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ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT WORKING PAPER

ENVIRONMENT [CLIMATE CHANGE] BIOENERGY MONITORING AND ASSESSMENT

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Analysis of Climate Change and Variability Risks in the Smallholder Sector

Case studies of the Laikipia and Narok Districts representing major agro-ecological zones in Kenya

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Department of Resource Surveys and Remote Sensing (DRSRS) in collaboration with the Food and Agriculture Organization of the United Nations,
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EXECUTIVE SUMMARY

Climate change is probably the most complex and challenging environmental problem facing the world today. Currently, the intriguing questions include weather uncertainties, persistent climatic abnormalities, rampant environmental degradation and eminent food insecurity. Some of these complexities are exacerbated by increased human population and demand for more agricultural land for food production, which have resulted in destruction of the vegetation cover and subsequently rampant environmental degradation. The demand for food, fuelwood (charcoal and firewood) and forest products for various uses (including timber and poles for building and construction, medicinal values and fodder in semi-arid and arid lands) expounds on this problem and the results are devastating effects that include environmental degradation, climate change, droughts, floods and ultimately food insecurity both to domesticated and wild animals, and human beings.

Presently, almost 57 percent of Kenya's population lives in poverty, largely reliant on climate-sensitive economic activities including rainfed "subsistence" or "smallholder" agriculture. Smallholder agriculture is generally used to describe the rural producers who farm using mainly family labour and for whom the farm provides the principal source of income. Smallholder farmers grow most of the country's maize and produce significant quantities of potatoes, beans, peas, sorghum, cassava, banana, oilseeds, vegetables, tree fruits, etc. However, these farmers are faced with a number of challenges including simultaneously increasing production and preserving natural resources. Meeting these challenges is vital to sustained livelihoods and reduction of poverty, especially within the fragile dryland and semi-arid areas.

The objective of this study was to raise local and community awareness and preparedness towards food insecurity, thus to reduce the impacts of climate change and variability on the food production system, natural resources base (land, water, forest and biodiversity) and ecosystem integrity, including establishment of baseline information at both local and agro-ecological levels. In addition, the study aims to demonstrate on-the-ground adaptation practices and technologies which can stabilize the productivity of vulnerable communities and enhance ecosystem resilience for possible up-scaling; (including the ongoing agricultural activities, food security measures and natural resources management programmes/projects) in comparison to the mainstream-proven technologies and best practices for climate change adaptation in most vulnerable regions focusing on the agriculture sector.

The main issues addressed in this study include climate change impacts and concerns, and adaptation and mitigation strategies among the smallholder farmer and rural communities in the fragile ecosystems of Narok and Laikipia districts in Kenya. The study has outlined climate change vulnerability issues based on **models and scenarios developed for** different agro-ecological zones. Climate **change** impact s**cenarios** developed using **high spatial and temporal** resolution datasets are crucial for the assessment and predictive analysis of the future **climate variability** on livelihoods of the smallholder farmers**.** This has been built upon the climate change models resulting in various scenarios developed based on the changing pattern and trends arising from the variability of meteorological parameters and the associated land use activities.

It should be noted that the current climate change scenarios demand the adaptation of smallholder farmers in drylands to temperature increases, changing amounts of available water, greater climatic instability and increased frequency of extreme weather events. Thus the future crop farming techniques and food production systems will have to be better adapted to a range of abiotic stresses such as greater heat accumulation, dwindling water and salinity availability as well as biotic stresses including pests and diseases, in order to cope with the consequences of progressively changing climate phenomena.

A summary of the climate change vulnerabilities, impacts and concerns, adaptation and mitigation strategies among the smallholder farmers and rural communities in the fragile ecosystems of Narok and Laikipia districts of Kenya is as follows:

CLIMATE CHANGE VULNERABILITY

The drylands of Kenya including the Laikipia and Narok districts are most vulnerable to climate change phenomenon due to the fragile nature of the environment that has been exacerbated by encroachment by agricultural activities associated with increasing human population and accompanied by unsustainable land-use activities. The frequency and severity of both droughts and floods is already high and is expected to increase in coming years. In these areas, smallholder farming and pastoral livestock production are dominant, but are dependant on the availability of rainfall. The major impact of droughts on smallholder activities is increased food insecurity (food shortage and poverty) and loss of livelihoods.

IMPACT AND CLIMATE CHANGE CONCERNS

The climate change impacts and concerns among smallholder farmers in the Laikipia and Narok districts are similar, as in other drylands of Kenya. The means to food security in every community vary from place to place as do the adaptation strategies to environmental hazards such as drought and floods. Also, each agro-ecological zone has distinct challenges in maintaining food security, which often cut across all the sectors.

i. Abnormal onset of the rainy season results in severe consequences, where abrupt floods destroy infrastructure and hamper physical mobility, damage crop fields, increase disease epidemics, death to livestock, and severe impact on livelihoods;
ii. Droughts have led to the rampant environmental degradation, resource use conflicts and desertification.

iii. Increased frequency and severity of droughts has aggravated the aridity of the drylands, making it drier and adversely affecting ecosystems balance (biodiversity and habitats), livelihoods of communities who depend on livestock keeping, smallholder rainfed agriculture and overall food security.
iv. Prolonged droughts lead to famine, which adversely affect particularly the elderly, women and children, and often result in severe malnutrition, diseases and deaths.

The impacts of climate change are compounded by non-climatic factors, including:

i. Population displacement as people become squatters or rely on relief aid/handouts, sometimes forced to live in abject poverty;
ii. Migration to nearby towns in search of relief and/or better opportunities (e.g. paid work, women involved in prostitution - often associated with HIV/AIDS risk), influx of slums where facilities and services are limited;
iii. Damage of crop fields and loss of livestock, with severe consequence including hunger and cattle rustling in order to restock;
iv. Persistent water stress causes drying up of rivers during prolonged droughts or waterways bursting their banks in case of floods, causing a severe change of water availability in terms of quantity and quality; and
v. Disease epidemics affecting both human, animals and crops as a result of rising temperatures or contagious waterborne bacteria due to floods, which lead to increased costs related to human and animal suffering or even life.

COPING MECHANISM AND ADAPTATION OPTIONS

The predicted climate change impacts that could affect smallholder agricultural production in Kenya include drought, floods, heat stress and soil structure change. Some of the proposed and ongoing adaptation practices include:

i. Promotion of drought-tolerant/escaping crops; application of irrigation agriculture; increased use of fertilizers; the development of high yielding, pest and disease-resistant early maturing crops. In dryland livestock production, disposal of stocks early before the onset of droughts and restock during the wet periods is a suitable adaptation strategy to the pastoralists. However, this strategy will depend on the availability of accurate early warning mechanism on weather forecast and range management to work adequately.
ii. Introduction of flood control measures in the most inundated and prone areas;
iii. Introduction of wind break trees;
iv. Promotion of agroforestry and application of mulching materials;
v. Application of organic fertilizers, establishment of soil conservation structures as well as soil liming to promote conservation agriculture, and discourage farmers from clearing the vegetation on steep slopes;
vi. Development of feedback mechanisms and training of smallholder farmers on sustainable dry land agriculture;

vii. Promotion of public awareness-raising on environmental conservation and sustainable development issues; and

viii. Undertake research and enhance capacity among the smallholder farmers.

CONTENTS

ACRONYMS AND ABBREVIATIONS

ACC	African Conservation Centre
AEZ	Agro-ecological Zones
ASAL	Arid and Semi-arid Lands
AWF	African Wildlife Foundation
CDM	Clean Development Mechanism
CETRAD	Centre for Training and Integrated Research in ASAL Development
DANIDA	Danish International Development Agency
DDP	District Development Plan
DRSRS	Department of Resource Surveys and Remote Sensing
ECZ	Eco-climatic Zones
ENSO	El Niño Southern Oscillation
EWS	Early Warning Systems
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographic Information Systems
GoK	Government of Kenya
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for Conservation of Nature
KARI	Kenya Agriculture Research Institute
KFS	Kenya Forest Service
KMD	Kenya Meteorological Department
KSS	Kenya Soil Survey
KWS	Kenya Wildlife Service
LWF	Laikipia Wildlife Forum
MEMR	Ministry of Environment and Mineral Resources
MoA	Ministry of Agriculture
MRV	Monitoring, Reporting and Verification
NCSA	National Capacity Needs Self-Assessment for Global Environmental Management
NDVI	Normalized Difference Vegetation Index
NEMA	National Environmental Management Authority
NGO	Non-Governmental Organization
NMK	National Museum of Kenya
RCMRD	Regional Centre for Mapping of Resources for Development
UNEP	United Nation Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNOPS	United Nations Office for Project Services
WMO	World Meteorological Organization
WWF	World Wide Fund for Nature

CHAPTER 1

INTRODUCTION AND BACKGROUND

In the twenty-first century, agriculture will face significant challenges, arising largely from the need to increase the world's food production to feed a population of over 10 billion, while adjusting and responding to climate change. In sub-Saharan Africa, agriculture remains the main contributor to socio-economic development of many countries. However, experts are concerned that the sector is already vulnerable to the effects of climate change and that this will worsen in the future as its variability increases. The experimental simulation data that suggests that African countries may lose up to 47 percent of their agricultural revenue because of global warming is the most pessimistic forecast (Mendelson, 2000). Although increased heat is expected to reduce crop yields and increase levels of food insecurity even in the moist tropics, it is predicted that during the next decade, millions of people, particularly in developing countries, will face major changes in rainfall patterns and temperature variability regimes thereby increasing risks in the agricultural sector (IPCC, 2007). Probably more than 90 percent of the activities of humankind are largely responsible for the modern day climate change.

Climate change is probably the most complex and challenging environmental problem facing the world today. Currently, the intriguing questions include weather uncertainties, persistent climatic abnormalities, rampant environmental degradation and imminent food insecurity. Some of the complexities are exacerbated by increasing human population and demand for more agricultural land for food production, resulting in the destruction of the vegetation cover and subsequently rampant environmental degradation. The demand for food, fuelwood (charcoal and firewood) and other forest products (including timber and poles for building and construction) increase this problem. The resultant web often brings about devastating effects, which include environmental degradation, climate change, droughts, floods and ultimately food insecurity.

During the last few decades, cyclic patterns between drought and flooding have become more frequent, while the intensity and spatial distributions have also changed, with severe impacts. The phenomenon and direction of trends in weather and climate events has become increasingly deviant from normal, with more warmer and fewer cold days and nights, also warmer and more frequent hot days and nights over most land areas (IPCC, 2007). Similarly, heavy precipitation events over many areas have become more frequent and brought more severe consequences. The impacts of these changes has manifested in decreased crop yields, increased pest outbreaks, rampant soil erosion and waterlogging. Drought-affected areas have become vulnerable to land degradation, crop damage or failure and increased livestock deaths due to dehydration and lack of forage. In some African countries (Kenya included), yields from rainfed crops could be halved by 2020 and the net revenues from crops could fall by 90 percent by 2100 (IPCC, 2007). Widespread poverty that limits adaptation capabilities makes many countries in sub-Saharan Africa highly vulnerable to the impacts of projected climate change. It has been predicted that there will be a rise in temperature of between 1-2.5°C by 2030, which coincides with Kenya's development agenda spelled out in Vision 2030 (IPCC, 2007). Consequently, in the next decade, it is expected that there will be a haphazard shift in crop growing seasons, poor crop productivity and abrupt outbreaks of diseases and vectors. Kenya's human population will therefore be at greater health and life risks than before. The immediate major development problem already facing the country is persistent and the increasing level of food insecurity linked to increasing poverty. Almost 18 million Kenyans live below the poverty line (WRI, 2007), the majority of which reside in the rural areas, with more than 90 percent relying on rainfed subsistence or smallholder farming to survive (KARI, 2008). Evidence strongly suggests that recurrent droughts and increased floods may exacerbate the poverty level, leaving many rural farmers, mainly the subsistence or smallholders, trapped in a cycle of poverty and vulnerability (Phiri *et al.*, 2005).

While many initiatives have attempted to strengthen the adaptive capacity of communities in Kenya to climate change, many of these have failed due to lack of awareness, induced by endemic poverty levels. The country therefore needs innovative and proactive adaptation strategies which will empower the rural communities, especially the smallholder farmers, in coping with increasing livelihood vulnerabilities. Perhaps the most obvious and commonly promoted innovations in climate change adaptation initiatives are the "hard" solutions or engineering approaches based on risks and vulnerabilities that help defend livelihoods from climate change impacts. However, innovation in adaptation also relates to the way the environment is governed and managed. In this context, "soft" solutions also play an important role in what can be defined as innovative adaptation. In general, in order to tackle the problems of food insecurity, the challenges and opportunities presented by climate change and innovative adaptation strategies must be related to the communities who interact directly with natural resources, especially the subsistence or smallholder farmers who form the majority of the population and live in the rural areas. This involves considering the following questions: what does climate change mean to sustainable development and technology for natural resources? Also, what does climate change mean to smallholder farmers and food insecurity? And what does all this mean for land-use policy?

Smallholder farmers of the ASAL will suffer greater impacts from the emerging climate change related problems, such as increasing weather variability, extreme temperatures (extreme hot or cold days), shorter growing seasons, high solar radiation, greater moisture stress and new pests and diseases. Today, the medium to low potential agriculture districts of Kenya are reeling from the effects of global warming with prolonged droughts and unexpected shift in normal weather patterns, which has resulted in the reduction of crop production by 30 percent (NEMA, 2007).

Land use is interlinked in complex and interactive ways to the local and global climate change. The feedback mechanism between land use and climate change exists at both the spatial and temporal scales. Changes in greenhouse gas emissions, albedo and land surface variation are the primary mechanisms by which land use affects climate. Climate variability in turn affects the ways in which the land is used and includes determination of the best/most appropriate use for a given area. Some of the impacts of these feedbacks are local while others have global ramifications.

The growing evidence from the Intergovernmental Panel on Climate Change (IPCC) that climate will change as greenhouse gases accumulate (IPCC 2007) has added urgency to the need to understand the consequences of warming. Initial studies of climate change, using a variety of methods, identified Africa as one of the locations on the planet most vulnerable to climate change, because it is already hot and dry, a large fraction of the economy is dependent on agriculture and that farming methods remain mainly traditional (Pearce *et al.* 1996; Tol 2002; Mendelsohn and Williams 2004). The livelihoods and welfare of hundreds of millions of Africans depend on how climate change will affect African agriculture.

In Kenya, temperatures have risen by 1°C over the past 50 years (GoK, 2009) and warming is expected to accelerate with temperatures rising by nearly 3°C by 2050 (IPCC, 2007). The recent prolonged and severe droughts in Kenya are widely perceived to be symptomatic of the changing climate (KMD, 2008). In Kenya, episodes of recurrent droughts and associated effects on the landscape and resources are not new. This is a normal but temporary characteristic of the arid and semi-arid areas, rather than an aberration brought about by climate change. However, the drought cycle in most parts of Kenya appears to be contracting sharply. It had been established that rains used to fail every nine or ten years (UNEP/GoK, 2005). The cycle seemed to have reduced to five years (GoK, 2009). Most recently, the country is experiencing droughts every two or three years (according to The Economist on East Africa Drought, 2009).

The UNDP's climate change country profile shows that Kenya's mean annual temperature has increased by 1°C since 1960. This increase has been higher from March to May, and has meant an increase in the number of hot days and hot nights. There has been no statistically significant trend that can be established for the annual precipitation in the country, but an increase in the proportion of rainfall amounts which fall during heavy rainfall events has been noted.

It is important to consider that other factors, such as increasing human population and associated destruction of water catchments and deforestation have also contributed significantly to environmental degradation and the depletion of natural resources base in Kenya. For instance, the increasing frequency of droughts in the Narok area is related to the recent expansion of agricultural land, mainly of large-scale wheat farms in the dry areas, rapid growth of settlements and increased rate of deforestation (mainly conversion of bushlands to smallholder farms, charcoal burning and illegal logging upstream in the Mau forest, which is Kenya's largest water catchment area (UNEP/GoK, 2008). The Laikipia plateau in northern Kenya has also experienced an increasing frequency of droughts, which is related to land-use changes associated with increasing human population and rampant subdivision of that large, fragile ecosystem (drylands) into smaller land parcels for cultivation and settlement. In both cases, the drying-up of rivers and the scorched lands appear to result from a combination of climate change, which has reduced rainfall generally, and the localized destruction of the environment and water catchment areas.

CLIMATE CHANGE PROJECTIONS

Kenya's climate is expected to warm across all seasons during this century. Under a medium emission scenario, the annual mean surface air temperatures are expected to increase between 3°C and 4°C by 2099, which means it will rise at a rate of 1.5 times that of the global average (Boko M. *et al.*, Climate Change 2007). This is expected to lead to overall increase in annual rainfall of around 7 percent over the same period, although this change will not be experienced uniformly across the region or throughout the year. An increase in the total quantity of rainfall does not always capture the impact of rainfall variability (including when, where and how much of the rain falls each time), which has serious implications for the capacity of the population to adapt. Variability of rainfall is expected to increase and warmer temperatures are likely to increase the intensity and frequency of extreme weather events in the region, meaning that many areas in East Africa will be faced with an increased risk of longer dry spells and heavier storms.

These regional trends are largely reflected in the climate projections for Kenya. Mean annual temperatures in the country are expected to increase by 1-2.8°C by the 2060s, and 1.3-4.5°C by the 2090s (IPCC, 2007). This will be accompanied by an increase in mean annual rainfall by up to 48 percent, with the increase in the total rainfall greatest from October to December while the proportional change is largest in January and February. The regional variation within Kenya means that rainfall increases are expected to be concentrated from the Lake Victoria region to the central highlands east of the Rift Valley. For the purpose of this study, it is notable that the eastern and northern arid and semi-arid lands (ASAL) are expected to see an overall decrease in precipitation due to climate change (IPCC, 2007). In addition, rising temperature levels will inevitably lead to higher rates of evapo-transpiration, further reducing the impact of rainfall on soil water for crop growth. There is general scientific consensus that climate change will lead to increased climatic uncertainty, with increasing variation in the weather pattern, mainly between the seasons and years. Increased uncertainty means that, in general, the food production will become less predictable and this will have an adverse effect upon food security (GoK, 2007). The effects of climate change on agriculture are likely to be regionally distinct and spatially heterogeneous, requiring sophisticated understanding of causes and effects, and careful design and dissemination of appropriate responses.

The climate projection for the ASAL of Kenya may include longer and more frequent dry periods interspersed with intense but shorter and unpredictable periods of rainfall.

Such weather patterns are likely to deplete water and pasture resources, leading to natural resource scarcity (GoK, 2007). Communities consulted during our research stated that there has been an increase in extreme weather events (droughts and floods) in the recent years, as well as overall higher temperatures, and increased variability and decline in rainfall amounts. They attributed the widespread degradation of their environment in part to climate change, so they perceive it already to be affecting their livelihoods. This is backed up to some degree by the available meteorological (rainfall and temperature) data, although the availability of such climate data at the local level is limited and therefore not conclusive.

It is the objective of this research to address issues concerning climate change impacts, adaptation and mitigation among the smallholder farmers and rural communities within the drylands and semi-arid areas of Kenya. In particular, the study focuses on two fragile ecosystems of the Laikipia and Narok districts in Kenya. The paper brings to the fore the climate change impacts/risks/vulnerabilities issues within different agro-ecological zones (AEZ) and highlights the adaptation and mitigation strategies practised, focusing on smallholder farmers and food security. Climate change projection models and/or scenarios (through downscaling) at national level for the major agro-ecological zones have also been developed. Scenarios of climate change based on high spatial and temporal resolution information are critical for predictive analysis and the assessment of impacts of climate change on agriculture. The climate change models built propose various scenarios, based on the changing pattern and trends in meteorological (rainfall and temperature) variables. Equally useful is the documentation of existing capacities and research/projects on climate change-related issue. The roles of key agencies/organizations involved in climate risk preparedness in the country at both the national and local levels have also been identified.

BACKGROUND

Kenya, one of the East African countries, lies between latitudes 4° 40'S and 5° 02'N and longitudes 34° and 41° 55'E. It covers an area of approximately 580 367 km^2, of which 567 137 km^2 is land surface and 13 239 km^2 occupied by inland water bodies. Protected areas (parks and reserves) occupy 46 430 km^2. Based on the vegetation characteristics, the amount and reliability of rainfall and land ecological potential, the country can be divided into seven eco-climatic zones (Fig. 1 - right). The high to medium potential areas comprise of eco-climatic zones I - humid, II - sub-humid and III - semi-humid and receive an annual rainfall of more than 800 mm. The marginal or low potential areas comprise of eco-climatic zones IV - semi-humid to semi-arid, V - semi-arid and VI - arid and VII - very arid, and constitute the ASAL or rangelands (Table 1 and Fig. 1 - left). These areas are generally hot and dry, with low and unpredictable rainfall of less than 600 mm per year. The high-medium potential (rainfall) areas or highlands cover almost 20 percent of the total area, supporting arable agriculture and almost 80 percent of the human population.

TABLE 1

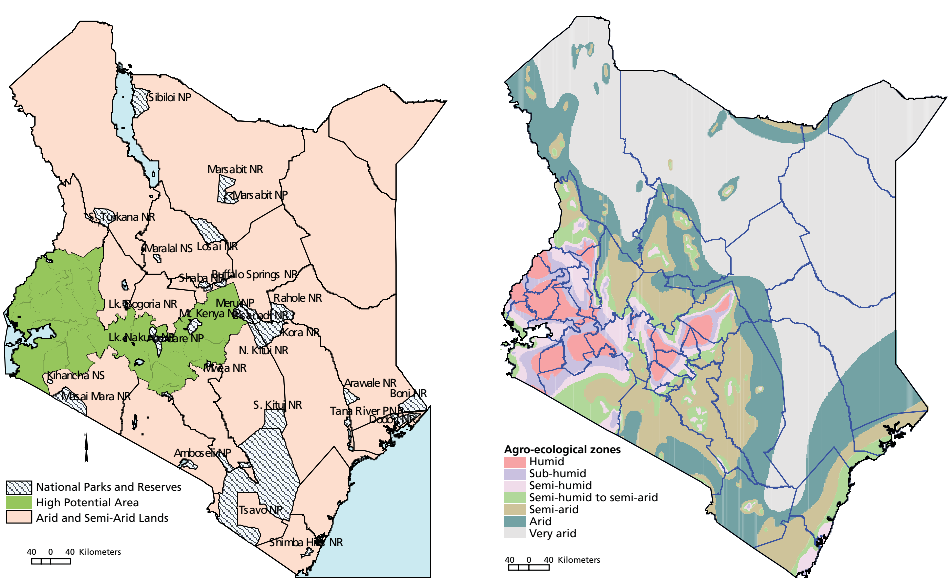
Characteristics of Agro-Ecological Zones (AEZ) in the arid and semi-arid lands (ASAL) of Kenya. *[Sources: Pratt et al., 1966; Woodhead 1970; Sombroek et al., 1982 * Moisture index (Water availability) expressed as percent of the potential evaporation)]*

AEZ	Water (av)	Climate	Annual Rainfall	Vegetation Type	Potential Plant growth	Land use
4	40-50	Semi-humid to semi-arid	600-110	Dry woodland & bushland	Medium	Marginal arable agriculture
5	25-40	Semi-arid	450-900	Bushland	Medium-Low	Livestock & wildlife
6	15-25	Arid	300-550	Bushland & scrubland	Low	Limited nomadism
7	<15	Very arid	150-350	Desert to scrubland	Very low	nomadism

The marginal or low potential (rainfall) area covers almost 80 percent of the total land area, supporting more than 50 percent of the livestock and 80-90 percent of large wildlife population. It is important to note here that over 70 percent of wildlife populations reside outside the protected areas (national parks and game reserves) and occur within the communal lands and private properties. This is a potential source of land-use conflict as a result of crop damage, competition for forage and water resources, livestock predation and disease transmission, which severely affects the smallholder livelihoods, especially during the dry periods.

FIGURE 1

High potential areas in Kenya (shaded green) and the arid and semi-arid lands (ASAL) - shaded purple [Left]. The Agro-ecological zones (AEZ), depicts characteristics closely related to Eco-climatic zones (ECZ) [Right]



The climate pattern in the country is influenced mainly by its position relative to the equator, its proximity to the Indian Ocean and Lake Victoria, varied topography and the El Niño-southern oscillation (ENSO) phenomenon resulting from the interaction between the surface of the ocean and the atmosphere in the tropical pacific. The Inter-Tropical Convergence Zone (ITCZ) is also a major synoptic feature which influences the climate over the country. The influence of the ITCZ is modified by altitudinal differences, giving rise to varied climatic regimes. Rainfall is the prime climatic factor underpinning dynamics of the landscape, but it is highly variable at a hierarchy of temporal scales (Fig. 2). The annual rainfall follows a strong bimodal seasonal pattern and generally the long rains occur between March and May, while the short rains occur between October and December.

Meteorological Disasters (Droughts and Floods) in Kenya

Fifty-seven percent of the population of Kenya live in poverty (WRI, 2004), many reliant on climate-sensitive economic activities including rainfed "subsistence" or "smallholder" agriculture (KNBS, 2008). Although rainfall is the major climate parameter with a high degree of space-time variability, temperature stress is also significant, particularly over the highlands, arid and semi-arid zones and near the large water bodies. The past drought episodes witnessed in 1984, 1990, 1994 and 1999, and the El Niño floods of 1997-98 resulted in huge loss of human lives, livestock and wild animal deaths, loss of plant biodiversity, and the destruction of large crop fields and infrastructural facilities (IPRA, 2004). Although the variability of rainfall pattern and intensity is a common feature in Kenya (Fig 2), due to variations in topography, the spatial and temporal changes in recent years point to the general climate change of the environment.

FIGURE 2

Seasonal variability of climatic condition in Kenya, showing a drastic environmental change over the same period (May) of interval of two years (1998 - El Niño) [Left]) and 2000 drought) [Right]. ***[Source: DRSRS NDVI dekadal plant biomass productivity analysis]***

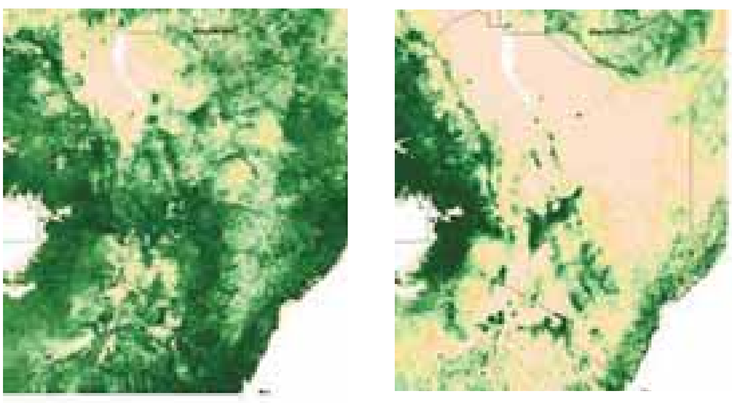


TABLE 2

Summary of drought and extreme rainfall events and the number of people affected in different parts of Kenya from 1970 - 2010

Year	Type of Disaster	Area of Coverage	People affected
2007/2008	Drought	Widespread	9 000 000
2007	Floods	Khuvasali, Kakamega	98
2004/2005	Floods	Budalangi, Nyando	34 000
2003	Floods	Budalangi	28 000
2002	Landslides	Meru, Murang'a, Nandi	2 000
1999/2000	Drought	Widespread	4.4 million
1997/98	*El Niño* Floods	Widespread	1.5 million
1995/96	Drought	ASAL zone	1.41 million
1991/92	Drought	ASAL zone	1.5 million
1985	Floods	Nyando/Western	10 000
1983/84	Drought	Widespread	200 000
1982	Floods	Nyando	4 000
1980	Drought	Widespread	40 000
1977	Drought	Widespread	20 000
1975	Drought	Widespread	16 000
1971	Drought	Widespread	150 000

Sources: DMP, 2009; Kenya Meteorological Department (KMD), 2007

Extreme weather events including higher temperatures and more variable precipitation are already having significant consequences on food security in the country. The 2009 climate change manifestation in Kenya was observed in the overall failure of crop harvest, the large number of wildlife and livestock that were lost due to dehydration and starvation related deaths, low water levels in power generation dams led to power rationing and high tariffs, rampant pastoralist movements with their livestock was evident in urban areas, sacks of charcoal ready for truckloads were widespread along major roads, food prices were high due to lack of commodities, and relief agents were busy distributing food aid to most vulnerable communities, among other coping mechanisms.

The country witnessed serious droughts at least 13 times in the past 50 years. Major floods that periodically afflict the Lake Victoria region, the lower Tana River basin and coastal areas have also occurred at least six times over the same period. Table 2 shows a summary of extreme rainfall events (drought and flood periods) and numbers of people affected in various parts of the country in the recent times. Since the late 1970s, the country witnessed 103 weather-related disasters, of which more than half had occurred after the year 2000. It is important to note that the drought frequency and number of people affected increased sharply from 1992 (Table 2), and from the beginning of 2009, localized floods have been observed to occur in 22 districts of the arid and semi-arid areas, causing the death of human and animals alike, damage to infrastructure as well as the destruction of large crop fields. Prior to this period, only the Kano plains and Budalangi area in western Kenya, and the lower Tana River basin were classified as flood-prone spots.

Agricultural Sector in Kenya

The broad policy objective of the agricultural sector in Kenya is to contribute to the overall national development goals of poverty alleviation and equitable income distribution, food security and elimination of malnutrition, and create employment and generation of income opportunities, foreign exchange earning and import substitution. Contributions to these policy goals will be realized through increased and concerted government support to the farming communities for improved management of the basic, natural and man-made resources necessary for sustainable agricultural development.

Agriculture remains the most important economic activity in the country, although less than 8 percent of the land is used for crop and feed production. Less than 20 percent of the land is suitable for cultivation, out of which only 12 percent is classified as high potential (adequate rainfall) agricultural land and 8 percent is medium potential land. The remaining 80 percent of the country is classified as arid and semi-arid lands (ASAL). Almost 80 percent of the work force in Kenya is engaged in agriculture or food processing. Farming is typically carried out by smallholder producers, who cultivate no more than two hectares (about five acres) using limited technology. These smallholder farms, which are operated by about 3 million families, account for 75 percent of total production. Although there are important large-scale coffee, tea, wheat, sugar, sisal and horticulture plantations, an increasing number of peasant farmers also grow cash crops. Despite the expansion of agricultural export crops as the most important factor in stimulating economic development, most of the agricultural activities are directed towards providing food for domestic consumption.

Realizing the fast growth in Kenya's population, which is expected to reach 40 million by 2010 and given that only 20 percent of the land area is arable, food insecurity, malnutrition and famine constitute a serious threat to socio-economic development of the country. The contribution of agriculture to GDP declined from 37 percent in 1964 to about 22 percent in 2007. Furthermore, the agricultural sector grew on average at a slower pace than overall GDP during the past 30 years. Agricultural potential depends on rainfall, soil characteristics and use of fertilizers, but has been adversely affected by land degradation, inappropriate land-use practices and recently the impacts of climate change. The past agricultural growth has only been impressive as a result of three main factors: expansion in areas under cultivation, albeit to land of more marginal quality which degrades easily; subdivision of large farms into more intensively cultivated small-scale farms; and research training and extension leading to the adoption of high yielding crop and animal varieties. In addition, the agricultural sector has expanded by undergoing two basic changes: acceptance of private land ownership (replacing communal/tribal lands) and cash crop farming, and intensive efforts to expand and upgrade the smallholder production.

Smallholder farming in drylands

Smallholder agriculture is generally used to describe the rural producers who farm using mainly family labour and for whom the farm provides the principal source of income. In Kenya, the smallholder farmers grow most of the maize and produce significant quantities of potatoes, beans, peas, sorghum, cassava, bananas, oilseeds, vegetables, tree fruits, etc. However, these farmers face a number of challenges, including simultaneously increasing food production and preserving the natural resources. This is a vital role in sustaining their livelihood and reducing poverty, especially those residing within the fragile dryland and semi-arid areas.

Conventional agriculture, which often involves intensive tillage, has been shown to cause soil degradation, particularly when practised in areas of marginal productivity. Therefore the smallholder farmers in these areas must embrace such practices such as environmental conservation as an integral part of sustainable agricultural production system in order to improve food insecurity. Conservation agriculture (CA) refers to a range of integrated soil management practices which aim to minimize the negative effects of intensive farming. Practices such as direct sowing, zero or minimum tillage and the establishment of cover crops help to protect organic matter and soil fertility. The only other requirement is high dependency on availability of reliable rainfall for rainfed cultivation or supplementary water for irrigated cropping.

Expansion of agriculture into the arid and semi-arid lands

The fragile drylands and semi-arid areas still remain the least populated areas in Kenya (Fig. 4). However, the recent escalation of population in the country has resulted in high pressure on resource use. The huge demand for agricultural land has forced many people to migrate into the arid and semi-arid lands, taking with them unsustainable farming practices which often accelerate land degradation (Fig. 5). Consequently, this has further complicated the problems associated with smallholder livelihood sustenance and climate change. Land degradation occurs as a result of inappropriate land use or poor land management practices, including use of agrochemicals and tillage methods. Such practices often lead to declining soil fertility, erosion of top soils, siltation of flood plains and dams, unstable hydrological condition and the overall reduction in land productivity.

It is emphasized that no arable land will be available for further expansion in the drylands and semi-arid areas unless proper environmental conservation is placed as an integral part of sustainable production system. The present approach to environmental conservation is directed towards the symptoms of land degradation (gullies, sedimentation and low fertility) but silent on the real causes of the problem (undesirable land use and management practices). Land-use intensification and agricultural diversification, with research and capacity building (training and extension) and participation of the vulnerable farming communities being of critical importance, is the remaining alternative to arable farming in the drylands and semi-arid areas.

FIGURE 3

Human population density distribution between the 1960s and 1990s, showing expansion from the high potential areas (western and central parts of the country) [Left] to the drylands, arid and semi-arid areas (the rest of the country) [Right].

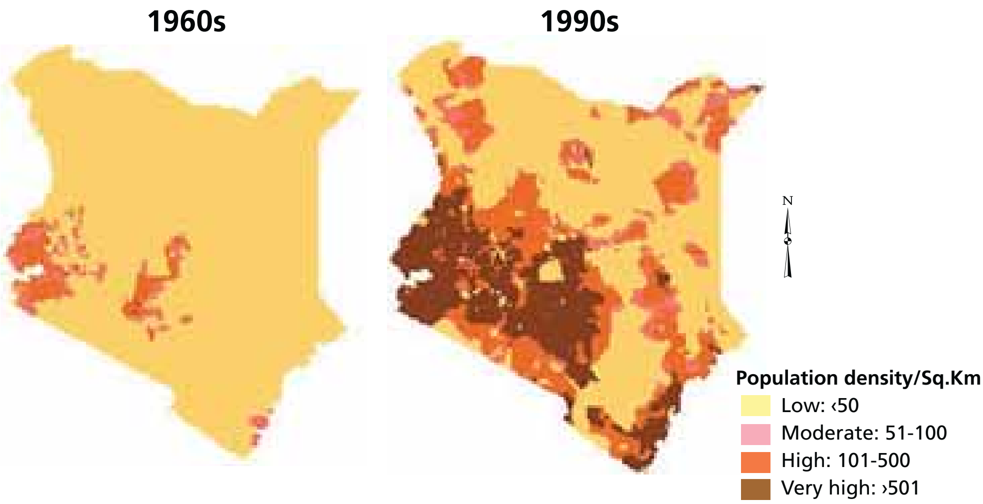
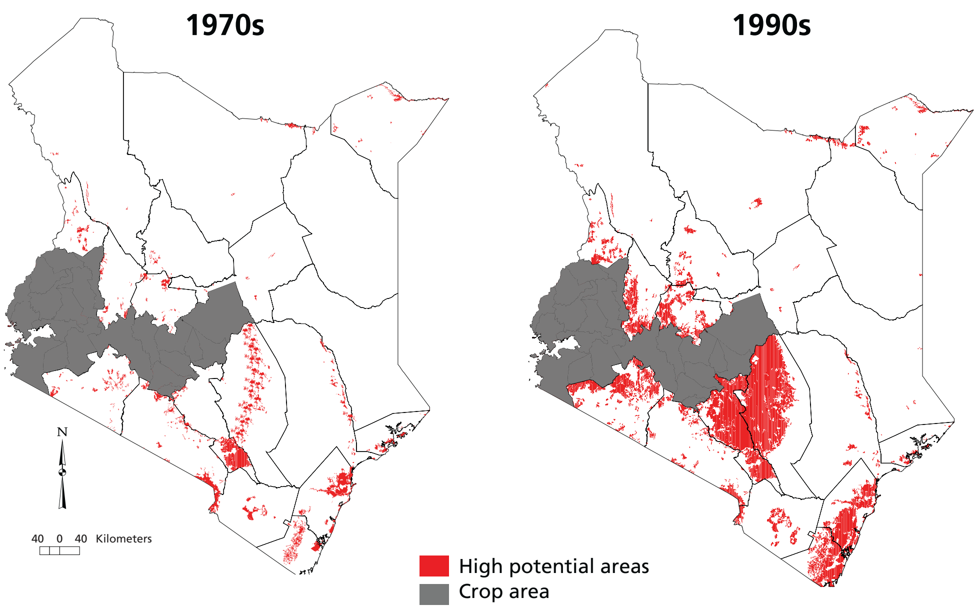


FIGURE 4

Agricultural expansion between 1960s [Left] and 1990s [Right] from high potential (shaded black) to the ASALs zone (shaded white). [Source: DRSRS]



Objectives

The main objectives of the study:

i. Raise the local and community awareness and assess their preparedness towards reduction of risks and impacts of climate change and variability on food production systems, natural resources base (land, water, forest and biodiversity) and the ecosystem integrity at local, agro-ecological and national levels.

ii. Demonstrate on-the-ground adaptation practices and technologies (including ongoing smallholder activities, food security and natural resources management programmes / projects) that stabilize food productivity of vulnerable communities and enhance ecosystem resilience for possible up-scaling, and mainstream proven technologies and best practices for climate change adaptation in most vulnerable regions, while focusing on the agriculture sector.

CHAPTER 2

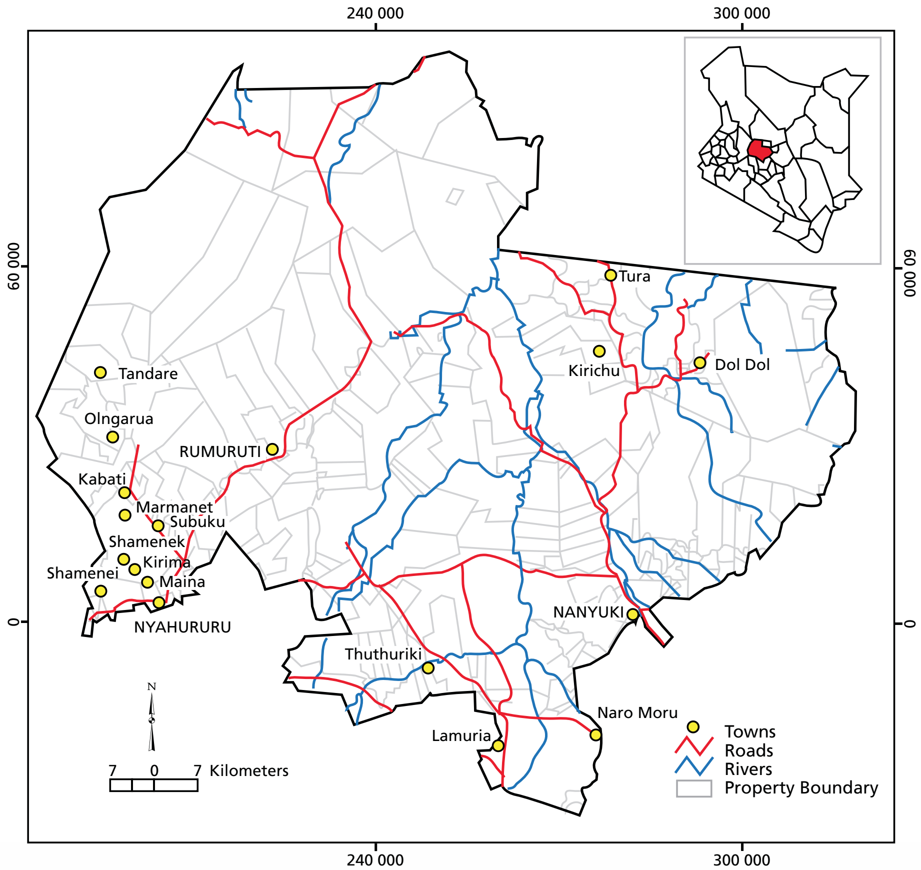
STUDY AREA

LAIKIPIA DISTRICT

The Laikipia district lies between latitudes 0°17'S and 0°45'N and longitudes 36°15'E and 37°20'E, occupying an area of approximately 9,666 km2 (Fig. 6). The district extends from the western foot of Mount Kenya to the north-eastern base of the Aberdare ranges. It stretches widely northwards and descends towards the Rift Valley in the northwest with spectacular complex of fault-line volcanic ridges and escarpments. The altitude ranges between 1 600-2 300 m above sea level on a dryland and semi-arid plateau.

FIGURE 5

Maps showing the location of the Laikipia district, Kenya with property (land parcel) boundary in the background



Human Population

The human population in the district was 322 187 persons based on the 1999 census, which has been projected be 457 663 persons by 2008. The growth rate was 3.9 percent between 1989 and 1999 as compared to the national average of 2.4 percent (Laikipia DDP, 2002-2008). High population growth rate has negative effects on the socio-economic development and aggravated the poverty situation in the district. Increased pressure on available infrastructure and resource use has quite often degenerated into conflicts between the pastoral community, large-scale ranching enterprises, smallholder farmers and wildlife, as a result of the rapid diminishing resources. The effects of recurrent droughts, combined with the low productivity of small and uneconomical land holdings, have no doubt further aggravated the severity of land degradation, with repercussion on the livelihoods of many local communities.

Climate

The climatic influence of high mountains surrounding the semi-arid plateau of Laikipia district produces a steep ecological gradient, giving rise to several eco-climatic regimes, which range from the sub-humid to semi-arid conditions (Berger, 1989). The rainfall increases at higher elevation in the south and weakly tri-modal. The long rains occur in April-May, the continental or middle rains in August and November, and a pronounced dry season in January-March. The average annual rainfall varies from 400 mm to 750 mm across the district, with higher values observed at the foot of both Mt. Kenya and the Aberdare Range.

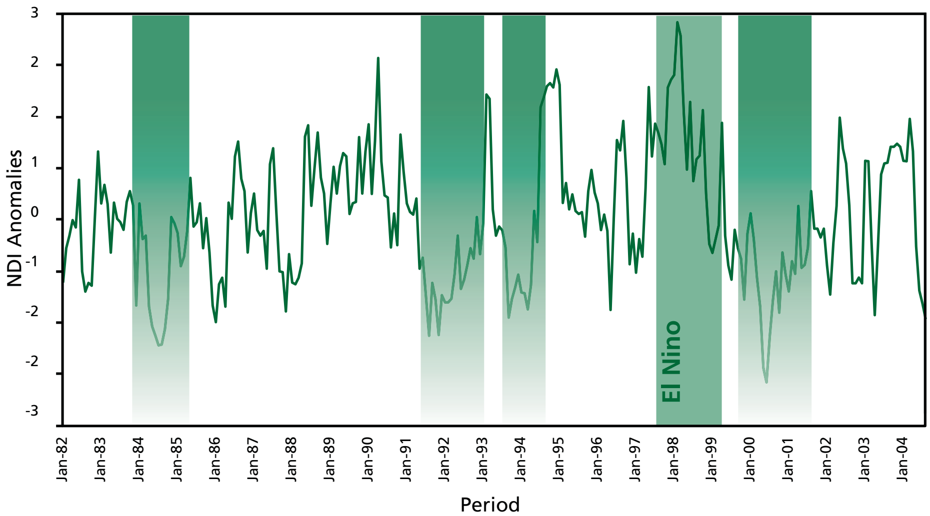
Changes in Environmental Conditions

The evaluation of net primary productivity, as monitored by NOAA-AVHRR, shows both the seasonal and long-term variability of biomass productivity in the Laikipia district (Figure 7). The plant biomass productivity has been variable over the years, after a pronounced drought experienced in 1984, but largely stabilized between the 1988-90, followed by another drought in 1991-92 and 1993. This was followed by remarkably improved climatic conditions, which culminated in very high rains in 1997/98 (El Niño period).

The lowest biomass productivity was observed again in 1999-2000, when a severe drought was witnessed in the entire country. A normal level of environmental variability in terms of weather changes occurred after the 2000 drought, and the latest trend until 2004 indicated an overall improvement. It is hypothesized that improvements in range conditions will consequently improve livestock activities and agricultural production, thus improving the smallholder livelihoods. The recent drought experienced in 2009 in the entire country severely effected agricultural production, wildlife and livestock populations, and natural resources in general. This brought about serious environmental and socio-economic impacts on livelihoods of the smallholders, especially the vulnerable groups that inhabit the drylands and semi-arid areas.

FIGURE 6

Occurrence of drought events in the Laikipia district between 1982 and 2004. Severe environmental stress occurred in 1984, 1991-92, 1993-94 and 1999-2000, while rainfall above normal was observed in 1997-98 (El Niño period). Several intermittent dry spells and abnormal rainfalls have been observed across the years. [Source: NDVI biomass productivity analysis]



Hydrology

Several streams, including Nanyuki, Rongai, Burguret, Segera, Naro Moru, Engare, Moyak and Ngobit, have their catchments in the slopes of Mt. Kenya and Aberdare Range. They drain the uplands and spread widely northwards across the Laikipia plains, then ultimately combine to form two perennial rivers, the Ewaso Ny'iro and Ewaso Narok. The two rivers are confluent in the central "Laikipia plateau" and flow northwards then eastwards through Samburu, Baffalo Springs and Saba National Reserves. The streams that originate within the Laikipia district are seasonal or episodic in flow and their valleys often remain dry for most parts of the year. The two major swamps, Maruca and Ewaso Narok, are found along the major valley of the Ol-Pajeta Ranch and around Rumuruti respectively. Several artificial waterholes or shallow depressions also occur, which are filled by run-off during the rainy seasons and may contain water for many months into the dry season.

Soils

The soils in Laikipia can be grouped on the basis of terrain, agro-ecological zones and potentiality. The red brown sandy clay loam luvisoils are found on the foot-slopes north and south-west of Mt. Kenya and north of Aberdare Ranges. These soils are fertile and suitable for forest and crop production, occurring in part of the Central, Ngarua and Rumuruti Divisions. The reddish clay loam with rock outcrops is found on hills and minor scarps. They are excessively shallow with poor workability and suitable only for sheep and cattle grazing. Dark brown clay loam phaezoms, which occur on low ridges of the plateau, have poor moisture retention and are not suitable for crop production. Dark grey to black clay vertisoils and planosols are concentrated on the plateau. These soils have poor drainage, with limited potential for crop production, but can be suitable for arable agriculture with well- managed irrigation. The ranching zone is found on the plateau and high plains, uplands and dissected erosion plains. Soils on this zone are reddish brown, clay loam, grayish, brown clay, dark brown clay loam, sandy clay loam to sandy clay, and stormy sandy loam with quartz gravel (Nanyuki DAO, 1996).

Land Use

Land use in Laikipia is dictated mainly by the low rainfall amount and unpredictable variability of available water, as epitomized in the great diversity of appearance and resultant impacts on the socio-economic activities in the district. The climatic gradient created by the presence of Mt. Kenya (5 199 m) to the southeast and the Aberdare Highlands (3 999 m) to the southwest is associated with marked change in land cover and land-use activities, from alpine moorlands through the protected montane rain forests and the intensively cultivated moist zone to the relatively dry savanna grassland and bushland at the lower elevations (Taiti, 1992). There are four principal land-use categories, namely commercial livestock ranching that favours wildlife or pro-wildlife properties (500-750 mm annual rainfall), communal lands (400-500 mm annual rainfall), transitional properties (550-900 mm annual rainfall) and forestry. The land-use activities are varied and include large-scale ranching, biodiversity conservation, pastoralism, arable agriculture and forestry.

In the early 1970s, the government initiated the creation of group ranches in an effort to commercialize livestock production in the drylands and semi-arid areas, while assigning the right and responsibilities of land ownership to specified pastoral communities (Langat 1996, Pasha 1986). The introduction of a new land tenure system in the principal wildlife and livestock grazing areas was prompted by the rapid growth in human and livestock population, in combination with the finite range and increasing land degradation (Helland, 1980). Wildlife populations persist in some large-scale (commercial livestock) ranches which incorporated wildlife management objectives within their properties, but have been excluded from small-scale ranches to minimize livestock-wildlife competition. The majority of the large-scale ranches (pro-wildlife enterprises) range from 3 000 ha to more than 100 000 ha and are located along the central strip across the district (towards the north, central plains and southern fringe). As a result of increasing land-use pressure (Kiteme et al., 1998), the government further allowed the subdivision of some large-scale ranches into individual farms with titles. These parcels of land are consequently fenced for subsistence crop cultivation. Traditional pastoralism is also practised mainly in the drier north-east sector (Mukogodo area), which was progressively subdivided into unfenced "group ranches" (2 000-10 800 ha) in the 1970s.

Arable Agriculture

Arable agriculture occupies 26.46 percent of the total area of the district (Ojwang' et al., 2006). Agricultural practice in the region is mainly rainfed herbaceous crops, which occupy

251 263.64 ha (25.99 percent), irrigated herbaceous crops in 4 259.56 ha (0.44 percent) and tree crops in 241.99 (0.03), which are cultivated for subsistence or smallholder needs and as cash crops. In recent years, a large portion of Laikipia has increasingly been converted to smallholder agricultural activities, especially the wetter south-west, south and south-eastern parts of the district. The emerging trend is the desire to subdivide the large-scale group ranches into smaller parcels, which are put under subsistence crop cultivation that only differ in size (1-10 ha) and settlement densities. These land parcels can be referred to as "transitional" properties, because some of the plots have only been occupied and cultivated when the rainfall permits. Elsewhere, large areas exist in varying stages of transition and are often heavily grazed, largely by the pastoralists. The main land use in "transitional" properties is agropastoral, involving both subsistence crop cultivation and cash crop production (mainly rainfed crops including maize, beans, potatoes, sorghum, wheat, barley, fruit trees, and horticulture in the upstream). Domestic animals including cattle, sheep, goats, donkey and poultry are also kept for meat and milk requirements.

NAROK DISTRICT

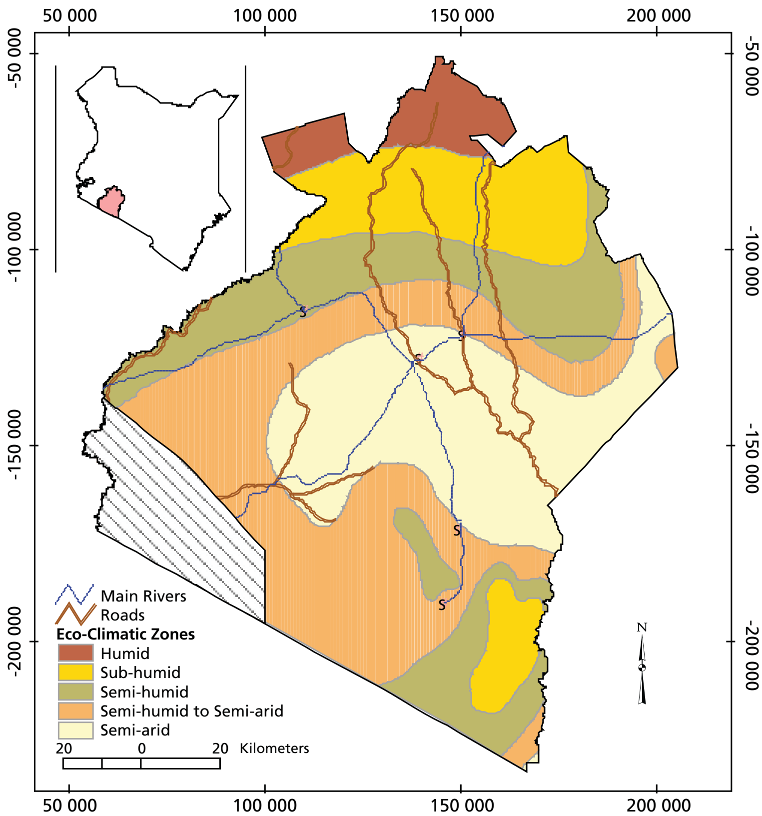
The Narok district is situated in the southwest of Kenya and lies between latitudes 34°45'E and 36°00'E and longitudes 0°45'S and 2°00'S (Fig. 8). The rainfall of the region is partly related to the ITCZ, with local variations in topography playing a major role in the distribution patterns (Brown and Cochem, 1973). Rainfall increases along a gradient from the dry southwest plains (500 mm/yr) to wet northern highlands (2000 mm/yr), with higher rainfall amounts being realized in higher altitude areas including the hills and escarpments.

The district supports one of the richest assemblages of large herbivores in the world, including half a million migratory wildebeest and a host of associated grazers, browsers and predators. The Mara ecosystem forms the dispersal areas for the Serengeti migratory wildlife, due to its high rainfall, permanent water sources and high grassland productivity during the dry season. The area also sustains a large population of livestock.

High human population density in the district is found in the humid, sub-humid and semi-humid zones. These are also the areas associated with high agricultural activities, while the remaining portion of the district is occupied by pastoral activities. The recent change in land use in the district has hampered sustenance of the environment and ecosystems integrity in the region. Between 1985 and 1995, a substantial change occurred in land use, where large tracks of formerly dry season dispersal areas for both wildlife and livestock was converted into agricultural land, mainly for wheat, barley and smallholder agricultural production (Karime 1990, Lamprey 1984, Serneels *et al.*, 2001). The expansion of agricultural land was associated with rampant clearing of forests, bushland and grasslands for fuelwood, timber and settlements that significantly affected the local climatic conditions, and consequently aggravated the impacts of climate change on the livelihoods of communities, which depended on pastoral lifestyle over the years.

FIGURE 7

Location map of the Narok district, showing the Masai Mara National Park - 1 516 km² (shaded in hatch) and eco-climatic zones (background)



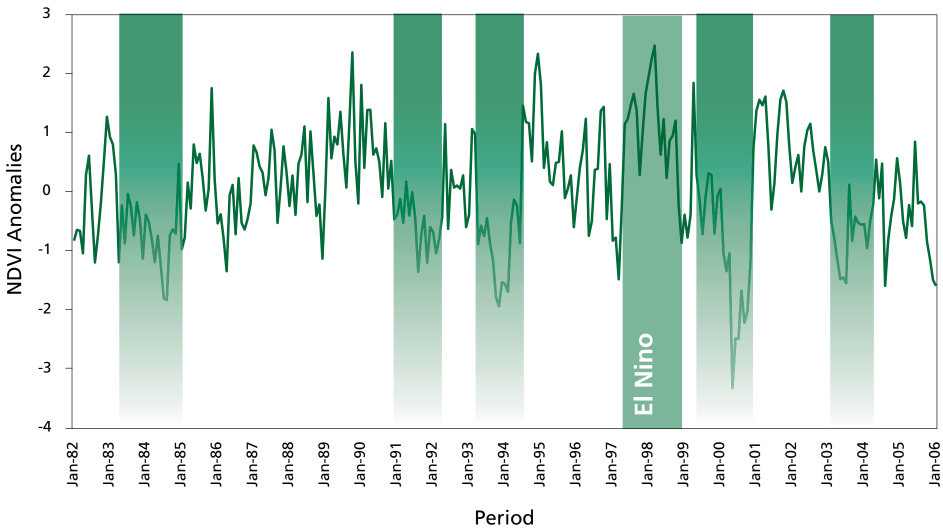
Variability of rainfall in the Narok district (1982 – 2004)

The representation of diverse agro-ecological zones helps in understanding the impacts of climatic variation as it relates to biomass productivity in different parts of the country. Figure 8 shows the NDVI biomass deviation from normal based on historical data in the Narok district between 1982 and 2006. The years in which droughts were persistent is shown by troughs below normal (Zero axis of DVI anomalies). The critical drought years are highlighted in grey shade. The analysis of NDVI anomalies reveals a cyclic recurrence of droughts within the district with major events experienced in 1983-84, 1991, 1993-94, 1999-2000 and 20003 periods.

A severe environmental stress was also observed during the 1997-98 El Niño period, where floods overwhelmed almost the entire country. The 2000 drought indicates the highest negative NDVI anomaly of more than -3, which appeared more severe than previously experienced, however the communities interviewed perceived the 1983-84 drought as the worst, probably due to enhanced coping and adaptation mechanisms that were in place in recent times.

FIGURE 8

Occurrence of drought events in Narok district between 1982 and 2006. Severe environmental stress occurred in 1983-84, 1991, 1993-94, 1999-2000 and 2003, while rainfall above normal was observed towards the end on 1989, 1994 and 1997-98 (El Niño period). Between 1985-1990, a normal seasonal variation in rainfall was observed [Source: NDVI biomass productivity analysis]



CHAPTER 3

METHODS

EVALUATION OF ENVIRONMENTAL CHANGE AND FLUCTUATION IN NET PRIMARY PRODUCTIVITY

Satellite imagery from NOAA AVHRR was used to characterize the climatic fluctuation as it relates to the net primary productivity and to evaluate the inter-annual variations in the vegetation condition. The normalized difference vegetation index (NDVI) anomalies were calculated for the periods between 1982 and 2004 (Fig 7 and 9) using the "z" transform as follows: $Anomaly = ((x_i - \mu)/std)$, where x_i is the NDVI value for a given month in year i, μ is the mean for that month across all the years, and (*std*) is the standard deviation for that month across all the year (Serneels *et al*., 2001; Anyamba *et al*., 2001).

CHARACTERIZATION OF CLIMATE CHANGE VULNERABILITY, RISKS, IMPACTS, COPING AND MITIGATION MANAGEMENT BASED ON QUESTIONNAIRES

Key informants (Government officials including chiefs and sub-chiefs, village elders and smallholder farmers) resident in different agro-ecological zones (AEZ) were randomly selected and interviewed on livelihood activities and climate related issues.

DEVELOPMENT OF CLIMATE CHANGE SCENARIOS/MODELS

The mean annual temperature and rainfall for the different districts collected by the Kenya Meteorological Department (KMD) between 1950 and 2007 were used to develop climate change scenarios based on a combination of moisture availability zones I-VII and temperature zones 1-9 (Table 3). Both the rainfall and temperature data were interpolated from a synoptic point data, resulting in spatial grid data formats. The climate forecasting models used relied on variability of temperatures, at increments of 1ºC and 2ºC.

Many climate models exist that predict future scenario and agriculture outlook. Crop growth models which predict crop performance at specific climatic conditions were employed. The land cover and land-use data derived from Landsat MSS imagery of 1973 and Landsat ETM+ of 2000 was also incorporated into the model to assess the trend of change over time. Fig. 9 shows a simple schematic rainfall-temperature variability model depicting the methods used to develop the future scenarios in agriculture in relation to climate change.

TABLE 3

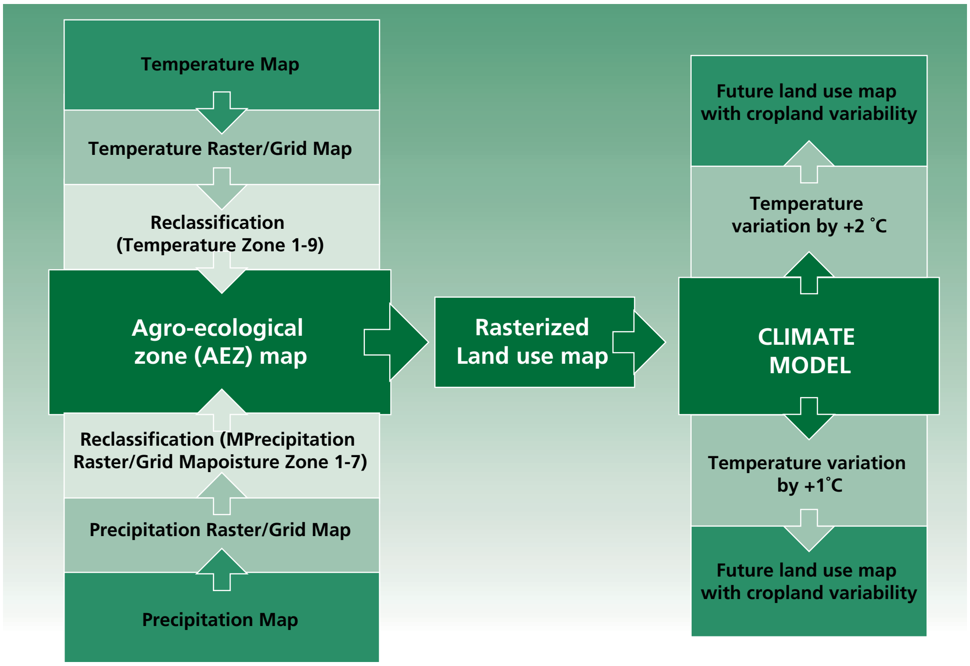
Moisture availability in different eco-climatic zones in Kenya and temperature range scheme

Eco-climatic zone (ECZ)	Moisture Availability (mm)
1 - Humid	>0.80
2 - Sub	0.65 - 0.80
3 - Semi-humid	0.50 - 0.65
4 - Semi-humid to semi-arid	0.40 - 0.50
5 - Semi-arid	0.25 - 0.40
6 - Arid	0.15 - 0.25
7 - Very arid	<0.15

Temperature Zone	Temp Range (°C)
1	24 - 30
2	22 - 24
3	20 - 22
4	18 - 20
5	16 - 18
6	14 - 16
7	*12 - 14
8	*10 - 14
9	‹10

FIGURE 9

Schematic diagram showing prediction of agricultural expansion and climate change



CHAPTER 4

CLIMATE CHANGE TRENDS, IMPACTS/ RISKS/VULNERABILITIES IN KENYA

LOCAL EVENT CHRONOLOGY (DROUGHTS AND FLOODS)

Kenya experiences drought on a cyclic basis. The major ones occur every ten years and the minor ones almost every three to four years. However, in recent years, the frequency of these droughts has increased. The 2009 and 2004 droughts are a replica of the previous cycle of severe droughts that affect the country almost every decade as experienced in 1974, 1984 and 1994. In the past, the country has recorded deficits of food due to drought resulting from a shortfall in rainfall in 1928, 1933-34, 1937, 1939, 1942-44, 1947, 1951, 1952-55, 1957-58, 1984-85, and 1999-2000. The 1983-84 drought and the 1999-2000 ones are recorded as the most severe, resulting in loss of human life and livestock, heavy government expenditure to facilitate response and general high economic losses of unprecedented levels (UNDP, WMO, GOK, IGAD, and DMCN, May 2002). After the El Niño induced rains of 1997 and 1998, Kenya experienced prolonged drought in many areas leading to famine and starvation.

Drought affects mostly Eastern, Coast, North Eastern and parts of Rift Valley provinces of Kenya. The specific districts include Baringo, Laikipia, Turkana, Samburu, Narok and Kajiado in the Rift Valley, Marsabit and Isiolo in Eastern province, Mandera, Garissa and Wajir in North Eastern and the Tana River, Kilifi, Kwale and Taita-taveta in Coast Province. Most of these districts experience dry weather conditions causing pressure on smallholder agriculture, existing pastures and water resources on which the communities depend for livelihood.

TABLE 4

Chronology of drought events in the Laikipia and Narok districts based on information from key informants during the field survey.

Year	Laikipia District	Narok District
2009	Drought (severe), millipedes in highlands	Drought (severe), F&D, Anthrax, diseases
2008	Drought, millipedes in highlands	Drought (mild)
2007	Drought (mild), millipedes	Drought (mild)
2006	Drought	
2005		Drought
2004	Drought	Drought (mild)
2003	Drought	
2002		Drought (mild)
2001	Drought	Drought
2000	Drought (severe)	Drought (severe)
1999	Drought	Drought
1998	El Niño	El Niño
1997	El Niño	El Niño
1996	Drought	Drought
1995	Drought	Drought
1994	Drought	Drought
1992	Drought	Drought
1991	Drought	Drought
1990	Drought	
1989	Drought (mild)	Highland Malaria
1985	Drought	
1984	Drought	Drought, ECF
1982		Drought, ECF
1980	Drought	Drought
1977	Drought	Drought
1975	Drought	Drought
1973	Drought	
1971	Drought	
1968/69		Drought
1962		El Niño
1960/61		Drought

CLIMATE CHANGE RELATED FACTORS, MITIGATION AND COPING MECHANISMS

Climate change is increasing interannual rainfall variability and the frequency of extreme events, leading to accelerated rates of degradation of soil and water resources upon which farming communities depend for their livelihoods. Appropriate response strategies must therefore take account of the expected future impacts to develop more robust and resilient systems for smallholder farmers. Agricultural systems most vulnerable to climate change are those already affected by unsustainable management, and land and resource degradation.

Over the past ten years, the following climate-related factors have drastically changed in the drylands of Kenya, severely affecting the livelihoods of smallholder farmers.

1. The total amount of rainfall per year has significantly decreased in many areas, resulting in inadequate distribution of water and negatively impacts on agriculture and livestock production systems. Water supplies for human and animal consumption are primarily derived from surface and subsurface water. With decreasing rainfall, surface runoff water becomes sparse, and subsurface water is not recharged affecting the local aquifers.
2. Temperatures have become much hotter in almost all the areas.
3. Drought incidence and severity have highly increased.
4. The traditional ability to make accurate weather predictions has become much less accurate, as weather patterns become more variable and the environmental conditions highly unpredictable.
5. The length of the crop-growing period has shortened. Most crops (especially the cereals) mature early, resulting in much lower yields. For instance, in most areas the maize crop tussles much earlier than the required period, while in the highlands, the stalks become short and stout with smaller cobs.
6. The consistency of rainfall is much more variable, due to its unpredictability in space and time, and amounts.
7. Incidences of livestock, crop and human diseases have significantly increased due to the increase in temperatures: for instance, the emergence of previously non-existent highland malaria in certain areas, high levels of East Coast Fever (ECF), anthrax and other crop-related diseases (associated with maize, potatoes, wheat, etc.).
8. Smallholder farmers and rural communities in general have become more food insecure, with rising poverty levels due to the effects of recurrent droughts, floods and rising temperatures, which have led to loss of their livelihoods.
9. Land tenure system adopted in many areas had sorted out most of the land ownership issues, however land disputes often associated with people migrating for opportunity options and encroachments on private properties have increased, especially during the drought periods. Pastoralists are known to traverse vast areas with their livestock in search of grazing pasture during the dry periods, and in the process leave behind a trail of destruction especially damage on smallholder crops and water source.
10. Pastoralists' livestock traverse longer distance in search for fodder and water, especially during the drought periods. For instance, in the Laikipia district, the livestock are moved more than 200 km into the Mt. Kenya forests, the neighbouring districts of Nyandarua, Eldoret, Nakuru and the Aberdares range during the drought, while in Narok, they are trekked to Bomet and the Kericho district, and across the border to the slopes of Mt. Kilimanjaro in Tanzania.

11. Most of the grasslands have either been degraded due to overgrazing or converted to cultivation areas. Fodder availability has therefore decreased considerably.
12. Floristic composition of the vegetation, which is an indicator of habitat quality have highly decreased as large areas of forests, shrub and grasslands have been cleared for bioenergy (charcoal and firewood), building and construction materials (timber, poles, thatch), crop cultivation and settlement.

Coping and Adaptation Mechanisms

Smallholder farmers in marginal environments and/or other areas of high rainfall variability such as the Laikipia and Narok districts have characteristically adopted livelihood strategies which have evolved to reduce the overall vulnerability to climate shocks ("adaptive strategies") and manage their impacts *ex-post* ("coping strategies"). However, the distinction between adaptive and coping strategies is frequently blurred, as what looked like coping strategies in one period may become an adaptation for households or whole communities the following period. In Kenya, the major elements of smallholder farmer adaptation across major agro-ecological zone of the drylands and semi-arid areas include:

1. Allocation of farm labour across the seasons in such ways that follow the unpredictable intra-season rainfall variations or "negotiating the rain".
2. Making use of biodiversity in cultivated crops and wild plants. Small-scale cultivation will involve intercropping of several crops (Fig. 13) or rotational cropping, often practised under rainfed agriculture or irrigation along streams and riverbanks.
3. Integration of livestock keeping into the family farming systems. Although this increases the cost of labour demands, it ensures easy availability of food needs including milk and meat, as well as cash from livestock sale in case of failure of crop system.
4. Diversifying livelihoods - key to preventing negative food availability effects of diversified farming is significant yield increases in food crops, which will offset the reduction in land allocated for the production of these crops. The effect of income from other sources for food purchases must also be consistently strong enough to compensate for the reduced availability of own-produced food.
5. On-farm storage of food and feed involves keeping cereals in family storages during good harvests for use during crop failures.
6. Strategic use of fallow (e.g. alternative grazing area or field left over a period to regain fertility) and/or late planting of legumes crops, when the cereals fail, as a drought response. This practice is mainly common in the rainfed areas (humid and sub-humid zones).
7. Irrigation agriculture – irrigation accounts for the largest consumption of water in the country. Unfortunately most of the water, an estimated 60 percent, is wasted due to poor irrigation practices. Public and private small-scale irrigation is still very small compared to the estimated potential of more than 300 000 ha. Many different technologies and techniques are used for water collection and distribution for small-scale irrigation, including rainwater harvesting, bucket irrigation, gravity-fed

sprinkler and drip, treadle and pedal pumps, rope and washer, motorized pumps, windpower and construction of small earthen dams. In recent years, inexpensive and simple gravity and pump sprinkler systems for horticultural crops have been extremely profitable investments.

8. Reclamation of denuded land through reafforestation and agroforestry practices is crucial for decreasing land degradation and provision of household bioenergy. Trees have an important role in reducing vulnerability, increasing resilience of farming systems and buffering households against climate related risks. Agroforestry systems are ideally placed to provide the additional resilience of agro-ecosystems to future climate change for a number of reasons.

The drought-coping strategies as used by the pastoralists in drylands and semi-arid areas of Kenya, and longer-term adaptations that underlie them are:

1. Mobility is the most important adaptation of pastoralists to spatial and temporal variation in rainfall. During the drought periods, many communities make use of fall-back grazing areas that are unused in "normal" dry seasons, because of distance, land tenure constraints, animal disease problems and resource use conflicts. However, in the recent years, rampant subdivision of communal grazing areas to individual ownership and changes in land use to intensify crop production has severely limited this pastoral mobility. The mobile pastoralists' only desire to settle is to access human services and food aid.
2. Herd accumulation - most evidence suggests that engagement in keeping a large number of livestock in the drylands is a rational form of insurance against period of severe environmental stress such as drought. There is evidence that they would sell more stock if markets were more efficient, however there is a considerable debate on the extent to which the pastoralists cope by systematically selling livestock during or onset of drought and why they might not do this.
3. Livelihood diversification away from livestock keeping predominantly takes the form of shifts into low-income or environmentally unsustainable occupation such as charcoal production. Although there is no quantitative information showing the extent to which forests are affected by droughts, qualitative observations in different parts of the country indicate the drought negatively impacts. As a result of the collapse of farming and livestock activities due to droughts, charcoal burning for commercial purposes increased, especially in the ASAL areas where land tenure is communal. Sacks of charcoal by truckload and at the roadside were a common sight. However, charcoal burning is a threat to forests through potential loss of biodiversity, rather than an adaptive strategy to reduce ex-ante vulnerability.
4. Pastoralists classically keep multispecies herds (cattle, sheep and goats, donkeys, camels) to take advantage of different ecological niches and labour of men, women, and children. Shifts in the balance of species can occur as responses to climate variability and changes in the environment, market conditions and availability of labour. For instance, the Maasai pastoralists are known to shift to the keeping of more sheep and goats during the dry periods, but will increase their cattle numbers during the onset of the rains.

5. A small proportion of the pastoralists are now holding some wealth in bank accounts, while others use informal savings and credit mechanisms.
6. Supplementary feed for livestock - livestock keepers turn to the forest in search of fodder. In dry areas, some forests have been left bare with no undergrowth as a result of overgrazing. Fodder traders and livestock keepers have exacerbated the situation by lopping tree branches for livestock during the dry periods. This has seriously affected the quality of forests in terms of biodiversity loss and water source retention.
7. Intensification of animal disease management - livestock keepers use a combination of indigenous and scientific techniques (dipping and veterinary drugs) as a method of maintaining their stock in case of disease outbreaks. However, due to high poverty levels in most rural communities, many livestock keepers cannot afford the expensive modern veterinary services.
8. Due to diminished grazing range as a result of loss of former communal dry season grazing areas (changing land tenure and land use activities), livestock keepers are increasingly paying for water from boreholes as well as pasture grazing time on private lands.

RISK PROFILE

Promoting climate change-responsive risk management requires mainstreaming climate factors into improvement of livelihoods to prevent major impacts of climate-related hazards and to promote effective responses to the impacts. However, the tools (knowledge, awareness, policy, funds) are not widely accessible. There is a need for more focused and action-oriented public commitment, particularly the political, societal, science and technology leadership. Climate change adaptation is a public good providing benefits shared by all, and therefore the governments have the main responsibility to lead and provide support for adaptation responses by all segments of the society. A key instrument of public support is a national framework for mainstreaming climate change adaptation. This should specify the main strategic approaches to disaster reduction, and to reduce vulnerability through pertinent and feasible adaptation measures. Also crucial is epitomizing enabling environments that promote the strengthening of climate change adaptation measures and create opportunities for livelihood sustenance.

Risk Mitigation and Coping Strategies

Climate is important for development and livelihood substance, but natural climate fluctuations from autonomous climate cycles (such as those linked to drought and flood) disrupt ecological, economic and social systems. Although human factors have also affected the local climate pattern, together with natural climate variability, the long-term climate changes are already showing clear impacts on agricultural production and ecosystems integrity.

TABLE 5

Types of risks and prevention measures among smallholder farmers in drylands

Risk Type	Prevention
1. Drought	Adequate food policy; Construction of dams, wells, boreholes; Crop/livestock insurance scheme; Adoption and implementation of modern farming techniques; Political will.
2. Food	Sustainable land use management (conservation agriculture, irrigation, etc.); Adequate Early Warning Systems; Adoption and implementation of modern farming techniques.
3. Land dispute	Implement proper land tenure system; Sustainable land use management.
4. Loss and/or theft of key assets	Adequate security; Poverty eradication.
5. Food insecurity	Awareness creation to reduced post-harvest losses; Improved food storage; Modern farming techniques; Provision of government subsidies.
6. Crop failure or poor harvest	Improved farming methods; Conservation agriculture; Improved seeds and judicious application of fertilizers; Drip or other supplementary irrigation methods.
7. Shortage of water for domestic and livestock	Construction of dams, boreholes and wells provision of piped water, improvement of water harvesting techniques; Conservation of water catchments.
8. Low prices for animals	Sale of livestock before onset of droughts; Improved animal husbandry.
9. Insufficient pasture for livestock	- Improved range management; - Subsidized supplementary feeds.
10. Shortage of land for cultivation	- Conservation agriculture, intensive land management.

Climate change will modify risk characteristics through: (a) increased frequency and intensity of extreme climatic events, such as drought and flood; (b) occurrence of hazards (such as malaria and other diseases) in areas previously free from their impacts, and (c) increased vulnerability as climate-induced hazards exacerbate underlying risk conditions.

TABLE 6

Risks mitigation and coping strategies among smallholder farmers in the drylands

Risk Mitigation	Risk Coping Strategies
1. Sustainable land management, especially increasing soil organic content by agroforestry, conservation agriculture, etc.	Relying on savings.
2. Investment in social capital (joining community groups).	Credit from banks or microfinance institutions.
3. Change mix of livestock to exploit a variety of forage (vegetation).	Food sharing, gifts, credits from relatives or friends.
4. Livestock dipping and/or vaccination.	Reduction in household food consumption; frequency of daily food consumption, quality, order of food sharing.
5. Alternative income sources.	Seeking alternative income opportunity including employment.
6. Application of fertilizers (chemical and natural).	
7. Giving out livestock to relations for care-taking.	Sale of livestock or other assets.
8. Acquisition of drought tolerant livestock species and/or breeds.	Consumption of wild plant and animal species.
9. Provision of supplementary feed to livestock.	Change of livestock grazing itinerary (moving far in search of forage and water).
10. Encouragement of pure pastoralists to practise crop cultivation.	Migration to urban or other areas unaffected by the drought.
11. Expansion of cultivated land for agropastoralist use.	Food for work or cash for work programme from community organizations or NGOs.
12. Irrigation agriculture where water is available.	Additional responsibilities for women.

Livelihoods activities with the greatest risk across the main agro-ecological zones

The impacts of climate change on household food security will vary across agro-ecological zones. While the drylands (arid and semi-arid areas) are predominantly inhabited by pastoralist and agropastoralists, the livelihood makeup for each group varies from place to place, and includes the sub-humid zone which is inhabited by agriculturists. Each zone offers distinct threats and opportunities for livelihood sustenance and development, reflecting different agro-ecological conditions. In our study, two livelihood activities with the greatest risks across the agro-ecological zones were free ranging livestock keeping and rainfed agriculture.

In the arid zone, characterized by low moisture availability and lack of vegetation cover owing to a combination of low annual rainfall (300-550 mm) and high potential evapo-transpiration rates, the pastoral systems based on communal grazing (dominant farming system) is highly threatened by climate change as the inhabitants dependent on trade of their free ranging livestock and market access to purchase food stuffs. Other pastoral groups including the Maasai, Samburu and Turkana also still depend on milk from household's own cattle as source of calorie intake, as well as meat and blood which form a considerable proportion of the diet. In addition to the obvious economic concerns, when a market for their animals is not present or access is blocked, the pastoralists' overall food security is at risk. Other factors including animal health, the distribution and amounts of rainfall received, and overall status of the environment will play a key role in the success or failure of livelihood activities and the overall quality of life.

The semi-arid zone receives 450-900 mm of rainfall annually and typically inhabited by agropastoralists who make their livelihoods out of drought-tolerant crops production and livestock rearing. The rain comes over two periods (bi-model distribution) and the crop growing period is 3-6 months. Crop production is mainly for subsistence purposes, except a few cash crops including fruit trees, cotton, etc.). While the agropastoralists rely on markets for cereals and other products not produced domestically, they have greater flexibility in the sale of their livestock compared with occupants of the arid zone. Given the poor soils and limited precipitation, crop production (apart from cash crops) is undertaken for subsistence, with few resources devoted to livestock production, except in areas with good access to markets. Rainfall is expected to become more variable and introduction of new livestock diseases may occur with climate change. The agricultural aspect of livelihoods will be challenged in a similar way as populations in the sub-humid zone. In order to realize the potential of this zone, especially in areas with good market access, investments should focus on extension, education, and credit in beef production, milk production, and improved marketing and health facilities.

The semi-arid-sub-humid and sub-humid zones consist of mixed crop-livestock farming systems. The smallholder subsistence agriculture, largely dependent on rainfed cultivation is predominantly the livelihood activity. A wide array of food and forage crops are grown including maize, millet, sorghum, cassava, yam, cowpeas and leguminous forages. While the pastoral and agropastoral livelihoods are based in some part by herding and breeding of livestock, the agricultural communities are fully dependent on the environment for production of the majority of food they consume. With the increasing change in the climate, the amount of rain and soil moisture availability will most likely decrease. The heat stress on crops and increased pest, disease and weeds will also be prevalent. These changes will result in reduced yields and increased overall volatility. The livestock will be affected similarly as the arid zones.

Livelihood with greatest opportunity

Communities inhabiting the drylands are the most vulnerable to impacts of climate change and the implications are significant. With the projected impacts of climate change, including on ecosystems, water availability, agriculture, and pastoralism on the whole, the practical adaptation measures must include policies that build the resilience of communities to climate change. Without adaptation efforts to the threats of changes in climate, the people of the drylands may be forced to consider other livelihood options, including migration, in order to cope with the extreme changes. In identifying adaptation strategies and activities, the means to food security in every community will vary from place to place. Household food security will be a function of what activities make up their livelihood and each agro-ecological zone has separate challenges to maintaining food security in the light of climate change. The following livelihood activities were identified as having the greatest opportunity to rural communities of the dry lands:

a) Modern farming techniques;
b) Conservation agriculture;
c) Agroforestry;
d) Poultry keeping;
e) Dairy goat farming;
f) Zero grazing;
g) Greenhouse and horticulture;
h) Irrigation agriculture;
i) Food marketing;
j) Livestock marketing.

CLIMATE CHANGE SCENARIOS BASED ON AGRO-LIVELIHOODS IN DRYLANDS

Agroclimatic classification systems have evolved from empirical descriptions based on raw climate data into systems based either on estimates of the length of growing periods, or agronomic models that describe plant responses to light, temperature and moisture. Today, satellite imagery and field data are used to improve the goodness of fit of these different zonation schemes. Estimates of the regional distribution of domestic livestock and livestock commodities, including crop distribution information have evolved from annual datasets generated at the national level (Schmidt, 1984). The inclusion of moisture and temperature decreases and/or increases for use in agronomic models helps to guide and define adaptation and mitigation strategies.

Opportunities for adaptation and mitigation of smallholder farmers to improve the crop productivity, sustainability and viability based on existing farming systems are often specific to particular eco-climatic (and agro-ecological) zones. The advent of new technologies such as remote sensing and geographic information systems (GIS) are powerful tools for facilitating this process. The collection of land use, crop and livestock density data complemented by local data at the subnational level, such as mean rainfall and temperature, are useful defining new and more relevant zonation in the wake of climatic variability. Already, rainfall and temperature data are being used to delineate farming systems. GIS systems to link this information to satellite imagery and the outputs of agronomic models enables better definition of exploitation levels and areas of agro-ecological vulnerability.

SEASONAL VARIATIONS OF RAINFALL AND TEMPERATURE

In general, the spatial and temporal pattern of climate over Kenya is quite variable, partly due to the existing complex landforms and several large inland water bodies, including the

Lake Victoria basin. The mean annual rainfall in the country shows a wide spatial variation, ranging from 200 mm in the driest areas to 1 200-2 500 mm in wetter areas bordering the Lake Victoria and central highlands east of the Rift Valley.

Rainfall is the major climate parameter with the highest degree of spatial and temporal variability in the Narok and Laikipia districts. However, Narok has one seasonal rainfall peak, receiving the highest amount of precipitation in December - March, when the rest of the country is experiencing a dry spell (Fig. 10a). The Laikipia district on the other hand, has two seasonal rainfall peaks: March - May and October - November (Fig. 10b) as in the rest of the country, which is mainly associated with the passage of the ITCZ. The spatial distributions of precipitation indicate low rainfall reliability. Most of the areas in the Narok and Laikipia districts are characterized by a high incidence of droughts. Trends in the distribution annual rainfall variability and temperature in the two districts from 1950s to the present indicates a considerable variation in the mean annual rainfall with an overall decline, and appreciable change in mean annual temperature throughout the years (Fig. 11a and b). Future climate changes in these districts are likely to be reflected in the changes in space-time patterns of one or more of the climate-controlling systems, namely the seasonal northward and southward movement of the ITCZ.

FIGURE 10(a)

The trends in mean monthly rainfall and temperature variation in Narok district shows one seasonal rainfall peak from December to March, with high mean temperatures from October to February

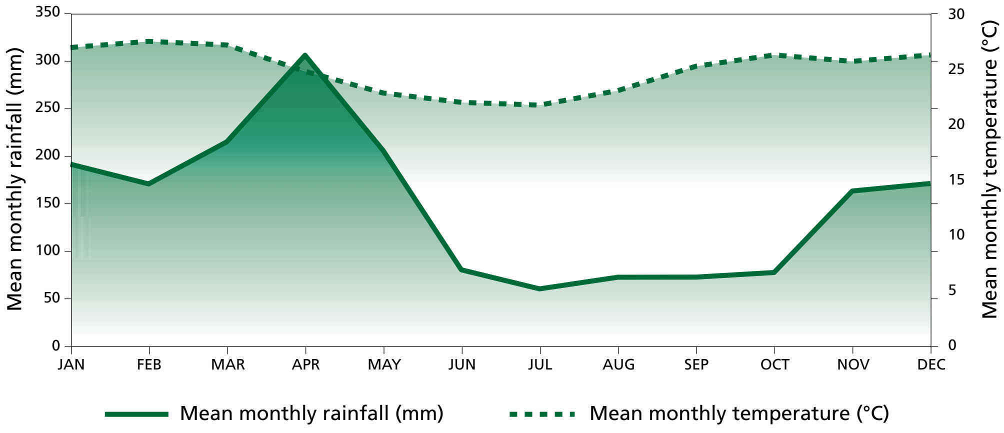


FIGURE 10(b)

The trends in mean monthly rainfall and temperature variations in the Laikipia district show two seasonal rainfall peaks from March to May and October to November, while high mean temperatures observed in January, February and September

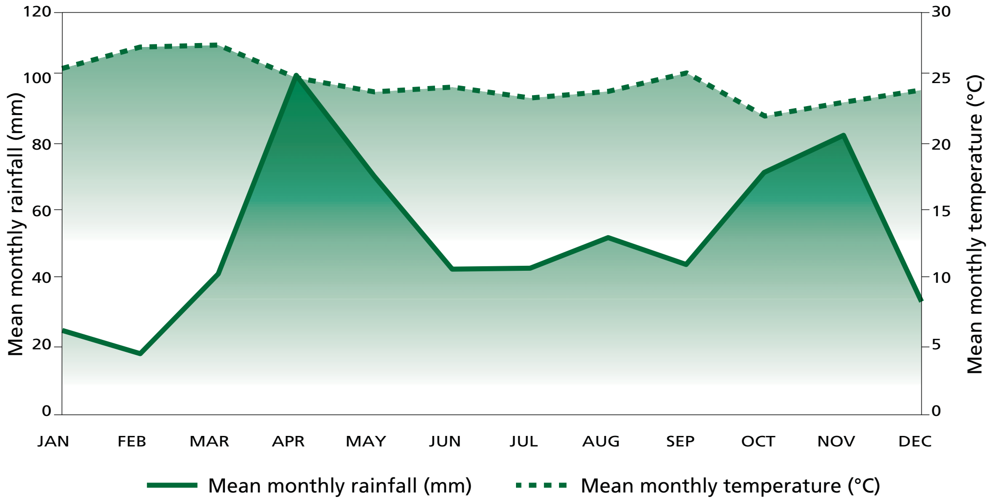


FIGURE 11(a)

Trends in the mean annual rainfall and temperature variations in Narok district between 1950 and 2008 shows an overall long-term decline in rainfall amounts and appreciably rising temperatures.

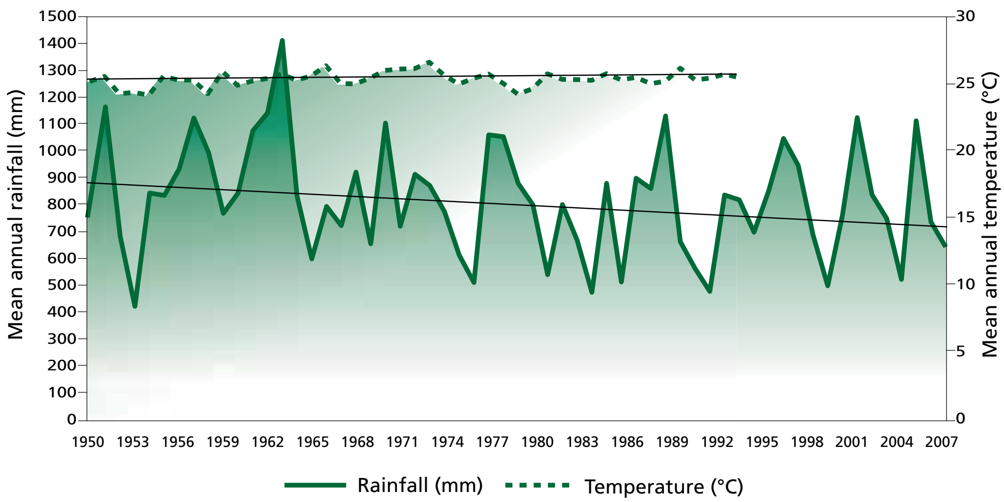
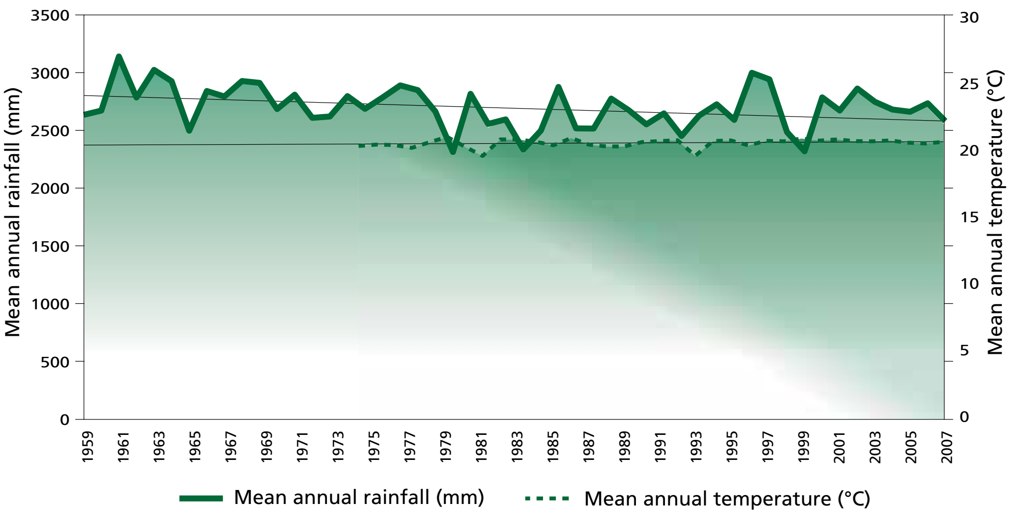


FIGURE 11(b)

Trends in mean annual rainfall and temperature variations in the Laikipia district between 1959 and 2007 shows a slight decline in rainfall amounts and appreciably rising temperatures.



EARLY WARNING SYSTEMS (EWS)

Key to planning and implementing effective climate change adaptation measures are identification, assessment, monitoring and warning on climate change and its effects on the environment and livelihoods. Climate risk screening and assessment tools provide critical information at various levels. In general, modeling climate risk management requires adequate information on climate patterns and hazard, and vulnerability assessment. For sound decision-making in mainstreaming, climate screening tools are required to assess several issues, including the extent, probability and effect of climate change-related damage and losses based on scenarios of future climate change, population growth and other factors, the determinants of adaptive capacity, and the viability of adaptation options.

Although Kenya has put in place climate monitoring systems, the country's capacity for climate change is limited by inadequate data, the relatively short duration of available climate records and/or missing values in the records, as well as changes in instrument types, routines, etc. These problems make it difficult to detect and attribute climate change signals (climate change detection and attribution are mostly based on statistical analyses of past trends in rainfall, temperature, stream flow, lake levels, mountain glaciers, paleo-climatological records and variability in biomass production).

Effective decision-making in mainstreaming adaptation requires relevant and adequate climate information on several other issues, including the local and regional climate patterns. The government, scientific community, development assistance agencies and other role players should therefore make concerted efforts to increase the availability of adequate information on climate change processes, effects and adaptation options in order to create value for all segments of the society, and economic, social and development opportunities.

TRADITIONAL KNOWLEDGE

For thousands of years, Early Warning Systems (EWS) have been existent. In the African setup, there have been various traditional ways in which prediction of future events can be foretold. For example, an occurrence of a certain phenomena (biological, climatic or socio-economic) heralds the anticipation of an event. The use of these indicators in response to EWS ranges from the simplest traditional methods to more complex scientific methods. However, in all cases, these methods cannot reliably forecast an event per se due to the unpredictable nature of certain phenomena. Some techniques used today in predicting hazards are just a modification of the former ones. The following methods were used and are still practised in some areas.

i. Traditional Indicators

In sub-Saharan Africa, especially the pastoral areas, the elders read the intestines of slaughtered small stock (goats and sheep) to forecast the forthcoming drought. The use of such knowledge triggers movement of pastoralists with their livestock to areas of low risks. Alternatively, observations arising from change in animal behaviour (including wildlife, birds and livestock) may indicator an on-coming event (rains, drought, prolonged famine, etc.). These may be a warning for the people to store enough food, brace for sickness or perhaps trigger movement.

ii. Nutritional Indicators

Observation arising from malnutrition is an indicator of stress. Children are usually the vulnerable group under this condition and observed to show exhaustion. This method is popular in monitoring the dietary balance in the ASAL and acts as a warning to relief agencies to donate food or simply signify deficiencies in food supply during the prevailing season.

iii. Weather and Climate Indicators

The most common method used in traditional forecast is observation of weather and climate indicators. This relies on the change in weather patterns. For example, a change in wind direction or formation of dark clouds is a precursor to the coming of rains. This acts as a warning to trigger land preparation or movement/migration to certain areas for anticipated good pasture. In some instances, the elders are capable of predicting the onset of rains from simple astrological observations, while certain pastoral groups rely on the phenological change taking place on certain vegetation. In the drylands the flowering of certain Acacia species heralds the end of a dry season, while increased variability in temperatures, shortage of well water or drying up of riverbeds symbolizes drought resurgence.

These traditional methods are still in use at local levels and circulate amongst small communities. The indicators are not quantified on any scale, hence comparisons between the years or amongst different communities is not possible. In addition, this information is normally subjective, the events/indicators are never recorded and no institutional or communication mechanism is available for its transmission and exchange. The past severe hazards may be remembered verbally by an incident or nickname since certain decisions were made on the best responses.

CLIMATE CHANGE SCENARIOS/MODELS

Climate modeling and scenario building are important for the prediction and analysis of future challenges. First, however, an understanding of local impacts of climate change is paramount. There are uncertainties involved in scaling up local climate model output to produce the high spatial resolutions needed for effective adaptation work at regional and national levels. Substantiating the local effects of the long-term change in smallholder farming requires key agro-ecologically defined regional sites. Secondly, a significant gap exists between the seasonal information and climate change in the long run (2030 and beyond). This presents a critical problem, as time-scale is vital for vulnerability assessment and agricultural planning. Thirdly, convincingly communicating the results from modeling scenarios to decision-makers, including farmers and policy-makers, is a most significant challenge. Scenarios integrating possible socio-economic (and climate) futures therefore will be central to exploring and communicating adaptation and mitigation approaches. There must be a long-term approach to building knowledge and capacity at the local scale for effective responses to occur.

The future scenario prediction of cropland practice in the Laikipia and Narok districts revealed a decline of 94 percent and 46.3 percent respectively by 2030 (Table 7 and 8), if the prevailing climatic variability persists. The decline will also affect other land use categories including forestry by more than 67 percent. The spatial distribution of crops will be limited to zones with moderate moisture, although with reduced length of growing season due to temperature rise.

TABLE 7

Land cover / land use change in the Narok district between 1970s and 2000s and the projected 2030 scenario by, depicts a substantial change, and further future change

Category	Total Area (Ha)		%Change	% Change
	1970s	2000s	(1970s2000s) (Ha)	2030 (Ha)
Woodland	444079	49231	-88.9	Substantial
Shrubland	374202	785890	52.4	53.0
Bareland	59242	804	-98.6	-
Cropland	42388	328104	87.1	94.0
Close Natural Forest	390871	189050	-51.6	-60.2
Open Natural Forest	-	103174	100.0	100.0
Grassland	201223	55752	-72.3	-74.3
Total (Ha)	1512005	1512005		

TABLE 8

Land cover / land use change in the Laikipia district and projected scenario by 2030, depicting a substantial change between the 1970s and 2000s, and further future change.

Category	Total Area (Ha)		%Change (1970s-2000s) (Ha)	% Chang 2030 (Ha)
	1970s	2000s		
Woodland	366,004	317,892	-15.1	16.8
Shrubland	212,794	401,251	46.9	-49.1
Swamp	7,384	752	-89.8	Dry
Cropland	37,390	63,990	41.6	-46.3
Forest	306,788	137,712	-55.1	66.8
Grassland	-	7,588	100.0	-
Total (Ha)	930,361	929,185		

CHAPTER 5

THE ROLE OF KEY AGENCY/ORGANIZATION IN CLIMATE CHANGE ADAPTATION, VULNERABILITIES/ RISKS AND COPING MECHANISMS

Kenya has numerous institutions addressing issues of climate change, although usually on a sectoral basis depending on the interest and mandate of the institution. Key players range from community based (mainly involved in environmental activities and food security issues), the private sector, local non-governmental organizations and government ministries and agencies, to international organizations. However, the roles and degrees of involvement vary, and interaction is limited, often based on a sectoral basis.

At present, there is no single institution that deals with climate change issues across the sectors. Further more, there has been little or no coordination among the institutions that have attempted to address the adverse impacts of phenomena such as recurrent droughts and floods, rising temperature changes and environmental degradation. In most cases, actions have been rather ad hoc, especially when there is a crisis.

Success in meeting the challenges associated with climate change issues require a steady stream of technical and institutional innovation in risk preparedness at the national and local levels. Of particular importance is ensuring that the adaptation strategies are consistent with efforts to safeguard the food security of the most vulnerable people (mainly the rural communities living in drylands and semi-arid areas) and maintain ecosystem services, including initiating mitigation strategies that provide carbon sequestration and offsets under sustainable land management. Already, the increasing land competition between bioenergy and food crops, the climate extremes or its unpredictable variability, and increased population with rapidly shifting diets, has brought about a serious instability of the food production systems. The poor rural communities and smallholder farmers, especially those located within the arid and semi-arid lands (ASAL) are particularly vulnerable to further increase in these pressures.

KENYA'S CLIMATE CHANGE CAPACITY: MONITORING, REPORTING AND VERIFICATION (MRV)

TABLE 9

Kenya's climate change capacity in monitoring, reporting and verification (MRV)

Data Type	Description	Data Availability		Responsible Institution
		Paper	Digital	
Climate change inventory (Meteorology - rainfall and temperature)	Climate	Y	Y	KMD
Land-use evaluation and planning (crops and grazing land management, re-vegetation)	Agriculture	Y	Y	DRSRS MoA, KARI, FAO, UNEP
	Woodland	Y	Y	DRSRS, KFS, KWS, LWF
	Grassland	Y	Y	DRSRS, KFS, KWS, LWF
	Wetland	Y	Y	KWS, DRSRS, NMK
	Soils	Y	Y	KARI, KSS
Stakeholder role in climate change inventory, agricultural planning and soil management	Climate change monitoring and inventory	Y	Y	KMD, FAO, UNEP, MEMR, KFS, CETRAD
	Agriculture (crops, livestock, soils)	Y	Y	FAO, DRSRS, KARI, MoA, MoL&F
	Natural ecosystems (woodland, grassland, wetland, rangeland)	Y	Y	DRSRS, KWS, NMK, IUCN, AWF, WWF, ACC
Others	Energy	Y	Y	MoE, KFS

N = Not available; P = partially available; and Y = Available

TABLE 10

Climate change stakeholder landscape (including science) in Kenya

Name of Actor/ Institution	Type	Operation Area	Description of Work	Leading Expert(s) and Contacts
Ministry of Environment & Mineral Resources	GoK	Policy and Coordination	- Coordination of climate change activities. Houses the national focal point for climate change activities - Coordination of the activities of National Climate Change Coordination Committee	Dr Alice Kaudia Box 30260, Nairobi Email: environmentsecretary@environment.go.ke Phone:2730808
Ministry of Forestry & Wildlife	GoK	Policy	Policy guidance on forestry and wildlife development and management.	Mr J. Gathaara Forest/Wildlife Secretary,
Ministry of Energy	GoK	Policy and Development	Provision of policy guidance on energy development and use. Also involved in the development of CDM activities in the power sector.	Mr Erick N. Akosti Director (Ag) nyalwali@yahoo.co Phone: 0721367601
Ministry of Agriculture	GoK	Policy and Development	Policy development and implementation in agriculture sector (including climate change adaptation and mitigation measures).	Ms Esther Magambo ekmagambo@yahoo.co.uk

Ministry of Industrialization	GoK	Policy and Development	GHG inventory from industries	Mr Gregory Munyao gmunyao2000@yahoo.com Phone: 0722749770
National Environmental Management Authority	GoK	Policy and Coordination	- National authority on CDM - Coordinate the development of regulations and guidelines to support implementation of mitigation activities - Coordinate the preparation of reports to UNFCCC	Dr Muusya Mwinzi Director General, Box`67839 - 00200 dgnema@swiftkenya.com Phone: 605522
Kenya Meteorological Department	GoK	Research, Information and Education	- Weather monitoring - Weather forecasting - Climate prediction - Early warning - Climate advisory - Food security - Climate change detection	Director Dr Mukabana or Dr S. Marigi director@meteo.go.ke, drmarigi_samwel@yahoo.co.uk
Kenya Forest Service	GoK	Research, Development and Education	- Implementation of forest policy - Coordination of development and promotion of forestry projects related to climate change mitigation. - REDD activities	Mr Alfred N. Gichu Kenya Forest Service P.O. Box 30513-00100 Nairobi Tel:0722-787403 Email: alfredgichu@yahoo.com
Department of Resource Surveys and Remote Sensing	GoK	Development	- Collection, analysis, storage, archiving, updating and dissemination of geo-spatial information on natural resources. - Leadership in geospatial information for emission levels and report to UNFCCC	Mr Jaspat Agatsiva, Director, Box 47146 – 00100, Nairobi. jagatsiva@yahoo.co.uk Phone:609013/27 or 0721421874
University of Nairobi (Department of Geography)	Education	Education and Research	Furthering research in climate science and adaptation mechanisms.	Prof. Odingo, Dr. Agnes W. Mwang'ombe, Dr Maggie Opondo Tel: +254 722 788 995 mwangombe@kenyaweb.com
University of Nairobi (Department of Meteorology)	Education	Education and Research	Research in climate modeling, scenario development, vulnerability and adaptation mechanisms.	Prof. John Ng'ang'a, Prof. Mutua, Dr Oludhe Box 30197, Nairobi Email: jknganga@uonbi.ac.ke
Kenya Association of Manufacturers	Private Sector	Development	Promotes the adoption of low carbon emission technologies. Assist members in identifying offset investment projects.	Mr Suresh Patel better@wananchi.com
Climate Network Africa	NGO	Education and Awareness	- Sustainable and social equitable development in light of serious danger of climate change, desert and biodiversity loss. - Public education and awareness, advocacy and campaigns, CDM training, natural resource mgt, - Sustainable energy development and services. - Strengthen Africa's voice in negotiations.	Ms Grace Okumu P.O. Box 76479 - 00508 Nairobi, Kenya Tel: +254 20 3864040 Email:cnaf@cnaf.or.ke

Centre for Biodiversity (WRP)	NGO	Development	Wetland resource management and biodiversity studies.	P.O. Box 40658 Nairobi Kenya Tel: +254 20 3742161/4 or 374 2131/4 Email: biodive@tt.gn.apc.org
Network for Water and Sanitation (NETWAS)	NGO	Development	Policy and development.	P.O. Box 76479 – 00508 Nairobi, Kenya Email:cnaf@cnaf.or.ke
Alliance for a Green Revolution in Africa	NGO	Development	Development.	P.O. Box 66773-00800, GPO Nairobi, Kenya Tel: +254-20-3750627
African Forest Research Network (AFORNET)	NGO	Policy and Development	Policy and development.	P.O.Box 14798 or 24916 Nairobi Tel: +254 20 884401 afornet@africaonline.co.ke
Environment Liaison Center International (ICIPE, Duduville)	NGO	Research	Research.	Ms Cyril Ritchie P.O.Box 72461-00200, Nairobi Tel 011 254 20 856 6172/3/4 E-mail: c.ritchie@fiig.org
International Union for Conservation of Nature (IUCN)	NGO	Research	Forest conservation (including assessment of carbon stocks).	P.O. Box 68200-00200, Nairobi, Kenya Tel: +254-20-890615 Email: earo@iucn.org
US Agency for International Development (USAID), Kenya	Embassy	Policy and Development	CDM and climate change policy funding for research (including adaptation mechanism).	Dr Erna Kerst P.O. Box 629 Village Market 00621Nairobi Tel: 254-20-862 2000 Email: usaidke@usaid.gov
The Global Environment Facility (GEF)	Fund	Policy and Development	Funding for climate change issues (policy strategies, impacts, CDM, vulnerability, adaptation, mitigation).	DGEF P.O. Box 30552-00100, Nairobi, Kenya. Tel: +254 20 7624 165 Email: getinto@unep.org
United Nations Environment Programme (UNEP)	UN	Policy, Research and Development	Policy strategies, climate change impacts, CDM, vulnerability, adaptation, mitigation.	P.O. Box 30552, Nairobi, Kenya Tel: 254-20-621234/230800 Email: ipainfo@unep.org, eisenfo@unep.org
CARE International Kenya	NGO	Policy, Research and Development	Regional climate change focal point (East and Central Africa) Policy strategies and community support.	Dr Cynthia Brenda Awuor P. O. Box 43864-00100, Nairobi Tel. +254 20 2710069/ 2712374 Email: cynthia@care.or.ke
IDRC	NGO	Education and Development	Consultancy on policy strategies, climate change impacts, vulnerability, CDM, adaptation and mitigation.	Dr Evans Kituyi / Victor Orindi P.O. Box 62084, 00200, Nairobi, Kenya
Food and Agriculture Organization (FAO), Kenya	UN	Policy and Development	Policy strategies, climate change impacts, vulnerability, CDM, adaptation and mitigation.	P.O. Box 30470-00100, GPO, Nairobi, Kenya Email: FAO_KE@fao.org
World Agroforestry Centre (ICRAF)	NGO	Research and Development		Dr Louis Verchot P.O. Box 30677-00100, Nairobi. Tel: +254 20 524 000 Email: icraf@cgiar.org
United Nations Development Programme (UNDP)	UN	Development	Funding for policy strategies, climate change impacts and vulnerability, CDM, adaptation and mitigation measures.	Ms Nancy Chege P.O. Box 30218-00100, Nairobi Tel: 254-20-7624474 Email: nancy.chege@undp.org
Ford Foundation	NGO	Development	Funding of policy strategies, climate change impacts, vulnerability, CDM, adaptation and mitigation.	Susan Kawira Kaaria P.O. Box 41081-00100, Nairobi Tel: 2710444,2713574 Email: fordnairobi@fordfound.org

TABLE 11

Projects concerned with climate change issues in Kenya

Project Name	Type	Change Mechanism	Agency/ Organisation	Donor/ Investor	Project Stage	Scope
Monitoring of greenhouse gases (including Ozone)	Multi-purpose		WMO	UNDP	Complete	Global
Expedited financing of climate change enabling activities part II: Measures for capacity building in priority areas (interim)	Multi-purpose		MEMR	UNEP	Ongoing	National
Enabling activities for preparation of initial national communications related to UNFCCC	Multi-purpose	CC	NEMA	UNEP	Complete	Regional
Building capacity in sub-Saharan Africa to respond to UNFCCC	Multi-purpose	CC	NEMA	UNDP	Complete	Regional
Alternative to slash and burn agriculture climate change	Agriculture	CDM		UNDP	Complete	Regional
Integrated Strategy for Promoting sustainable response to climate change	Multi-purpose	CC		UNDP	NFP Endorsed	National
Mitigation of climate change	Energy/ Forestry	CC	Total Kenya	IBRD	NFP Endorsed	National
Climate change capacity building	Multi-purpose	CDM	MEMR	UNDP	Complete	National
Small scale wind power pilot project for rural areas	Energy	CDM	Environmenta-listes Sans Frontieres (ESF)	IBRD	NFP Endorsed	National
Climate Awareness Programme	Multi-purpose	CC	MEMR	UNEP	NFP Endorsed	
Soil-carbon stock and change at national level		Agricult-ure	CDM	KSS	UNEP	NFP Endorsed
Climate, Water and Agriculture: Impacts and adaptation of agro-ecological systems in Africa	Water, Agriculture	CDM	GoK	IBRD	Ongoing	Regional
Coping with Drought and Climate Change: Best use of climate information for reducing land degradation and conserving biodiversity	Land use, Forestry, agriculture	CC	UNOPS/GoK	UNDP	Pipeline	Regional
Mount Kenya pilot project for land and water management	Water, Agriculture	CDM	IFAD	UNDP	Ongoing	Regional
National capacity needs self-assessment for global environmental management (NCSA)	Multi-purpose	CC	MEMR	UNEP	Ongoing	National
Finalization of the Action Plan on the Environment Component of the New Partnership for Africa's Development	Multi-purpose	CC	GoK	UNEP	NFP Endorsed	Regional
Climate Change Strategy	Multi-purpose	CC	MEMR	DANIDA	Ongoing	National

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

In recent years, the frequency and severity of natural disasters in Kenya, including drought and floods is already high and will increase in the future. There is growing evidence from the Intergovernmental Panel on Climate Change (IPCC) that these occurrences are associated with the climate that will change as greenhouse gases accumulate (IPCC 2007) and consequent impacts of global warming. The major impacts of these phenomena are felt among the smallholders, especially those inhabiting the fragile ecosystems of the drylands and manifest with severe implications of increased food insecurity (food shortage and deprivation, increased poverty level, resource use conflicts, high disease levels, etc.). It is therefore critical to understand and react to the challenges facing these farmers. Practical adaptation measures including policies which will build the resilience of these communities to climate change are more important than ever with the projected impacts of climate change on ecosystems, water availability, agricultural production, and the pastoral communities on the whole. Without adaptation efforts to the threats of changes in climate, the people of the drylands may be forced to consider other livelihood options, including migration, in order to cope with the extreme changes. It is important to note in identifying adaptation strategies and actions that the means to food security in every community vary from place to place. Household food security is a function of activities that make up their livelihood and each agro-ecological zone has distinctive challenges in maintaining food security in light of climate change. It must also be understood that with increased climate change and desertification, these zones are expected to shift causing many livelihoods to change and forcing the population to adapt, with various possible degrees of effectiveness. As the looming threat of climate change threatens to alter the landscape and environments of the drylands, ensuring food security, which is normally undertaken by smallholders and livelihoods is of paramount importance.

Over the years, the human population in Kenya has increased tremendously and escalating poverty is high levels, mostly among the rural communities composed of smallholders who practise subsistence cultivation and livestock keeping. Most of these farming communities have been pushed to cultivate unsuitable lands, for example, the recent high encroachments of agricultural activities into the drylands with poor farming techniques. In addition, the lack of adequate policy and legislations on land use, water and other natural resource use have led to rampant deforestation and use of improper farming methods including cultivation on steep slopes that has reduced water infiltration into the soil during the wet seasons, increasing flash floods and soil erosion, and resulting in siltation of the rivers and reservoirs. Climate change impacts and concerns have added a new dimension to smallholder farmers (subsistence crop cultivation and livestock production) inhabiting fragile ecosystems such as the drylands where rainfall is limiting and soils are poor, and greatly affected their livelihoods. Adequate adaptation options to vulnerabilities, risks and impacts, and associated mitigation measures are therefore the most feasible and indeed essential safeguard to livelihoods of these communities.

1. The impacts of foregoing climatic change concerns compounded by non-climatic factors includes population displacement, water stress resulting in damage of crop fields, loss of livestock, changes in both water quality and availability, and increased incidence of diseases.
   a) Migration to more fertile and less moisture-stressed areas to engage in farming or non-farm activities is the only sustainable livelihood strategy. In addition to moving to more fertile land, there is a rising number of people moving to urban and peri-urban areas in search of better opportunities. With this move come different vulnerabilities and stresses that will change the way people live, and how livelihoods are made. This move will also present more opportunities including various new livelihood methods. However, some displaced people have become squatters, and are forced to live in abject poverty.
   b) Increased frequency and severity of droughts has made the drylands more susceptible to desertification, and adversely affected dryland agriculture and smallholders. Prolonged droughts often lead to famine, lack of food and increased malnutrition, disrupting livelihoods and adversely affecting mainly the elderly, children and women.
   c) Increased incidence of diseases including crops, livestock and human beings has increased costs related to crop damage, animal health and human suffering, and consequently abject poverty and loss of livelihoods.

2. The current impacts of climate change on smallholder farmers reflect the poor level of preparedness among the various stakeholders, probably due to lack of access to early warning information, weak policies and legislation, institutional capacities cascading to the community levels, funds as well as political will. Although the country has the necessary institutional infrastructure in place to mitigate disasters, it lacks coordination mechanism and adequate capacity to strongly implement and manage the disasters. There is need for the reorganization and strengthening of these institutions and enabling communities to monitor the onset of such disasters as droughts, floods, landslides and temperature changes.

3. The country is water-scarce and concerted efforts are needed to preserve the little that is currently available. There is a clear and urgent need to improve the management of water resources in the country. Inadequate water storage capacities in the form of pans, dams, underground storage and tanks have added to the general

water shortage during the dry periods. In addition, a large volume of rainwater which can be harvested during the rainy period is often wasted as it drains down the streams, rivers and eventually into lakes and the Indian Ocean.

a) Transfer floodwater to water-prone areas, for example from western Kenya that suffers from periodic devastating floods as a result of heavy rains in the Nandi hills, Tranzoia, Cherengani and Uasin Gishu. The floods cause loss of life, massive damage to property, crops and infrastructure, and yet some parts of the country suffer periodic droughts. A scheme to harvest the floodwater and transfer it to areas with water deficit should be developed and implemented. This will greatly improve the livelihoods of smallholder farmers in these areas through provision of water for both domestic and livestock use during the dry periods, as well as smallholder irrigation agriculture.
b) Rainwater harvesting strategies and use of low cost technologies need to be developed and encouraged. Increasing damming of rivers where other environment impacts are taken into consideration should be encouraged. This will provide water not only for domestic and livestock purposes, but also for productive use such as irrigation agriculture and electricity production, thus contributing to poverty alleviation.

4. Recurrent droughts, increased flooding, heat stress and change in the soil structure are predicted impacts of climate change on smallholder agriculture in the drylands. The proposed adaptation and mitigation options include:
   i. Better land management/conservation farming using improved methods of land husbandry to better conserve soil, water, and the integrity of natural and managed ecosystems is needed. Smallholder farmers who practise conventional farming methods on degraded soils are highly susceptible to the threat of climate change and total crop failure even in seasons of moderately poor rainfall. They are excessively dependent on increasingly expensive fertilizers which are now unaffordable for the majority. Practising better land management techniques such as: retention of crop residues, restricting tillage, completion of land preparation in the dry season, establishment of a precise and permanent grid of planting basins, planting furrows or contoured ridges, early and continuous weeding, rotation and intercropping, dramatically increase their yields, diversify their production base and engage in economic activity, regenerate their soils and sustain adequate levels of production in all but the worst droughts, liberate themselves from dependency on food aid and excessive use of costly external inputs, practise sedentary agriculture on a sustainable basis, and regenerate rather than exploit the environments in which they live.
   ii. High-yielding, drought-tolerant or escaping crop varieties: smallholder farmers dependent on agricultural production for there survival, drought resistant modern seed varieties are very important to the population of the

sub-humid zone. While high-yielding varieties do currently exist for most of the crops cultivated in the sub-humid zone (such as maize, sorghum, millet, beans and cowpeas), they are not widely adopted, especially in areas with low precipitation. The high costs of fertilizers required for these high-yielding varieties erode their profitability, especially since the removal of fertilizer subsidies. To realize the potential of the zone, modern, stress-resistant varieties that respond well to small amounts of external inputs are needed. Crops with shorter growing seasons will also be important as season variability is becoming more common, while these varieties must also meet the local tastes so that they can satisfy the farmers.

iii. Improved water management and irrigation: investment in water control is need to be planned and implemented in the much broader framework of agricultural and rural development, where production, finance and infrastructure are conceived in an integrated way and are mutually supporting. Policies and institutional frameworks must also be created in order to ensure fair and equitable access to water resources. In addition to water management, an increase in the use of irrigation technology will help take a lot of the guesswork out of agriculture production and allow for more effective use of this scarce resource. Irrigation for crop production will not only increase reliable crop production, but will limit the water that is used and allow for water that was previously used for crop production to go towards other household needs.

iv. Promotion of flood control measures especially in the drylands that currently experience increased flooding and landslides on hillslopes due to poor soil textures;

v. Disposal of livestock before the onset of drought (provided there is a reliable early warning system), and restocking during the wet seasons;

vi. Research, feedback mechanisms and training should include continuous public awareness-raising on climate change issues related to smallholders in drylands, environmental and sustainable development, and community capacity building.

vii. Agroforestry is a collective name for land use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land management unit. The integration can be either in a spatial mixture or in a temporal sequence. There are normally both ecological and economic interactions between woody and non-woody components in agroforestry. Promotion of integrated approach of using interactive benefits from combining trees and shrubs with crops and/or livestock should be considered.

viii. Small credit programme can be utilized to allow for farmers to borrow money for seeds and fertilizer in times of need. These micro-loan programmes have taken off in recent years but are mainly focused on women's groups and small business development. A focus on agriculture is needed for crop production to continue in light of climate change.

ix. Establishment of reliable databases to provide real time monitoring of rainfall, water balance and temperatures at local and regional levels is recommended. The data should be regularly updated to enable prompt recognition of anomalies well in advance, taking into consideration that the occurrence of droughts and the spatial and temporal variability of rainfall are usually the result of a variety of factors over a long period of time.

x. Exploitation of traditional knowledge for community water management alongside the modern methods – an example of a successful traditional method is the community management of wells in Harbhejan, in Wajir, where only two of the five wells are used. The other three are used only during periods of drought.

5. Development and implementation of climate change preparedness, including vulnerability, risks and impact management strategy and action plan:

a) The country lacks a holistic national climate change policy and strategy to prepare and manage related issues and associated impacts. The existing efforts to manage the impacts of natural disasters including recurrent droughts and floods, and artificial such as degradation of soil fertility are very short-term and concentrate on ad hoc crisis response focusing on the supply of relief food and chemical fertilizer subsidies to those already affected. This approach is not sustainable as often there is not enough food and funds to import fertilizers. In addition, those who do receive relief food and subsidized fertilizers to improve their farm production (taking into consideration the climatic conditions at that particular time) do not get enough for their needs and end up relying on natural resources for survival. Often the long-term measures such as environmental considerations (forestation, land use management, and water catchment protection) are ignored, while there is rarely any disaster recovery at national level. It is therefore recommended that a strategy detailing the steps and actions to be undertaken to prepare both the government and smallholder farmers to withstand the impacts of climate change be developed. The strategy should articulate the roles, responsibilities, coordination and networking, and participation of stakeholders.

b) Effective preparedness and management of climate change impacts will largely depend on the establishment of an all-inclusive coordination mechanism that will bring together various key actors. In order to achieve this, the following measures are recommended:

i. Establishment of a National Climate Change Council with a strong National Climate Change Secretariat;

ii. Strengthening of the existing district disaster management committees with strong participation of the vulnerable rural communities, especially the smallholder farmers;

iii. Strengthening the capacity of weather monitoring institution (Kenya Meteorological Department), early warning and drought warning systems from ALRMP and extend it to crop yield forecasts (currently undertaken by DRSRS) by providing the necessary skills, funds and capacity building at the community level.

iv. Identification of an appropriate institution to implement the National Climate Change Programme, which should cascade to the vulnerable smallholder farmers;
v. Improvement of the current climate change monitoring systems, which should incorporate local knowledge, assessments of the vulnerabilities, risks and impacts, on smallholder farmers that form the majority of the rural population and early warning in droughts, floods and temperature rise management; and
vi. Provision of appropriate financial, human resources and equipment to deal with the issues related to smallholder agriculture in drylands and impacts of climate change on their livelihoods.

Despite the popular belief of a generally low adaptive capacity of rural inhabitants of the drylands, communities can adapt and change practices if their way of life is to continue. Although there are many limitations associated with dryland agriculture, including smallholder farming and pastoralist livestock production, the drylands livelihood systems are inherently opportunistic. Introducing or up-scaling adaption would be the starting point, but their effectiveness will depend on an enabling policy environment and integrated approach that reinforces actions at both the local and national levels. The promotion of appropriate and environmentally-sound technologies for adoption is an effective mitigation option. However, the process of technology transfer is very complex and includes many stakeholders such as government, private sector entities, financial institutions, NGOs and research/education institutions. In the long run, appropriate and environmentally-sound technologies that incorporate tradition knowledge and methods of disaster management are effective. It is therefore recommended that the assessment of existing local and traditional knowledge, and gaps in technology are needed, including an evaluation of the degree of adaptability of these technologies to local needs to enable development of appropriate policies that would ensure adequate adaptation and management of the risks and impacts of climate change and livelihood sustenance of smallholders resident in the drylands.

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ANNEX 1

RISK MANAGEMENT: CLIMATE CHANGE SURVEY

1. There are many ways in which to receive forecasts of a coming rainy season. Did you access any forecast information for the past (current) rainy season? Y/N. If yes, what sources of information did you access and how much confidence do you have in forecasts from the specified source?

Source of Forecast	Source from which respondent has access	Level of confidence in the forecast
Radio		
Newspaper		
Other printed matter		
TV		
Government Extension Agents		
NGO Extension Agents		
Traditional Forecasters		
Local Elders/Religious Leaders		
Friends or Neighbours		
Other?		

For level of confidence in forecast: Very Confident = VC; Confident = C; Not Confident = NC; Not Sure = NS

2. Did you have access to early warning before the last drought? Y / N, If yes, what did you do with the information in preparation for the [drought]?

3. Name the droughts you experienced in the last (past) 20 years?
   ______________________ year __________ degree of severity _____
   ______________________ year __________ degree of severity _____
   ______________________ year __________ degree of severity _____
   ______________________ year __________ degree of severity _____
   ______________________ year __________ degree of severity _____
   ______________________ year __________ degree of severity _____

_________________________ year ___________ degree of severity ______
_________________________ year ___________ degree of severity ______
(Rank degree of severity from 1=most severe; 2=moderately severe; 3=least severe).

4. If forecasts about a coming rainy season could be provided reliably, how many weeks or months in advance of the season would you need to receive the information for it to be useful to you? _____________ *(Note whether answer is given in weeks or months)*

5. If forecasts about a coming rainy season could be provided reliably, what type of forecast information would be most useful to you? *(Rank from 1=most useful; 2=moderately useful; 3=least useful. If any are not useful, write NU).*
   ____ Forecasts about when rains are expected to start falling in your area
   ____ Forecasts about when the rains are expected to end in your area
   ____ Forecasts about whether the amount of rain falling will be above average, normal or below average
   ____ Forecast about the distribution of the rainfall during the season

6. How do you feel the following climate related factors have changed in the past ten (10) years?

The total amount of rainfall per year:

Increased a lot	**Increased**	**Stayed the same**	**Decreased**	**Decreased a lot**

Length of growing period per year:

Much longer	**Longer**	**Stayed the same**	**Shorter**	**Much shorter**

The ability to make accurate weather predictions:

Much more Accurate	**More accurate**	**Stayed the same**	**Less accurate**	**Much less accurate**

Temperatures:

Much Hotter	**Hotter**	**Stayed the same**	**Cooler**	**Much cooler**

Rainfall consistency:

Much more Variable	More variable	Stayed the same	Less variable	Much less variable

Incidence of livestock diseases:

Increased a lot	Increased	Stayed the Same	Decreased	Decreased a lot

Incidence of crop diseases:

Increased a lot	Increased	Stayed the Same	Decreased	Decreased a lot

Incidence of food insecurity:

Much more insecure	More Insecure	Stayed the Same	Less insecure	Much less insecure

Incidence of land disputes:

Many more disputes	More Disputes	No Change	Less disputes	Much less disputes

Fodder availability:

Increased a lot	Increased	Stayed the Same	Decreased	Decreased a lot

Incidence of drought:

Increased A lot	Increased	Stayed the Same	Decreased	Decreased a lot

Severity of drought:

Increased A lot	Increased	Stayed the Same	Decreased	Decreased a lot

Floristic composition of vegetation (which is an indicator of habitat quality):

Increased A lot	Increased	Stayed the Same	Decreased	Decreased a lot

Movement of livestock for fodder:

Longest distance of movements 20 years ago	Longest distance of movements 10 years ago	Longest distance of movements 5 years ago

Movement of livestock for water:

Longest distance of movements 20 years ago	Longest distance of movements 10 years ago	Longest distance of movements 5 years ago

Arrangements for fodder during the wet season in the last 10 years:

Stayed at the same place	Moved to another area	Where?	How far?

Arrangements for fodder during the dry season in the last 10 years:

Stayed at the same place	Moved to another area	Where?	How far?

Do you pay for forage or grazing during the dry season? How much per animal?

How do you move your livestock?

Herding	Lorry

APPENDIX 2

RISK MANAGEMENT: RISK PROFILE SURVEY

1. Rank top five (5) risks according to potential negative impact if you were to be effected. (1=greatest impact…)

Type of Risk/Adverse Event	1. Rank	2. Affected by these events (Y, N)	3. Is the risk avoidable? (Y, N)
Droughts			
Floods			
Crop Disease			
Human Disease			
Livestock Disease			
Livestock Death			
Land Dispute			
Loss/theft of key asset			
Food Insecurity			
Death of bread earner			
Crop failure or poor harvest			
Shortage of water for domestic use			
Shortage of water for livestock			
Low prices for animals			
Insufficient pastures for animals			
Shortage of land for cultivation			
Other?			

1. Rank top five (5) according to the potential negative impact if you were to be affected. (1=greatest impact…, 5=lowest impact)
2. Have you been personally affected by any of these events (Y, N)
3. Is the risk avoidable? If YES, what could be done to prevent it? If No, what sort of preparation is necessary

2. Name five (5) livelihood activities which you perceive to involve the greatest risk

5-20 years ago	Activity	Activity (Today)	10 years from now

APPENDIX 3

RISK MITIGATION SURVEY

1. Do you take any measures to reduce your exposure to risk? Y/N

2. If YES answer the following:

Risk Mitigation Strategies	1. Reduce your exposure to risk? Y/N	2.Rank according to level of effectiveness
Pay attention to climate forecasts/early warning systems		
Accumulate livestock or other assets		
Build savings		
Invest in Social Capital (Joining community groups, keep good relationship with community members)		
Change mix of livestock		
Dipping/Vaccinating animals		
Seek alternative income sources		
Use Pesticides/Fertilizers		
Prayers/Ceremonies		
Giving livestock out to relations to keep (care-taking)		
Acquisition of drought tolerant species and or breeds		
Migration		
Supplementary feeding		
Crop cultivation for pure pastoralists		
Expansion of cultivated land for agropastoralists		
Other: (Specify)		

1. Have you pursued the following strategy to reduce your exposure to risk? Y/N
2. Of the strategies pursued, rank according to level of effectiveness in reducing risk? (1=most effective; 2=moderately effective; 3=less effective)

APPENDIX 4

RISK COPING MECHANISM SURVEY

1. When negatively affected by adverse climatic condition, which of the following strategies do you pursue in order to reduce the impact?

Risk Coping Strategies	1. Reducing the impact of the shock? Y/N	2. Rank according to level of effectiveness
Relying on Savings		
Food aid, credit, inputs from Government		
Food for work or cash for work programme from Community Organizations or NGOs		
Food aid, credit, inputs from Church or Religious organizations		
Food sharing, gifts, credits from Relatives or Friends		
Reduction in household food consumption		
Credit from Banks or Microfinance Institutions		
Sale of livestock or other assets		
Remove children from School		
Seek employment		
Reduction in frequency of daily food consumption, quality, order of food sharing		
Consumption of wild plant and animal species		
Alternative income opportunity		
Migration		
Change in grazing itineraries (travelling farther in search of forage and water)		
Herding for wages		
Exchange of animals for cereals		
Additional responsibilities for women		
Giving daughter for marriage, etc.		
Other: (Specify ________________)		

1. Have ever you pursued the following strategy to reduce the impact of the shock? Y/N
2. Of the coping strategies pursued, rank according to level of effectiveness in reducing impact? (1=most effective; 2=effective; 3=moderate; 4-least; 5=Non Applicable)

The effectiveness and availability of risk-management support (both risk mitigating and risk management strategies) changes through time:

2. Are there certain types of support that were more useful 10 years ago than they are today? Y/N

3. If yes, name them and explain:

4. Are there certain types of support that were more useful/available today than they were then years ago? Y/N

5. If yes, name them and explain:

APPENDIX 5

EXPERIENCE AND BENEFIT PERCEPTION OF DEVELOPMENT EFFORTS (PAST AND PRESENT) SURVEY

1. Considering the past 10 years, which of these efforts do you think has provided the most benefits for people in the community? The second most? The third most? The fourth most? The fifth most?

2. Which has been the most beneficial for you personally? Second most? Third most? Fourth most? Fifth most? (Rank only the top five for each column)

3. and 4. Looking forward to the next ten (10) years, answer both questions again.

	Rank for the Community	Rank for you Personally	Rank for the Community	Rank for you Personally
	PAST		FUTURE	
Livestock Health				
Livestock Marketing				
Water				
Human Health				
Education and Literacy				
Agriculture Extension				
Improved Crop Varieties				
Restocking				
Food Aid				
Alternative Income Generation				
Savings and Credit				
Infrastructure (Roads, Electricity, Phones)				
Conflict resolution and security				
Natural Resources Management				
Wildlife Management				
Provision of feed supplements				
Supply of crop inputs at subsidized rate e.g. fertilizer, pesticides				
Training in livestock related technologies e.g. feed conservation				
Training in soil and water conservation technologies				
Other 1 (describe)				

Other 2 (describe)				

5. Do you think there have been any efforts that have hurt the community in any way? Yes / No
6. If yes, which ones and how?
7. Do you think there have been any efforts that have hurt you personally in any way? Yes/No
8. If yes, which ones and how?

CHARACTERISTIC OF ECONOMIC AND DEMOGRAPHIC SITUATION

Division: ______________________ Location: ______________________

Sub-location: ______________________ Village: ______________________

Interviewer: ______________________ Date ______________________

Household Code	Name - Household head and his wives	Child	Name - brothers of HH in the household	Animals #		Work animals #	Fields owned #	Non-agric occupant
Social Group:	HH:		FR1 ___ ___	Cow	1-3	Donkeys	Own	Chr
				4-9	>9		Purchase	Mer
Adults:	W1, Origin:		FR2 ___ ___	Sheep	1-3	Horses	Loan	Fab
				4-9	>9			Med
Children	W2, Origin:		FR3 ___ ___	Goat	1-3	Camels	Rent	Sal
				4-9	>9			Mig
	W3, Origin:			Cart	Plow	Oxen	Pledge	Other

LOCAL EVENT CHRONOLOGY

Division: ______________________ Location: ______________________

Sub-location: ______________________ Village: ______________________

Names of informants: ______________________

____

Year	Event and description if necessary	Year	Event and description if necessary
2009		1989	
2008		1988	
2007		1987	
2006		1986	
2005		1985	
2004		1984	
2003		1983	
2002		1982	
2001		1981	
2000		1980	
1999		1979	
1998		1978	
1997		1977	
1996		1976	
1995		1975	
1994		1974	
1993		1973	
1992		1972	
1991		1971	
1990		1970	
Other notable years before 1970			

HOUSEHOLD SURVEY – ECONOMIC CHARATERISTICS
Livestock production module

G00	G1		G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12
Does this HH keep any animal(s) 1. Yes 2. No (NEXT SEC)	If YES in G00, which animals? See Codes		How many [..]are kept by household Number	How many [..] were born during the last 3 months	How many [..] were sold in the last 3 months	Reason for selling [..] See Codes	What were the total earning from sale [..]	How many of your [...] were lost / stolen during the last 3 months? IF NONE, ENTER ZERO	How many of your [..] were given away during the last 3 months?	How many died during the last 3 months	What was the main reason for animal deaths See Codes	Number of animals slaughtered during the last 3 months	What was the reason for slaughtering See Codes
	Animal(s)	Code	own	Not own	Number		KShs	Number	Number	Number		Number	

G13	G14	G15	G16	G17	G18	G19	G20	G21	G22	How much did you spend on the following livestock inputs in the last 3 months? (Kshs)					
Did you sell either of your breeding/ milking/ draught stock in the last 12 months 1. Yes 2. No	If Yes, how many	What was the milk yield (in number of litres) from each FLOCK/ HERD (Last 7 days)	Milk sold from FLOCK/ HERD (Last 7 days)	What were the total earnings from the sale of milk? (in Kshs)	Milk (in number of Litres) Consumed by HH in last 7 days	Have you sought veterinary extension services in the last 12 months? 1. Yes 2. No	From whom did you seek these services 1. GoK 2. Private practitioner 3. CBAHW 4. Other (Specify)	Are veterinary drug supplies available in the locality? 1. Yes 2. No	From whom would you obtain the drugs? 1. Shops 2. Vet Pharmacy 3. Drug User Ass. 4. Other (Specify)	Drug and medicines	Vaccines	Livestock Chemicals Dipping and spraying	Livestock fodder	Artificial Insemination	Other hired services

Col G1
1. Cattle
2. Camels
3. Goats
4. Sheep
5. Donkeys
6. Other (Specify)

Col G5
1. Economics
2. De-stocking
3. Drought
4. Conflict
5. Other (Specify)

Col G10
1. Diseases
2. Drought
3. Conflict
4. Wildlife conflict
5. Other (Specify)

G12
1. For food
2. Economic
3. Coping strategy
4. Disease
5. Other (Specify)

Agriculture production module

H1	H2		H3	H4				H5		H6		H7		H8	H9
Does your household normally undertake crop farming? 1. Yes – Rainfed 2. Yes – Irrigated 3. Yes R & I 4. Non	Did your household grow any crops during the last 12 months? 1. Yes 2. No		If NO in H2, what was the REASON See Codes	Name all crops the household farmed in the last 12 months by season See Codes				How much {..} did HH harvest in the last 12 months from parcel planted? See Codes		How much of the {..} harvested in the last 12 months was consumed by HH? See Codes		How much of {..} harvested in the last 12 months was sold? See Codes		What was the total earning from the sales?	n the last 12 months has the household had to dispose off land due to distress? 1. Yes 2. No
	Long rains	Short rains		**Long rains**		**Short rains**		**Long rains**	**Short rains**	**Long rains**	**Short rains**	**Long rains**	**Short rains**		
				Crop Name	**Codes**	**Crop Name**	**Codes**	**Quantity**	**Code**	**Quantity**	**Code**	**Quantity**	**Code**	Kshs	

Col H3
1. No min
2. No Seeds
3. No Land
4. Social Conflict
5. Cultural belief & practices
6. Land not arable
7. Wildlife conflict
8. Other (Specify)

Col H4
1. Maize
2. Sorghum
3. Millet
4. Fodder crop
5. Beans
6. Cowpeas
7. Pigeon peas
8. Greengram
9. Dolicos (Njahi)
10. Groundnuts
11. Cassava
12. Yams
13. Sweet Potatoes
14. Arrow roots
15. Bananas
16. Pawpaw
17. Melon
18. Oranges
19. Vegetables
20. Khat (Miraa)
21. Tobacco
22. Cotton
23. Sunflower
24. Simsim
25. Wheat/Barley/Rye
26. Other (Specify)

Col H5, H6, H7
1. Kilogramme
2. 50 Kg bag
3. 90 Kg bag
4. Bunch
5. Piece
6. Heap
7. Debe
8. Gorogoro/Kasuku (2 Kg)
9. Basket
10. Crate
11. Net
12. Other (Specify)

Household amenities

To be answered by HEAD of Household/Knowledgeable person in the household

To be administered once for each household visited.

J1	J2	J3	J4	J5	J6	J7	J8
Do you own the main dwelling? See Codes	Roof material for the main dwelling unit See Codes	Main source of cooking fuel See Codes	Main source of lighting See Codes	What is the main source of drinking water DURING DRY SEASON See Codes	What is the main source of drinking water DURING WET SEASON See Codes	How long does it take you to get water DURING DRY SEASON? (include transportation to water and waiting time if applicable) See Codes	How long does it take you to get water DURING WET SEASON? (include transportation to water and waiting time if applicable) See Codes

J9	J10		J11		J12	J13	J14		
Do you pay for water? Yes No	How much did you spend on water? (Domestic use only) (Ksh)		How much did you spend on livetock only? (Ksh)		How much did you spend on grazing livestock during the dry season? (Ksh)	What kind of toilet facility does your household use? See Codes	How many acres of land		
	Wet Season	Dry Season	Wet Season	Dry Season	Amount		Crop	Grazing	Fodder
							Number	Number	Number

J15 Did the household own/have any of the following items in the last 12 months?							
Animal Cart	Radio	Bicycle	Sewing Machine	Mobile Phone	Posho Mill	Ox-plough	Furniture

J16 Did you dispose any of the above due to distress within the last 12 months? 1. Yes 2. No							

Col J1
1. Household
2. Rented
3. Implyer provided
4. Other (Specify)

Col. J2
1. Mud/cowdung
2. Store
3. Cement/Bricks/ Tiles
4. Wood
5. Grass/Makuti
6. Iron sheets
7. Sticks
8. Other (Specify)

Col. J3
1. Firewood
2. Characoal
3. Kerosene
4. Gas
5. Electricity
6. Cowdung
7. Farm residue
8. Other (Specify)

Col. J4
1. Electricity
2. Kerosene
3. Gas
4. Candle
5. Firewood
6. Solar
7. Other (Specify)

Col. J5 & J6
1. Piped into dwelling
2. Piped into yard
3. Public tap
4. Bottled water
5. Roof catchment
6. Tank/vendor
7. Protected well
8. Protected borehole
9. Unprotected well/ spring
10. Protected
11. Rivers
12. Dam
13. Lake
14. Pan
15. Stream
16. Other (Specify)

Col. J7 & J8
1. Near the dwelling
2. Less than 30 minutes
3. Between 30-60 minutes
4. More than two hours

Col. J13
1. Flush to sewer
2. Flush to septic tank
3. Buckets
4. Covered pit latrine
5. Uncovered pit latrine
6. Ventilated
7. Improved pit
8. Bush
9. Other (Specify)

Col. J15
1. Owned and less than 12 months old
2. Owned and more than 12 months old
3. Have but not owned
4. None at all

ENVIRONMENT – CLIMATE CHANGE – BIOENERGY – MONITORING AND ASSESSMENT

FAO - ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT WORKING PAPER

Smallholder farmers in Kenya grow most of the country's food, vegetables and fruit. These farmers face formidable challenges in increasing production, preserving natural resources and addressing the impact of climate change in food production systems. Meeting these challenges is vital to sustained livelihoods and reduction of poverty, especially in the fragile dryland and semi-arid areas, where the impact of climate change is expected to be severe in Eastern Africa and Kenya. It will severely effect the approximately 57 percent of Kenya's population already living in poverty and who are reliant on climate-sensitive economic activities under smallholder agriculture.

This study aims to raise awareness at national and local level on the impacts of climate change and variability on the food production system, natural resources base (land, water, forest and biodiversity) and ecosystem integrity, including establishment of baseline information at both local and agro-ecological levels. It also highlights on-the-ground adaptation practices and technologies which can stabilize the productivity of vulnerable communities and enhance ecosystem resilience for possible up-scaling.

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