21%). Surprisingly CGIAR centers were cited to rarely or never provide policy information on climate change and climate variability. Climate networks, ASARECA, NARS and Universities only ranked lowly (<20%). These results demonstrate important conduits through which information can be disseminated to vulnerable sectors and populations in the region**.**

For this report, we summarized the involvement of upstream institutions in generating and disseminating climate policy information. These included government as well as non-governmental actors, media, early warning systems such as FEWS-NET and civil society. We recognize as is demonstrated by Practical action and partners in Kenya that informal traditional governance structures also play a key role in dissemination of climate-related weather and drought information to pastoral herders seeking pasture and water.

Some of the information conduits can be summarized to reflect climate change information developers and consumers as:

1. Regional

Developers

-Inter-governmental Climate Prediction Center (ICPAC). The center is responsible for regional data and climate monitoring including delivery of decadal outlook forecasts.

-Global climate and modeling centers. These have the potential to support downscaling of global outputs to regional projections through RegCMs.

End-users

-Climate Networks, CGIAR Centers, FAO and WB Bulletins, ASARECA/SADC, UN agencies, Country government ministries. These organizations are midstream and serve to interpret and synthesize complex global and regional climate information for local adaptation.

2. National

Developers

-Country MET organizations. These centers maintain routine long-term historical weather and climate observation data. They can provide an interface between model and observed data simulations

End-users

-Country government ministries, Country NARS, Media broadcasts, Universities and state colleges, NGOs. Major constraint is access (see section 7.1, this report)

3. Local

Developers

Not available. This is a key missing link in the climate development to user chain. This link can be bridged through vulnerability assessment and adaptation outcomes.

End-users

Local governments, NGOs, Community based organizations, Communities, Populations.

4. Other sources and users

-Journals Online, Internet sources, Development & Donor Agencies

9. Targeting future CCAA project development

9.1 Implications of the regional assessment for existing projects

For this report we comment on the alignment of the current CCAA pipeline in relation to the sectoral assessment of vulnerability and hotspots of impacts from climate-related changes

Implications for vulnerability assessments

For a number of projects, questions still remain regarding resolutions of uncertainties about global, regional and local level effects of climatic changes. Even when studying local systems, it was not apparent whether historical and local folk knowledge of climate variability was available to inform project design. Within current and future projects, an inventory of local and national level historical trends is urgently needed as input to assessment frameworks. Where data is available, this inventory forms a baseline for local scenario testing and links scenarios and mapping to local level impacts specific to livelihood systems through country analyses of biophysical and social vulnerability

Implications for climate sensitive sectors

Of the projects discussed, none presents a sector led approach involving public participation in climate-related adaptations such as early warning systems. And for all projects, intended outputs will be delivered to end-users using existing conduits that are not necessarily suited for dissemination of climate change related products. In the absence of participatory engagement through the adaptation planning process, direct engagement of government agencies in ministries managing development sectors, it is difficult to envision how the project outputs will result in wide adaptation. Perhaps a first step is to use some of the current pipeline project outcomes as inputs to the assessment frameworks to test vulnerability of the climate sensitive development sectors. After which a consortium of partners can be identified, bringing together developers and users of climate information (as discussed in section 8.2 of this report) to develop tool box-(es) of regional adaptation options

9.2. Framework for assessing regional vulnerability

In table 9, we propose a knowledge framework for assessing vulnerability to climate change through the inclusion of mapping of hotspots of change as a key step to targeting adaptation projects to support the most vulnerable populations in the region. Such a framework integrates the identification of issues in the national planning process with a synthesis of existing information, storylines, GIS mapping, statistical tools, economic modeling and development policy analysis. It combines the elements of the assessment applied for the work reported here and suggests including economic modeling to further screen the policy outcomes of the framework. Some of the key elements of the assessment framework presented in the table below are:

Literature review; this brings together specific application of knowledge that has been developed by several disciplines. A comprehensive review will serve as a basis for identification of models, support of expert judgment and to fill in gaps whenever inputs needed for the projects have already been produced.

Scenarios; these are representations of the future state of climate including a projection of selected variables, in our case length of growing period (LGP) that determine the state. We use climate, social and biophysical scenarios which are primarily based on IPCC modeling.

Modeling; we use GCM scenarios to relate climatic variables to biophysical parameters and to assess changes in the length of growing period as a proxy indicator for climate change.

Data; climatic databases are used to develop climate scenarios and to analyze current and future climate changes. We also collect data on crop, livestock and other environmental variables that feed into the assessment.

Policy analysis; we summarize the previous steps and analyze gaps in climate data, and vulnerability knowledge to inform the policy process. A necessary step which was not attempted in this report is to further screen the policy outcomes of the framework using economic modeling.

Table 9. Proposed methodological framework for regional assessment of sectoral vulnerability to climate change

Assessment	Main output	Tools and means
Definitions of topics e.g. from National adaptation and development plans	Key role of policy where impacts from climate change hinder development	Contacts with governments and regional organizations
Literature reviews; On climate change and variability (exposure, coping and adaptation mechanisms)	Background information on impacts from current and future climate change scenarios	Literature, interviews and expert judgment
Scenarios: IPCC of a changing world	Storylines of change in economic structures with reductions in material intensity and the introduction of clean and resource efficient technologies.	IPCC framework and national adaptation plans, including national development plans
Models: changes in future from baseline scenario: GCMs and RegCMs with relevance to local conditions	Predictions of climate scenarios from Atmosphere-Ocean General Circulation Models (GCMs) and downscaled outputs to RegCMs	Climate data bases, statistical tools
Data: Continent, regional, country and local level data with increasing resolution	Data repositories on regional climate information variables and vulnerable climate sensitive sectors of agriculture and livestock, health, water resources and technological development	Regional and national institutes, NARS, IGADD, ICPAC, ASARECA, NBI, Country MET centers, UN agencies, NGOs and disaster/relief organizations
Hotspots mapping to capture impacts on vulnerable populations and climate sensitive sectors	GIS layers, spatial databases of vulnerability and climate-related risks. .Mapping livelihood assets of natural, human, physical, financial and social capital	Geographical Information Systems (GIS)
Expert knowledge inputs from surveys, workshops, meetings, conferences and seminars at national level.	Indicators and indices of biophysical and social vulnerability to climate change and variability for climate sensitive and development sectors	Statistical tools: Principal component analyses, pair-wise comparisons, Indicator ranking
Policy analysis and mainstreaming into the development process	Assessment of vulnerability including adaptation costs specific to development sectors	Policy analysis and economic modeling

9.3 Priority areas of future project development

Investments to increase capacity for crop and livestock production: Due to intensification, the demand for inputs to produce food and feed is likely to increase by orders of magnitude. Key among these will be water resources, both for domestic use and agriculture as well as energy production. Therefore, those water sectors that will support agriculture and energy production thereby guaranteeing food security have the greatest potential to reduce vulnerability of poor populations. This should include access to bio-fuels, clean energy and opportunities for trading carbon credits

Investments in risk mitigation: The main sources of variability will be related to the frequency of extreme rainfall and drought events as well as the resurgence of epidemics and new emerging diseases as a result of increasing contact from higher populations and livestock stocking rates. These events inflict catastrophic damage and require insurance protection

Investments in more resilient ecosystems and production systems: The regions dependence on rainfed agriculture which is a significant driver of current and future vulnerability. As it is projected there will be high water demand coupled with an increase in pollution from poor utilization of water for production. Due to accelerated loss of biodiversity and ecosystems degradation, there is need for diversification of crop and animal resources, including testing and adaptation of flood and drought tolerant crop germplasm and livestock breeds. The next focus is to design the delivery of crop and livestock innovations through demonstration kits of climate-proof technologies.

Investments in strengthening social and institutional capacity: The main consequence of weak institutions emanating from poor social structures is the labor-related migration of rural populations to urban and peri-urban centers. In order to strengthen social institutions, CCAA might consider supporting projects addressing labor-related migration, infrastructure, food and water systems in hotspots of urban and peri-urban settlements.

Investments in capacity to address climate change science: The use of model tools to inform adaptation policy is not a well integrated approach among local and national institutions in the region and still by far not sufficiently incorporated into the mainstream science and development processes. Investments in new methodologies may therefore play a crucial role through their integration with policy and where appropriate, into well enumerated local knowledge

10. Conclusions and recommendations

In this report we highlight significant biophysical and social conditions affecting adaptations and the adaptive capacities in climate sensitive agriculture, livestock, water resources and health sectors. Despite the uncertainties that exist in long-term climate predictions we conclude from the regional vulnerability assessment that:-

a) Climate change will occasion changes to agricultural land suitability in various production systems thereby reducing agricultural productivity and further exacerbate food insecurity in the region.

b) Populations living in areas represented as very low in suitability of malaria transmission will have added risks of exposure to malaria due to climate variability and change. Similarly, epidemics of livestock diseases, such as rift valley fever, will not only impact livestock production but also have a dramatic negative influence on the livestock trade in the horn of Africa

c) Arid and semi-arid regions (no growing period) may double in size occasioning widespread exposure to climate variability of livestock herders and populations deriving their livelihoods from rangeland ecosystems. Furthermore the agro-ecological limit of cereal production may retreat to higher elevations and causing serious shortfalls in grain production

d) Drought conditions will prevail where surface and groundwater is the main water resource. And wetlands which represent critical grazing areas for pastoralists could shrink drastically in size or even disappear altogether.

e) Climate change projections of the distribution of length of growing period (LGP) predictions show that arid regions (no growing period) may double in size, the limit of maize cultivation may retreat to higher elevations, increasing vulnerability since the capacity to produce adequate food and feed resources will be limited by these changes.

f) A future with greater intensification of crop and livestock production will escalate risks of vector borne disease with increased danger of cross-transmission between humans and livestock as contact increases from higher stocking rates and population density.

g) In order to cope with the magnitude of the impacts caused by climatic changes, CCAA will need to focus on strengthening institutional capacity for planning, developing and implementing climate change adaptations across all climate sensitive development sectors.

h) The main constraints to climate research in the region are: (i) the lack of climate data (ii) lack of access to climate modeling and its applications and (iii) poor access to literature sources.

i) Regional institutions needs to adopt policies that promote integration of climate information into development activities, develop community assets and other types of social and livelihood capital as well as allow public participation in the climate adaptation process.

Recommendation 1. In future projects, there is need to support studies of system level impacts of climate change to improve resolution in targeting local-effects on livelihoods of the poor and be able to better track adaptation within changing resource use patterns in crop-livestock systems. Due to a low level of access to livelihood capital assets in the rangeland systems, a first step might be for CCAA to fund the development, dissemination and field testing of demonstration kits of climate-proof technologies.

*Recommendation 2.*Current IDRC/DFID projects focus on addressing country-level impacts of climate change as these are better documented. However, sectoral impacts which affect population support systems in the region are still not well understood. For this reason, we recommend that project calls for proposals include a focus to address the impacts of population migration on infrastructure, food and water systems in rural, urban and peri-urban settlements. The outcome being sectoral adaptation measures needed to reduce vulnerability of the urban and peri-urban poor.

Recommendation 3. As most of the current projects are implemented by institutions dealing with issues of natural resource management, we recommend integration with social institutions in order to incorporate studies of livelihoods, poverty and economic well-being as these provide a better linkage with sector-led assessments. Also many of the present lessons on development planning which is a critical input to reducing social vulnerability to climate change are drawn from estimates of rural and urban poverty indicators.

Recommendation 4. For the scope of this report, we lacked sufficient inputs to synthesize the national adaptation plans but recommend that these plans should incorporate lessons emerging from the work of partners funded under the CCAA pipeline. Through outcome mapping the national plans can better be adapted to provide the key inputs to the assessment framework discussed in section 9.2 of this report

Recommendation 5. There is need to build climate research and policy networks to facilitate interaction and knowledge sharing among stakeholders as current projects tend to specialize within country. The structure of the networks needs to emerge out of a consultative process but should certainly include key players in agro-meteorological services, agro-industry and information technology transfer.

Recommendation 6. In order to better document key lessons from adaptation projects, we recommend forming a mechanism for long-term monitoring and evaluation of the evolution of institutional adaptive capacity which might be linked to future project outputs. This evaluation process could be expanded to enhance the work of ICPAC as a long-term regional climate modeling and evaluation center.

Recommendation 7. Through public participation, and with the regional centers (ICPAC etc), we recommend the development of communication tools for exchanging climate information, disseminating climate decision guides and vulnerability adaptation tool-boxes. Through linking upstream developers to end-stream consumers, we see opportunities for use of information technology when complimented by broadcast and media, to serve as a viable channel for implementation of regional policies in climate change science and adaptation. This recommendation attempts to address questions regarding the treatment of climate outlook forecasts in the adaptation process

Recommendation 8. Among partners there needs to be discussion on linking agricultural experimentation to rainfall variability perhaps through crop models. This would provide for forward projections using the models thus helping to better separate climate change with climate variability. In addition, we recommend performing trend analysis of existing data and extrapolating for 20-30 years as this would serve the region better than downscaled climate change scenarios. In particular, there is need to run models for same time and space giving daily, seasonal and future predictions.

Recommendation 9. In order to further guide future CCAA investments, we identify need for urgent action on four key needs that emerge from the scope of the present study:

i. An inventory of existing climate change-related policies at regional, national and local levels
ii. A network analysis of climate change science actors and stakeholders integrating the efforts of donors and research partners with those of development agencies and public institutions
iii. Mapping pathways of other sector policy influences on adaptation to climate change
iv. Developing strategies and mechanisms for science-policy dialogue aimed at assisting regional climate-related policy formulation, implementation and enforcement.

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APPENDIX 1: Study terms of reference (ToR)

Africa is the continent most vulnerable to the adverse impacts of variability and extreme events that result from climate change. On the other hand, mechanisms for coping and adapting to these adverse effects of changing climate are weak or lacking. In order to bridge this gap, IDRC, under the Climate Change Adaptation in Africa (CCAA) program is providing support to institutions in order to improve the capacity of African people and organizations to adapt to climate change in ways that benefit the most vulnerable sectors of society. The project is building on existing initiatives and past experience to establish a self-sustained, skilled body of expertise on climate change and adaptation science in Africa. So far, CCAA has funded the first 5 research projects of this program in the greater horn of Africa

In order to better inform current research projects and to identify priority areas for future activities and project development, we examine the relationship between projects currently in the CCAA pipeline and link them to hotspots of vulnerability, with particular focus on key climate sectors. This study aims to deal with the identification and analysis of the multiple drivers of vulnerability in the GHA and the different approaches to improving livelihoods and building adaptive capacity in relation to current CCAA activities.

Specifically:-

1. Help plan, and participate in, an inception meeting for one day at ILRI very early in the project, and contribute to the detailed planning of the work.

2. Carry out a review of existing information on vulnerability and its assessment for the GHA. This will involve a combination of desk work and field visits. The desk study will build on previous work carried out in the region concerning the likely impacts of climate change in GHA. Information will be summarized and synthesized appropriately.

3. After consultation with appropriate partners, undertake field visits to the key institutions in the region that are working on climate change and adaptation science,

including visits to partners working on current CCAA-funded projects. The purpose of the visits will be (1) to summarize current activity in the GHA on vulnerability assessment and identify gaps, and (2) to identify policy champions, entry points and conduits, which may in the future be able to help bring about the institutional changes needed for more effective adaptation to climate change and variability.

4. Write a report that combines the information garnered in the desk study and field visits, which provides the regional context within which vulnerability can be characterized and plans made for addressing it.

5. Contribute to other project activities as appropriate, including the spatial and gap analyses planned and the writing of the final project report.

APPENDIX 2: CCAA program abstract

CLIMATE CHANGE ADAPTATION in AFRICA: A Research and Capacity Development Program

The threat of climate change is real, is happening now, and is expected to hit developing countries the hardest. Developing countries already face social, economic, and environmental stresses and resource constraints that limit their ability to adapt to climate change, and these stresses are likely to be exacerbated by climate change. It is anticipated that African countries in particular will endure some of the worst effects of climate change. Many parts of Africa already experience high variability in rainfall, which threatens the livelihoods of the many people who depend on rain-fed agriculture. African people have developed coping strategies to deal with this variability, but the ability of African institutions and people to adapt to the magnitude and rate of anticipated climate change impacts over the next 20 to 30 years is limited by social, technical, and environmental factors including widespread poverty, fragile ecosystems, weak institutions, and ineffective governance. Recognizing the urgent need to enhance the ability of people to adapt to climate change in Africa, the International Development Research Centre (IDRC), Canada, and the Department for International Development (DFID), U.K commenced the Climate Change Adaptation in Africa Research and Capacity Development Program (CCAA) in April 2006. The CCAA is envisioned as run and executed in Africa by Africans, and to the extent possible, involving the whole of Africa. The program intends to build on existing initiatives, experience, and adaptive capacity. Its purpose is to significantly improve the capacity of African countries to adapt to climate change in ways that benefit the most vulnerable. The CCAA pursues its objectives by funding promising research and capacity building projects. To be funded by the CCAA, research must not simply enhance the scientific literature, but rather, must be applied and useful. The CCAA funds action research that involves some component of learning by doing or demonstration (*e.g.* pilot projects), engages end-users in the definition of the research, and shows awareness of and, where possible, builds on existing capacities and knowledge.

APPENDIX 3. Summary of CCAA projects in the greater horn of Africa

Lack of resilience in African smallholder farming: Enhancing adaptive capacity of local communities to pressures of climate change (Malawi, Mozambique, Zambia, Zimbabwe; **Kenya, Uganda, Tanzania**; Cameroon, Ghana and Mali). University of Zimbabwe.

This proposed work assesses the vulnerability of smallholder farming communities in Sub-Saharan Africa (SSA) to the effects of climate change and variability on agricultural productivity and livelihoods and identifies opportunities for enhancing the adaptive capacity of different categories of households and communities. SSA is characterized by high prevalence and intensity of poverty, indicating high vulnerability of the populations to the potential negative impacts of climate change and variability, particularly among rural and peri-urban populations who depend on an already degrading environment. Any short- or long-term climate change will force farmers to adopt new agricultural practices including choice of crop varieties, timing of major operations and designing of alternative food supply systems. The project thus focuses on enhancing capabilities of households, communities and relevant institutions to appropriately respond to these changing circumstances in order to reduce vulnerability and future threats to food security and environmental integrity in Sub-Saharan Africa.

Combining participatory action research and integrated systems analysis, the proposed project aims to enhance the knowledge and capabilities of households and communities to adapt to the effects of climate change and variability on agricultural productivity and livelihoods, and to stimulate development of the much-needed expertise among collaborating institutions and stakeholders. The project builds on current research initiatives in major climatic zones of Africa, and takes advantage of active coordinating role of regional networks.

Managing risk, reducing vulnerability and enhancing productivity under a changing climate (**Tanzania, Kenya, Ethiopia, and Sudan**). Sokoine University of Agriculture (SUA).

The countries of the Greater Horn of Africa (GHA) are particularly vulnerable to droughts, which characterize the region with increasing economic impacts. This vulnerability is further exacerbated by factors such as widespread poverty and over-dependence on rain-fed agriculture. Even with normal rainfall, the region does not produce enough food to meet its needs and this reinforces the endemic poverty in the region. Consequently, the region experiences frequent climate-induced famines and related disasters. Governments in the region often address drought problems using short-term emergency measures. Little or no strategic attempt is made to encourage primary producers and others to adopt self-reliant approaches to prepare for these droughts. The project recognizes that opportunities exist to reduce the impacts of droughts and consequently poverty in the region by formulating effective and efficient adaptation strategies aimed at reducing the vulnerability of the marginalized, safeguarding livelihoods threatened by droughts, increasing the flexibility in management of vulnerable systems, and enhancing inherent adaptability among smallholder farmers. Using case studies in Tanzania, Kenya, Ethiopia Eritrea and Sudan, this action research project seeks to contribute to the development of such strategies by (a); establishing an informational database that is necessary to understand vulnerability to droughts within different social, political, and economic contexts; (b) developing robust decision making tools for improved strategic and tactical decision making to reduce vulnerability.

Strengthening local agricultural innovation systems in less favored & high potential areas of Tanzania & Malawi (**Tanzania** and Malawi). Institute of Resource Assessment (IRA), University of Dar Es Salaam.

In many sub-Saharan African countries, poverty is linked to low agricultural productivity, which accelerating climate change and variability threatens to make even worse, not withstanding the implementation of several initiatives aimed at boosting agricultural production. In Tanzania and Malawi, a key challenge for decision makers is to understand the context and strategies of farmers and other stakeholders in agriculture for adapting to climate change and variability. One reason for this is the lack of interaction between researchers, policy makers and vulnerable farming groups. This action research project seeks to foster processes for effective engagement amongst these stakeholders to develop agricultural innovation systems that are better able to adapt to climate change and variability, using case studies of communities in two different agro-climatic sites in Tanzania and Malawi. The research intends to facilitate a process of interaction and learning where information/ knowledge from different sources (local, national, regional and international) is shared and integrated in a way that results in its novel use by stakeholders in agricultural innovation systems to better adapt to climate change and variability. It will contribute directly to capacity strengthening primarily at the local scale through improving the ability of participating individuals, organizations and systems to utilize knowledge more effectively, efficiently and sustainably in addressing local, national and regional priorities that will contribute to adapting to climate change. The process will systematically identify and share lessons with key decision makers for further capacity strengthening to enhance innovation and adapt to climate change in ways that benefit the most vulnerable

Pastoralist livelihood security: Developing Adaptive Capacity with a Focus on Nomadic Livestock Production under Climate Change. Intermediate Technology Development Group Ltd. **Kenya**.

Pastoralists constitute about 13% of Kenya's 30 million people (1999 population census), with livestock as their major source of livelihood and food security. The Pastoralists provide a significant share (70%) of livestock to the country's market. The pastoralists herd their livestock in the arid and semi-arid lands (ASALs), which constitute about 75% of the country's landmass. These areas are home to extreme droughts. Rainfall variability largely drives vulnerability to climate change as it affects forage availability, livestock production and ultimately the livelihoods of pastoralists. The increasing vulnerability of pastoralists' livelihoods to climate change results from the interaction of ecological, socio-economic and socio-political factors. Increasing poverty levels exacerbates this vulnerability; and poverty is greatest (65%) in pastoralist areas of northern Kenya, specifically in Turkana and Mandera districts (Welfare Monitoring Survey, 2003). Efforts are required to reduce vulnerability of pastoralists to climate change through adaptation. This study proposed by Practical Action seeks to develop a comprehensive understanding of pastoralists' vulnerabilities and their coping strategies to climate change in two pastoralists' areas of Turkana and Mandera districts, to understand the indigenous technologies, best practices and processes, and existing institutional arrangements for enhancing effective adaptation. This knowledge is useful for the various groups and stakeholders, including the pastoralists' communities. Unfavorable policies have restricted herd movement in the region making pastoralists become sedentary with limited access to critical resources. In a changing climate with increased droughts, herd movement, for instance, will become even more crucial as an adaptation strategy. This project will, among other strategies seek to enhance adaptive capacity of pastoralists through practices that will improve herd movement such as creating and sustaining livestock corridors, while securing rights to critical pastures and water resources.

Transferring the malaria epidemic prediction model to end users in East Africa. Kenyan Medical research Institute (KEMRI). **Kenya, Tanzania and Uganda**..

About 17% of the population of East Africa lives in the highlands (1,500 - 2,500 m above sea level) where epidemic malaria is a climate-related emerging hazard that urgently calls for measures to reduce its negative health impacts. In a highland area of Rwanda, malaria incidence increased by 337% in 1987. About 80% of the statistical variation in malaria incidences could be explained by rainfall and temperature. In Tanzania, Uganda and Kenya, malaria cases increased by 146%, 256% and 300% respectively during the 1997/98 epidemic, both periods coincided with El Nino events in the region. Current methods used for epidemic detection do not have sufficient lead-time, thus the epidemic is detected in its exponential phase and interventions often come too late. A malaria epidemic prediction model was developed by the Kenya Medical Research Institute in 2001 that primarily uses climatic factors to detect an epidemic 2-4 months before its occurrence, thus providing sufficient lead time for interventions. The model has been tested and validated in some parts of Kenya and Tanzania. The goal of this project is to fine-tune this model to incorporate site-specific factors, transfer the model to end users in Kenya, Tanzania and Uganda, as well as enhance the capacity of end-users (policy-makers and health officials) to be able to provide effective early warning against malaria epidemics and implement appropriate interventions to prevent malaria epidemics. The project also aims at enhancing the capacity of local populations and vulnerable groups to understand and respond adequately to early warning predictions to reduce the impacts of malaria epidemics in the region. Considering that malaria is not only driven by climate, the project also intends to assess the role of other non-biophysical factors in determining the incidence and control of malaria.

APPENDIX 4. Scenarios of the Special Report on Emissions Scenarios (SRES) of IPCC, 2000

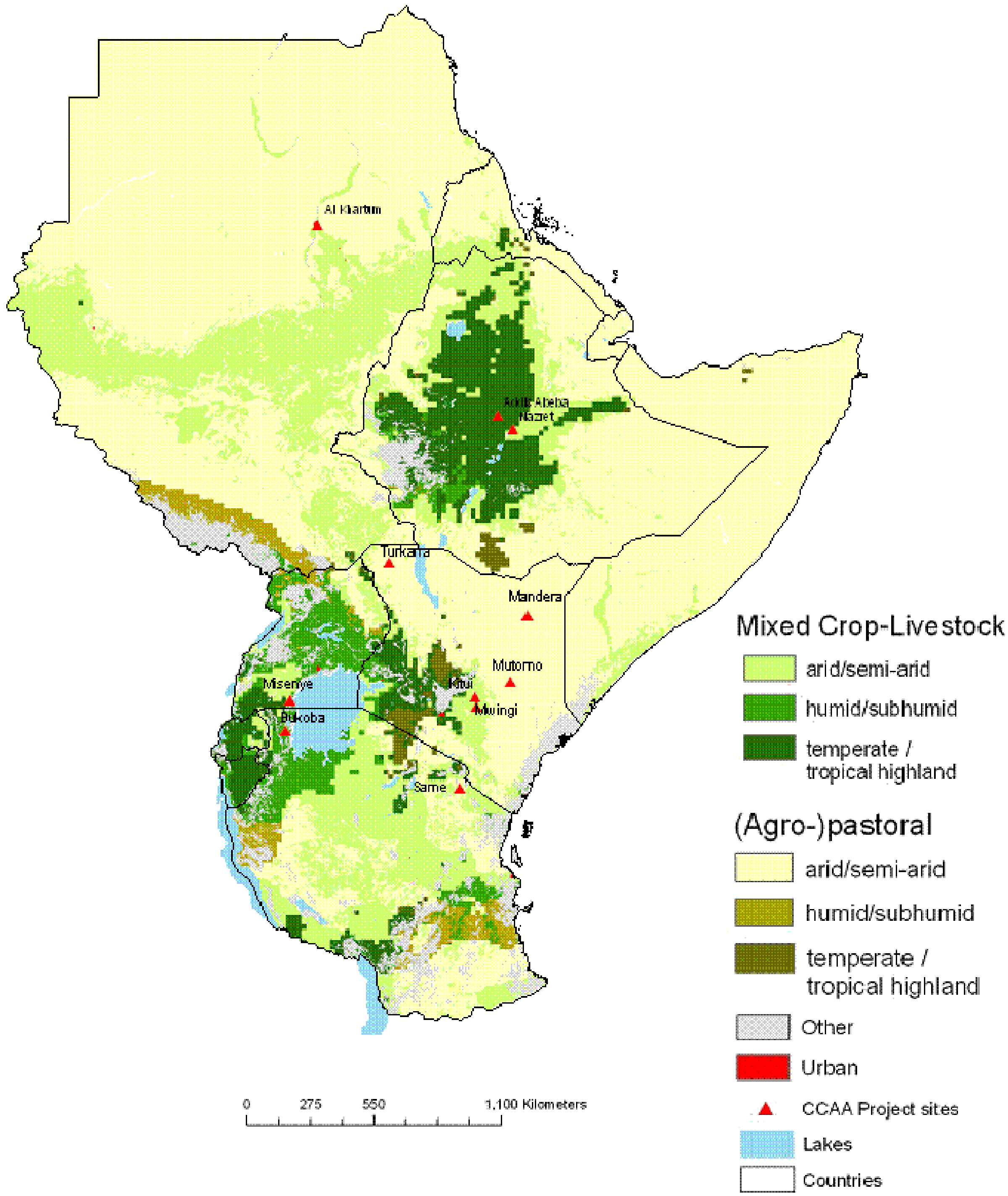
A1. The A1 storyline and scenario family describe a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2. The A2 storyline and scenario family describe a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change is more fragmented and slower than in other storylines.

B1. The B1 storyline and scenario family describe a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2. The B2 storyline and scenario family describe a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

APPENDIX 5: CCAA ongoing programs and map location of projects sites



APPENDIX 6: Institutional survey

Assessment of Vulnerability to Climate Change and Climate Variability in the Greater Horn of Africa: Survey of CCAA Projects and Climate Science Research Partners

(Please respond by **May 16, 2008)**

Why a "vulnerability assessment" in the GHA?

Africa is the continent most vulnerable to the adverse impacts of climate change and climate variability. In addition, mechanisms for coping and adapting to these adverse effects of changing climate are weak or lacking. In order to bridge this gap, the Climate Change Adaptation in Africa (CCAA) program aims to significantly improve the capacity of African people and organizations to adapt to climate change in ways that benefit the most vulnerable sectors of society. It is intended that the project builds on existing initiatives and past experience to establish a self-sustained, skilled body of expertise on climate change and adaptation science in Africa. So far, CCAA has now funded the first 6 research projects of this program in the greater horn of Africa (GHA). To better inform current research projects and identify priority areas for future activities and project development, we intend to examine the relationship between projects currently in the CCAA pipeline and their linkage to hotspots of vulnerability, with particular focus on key climate sectors such as agriculture, water and health, as well as social, institutional, and technological sectors. This assessment is being done with a view to mapping regional vulnerability hotspots and identifying current and future vulnerabilities and trends. By examining biophysical and social vulnerability, we hope to gain insight into pathways for their potential mitigation.

A. Personal information:

1. Country:
2. Name:
3. Job title:
4. Institution:
  Address:

1. I am a (Tick or cross mark)

☐ researcher in an institute/station
☐ faculty member/researcher
☐ professor/lecturer (no research)
☐ student
☐ NGO staff
__ other __________

__

2. I work at (Tick or cross mark)

☐ an international research centre
☐ a national agriculture research centre
☐ other government agency
☐ a non-governmental organization
☐ a university (department__________);
☐ other___________

B. Institutional affiliation

Below are the institutions currently providing meteorological services and information on country climate data and weather reporting. By ticking or cross mark, please indicate to what extent you or your project/research is affiliated to these organizations

Country institution	Affiliated	Not affiliated	Other (specify)
Insititut Geographique du Burundi			
Meteorologie Nationale de Djibouti			
Eritrea Meteorological Services			
National Meteorological Services Agency of Ethiopia			
Tanzania Meteorological Department			
Rwanda Meteorological Service			
Somalia Meteorological Department			
Sudan Meteorological Authority			
Uganda Department of Meteorology			
University of Nairobi/Department of Meteorology			
Kenya Meteorological Department /Drought Monitoring Centre			

C. What vulnerability focus does you project/research address?

1. Vulnerability may arise from biophysical natural environment (1-3) or social human environment (4-5). Recognizing the thematic focus of your project, please indicate its relevance to one or more of the following sources of vulnerability. (Tick or cross mark)

Climate sector	Very relevant	Somewhat relevant	Not very relevant
1. Agriculture (crops and livestock) and food security			
2. Population health and well being			
3. Water resources (its quality and availability for use)			
4. Social & Institutional (governance, labor, gender etc)			
5. Technological developments (uses) applicable to project			

2. Describe how your project relates to climate change?

____
____
____

3. List any climate change and adaptation research-related organizations, networks, associations or other groups you belong to (if any):

____
____
____
____
____
____

D. Adaptation and existing coping mechanisms

1. Adaptation opportunities

For adaptation, we refer to the changes that natural and human systems undergo in response to changing conditions in their immediate environment, for example changes in farming practices. Poverty increases vulnerability to climate change and climate variability by reducing options for adaptation Lack of secure livelihoods may be due to depleted social, financial, physical and human assets such as upon displacement of people. For example rural populations that are exposed to social vulnerability often migrate to urban centers in search of work and alternative livelihoods. Therefore the migration frequency will depend on the scope of the vulnerability

For each vulnerability sector, please list and box tick or cross mark the frequency of alternative livelihood strategies relevant to your project/research

Climate sector	List adaptation strategy	Frequent	Occasional	Rare
1. Agriculture (crops and livestock) and food security	1. 2. 3.	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
2. Population health and well being	1. 2. 3.	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
3. Water resources (its quality and availability for use)	1. 2. 3.	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
4. Social & Institutional (governance, labor, gender etc)	1. 2. 3.	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
5. Technological developments (uses) applicable to project	1. 2. 3.	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐

2. Existing coping mechanisms

Coping refers to any adjustment in natural or human systems that take place in response to actual or expected impacts of climate change. It is intended either to moderate harm, or to exploit beneficial opportunities. For many GHA countries, their capacity to cope with the negative effects of changing climate and climate variability is limited by high levels of extreme poverty, weak traditional support mechanisms and poor social institutions. These structural vulnerabilities often lead to further decline in their ability to respond to future climate shocks. For instance livestock herders frequently migrate in search of water and pasture in response to drought but herd size reduction is perhaps only an occasional drought coping strategy.

Please list and rank by box tick or cross marking coping mechanisms relevant to your project/research

Climate sector	List mechanism	Frequent	Occasional	Rare
1. Agriculture (crops and livestock) and food security	1. 2. 3.	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
2. Population health and well being	1. 2. 3.	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
3. Water resources (its quality and availability for use)	1. 2. 3.	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
4. Social & Institutional (governance, labor, gender etc)	1. 2. 3.	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
5. Technological developments (uses) applicable to project	1. 2. 3.	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐

3. Distribution of current vulnerability to climate change

In our context vulnerability to climate change and climate variability refers to the frequency and magnitude of risks that a sector is exposed to, and to the ability of that sector to withstand the impact of the resulting negative shock. Possible examples that characterize vulnerability of agriculture to climate change and climate variability are changes in length of growing period and crop losses from droughts. For biophysical (1-3) and social (4-5) vulnerability sources, the severity of the changes may differ depending on the geographic location or scope of your project/research.

Please list characteristics and score by box tick or cross mark the extent of severity of vulnerability to climate change and climate variability relevant to your project/research

Climate sector	Characterization	Severe	Less severe	Not severe
1. Agriculture (crops and livestock) and food security	1. 2. 3.	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
2. Population health and well being	1. 2. 3.	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
3. Water resources (its quality and availability for use)	1. 2. 3.	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
4. Social & Institutional (governance, labor, gender etc)	1. 2. 3.	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
5. Technological developments (uses) applicable to project	1. 2. 3.	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐

3.1. Do you feel your answers (1-4) about climate information access are typical of other researchers in your institution? __Yes;__No. If no, please briefly explain:

____

____

E. Building Capacity to Address Information and Policy Gaps

CCAA is interested to support the development of capacity to address to negative impacts of climate change and climate variability. For his reason, we intend to demonstrate the availability of information sources some of which can serve as a basis to construct knowledge networks that could be shared across countries in the GHA

1. Where do you obtain information on climate change research? Please score the frequency

Information source	Often	Sometimes	Rarely	Never
Colleagues/others at work				
Library at my institution				
Ask the librarian				
Online journals				
Personal subscriptions				
Newsletters				
Conferences/inter-institutional meetings				
E-mailing colleagues in other institutions				
Internet searches				
Other				

2. **Constraints to climate change research**: (check all user needs that apply)

__ lack of climate data __ no computer/equipment __lack of training

__lack of literature/information; __no funding Other:_________

3. Library Access

a) My institution/project __has; __does not have. a library or climate change research center.

b) I use the library __never; __rarely; __frequently

Why? ____

c) My institution's library has: (check all that apply to climate change research resources):

__no computer; __no internet access; __fast internet access;

d) For climate journals, my institution's library has:

____adequate access ____very limited to access ____no access

e) Are there any specific climate journals you would like to have access to, but currently do not?

Which ones? ____

f) I consult the librarian to access climate change information: __never; __sometimes;__often

4. List your favorite climate information websites (if any):

a) Specifically for climate change related research:___________________________________

b) For project funding sources:____

3.2. Policy Information Gap: Sources for policy information on climate change, GHA: The availability and distribution of climate change information is becoming common within many government, development and disaster relief agencies. In many cases the information is tailored to inform agencies in order to improve disaster preparedness. It seems there may exist opportunities to better share information between sources through established service providers. For this objective, please indicate by tick or cross mark, of the listed agencies, which is your primary source of access to climate change information in your region/project

	Access often	Know about, but rarely access	Never access
Journals Online			
Regional Climate Networks			
ASARECA/CORAF/SADC			
UN agencies			
Country government ministries			
CGIAR Centers			
IGADD Drought Center (ICPAC)			
Development & Donor Agencies			
FAO and WB Bulletins			
Internet sources			
Your country MET organizations			
Media broadcasts			
Universities and state colleges			
Country NARS			

F. Decision framework on adaptation to climate change

Institutional mechanisms are part of a decision framework that is essential in designing ways to cope and adapt to changing climate. In addition using climate information to manage climate-related risks involves supporting better decisions by risk managers. For your project/research, please indicate for both framework and tools/guides the specific mechanism(s) that are available for coping with climate variability

A Describe institutional decision framework and indicate presence or absence

Decision framework	Present	Absent

B Describe project decision tools/guides and indicate presence or absence

Decision tool/guide	Present	Absent

G. Assessment of Funding Gaps on Climate Change Research: Capacity based on Project/Research Foci:

Funding gaps, when assessed in the context of existing hot spots of vulnerability may provide valuable information as to whether support is well targeted to the most deserving projects.

For your country, please rank your current assessment of existing capacity to address climate change science.

Climate Change Science	Adequate	Inadequate	Never
Current & Future Climate Model Prediction			
Agriculture & Food Security			
Drought & Floods			
Land use & Land Cover Change			
Water resources			
Ecosystems & Biodiversity			
Human Health and Diseases			
Social & Institutional Governance			
Infrastructure & Technology			

H. Please provide the geographic location of your project/research site(s)

Please indicate the location data to map sites alongside the hotspots of vulnerability

Site (name, location, country)	Elevation	GPS coordinates	

THANK YOU again for your input!

James

Please return the survey as an e-mail attachment to **j.kinyangi@cgiar.org**
Or, by regular mail to:
James Kinyangi
International Livestock Research Institute (**ILRI**)
Targeting and Innovation
Box 30709, Nairobi, 00100, KENYA,