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Climate Risks, Vulnerability and Governance in Kenya: A review

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Abbreviations and Acronyms

AfDB	African Development Bank
ASALs	arid and semi-arid lands
ASDS	*Agriculture Sector Development Strategy, 2010–2020*
CIA	Central Intelligence Agency (United States)
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
GDP	gross domestic product
GOK	Government of Kenya
GWA	Gender and Water Alliance
HDI	Human Development Index
ICPAC	Intergovernmental Authority on Development Climate Prediction and Applications Centre
IEW	Institute of Environment and Water
IFAD	International Fund for Agricultural Development
IISD	International Institute for Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
KEMRI	Kenya Medical Research Institute
KMD	Kenya Meteorological Department
KNPDRR	Kenya National Platform on Disaster Risk Reduction
KES	Kenyan shillings
MEMR	Ministry of Environment and Mineral Resources
MENR	Ministry of Environment and Natural Resources
MOFD	Ministry of Fisheries Development
MOH	Ministry of Health
MOPHS	Ministry of Public Health and Sanitation
MOSSP	Ministry of State for Special Programmes
NCCACC	National Climate Change Activities Coordinating Committee
NCCRS	National Climate Change Response Strategy
NCLR	National Council for Law Reporting

NDOC	National Disaster Operations Centre
NGO	non-governmental organization
NEMA	National Environment Management Authority
NHSSP II	Second National Health Sector Strategic Plan of Kenya
ROK	Republic of Kenya
SEI	Stockholm Environment Institute
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNHCR	United Nations High Commission for Refugees
UNICEF	United Nations Children's Fund
UNISDR	United Nations International Strategy for Disaster Reduction
USDS	United States Department of State
WHO	World Health Organization
WMO	World Meteorological Organization
WRI	World Resources Institute
WSIP	water sector investment plan
WWAP	World Water Assessment Programme

1.0 Executive Summary

The Government of Kenya, recognizing the growing threat climate-related risks pose to its near- and long-term development prospects, has begun to improve its capacity to prevent, manage and recover from disasters and adapt to the impacts of climate change. However, a comprehensive analysis of the climate risks facing Kenya, and the country's capacity to respond to these risks, has not yet been undertaken. The absence of such an analysis impedes Kenya's capacity to identify areas for intervention. To address this gap, we undertook a desk-based review of climate-related risk in Kenya to summarize:

- Kenya's vulnerability to climate risks given current progress toward meeting its defined development goals.
- Kenya's exposure to climate risks historically, and how these risks might change in the future given available climate change projections.
- The degree to which key sectors of the Kenyan economy and particular groups are vulnerable to existing and future climate risks.
- Kenya's current capacity to address climate risks given its policy framework, institutional arrangements, information availability, ongoing projects and capacity needs.

Progress Toward Development Goals

After three decades of stagnant economic growth in Kenya, GDP rose from 0.2 per cent in 2002 to 5.6 per cent in 2010, and was projected to be 4.8 per cent in 2011 (World Bank, 2011). Other development indicators have also improved, including life expectancy at birth, access to primary and secondary education, and access to clean water (UNDP, 2010). Perhaps most importantly, Kenya has experienced meaningful improvements in its system of governance, including adoption of a new constitution in August 2010 that includes provisions for devolving decision-making to county governments. The devolution process aims to bring provision and delivery of services closer to the people and to increase accountability.

While positive progress toward sustainable development has been made over the past decade, Kenya continues to face a number of challenges that increase its exposure to climate-related risks. In particular, nearly half of all Kenyans (46.9 per cent) continue to live below the national poverty line (GOK, 2008, p. 4)—a proportion that has remained relatively unchanged over the past couple of decades. The economic gains made since 1997 have largely benefited the wealthiest quintile of Kenyans (World Bank, 2009), further contributing to Kenya's high level of economic and social inequality (UNDP, 2010). Access to water has improved, but more than 40 per cent of Kenyans continue to draw water from unsafe sources. Reliable health care continues to be limited, particularly in rural areas, home to 70 per cent of Kenyans (World Bank, 2011). Consequently, little progress has been made with respect to reducing mortality of infants and children under the age of five. Due to these factors, Kenya continues to rank low on the Human Development Index (UNDP, 2010) and is not expected to reach its Millennium Development Goals related to the eradication of extreme hunger, gender empowerment and ensuring the sustainability of its environment (UNDP, n.d.b).

Building on progress to date, *Kenya Vision 2030*—Kenya's ambitious development agenda for the period from 2008 to 2030—aims to maintain macroeconomic stability, reform governance, correct economic and social inequalities, build the infrastructure and energy systems needed for economic growth, reform land policy and legal frameworks, enhance human capital, and improve the public service (GOK, 2007a). *Vision 2030* and Kenya's *First Medium Term Plan*

(2008–2012) acknowledge climate risk and the need to enhance capacity to manage it. However, these documents do not fully recognize the potential for climate change to hamper Kenya's efforts to achieve its development objectives (GOK, 2010).

Exposure to Climate Risks Now and in the Future

Kenya has a complex climate that varies significantly between its coastal, interior and highland regions and from season to season, year to year, and decade to decade. This climatic variability is influenced by naturally occurring factors such as movement of the Intertropical Convergence Zone and the El Niño Southern Oscillation (ENSO). In recent decades, observed mean annual temperatures have increased by 1.0°C since 1960, or an average rate of 0.21°C per decade (McSweeney et al., 2009). Changes in rainfall patterns have also been noticed since the 1960s. Greater rainfall has been observed during the short rains of October to December (GOK, 2010), and the long rains of March to April have become increasingly unreliable in locations such as Eastern Province (Awuor, 2009). However, no statistically significant national trends toward wetter or drier conditions have been found (AEA Group, 2008a).

Extreme climatic events have long posed a significant risk to regions in Kenya, and they have contributed to making it one of the most disaster-prone countries in the world (MOSSP, n.d.). Of particular concern are floods and droughts, with major droughts occurring about every 10 years, and moderate droughts or floods every three to four years (AEA Group, 2008a). Historically, these extreme climatic events have caused significant loss of life and adversely affected the national economy. Droughts have affected the most people and had the greatest economic impact (Earth Institute, n.d.); it is estimated that droughts cost about 8.0 per cent of GDP every five years (AEA Group, 2008b, p. 1). While usually more localized, floods have led to the greatest loss of human lives (Earth Institute , n.d.). Other climate-related hazards in Kenya include forest fires and landslides, the latter of which mostly affect the highland regions (UNDP, n.d.a).

Global climate change is projected to alter Kenya's mean annual climatic conditions as well as its pattern of climate extremes. Temperatures are expected to continue to rise in all seasons, with models suggesting that warming of about 1°C will occur by the 2020s, and 4°C by 2100 (AEA Group, 2008a). Warming will vary from region to region within Kenya (Funk et al., 2010). Greater uncertainty persists regarding how precipitation patterns might be altered by climate change. Analysis by the Intergovernmental Panel on Climate Change using global circulation models projects that East Africa will likely become wetter, particularly during the rainy seasons (Boko et al., 2007). However, analyses focused on Kenya project that a general decrease in mean annual precipitation will occur within the country, although wetter conditions are likely during the short rains of October to December (AEA Group, 2008a; Funk et al., 2010; D. Gikungu, personal communication, March 29, 2012). Projections vary widely regarding how extreme weather event patterns will change (SEI, 2009). Possibilities include increased flooding due to more heavy rainfall events (AEA Group, 2008a; SEI, 2009) and continued occurrence of droughts at least as extreme as at present, possibly increasing in intensity over this century (AEA Group, 2008a). Current uncertainty regarding how climate change might manifest in Kenya reflects, in part, ongoing gaps in knowledge at the regional and international levels, such as incomplete understanding of how critical drivers such as ENSO influence Africa's climate, a severe lack of local weather data in Kenya specifically and in Africa as a whole, the granularity of global circulation models, and the limited development of regional climate models (Conway, 2009).

Vulnerability of Key Sectors and Groups

Kenya's economy remains highly dependent on a number of climate-sensitive sectors, including agriculture, tourism and energy production. This sensitivity stems in large measure from the dependence of these economic sectors on a sufficient supply of **water**. Kenya already is one of the most water-scarce countries in Africa (Kandji, 2006; Mango et al., 2010; WRI et al., 2007); based on current population growth, water availability is projected to fall to 350 cubic metres per person by 2020 (WRI et al., 2007). Climate change could further reduce the availability of this resource through higher evaporation, altered rainfall patterns, accelerated loss of glaciers and sea-level rise. Policies and strategies adopted by Kenya to address water scarcity include the water sector investment plan (WSIP) for 2008 to 2030 and the Water Catchment Management Initiative. As a whole, these initiatives focus on the economic benefits derived from improved access to and use of water resources, and they only indirectly address climate risks. Enhanced integration of climate risk management into these and other water management initiatives could improve Kenya's capacity to achieve its development goals.

Agriculture remains the backbone of Kenya's economy, directly generating about 26 per cent of annual GDP and providing employment, food security and (rural) livelihoods. Productivity in the sector is directly influenced by climatic conditions. Nearly all of Kenya's crop production (98 per cent) is rain-fed (WRI et al., 2007, p. 34); the small proportion of irrigated cropland is largely used for export crops (WWAP, 2006). Within the livestock sector, nearly half of production occurs in the water-scarce arid and semi-arid lands (ASALs) (IFAD, 2007), and droughts have historically led to significant loss of animals. Drought also adversely affects the forestry sector by increasing the likelihood of forest fires and promoting the clearance of forests for agriculture, grazing of livestock in forested areas, and charcoal production.

Climate change is expected to adversely affect the stability of Kenya's agricultural sector—with particular concern being raised regarding the vulnerability of the country's millions of smallholder farmers. Understanding of precisely how the sector will be affected is limited. Studies have identified the potential for greater production in the highlands and lower production in the ASALs, and potential impacts on key crops such as maize. Current understanding points to the need for investment in adaptation measures such as development of drought-tolerant crops, income diversification, improved access to meteorological information, and conservation of water resources. The forestry sector faces risks such as increased water scarcity, fire risk, and exposure to invasive species and pathogens. Little assessment appears to have been undertaken of the potential impacts of climate change on Kenya's important freshwater fisheries sector.

The Government of Kenya has initiated efforts to improve climate risk management within the agriculture sector through its *National Policy for the Sustainable Development of Arid and Semi Arid Lands of Kenya (2007)* and *Agriculture Sector Development Strategy 2010–2020*. The latter identifies climate change as a main constraint on future development and includes commitments to climate risk management actions such as expansion of irrigation infrastructure, investments in water storage and rainwater harvesting. Addressing the numerous non-climatic challenges facing the sector—such as a skewed landholding system, poor infrastructure, inefficient land policies and legislation, and government corruption (ETC, 2006; FAO, 2011; ROK, 2010; Ikiara et al., 2009)—would also enhance the country's capacity to manage climate risks.

The **health** of Kenyans is also influenced by extreme weather events such as storm surges, heat waves, and droughts, and by climate-influenced vector- and water-borne diseases such as malaria, cholera, and typhoid. In particular, 5 per cent of deaths in Kenya are due to malaria (ROK, 2009, p. 3). Climate change is expected to increase exposure

to malaria, as well as malnutrition, Rift Valley fever and various water-borne diseases (WHO, 2010). Climate change research to date has largely focused on malaria and, to a lesser extent, cholera in the Lake Victoria Basin. Uncertainty remains, however, regarding if and how outbreaks of these diseases will change in the future. More research is required in this area, as well as on the relationship between climate change and health concerns such as heatstroke, malnutrition and HIV/AIDS.

Reducing climate-related health risks in Kenya, particularly among poor households, will require addressing the underlying causes of vulnerability (including poverty and poor water and sanitary services) and the capacity of the health-care system to manage climate-influenced diseases. The country's current capacity to respond is low (Yanda et al., 2006), due in part to limited expenditure on health per person per year (GOK, 2008) and an uneven distribution of funding resources in which only 30 per cent of Kenya's total health-care budget is allocated to rural areas (GOK, 2008). Improving the health-care system by moving from a curative to a preventive system, decentralizing health delivery and strengthening district medical centres forms part of *Kenya's Vision 2030* and its *First Medium Term Plan (2008–2012)*. Implementation of these plans should positively impact climate risk management efforts, but will require the commitment of considerable technical, financial and human resources.

Climatic conditions also influence **energy** production in Kenya. Traditional fuels like wood, charcoal, dung and agricultural residues continue to be used by over 85 per cent of Kenyans (ROK, 2011). Access to these energy sources is becoming increasingly restricted due to the loss of forest cover, rising populations, existing land tenure arrangements and inefficient utilization (Mugo & Gathui, 2010). Climate change could accentuate this situation by altering the growth of forests and agricultural crops. Within the modern energy sector, large hydroelectric power stations generate just over half of Kenya's electricity supply, which is used by about 23 per cent of Kenyans, primarily in urban areas. Demand for electricity is increasing significantly as the population and economy grow, and is expected to continue to expand (ROK, 2011). Reduced rainfall in recent years has already made hydroelectric power production increasingly unreliable, leading the Government of Kenya to introduced new policies and strategies that place greater emphasis on promoting renewable sources such as geothermal, solar, wind and biofuels. Research is needed to understand the potential vulnerability to climate change of these renewable sources and of Kenya's transmission infrastructure (GOK, 2010).

Other sectors facing growing climate risk include tourism, industry and infrastructure. The **tourism** industry forms a vital part of Kenya's economy—one that is expected to grow, as the country aims to become one of the top-10 long-haul destinations in the world (GOK, 2007b). Achieving this goal will be challenged by climate risks that include the loss of tourism attractions such as coral reefs, coastal beaches and Mt. Kenya's glaciers; changes in wildlife migration patterns and species diversity; damage to infrastructure; water restrictions; and higher demand for air conditioning. The government has called for the development of a national wildlife adaptation strategy to help better understand the risks facing this industry (GOK, 2010).

Significant expansion of Kenya's **industrial** sector is envisioned as part of *Vision 2030* and is expected to occur in part through expansion of climate-sensitive industries such as agro-processing. Industry can also be affected by reduced access to water supplies and hydroelectric power during times of drought, and its coastal installations may be damaged by future sea-level rise. Expansion of Kenya's transportation and communication **infrastructure** is also planned under *Vision 2030* to support achievement of Kenya's economic development goals (GOK, 2007b). As the government recognizes, these new investments will need to be "climate proofed" to ensure resilience over their lifespans (GOK,

2010). Similarly, with projections suggesting that Kenya will become a predominately urban country by 2033 (World Bank, 2011), building capacity to manage climate risks in **urban** centres will increase in importance. The integration of climate risks into plans for industrial, infrastructure and urban expansion is needed to foresee and mitigate concerns.

The needs of a number of **vulnerable groups**, including the poor, women, children, the disabled and those living with HIV/AIDS, need to be carefully considered in any assessment of climate risk in Kenya. Members of these groups typically have restricted access to and control over resources such as capital, credit and land, and are therefore less able to cope with climate shocks and stresses. While all of these groups face unique challenges, most research to date has focused on the vulnerability of women to climate risks. Commitments under *Vision 2030* and the *First Medium Term Plan* that aim to reduce poverty and wealth disparities, such as a consolidated social protection fund, a disability fund and a national drought contingency fund, should contribute to lessening vulnerability to climate risks (GOK, 2008). To date, however, climate risk does not appear to have been integrated into efforts to advance gender equity and the needs of vulnerable groups. This gap needs to be addressed for the vulnerability of marginalized groups to be effectively mitigated.

Capacity to Mitigate Climate Risk

Effective management of climate risks requires ensuring that functioning governance frameworks and institutions are in place, high-quality climate data and information is accessible, and sufficient human, technical and financial resources are available (Hellmuth et al., 2007).

Governance frameworks and institutions

Separate systems for management of disaster risk and adaptation to climate change have been established in Kenya. Disaster risk management is led by the Ministry of State for Special Programs, the National Disaster Operations Centre, the Cabinet's National Disaster Management Executive Committee and the National Platform on Disaster Risk Reduction. Specific bodies have also been established to manage droughts, including the Kenya Food Security Steering Group and the Drought Management Authority in the Ministry for Development of Northern Kenya and Other Arid Lands. Current efforts are guided by the *Disaster Risk Reduction Strategy for Kenya 2006–2016*. A draft *National Disaster Management Policy* (GOK, 2009) is currently awaiting approval by Cabinet. Overall, disaster risk management efforts in Kenya remain largely focused on reactive, short-term emergency or relief responses. Poor coordination among institutions has slowed responses to disasters and increased associated costs (IRIN, 2010). As well, the absence of an official national policy has impeded access to the budgetary resources needed to support more proactive disaster management efforts (KNPDRR, 2011).

Government bodies established to coordinate Kenya's response to climate change include the National Climate Change Activities Coordinating Committee, the Environment and Climate Change Coordination Unit in the Office of the Prime Minister, and the Climate Change Secretariat, which is housed within the Ministry of the Environment and Mineral Resources (MEMR). While MEMR has lead responsibility for coordinating and supervising climate change efforts across government, numerous other ministries and parastatal organizations are also actively engaged in climate change actions.

A policy framework to guide Kenya's climate change response is beginning to emerge. The country's 2010 National Climate Change Response Strategy (NCCRS) provides guidance on how the ambitious goals set forward in *Vision 2030* could be achieved through "climate smart" development. To enable the NCCRS, a climate change action plan is expected to be completed in 2012. As well, to strengthen institutional capacity for integrating climate change adaptation into the national development planning process, the Ministry of Planning has developed the Threshold 21 Model (T21). This planning tool integrates analysis of the risks and impacts of climate change across the major sectors in the economy, society and environment, in order to inform coherent national development policies that encourage sustainable development, poverty eradication, and increased well-being of vulnerable groups, especially women and children, within the context of *Vision 2030* (Ministry of State for Planning, National Development and Vision 2030, 2011).

Through these and other efforts, the Government of Kenya has acted to improve its capacity to manage climate change and is working to improve inter-ministerial coordination and integrate climate change considerations into national planning processes. However, challenges remain, including:

- Current policy action related to climate change and disaster risk management has largely been undertaken at the national level. Greater effort is needed to strengthen capacity at the district and provincial levels, particularly given the devolution process taking place under the new constitution.
- Climate risks need to be more fully integrated into policy planning and budgetary processes. For example, climate risks have not been integrated into a number of key policies, such as Kenya's WSIP, *Second National Health Sector Strategic Plan* and *National Gender and Development Policy*.
- Greater resources and capacity are needed to enable the MEMR and other established institutions to effectively fulfill their responsibilities (Mutimba et al., 2010).
- Clear institutional guidance regarding how to achieve an integrated response to disaster risk reduction and adaptation to climate change is needed for Kenya to strengthen inter-governmental cooperation and effectively manage its growing exposure to climate risks.

Climate data and information

Within Kenya, historical climate data and climate forecasts are provided through the Intergovernmental Authority on Development Climate Prediction and Applications Centre, as well as the Kenya Meteorological Department (KMD), which is housed within MEMR. The reliability of KMD's forecasts, including seasonal forecasts, has increased in recent years, and they are generally accurate (Ndegwa et al., 2010). Continuous improvement, though, would address concerns such as human resource constraints, restricted capacity to collect and disseminate data, the need for greater real-time data collection and transmission (Mwagi, n.d.), and a lack of regional modelling capacity. The Meteorological Systems Modernization Programme in *Vision 2030* should help address some of these concerns.

Climate risk management efforts further require a strong understanding of current and anticipated environmental, topographic, economic and social conditions. The Central Bureau of Statistics, the Department of Resource Surveys and Remote Sensing and a variety of institutions outside of government collect and analyze this data. However, their work remains largely uncoordinated, and gaps remain in the availability, accuracy and accessibility of data (GOK, 2008). Examples include limited availability of information on major water catchment areas and gender-disaggregated data. Plans such as those to establish a geographic information system–based land information management system,

strengthen the Health Management Information System and prepare a national spatial plan (GOK, 2008) should help overcome these gaps.

Human, technical and financial resources

A broad array of technical and human capacity constraints exists at all levels in Kenya, from the national to the community, and impedes climate risk management efforts. Gaps in capacity exist in regard to:

- Awareness among the public and policy-makers of climate change, its potential consequences and its possible ramifications for Kenya's development goals.
- Risk assessment, development of options for managing risks and the ability to integrate climate risk into ongoing adaptation projects (Matiru, 2009).
- Designing, funding and implementing projects and programs (KNPDRR, 2011; Matiru, 2009).
- Systematic collection of lessons learned and dissemination of information among a wide range of stakeholders active in different sectors and jurisdictions.
- Coordination of national strategies and policy frameworks to facilitate oversight of climate risk management and to guide integrated, multisectoral efforts (GOK, 2010; NEMA, 2005).
- Financial constraints at the district, provincial and national levels.

The Government of Kenya has identified the need to establish a capacity-building framework to overcome these challenges (GOK, 2010). This strategy is expected to be included in the climate change action plan to be completed in 2012.

Recommendations

Based upon this review, we make the following recommendations:

Sector-specific recommendations to address knowledge gaps

- *Crop production*. Conduct a deeper analysis regarding the potential impact of climate change on a broad range of agricultural crops in different regions of the country to ensure food security and this sector's continued contribution to the national economy.
- *Livestock production*. Further analyze how to build herders' capacity to cope with more arid conditions and the potential for more intense droughts, including investigating opportunities for livelihood diversification (Aklilu & Wekesa, 2002; Kabubo-Mariara & Karanja, 2007).
- *Fisheries*. Perform a full assessment of how Kenya's freshwater fisheries sector will be affected by climate change, given its important role in food security and the provision of local livelihoods.
- *Forestry*. Improve understanding of the status of existing forests in Kenya, within and outside of gazetted areas, particularly their location, composition, contribution to the provision of ecosystem services, rehabilitation requirements, and trends in growth, yields and quality. Further research is also needed regarding potential changes in forest characteristics and their exposure to fire, pests, diseases and invasive species.

- *Water*. Improve comprehension of how climate change will affect Kenya's five "water towers" (forested highland and mountain areas that supply most of the country's fresh water) and other watersheds, particularly those in areas already experiencing water stress. A catchment-basin-by-catchment-basin study could be undertaken that accounts for not only potential changes in climatic conditions but also potential increases in demand due to population growth and economic development (Mogaka et al., 2006). Greater understanding of appropriate policies and measures for achieving sustainable and efficient use of water is also needed.
- *Tourism*. Perform an economic analysis of the myriad potential consequences of a changing climate on Kenya's tourism sector, and how these impacts might be ameliorated. Greater understanding is needed of possible changes in habitat distribution, composition and function, wildlife abundance and migration patterns, and tourism demand. Completion and implementation of the national wildlife adaptation strategy should contribute to achieving this objective.
- *Coastal zones*. Research how Kenya's coastal areas could be affected by climate change, including the impact of sea-level rise on the loss of low-lying areas, salt-water intrusion into freshwater resources and damage from storm surges. Additional analysis of potential impacts on coastal resources such as coral reefs and inshore fisheries would also enhance capacity to manage climate risks.
- *Energy*. As recommended in the NCCRS, assess the vulnerability of renewable energy sources such as solar, bioenergy and wind to climate change, as well as the vulnerability of Kenya's energy transmission infrastructure (GOK, 2010).
- *Infrastructure*. Improve understanding of the vulnerability of critical infrastructure, including ports, roads, railways and telecommunication networks, to the impacts of climate change. As well, awareness, capacity, tools and (as appropriate) legal requirements are needed to ensure that new infrastructure is "climate proofed" and therefore able to withstand higher temperatures, more intense rains, stronger winds and rising seas (GOK, 2010).
- *Health*. Enhance knowledge of the relationship between climate change and health-related risks. Along with continued research on the implications of climate change for malaria and cholera, more research is needed on concerns such as malnutrition, heatstroke and HIV/AIDS. Health early-warning systems also need to be strengthened (Wandiga et al., 2010).
- *Disaster risk*. To inform future planning, expand research on the nature of past disasters, along with performing a comprehensive disaster-risk assessment (Ngethe, 2010).
- *Urban areas*. Seek to better understand the vulnerability of Kenya's urban centres to the impacts of climate change and climate risk reduction options. As centres such as Nairobi and Mombasa are expected to play a vital role in Kenya's economic development, and with more than half of all Kenyans projected to live in urban areas by 2033 (World Bank, 2011), greater understanding of urban vulnerability is vital to the achievement of long-term development goals.
- *Vulnerable communities*. Address the differential effects of climate change on specific groups within Kenya. New research could be undertaken to increase comprehension of the potential implications of climate change for groups such as women, children, the disabled, internally displaced people and international refugees.

General recommendations to strengthen response capacity

- *Climate projections*. Strengthen understanding of projected changes in climatic conditions, particularly rainfall patterns, at the subnational level. Achieving this understanding will require fulfilling commitments to rehabilitating Kenya's hydrometeorological data-gathering network and implementing the Meteorological Systems Modernisation Programme. It will also require further developing regional climate models, providing greater access to real-time data collection and transmission, and addressing human resource constraints.
- *Capacity at the subnational level*. Enhance knowledge and capacity to manage climate risks at the subnational level, establish appropriate horizontal and vertical coordinating bodies, and put in place the technical, financial and human resources needed to support climate risk prevention, response and recovery. Efforts so far to strengthen institutional and human capacity to manage and coordinate climate risks have largely been focused at the national level. Less capacity has been built at the provincial and district levels, limiting implementation of climate risk management actions. The importance of this issue will increase with the devolution of power to the county level, as set out in the new constitution.
- *Adaptive planning*. Improve communication between climate scientists and policy-makers, to contribute both to ensuring that decisions consider climate risks and to strengthening adaptive planning efforts. Recognizing the considerable uncertainty that remains regarding the types of future climate risks Kenyans will face in different regions of the country, as well as the ongoing evolution of knowledge in this area, emphasis should be placed on iterative planning methods that respond to changes in the availability of information.
- *Gender integration*. Give greater attention to understanding how climate risks differ between men and women, and incorporate this knowledge into planning and programming. Although the Government of Kenya aims to mainstream gender considerations into government policies, plans and budgets, progress to date has been limited. Increasing the availability of gender-disaggregated data would further support progress on this issue. As well, the National Commission on Gender and Development appears to have the potential to play a stronger role in raising awareness of the links between gender and climate risks.
- *Data collection and sharing*. Centralize the relevant socioeconomic, environmental and topographic data currently scattered among different institutions, which will strengthen climate risk management capacity. These efforts should be complemented by harmonizing collection methodologies, storage and data access related to the environment and natural resources (GOK, 2008).
- *Integration of climate considerations into policy and programming*. Building on existing initiatives, strengthen efforts to enable integration of climate risks into relevant policies and programs. Examples of current and future initiatives into which climate risk considerations could be integrated include the Water Catchment Management Initiative, the WSIP and the National Spatial Plan. Continued efforts to raise awareness of policy-makers regarding climate risks and response options would facilitate these efforts.
- *Coordination between climate change and disaster risk management*. Clarify and promote harmonization of the institutional framework guiding climate change and disaster risk management, as well as strengthen the capacity of existing institutions to promote a more integrated approach to addressing these issues.
- *Vision 2030*. Ensure achievement of relevant components of this document, which puts forward an ambitious development plan for Kenya—one that identifies concrete goals related to the three pillars of economic, social and political performance. Some of the commitments directly support climate risk management, such

as implementation of the Meteorological Systems Modernisation Programme. Many others, though, have the potential to indirectly help reduce vulnerability to climate risks, such as establishment of a consolidated social protection fund to support orphaned and vulnerable children, the disabled and other vulnerable groups; strengthening Kenya's health system, particularly in rural areas; and diversifying Kenya's energy supply system—moving away from large-scale hydroelectric power and toward decentralized, renewable energy sources.

- *Technical and human capacity to manage climate risks*. Continue to build climate risk management capacity through a diversity of action in different sectors aimed at various actors from the national to the community level. For instance, training is needed to enhance capacity to assess climate risks, increase the capacity of local communities to reduce climate risks, and enable scientists to undertake required research and development in the field of climate risk management (GOK, 2010). Priority capacity-building needs are expected to be identified in the new climate change action plan.
- *"Climate proofing" the medium-term planning process and Kenya's budgetary process*. "Climate proof" these key national processes by mainstreaming climate change into their development and implementation. This process could be supported by use of the T21-Kenya model, which provides a substantive step toward incorporating climate risks into the planning process. In undertaking this process, priority could be given to ensuring implementation of the priority adaptation actions identified in Kenya's new climate change action plan.

Climate Risks, Vulnerability and Governance in Kenya

Climate-related risks have always influenced life in Kenya. Along the coasts, fishermen worry about cyclones and sudden storms. Inland, in the arid and semi-arid regions of eastern and northern Kenya, the livelihoods of farmers and pastoralists depend on the arrival and quality of the rains. In the central and western highlands, bisected by the Great Rift Valley, heavy rains can lead to floods and landslides. Kenya's people have developed complex mechanisms for coping with the climate risks associated with the dynamic natural system in which they live. Today, however, these mechanisms are under greater stress.

In Kenya, as around the world, the balance between natural systems and human livelihoods has increasingly been upset by flawed development practices that have led to environmental degradation and weakened socioeconomic systems (e.g. UNDP, 2002a). New climate hazards have been created as expanding populations have pushed settlement into marginal areas and ecosystem services have been undermined. At the same time, traditional sociocultural relationships have been altered by the process of modernization and development. The ongoing process of human-induced climate change is likely to accentuate these stresses. Climate change is expected to increasingly be a key contributor to morbidity, mortality and poverty—particularly among populations that depend on climate-sensitive natural resources, experience high poverty, and have insufficient access to the social, environmental and economic resources needed to adapt (O'Brien et al., 2008).

Kenya has recognized the growing threat of climate-related risks to its near- and long-term development prospects. Kenya's *Vision 2030* has set a goal of improving capacity to adapt to global climate change, and the National Climate Change Response Strategy (NCCRS) has identified adaptation priorities. However, *Vision 2030* does not adequately incorporate climate change and is not linked with the NCCRS. Other actions are being undertaken to understand and strengthen climate risk management at the policy level, as well as through various programs and projects from the community to the national level. While these efforts have increased Kenya's capacity to understand and respond to the risk posed by climate change, a comprehensive analysis of the climate risks facing the country and its capacity to address these risks has not yet been undertaken.

The objective of this paper is to fill this gap. It provides a concise, desk-based review of what is already understood regarding climate-related risk in Kenya. Its structure reflects an understanding of *climate risk* (defined in Box 1) as resulting from the interaction between two factors: the vulnerability of human systems in the context of climate variability and change, and the likelihood of exposure to different climate hazards. The paper therefore begins by providing an overview of Kenya's general development context in order to provide a clear understanding of the factors that will influence the vulnerability of its people and economy to climate risks. The next section reviews Kenya's historical, present and projected climate context, giving attention to climate parameters (such as temperature and precipitation) and climate hazards.

The paper subsequently assesses the degree of climate risk facing Kenya and the country's capacity to manage this risk. By bringing together an understanding of Kenya's development and climate context, Section 4 presents the climate risk profile of six key sectors—water, agriculture, health, energy, industry and services—and particularly vulnerable segments of the population (with a focus on gender). It assesses the implications of these climate risks for the achievement of Kenya's national development goals. The subsequent section examines the country's ability to respond to climate risk. It analyzes the extent to which institutional and policy arrangements for controlling, reducing and transferring

climate risk have been established; current efforts to manage climate risk in Kenya—predominantly through disaster risk reduction and climate change adaptation actions—and the lessons derived through these initiatives; and national capacity needs. The paper concludes by identifying critical gaps in Kenya's climate risk management efforts and recommending actions to better ensure the country's sustainable development objectives can be achieved with a changing climate.

BOX 1: DEFINITIONS

Climate risk: The probability of harmful consequences or expected loss (e.g., death, injury, loss of livelihoods, reduced economic productivity and environmental damage) resulting from interactions between climate hazards and vulnerable conditions in the context of climate variability and change (adapted from UNISDR, 2009).

Hazard: A potentially damaging physical event, phenomenon or human activity that may cause the "loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage" (from UNISDR, 2009, p. 17).

Climate hazards (also referred to as hydrometeorological hazards): "A physically defined climate event with the potential to cause harm, such as heavy rainfall, drought, storm, or long-term change in climate variables such as temperature and precipitation" (UNDP, 2005, p. 249). Climate hazards may occur suddenly (e.g. tornados) or slowly (e.g. droughts); they may be transient (e.g. storm) or permanent (e.g. increase in average temperatures); and may be observed in the present or projected to occur in the near, mid- or long-term.

Vulnerability: "the degree to which a system is susceptible to harm due to exposure to a perturbation or stress and the ability (or lack thereof) of the exposure unit to cope, recover, or fundamentally adapt (become a new system or become extinct)" (Kasperson et al., 2000; cited by UNDP, 2005, p. 250). The vulnerability of a system is influenced by the adaptive capacity of its people and institutions, or their ability to take advantage of opportunities or to cope with the consequences of potential damages (IPCC, 2001).

2.0 National Development

The capacity of a country and its people to plan for, manage and cope with anticipated and unanticipated climate risks depends in large measure on its economic, demographic, political and environmental circumstances. With a well-functioning and transparent governance system, countries are able to rapidly deploy resources to areas adversely affected by climate hazards. With effective communication systems, they can warn their citizens of pending hazards and appropriate actions for reducing risk. A healthy population and a strong health system enable countries to better prevent injury and mortality. Functioning ecosystems can mitigate the damage of extreme climate events, such as by storing water in times of limited availability and producing alternative food sources. And a robust and diverse economy can generate the financial resources required to support all of these efforts, especially in times of climate-induced stress.

To set the context for assessing Kenya's vulnerability to climate risks, this section therefore examines the country's economic, demographic, political and environmental circumstances. It reviews Kenya's historical and current development aspirations and its strategy for achieving these goals, and provides an overview of progress made to date.

2.1 National Development Vision, Objectives and Priorities

Since Kenya gained independence in December 1963, the thrust of the country's development agenda has been to alleviate poverty, improve human capital, reduce the disease burden among its people and foster economic prosperity (GOK, 2003; GOK, 2007b). Capacity to achieve these objectives has varied over the years.

Following independence, Kenya's economy initially grew as the government encouraged smallholder agriculture and public and foreign investment (USDS, 2011). Annual growth of per capita income averaged 2.8 per cent between 1964 and 1970 (Erixson, 2003, p. 28), while GDP grew at an average annual rate of 6.6 per cent between 1963 and 1973 (USDS, 2011). Economic growth slowed in the 1970s, 1980s and early 1990s. Kenya experienced a sharp rise in its fiscal deficit, a severe balance-of-payments crisis and rising inflation. In the 1980s, average per capita income growth was only 0.6 per cent. In response, Kenya became the first country in Africa to sign a structural adjustment loan (Erixson, 2003). Lack of government accountability, inefficiencies in the delivery of services at local and national levels, and corruption contributed to growing social inequality between regions and populations, high levels of poverty, poor living standards and degradation of natural resources (Ikiara et al., 2009). By the early 1990s Kenya was an aid-dependent country, with international development assistance constituting almost 27 per cent of GDP and 55 per cent of government expenditures (Erixson, 2003, p. 30).

Calls for political and constitutional reform increased after the period from 1991 to 1993, when Kenya experienced its worst economic performance since independence (USDS, 2011). Democratic, multi-party elections were held in 1992 and 1997, and economic reforms were initiated, including lifting controls on agricultural production, pricing and marketing (USDS, 2011) and focusing trade policy more on export promotion than import substitution (Erixson, 2003). Despite these efforts, Kenya's economic growth did not improve (GOK, 2003); between 1997 and 2002, the economy grew by an average of 1.5 per cent annually (USDS, 2011), and per capita income declined (GOK, 2003, p. viii).

The reform agenda continued in the 2000s, as articulated in Kenya's *Economic Recovery Strategy for Wealth and Employment Creation: 2003–2007*. This strategy sought to restore economic growth, create employment opportunities (particularly for youth) and reduce poverty levels (GOK, 2003). At this time, the country began to shift its focus

away from trade with Europe to other African countries (which accounted for 45 per cent of trade in 2011) and Asia (World Bank, 2011). As an indicator of the success of the Economic Recovery Strategy, between 2003 and 2007 food insecurity was reduced by 12 percentage points (from 48.5 to 36.5 per cent), and the poverty rate declined by 10 percentage points (from 56 to 46 per cent) (ROK, 2010, p. 5).

Kenya Vision 2030

In 2007 the Government of Kenya unveiled a new development platform under the flagship of *Kenya Vision 2030*. Building on the *Economic Recovery Strategy*, the government's development blueprint for the period from 2008 to 2030 aims to transform Kenya into a "middle-income country providing a high quality of life to all of its citizens by the year 2030" (GOK, 2007b, p. 1). To achieve this goal, specific objectives are set forward in relation to three pillars:

- The *economic pillar* sets the goal of improving the "prosperity of all Kenyans through an economic development programme, covering all regions of Kenya, and aiming to achieve an average Gross Domestic Product (GDP) growth rate of 10% per annum beginning in 2012" (GOK, 2007b, p. 1). Six sectors are identified as priorities for investment: tourism, agriculture, wholesale and retail trade, manufacturing for markets in eastern and central Africa, business-process offshoring,[1] and financial services.
- The *social pillar* seeks to "build a just and cohesive society with social equity in a clean and secure environment" (GOK, 2007b, p. 1). Key components of the social pillar are education and training; health care; water and sanitation; environment; housing and urbanization; gender, youth and vulnerable groups (which includes sports and culture); and equity and the elimination of poverty.
- The *political pillar* aims to realize a "democratic political system that is issue-based, people-centred, results-oriented and accountable to the public" (GOK, 2007a, p. 22). The political pillar comprises activities concerning the rule of law, electoral and political processes, democracy and public service delivery, transparency and accountability, and security, peace-building and conflict management (GOK, 2007a).

Collectively the economic, social and political pillars of *Kenya Vision 2030* are anchored in a commitment to continuing Kenya's macroeconomic stability, reforming governance, correcting economic and social inequalities, building infrastructure and energy systems for economic growth, investing in science and technology, reforming land policy and legal frameworks, enhancing human capital through lifelong training and education, improving security, and building "an efficient, motivated and well-trained public service" (GOK, 2007a, p. 9).

Kenya Vision 2030 is being implemented through successive five-year medium-term plans, beginning with the period from 2008 to 2012. Key targets of this plan include (GOK, 2008):

- Increasing real growth of the country's GDP to between 7.9 and 8.7 per cent by 2009–2010, and to 10 per cent by 2012.
- Reducing the number of Kenyans living in poverty from 46 per cent to 28 per cent.
- Improving rural and urban access to clean water, in part through rehabilitation and protection of forests in five critical watersheds.
- Expanding the agricultural sector's contribution to GDP by between 6 and 8 per cent through measures such as irrigating an additional 1.2 million hectares of land.

[1] The provision of business services to companies and organizations in developed countries using Internet-based technologies (GOK, 2007b).

- Restructuring the health system to focus more on disease prevention.
- Connecting one million households to electricity and linking Kenya to the Southern African Power Pool.
- Trebling national earnings from the tourism sector.

Reflecting *Kenya Vision 2030*'s commitment to "enhance disaster preparedness in all disaster-prone areas and improve the capacity for adaptation to global climatic change" (GOK, 2007a, p. 19), the *First Medium Term Plan* also includes commitments that specifically address climate risk. To improve disaster preparedness, the government intends to implement a Meteorological Systems Modernisation Programme that will establish a tidal gauge station and marine automatic weather systems and introduce dynamic modelling capabilities for prediction of weather and climate (GOK, 2008). It has also committed to securing funding from international sources to support adaptation action in Kenya's ASALs and high-risk zones; improving Kenya's disaster preparedness strategy, "including an early warning system and environmental monitoring covering climatic events... as well as initiation of a public awareness, avoidance and preparedness campaign" (GOK, 2008, p. 111); and establishing conflict and disaster early warning and response mechanisms based on monitoring of trends such as food and water shortages (GOK, 2008). The government is also committed to strengthening its National Climate Change Secretariat by 2012 (GOK, 2008).

2.2 National Development Conditions, Trends and Challenges

A closer examination of the existing socioeconomic situation in Kenya provides a clearer picture of the capacity of its people to cope with the impacts of climate risks, and therefore of their vulnerability to these hazards. This picture reflects the outcome of the country's historical political and economic struggles and its recent efforts toward revitalization. Hence, although Kenya has made progress since 2000 toward achieving its sustainable development objectives, as reflected in the positive trend of its Human Development Index (HDI) (see Figure 1), its level of human development remains low. At 0.470, Kenya's HDI ranked 128 of 169 countries in 2010 (UNDP, 2010). Kenya's *First Medium Term Plan* set the target of increasing this score to 0.7 by 2012 (GOK, 2008).

Since achieving independence, Kenya has experienced significant changes. Demographically, the number of Kenyans has grown from just over 8 million in 1963 to more than 40 million today (World Bank, 2011). This growth is projected to continue at a rate of more than 1 million per year; by 2040, the population of Kenya is expected to reach 75 million (World Bank, 2011). While Kenya's population continues to rise, the reasons for this growth are changing. While growth was previously driven by an increase in the birth rate, the number of children per family has decreased substantially, from an average of 8.1 in 1987 to 4.6 in 2008—and is projected to be 2.4 in 2050 (World Bank, 2011, p. viii). Today, population growth is increasingly due to a combination of greater life expectancy and greater survival rates leading to more women in their twenties and thirties (World Bank, 2011).

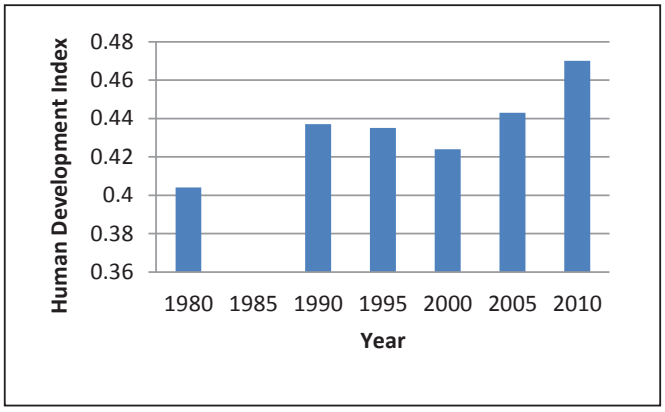

FIGURE 1: KENYA'S HUMAN DEVELOPMENT INDEX FROM 1980 TO 2010

Data source: UNDP (2010, p. 150)

Although 70 per cent of Kenyans continue to reside in rural areas (World Bank, 2011), including approximately 7.4 million people in its ASALs (GOK, 2007a), the growing population is increasingly urbanizing. With more than 250,000 migrating from rural areas each year, the number of people living in urban centres is expected to increase to 37 per cent by 2020; by 2033, Kenya will become a predominately urban country (World Bank, 2011). At present, many urban dwellers live in poverty; 60 per cent of the population of Nairobi lives in slums (ROK, 2009). A significant driver of the ongoing process of rural to urban migration is youth unemployment, as young people seek opportunities in larger centres. Youth between the ages of 15 and 35 compose approximately 38 per cent of Kenya's population; about 72 per cent of the unemployed workforce consists of people below the age of 30 (GOK, 2008, p. 38). Creating employment for this demographic is a critical priority for Kenya.

A larger and increasingly urbanized population creates challenges and opportunities, both of which must be addressed through the development of Kenya's economy. Following the economic decline of the 1980s and 1990s, Kenya's annual GDP growth rate rose from 0.6 per cent in 2002 to 6.1 per cent in 2006 (GOK, 2007a). This positive momentum was halted in 2008, first by the political crisis that followed the 2007 elections, and subsequently by drought and the international financial crisis; Kenya's annual GDP growth rate fell to less than 2 per cent in 2008 (USDS, 2011). Its economy has since rebounded, with economic growth reaching 5.6 per cent in 2010, and projected to be 4.8 per cent in 2011 and 5.0 per cent in 2012 (World Bank, 2011). While these rates of economic growth are less than what is envisioned in the *First Medium Term Plan*, they are higher than the rate of growth in all previous decades and put Kenya on track for achieving middle-income country status (US$1,000 GDP per capita) by 2019 (World Bank, 2011).

Although economic diversification is an important component of *Kenya Vision 2030*, the national economy remains driven primarily by agriculture, tourism and services, along with pastoralism, horticulture, fisheries and forest products. Remittances also form an important part of the economy, being the country's largest source of foreign exchange. In 2010, the Central Bank of Kenya reported US$640 million in remittances, but they might actually have been as high as US$1 billion (USDS, 2011). Agricultural production has strongly influenced Kenya's economic performance historically (as illustrated in Figure 2) and continues to do so today. For instance, Kenya's unexpectedly strong economic performance in 2010 was in part due to good rains that enabled the agriculture sector to grow by 6.3 per cent (World Bank, 2011). This also demonstrates the direct influence of climate on the national economy. Many of Kenya's critical economic sectors, including agriculture, tourism and pastoralism, are climate dependent.

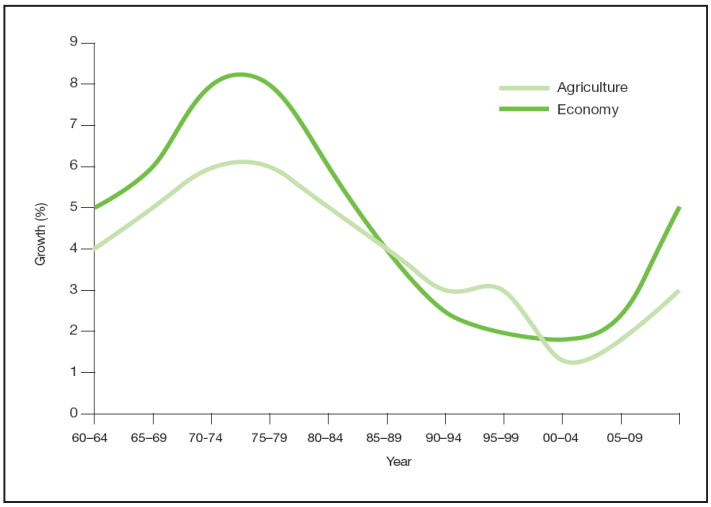

FIGURE 2: TRENDS IN AGRICULTURAL AND ECONOMIC GROWTH BETWEEN 1960 AND 2008

Reprinted with permission from GOK (2010)

Kenya's historically weak economic performance is reflected in the fact that nearly half of its people (46.9 per cent) lived below the national poverty line in 2006 (GOK, 2008, p. 4). As seen in Table 1, the proportion of the population living in poverty has changed little over the past couple of decades. Average annual income per person was US$650 in 2006 (GOK, 2008, p. 4). Although this has since risen to approximately US$780 per person (USDS, 2011), it remains short of the goal in the *First Medium Term Plan* of US$992 by 2012 (GOK, 2008, p. 4).

These national-level statistics disguise significant differences among regions due to factors such as climate, agroecological characteristics and differential access to services (World Bank, 2009). The vast majority of poor Kenyans are rural (World Bank, 2009). The proportion of poverty is highest in North Eastern Province, followed by Coast, Western and Eastern province; it is lowest in Nairobi and Central provinces (World Bank, 2009)—the only regions in Kenya where the incidence of poverty is less than 50 per cent (ROK, 2009, p. 1). In absolute terms, the provinces with the greatest number of people living in poverty are Rift Valley (consistent with its larger population), followed by Eastern (World Bank, 2009).

Economic gains since 1997 have been highly concentrated among urban residents and the wealthiest quintile of Kenyans. Consequently, high economic and social inequality persists (World Bank, 2009). Economic, social and environmental factors contribute to these inequities. Continual ecological decline combined with drought, for example, contributes to rising poverty in the ASALs. Addressing poverty and reducing disparities in wealth distribution is a priority goal of *Kenya Vision 2030*, with particular attention to urban slums, marginalized groups in the ASALs, and pockets of extreme poverty in other areas (GOK, 2007a). Addressing gender disparities is also a priority, recognizing that women constitute more than half of poor people in Kenya (Wong et al., 2005, p. 3). Kenya ranks 117 of 169 countries in terms of progress toward gender equality (UNDP, 2010).

The poverty of many Kenyans is influenced by their ability to access critical services such as water, health and education, as well as to benefit from a healthy ecosystem. As suggested in Table 1, access to safe water has increased since 1990; in recent years, these gains have been achieved across all provinces (World Bank, 2009). Still, more than 40 per cent of the population continues to draw water from unsafe sources (UNDP, 2010). Access is lower in rural areas, where it is estimated that only half of the population has access to safe water (compared with 75 per cent of the urban population [GOK, 2008]). It is also significantly lower among the poor (World Bank, 2009).

TABLE 1: INDICATORS OF HUMAN DEVELOPMENT IN KENYA

		1990[a]	2000[c]	2010[d]
POPULATION	Total Population (in millions)	24.0	30.7	40.9
	Annual population growth rate	3.6% (1960–1990)	3.3% (1975–2000)	2.6 (2010–2015)
	Population in urban centres	18.2%[e]	19.7%[e]	22.2%
ECONOMY	Gross national product per capita (in US$)	366[e]	406[e]	795[e]
	Population below (Kenya's) national poverty line		42.0% (1987–2000)	46.6% (2000–2008)[1]
ACCESS	Gender inequality index		0.511	0.738 (in 2008)
	Adult literacy rate (15 years of age and above)[b]	69%[b]	82.4	86.5% (2005–2008)[1]
	Population with access to improved/safe water sources	30% (in 1988–1990)	49%	59% (in 2008)[1]
HEALTH	Life expectancy at birth[b] (in years)	59.7[b]	50.8	55.6
	Mortality of infants (per 1,000 live births)	68	77	81 (in 2008)[1]
	Mortality of children under 5 years of age (per 1,000 live births)	108	120	128 (in 2008)[1]

[1] *Data refer to the most recent year available during the period specified.*

Source: (a) UNDP (1992) unless otherwise indicated; (b) UNDP (1993); (c) UNDP (2002b); (d) UNDP (2010); and (e) World Bank (2012). Calculations are based on population estimates of the World Bank and urban ratios from the United Nations World Urbanization Prospects (World Bank, 2012).

Health indicators for Kenya suggest that while life expectancy at birth has increased in the past decade, no progress has been made with respect to reducing infant mortality and the mortality of children under five years of age; in fact, both have increased since 2000 (see Table 1). Under its *First Medium Term Plan*, Kenya set the goal of reducing under-five mortality from 120 to 33 per 1,000 (GOK, 2008, p. ix). The challenges Kenya faces with respect to improving the health of its population are linked to its overall levels of poverty and limited access to clean water and preventive services (World Bank, 2009).

Kenya has made greater progress recently with respect to educating its population. Gross primary education has increased in all provinces since 2003 (World Bank, 2009), when Kenya introduced free primary education for all. This policy immediately enabled an additional 1.2 million people to enroll, raising the number of students to over 7.4 million (Omwami & Omwami, 2009), including members of the country's poorest households (World Bank, 2009). By 2009 Kenya had attained a net primary enrolment of 83 per cent and a net secondary enrolment of 50 per cent (World Bank, 2012). In 2008 Kenya introduced free secondary education (Anonymous, 2008a) as well as bursaries to make access more affordable (World Bank, 2009). Its target is to increase the number of students transitioning from primary to secondary school to 75 per cent by 2012 (GOK, 2008, p. ix). Despite this progress, access to education remains unequal: Net primary enrolment among the poorest has reached only 70 per cent of the population, and "is particularly low in Coast, Rift Valley and North Eastern provinces" (World Bank, 2009, p. xxii). Less than 20 per cent of children, particularly girls, are enroled in school in the northeastern districts (ROK, 2009).

Governance in Kenya has improved in recent years, beginning with the establishment of democratic, multi-party elections in the early 1990s. For example, some progress has been made toward reducing the endemic corruption that has negatively impacted Kenya's reputation. Still, as recognized in *Kenya Vision 2030*, further effort is needed to build a political system that responds to the needs of the people and is results-oriented and accountable (GOK, 2007a). A critical step toward this goal occurred in August 2010, when Kenya approved a new constitution that includes provision for the devolution of responsibility to county[2] governments (World Bank, 2011). This process creates both risks (if the devolution process is not managed properly) and opportunities—including the potential to bring decision-making closer to the people, make governments more accountable for the provision and delivery of services (World Bank, 2011), and tailor policies and measures more specifically to local contexts.

A final defining parameter of Kenya's development profile is the health of the ecosystems that underpin many of its people's livelihood activities and large parts of its GDP, foreign revenue and export earnings (SEI, 2009). Unfortunately, due to a combination of rapid population growth, shifting climate patterns and overgrazing (USDS, 2011), all critical ecosystem services are under stress, and in nearly every province of Kenya they are under threat (see Table 2) (Wong et al., 2005). Nearly one-third of Kenyans live on degraded lands (UNDP, 2010). These changes have led to a decline in living standards and persistent poverty, especially in the rural areas, and encouraged an increase in migration into urban centres.

TABLE 2: ECOSYSTEM SERVICES AND CONSTITUENTS OF WELL-BEING: DEGREE OF THREAT BY PROVINCE

PROVINCE	MAINTENANCE OF BIODIVERSITY	FOOD PRODUCTION	WATER SUPPLY	ENERGY RESOURCES	ADEQUATELY NOURISHED	CLEAN WATER	ENERGY FOR WARMTH AND COOKING	EARN LIVELIHOOD
Central	X	X	X	X	X	X	X	X
Coast	X	X	X	X	X	X	X	X
Eastern	X	X	X	X	X	X	X	X
North Eastern	X	X	X	X	X	X	X	X
Nyanza	O	O	O	O	--	O	O	O
Rift Valley	X	X	X	X	X	X	X	X
Western	O	O	O	O	--	O	O	O

X highlights those areas of immediate priority.
O indicates that an ecosystem service or well-being constituent is under threat in a particular province.
-- indicates that an ecosystem service or well-being constituent is not under threat.

Source: Modified from Wong et al. (2005, p. 2).

Overall, Kenya continues to experience a number of development challenges, such as high poverty (particularly in rural areas), economic inequality, limited access to critical services like water and health care, and environmental degradation. Kenya is not expected to meet all of its Millennium Development Goals (UNDP, n.d.b).[3] Nor is it likely to achieve the government's objective of "raising the level of Kenya's Human Development Index from approximately 0.5 in 2007 to 0.7 by 2012" (GOK, 2008, p. 4). However, Kenya has made positive strides in recent years with respect to the development and diversification of its economy and the provision of education. These actions suggest that the country is moving forward on its sustainable development objectives.

[2] Previously called districts.
[3] Kenya is expected to achieve its Millennium Development Goals related to universal primary education, and is making progress toward reducing child mortality and HIV/AIDS. Challenges remain with respect to eradicating extreme hunger, improving gender empowerment and ensuring sustainability of the environment (UNDP, n.d.b).

2.3 Development Similarities and Differences with East African Neighbours

For a fully defined picture of Kenya's socioeconomic development, it is useful to look at its progress compared with other East African countries, namely Burundi, Djibouti, Eritrea, Ethiopia, Rwanda, Somalia, Tanzania and Uganda. These countries share a number of similarities. Poverty, high inequality, social exclusion and vulnerability to shocks are pervasive in all. All have agriculture-based economies, and, with the exception of Djibouti, a high proportion of their people live in rural areas. Several are rebuilding following periods of civil unrest or war, and security remains a concern in some, particularly Somalia. Due to recent conflicts, many displaced people have migrated within the region. Kenya, in particular, hosts a large number of these refugees: approximately 566,500 as of January 2012. Most of these refugees were from Somalia (approximately 479,000 as of January 2012), followed by Ethiopia and Sudan (UNHCR, 2012a; UNHCR, 2012b). Most are women and children (GOK, 2008). The growing refugee burden on Kenya has the potential to limit the country's ability to properly attend to domestic demand for improved social services.

Kenya has the third-highest population in the region, estimated at 41,071,000 in 2010. It is surpassed by Tanzania and Ethiopia, with estimated populations of 42,747,000 and 90,874,000, respectively (CIA, 2011). Kenya has a projected annual population growth rate of 2.6 per cent between 2010 and 2015, ranking fifth in the region (UNDP, 2010).[4]

Traditionally, Kenya has been the economic powerhouse of the region. Kenya's GDP per capita in 2011 remained the highest in the region at US$808 (World Bank, 2012). However, as seen in Figure 3, the economic gap between Kenya and its neighbours—namely Eritrea, Rwanda, Tanzania and Uganda—is closing due to the growth they have enjoyed in the last decade.

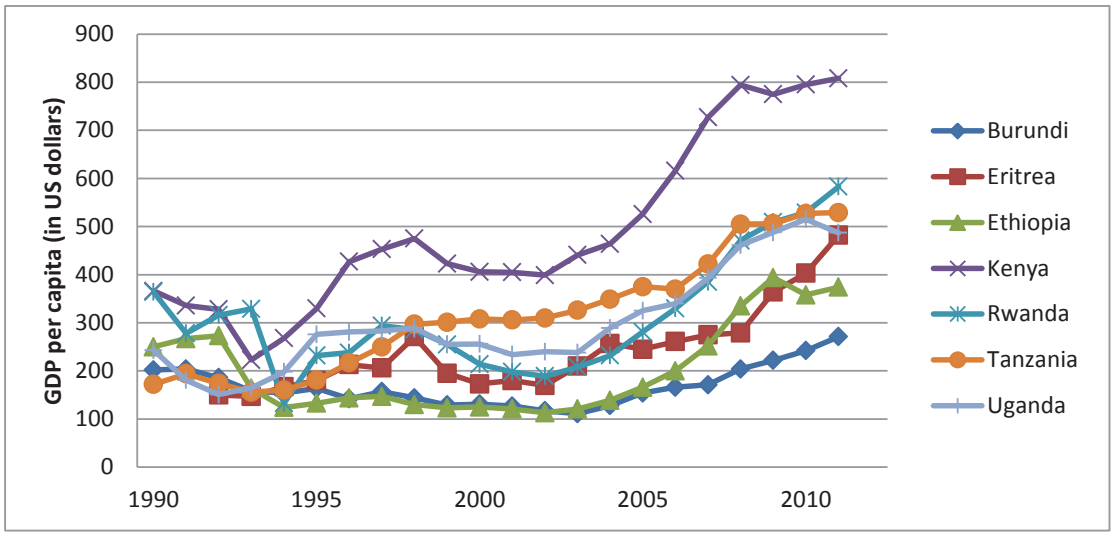

FIGURE 3: GDP PER CAPITA IN SELECTED EAST AFRICAN COUNTRIES BETWEEN 1990 AND 2011

Data source: World Bank (2012)

Complementing its static economic growth, Kenya's level of human development has remained relatively low compared with its regional counterparts, as Table 3 illustrates. The average annual HDI growth rate in Kenya was a sluggish 1.03 per cent over the last decade, while Rwanda, Burundi and Ethiopia had the highest HDI growth rates in the region, at 3.31 per cent, 2.73 per cent and 2.33 per cent, respectively. Between 2000 and 2010, Kenya had the highest inequality rate among the selected countries (UNDP, 2010).

[4] This ranking excludes consideration of Somalia, for which no information is available.

TABLE 3: COMPARISON OF DEVELOPMENT INDICATORS OF EAST AFRICAN COUNTRIES IN 2000 AND 2010

	HDI		LIFE EXPECTANCY		ADULT LITERACY RATE (%)		ACCESS TO CLEAN WATER (%)	
	2000[b]	2010[b]	2000[a]	2010[b]	2000[a]	2010[b]	2000[a]	2010[b] (IN 2008)[1]
Burundi	0.223	0.282	40.6	51.4	48.0	65.9	n/a	72
Djibouti	n/a	0.402	43.1	56.1	65.6	n/a	100	92
Eritrea	n/a	n/a	52.0	60.4	55.7	65.3	46	61
Ethiopia	0.250	0.328	43.9	56.1	39.1	35.9	24	38
Kenya	0.424	0.470	50.8	55.6	82.4	86.5	49	59
Rwanda	0.277	0.385	40.2	51.1	66.8	70.3	41	65
Somalia	n/a	n/a	46.9	50.4	n/a	n/a	n/a	n/a
Tanzania	0.332	0.398	51.1	56.9	75.1	72.6	54	54
Uganda	0.350	0.350	44.0	54.1	67.1	74.6	50	67

[1] *Data refer to the most recent year available during the period specified*

Data source: (a) UNDP, 2002b; (b) UNDP, 2010

Kenya has the highest adult literacy rate in East Africa (see Table 3), as well as one of the top primary and secondary net enrolments. Kenya's employment rate is also one of the strongest in East Africa; in 2008, 73.4 per cent of the population between the ages of 15 and 65 were employed; only Tanzania's employment rate was higher, at 87.4 per cent. While Tanzania has more employed people, 90 per cent of these earned less than US$1.25 per day; in contrast, only 22.9 per cent of employed Kenyans earned less than US$1.25 a day.

In the area of health provision, Kenya ranked ahead of only Burundi, Somalia and Uganda in infant mortality per 1,000 live births as of 2008. Furthermore, Kenya was surpassed by all other countries except Burundi and Somalia with respect to lowering its rate of mortality in children under the age of five. There is a substantial gap in maternal health care in Kenya compared with the rest of the region, and maternal mortality has increased significantly (from 380 per 100,000 live births in 1990 to 530 in 2008), while the country's neighbours have experienced a steady decline (UNDP, 2010). Although the life expectancy of Kenyans improved from 50.8 years in 2000 to 55.6 in 2010, six countries in the region experienced an average increase of ten years in the last decade.

Kenyans' access to water between 1990 and 2008 declined in urban areas, though it improved significantly in rural sectors. Nevertheless, overall access to water in the country improved, from 43 per cent in 1900 to 59 per cent in 2010. Access to water has improved in all countries in the region since 2000, with only Kenya experiencing a decline in urban access and a rise in rural access. Improved access to sanitation facilities has occurred in both urban and rural regions in all East African countries over the past decade (WHO, 2011).

Similar to its regional counterparts, Kenya has experienced a mixture of progress and decline in its human development indicators. Although its per capita GDP and employment rate are among the highest in the region, its economy has grown more slowly in recent years than that of Eritrea and Rwanda. Moreover, Kenya has greater income inequality than Tanzania, Rwanda or Burundi, and its health indicators lag behind those of countries of similar size and economy. A positive trend is the rising economies of several of Kenya's East African neighbours, which creates opportunities for improved trade relations and cooperation in areas such as disaster response.

3.0 Climate and Climate Hazards

Climatic conditions in Kenya vary from season to season, year to year and decade to decade, and they are marked by a number of different climatic extremes. A clear understanding of Kenya's historic, current and likely future climatic conditions is essential to engaging in effective climate risk management. This section begins by providing an overview of general climatic conditions in Kenya and historic climate hazards, then examines how general climatic conditions and the characteristics of climate hazards might be altered by the ongoing process of climate change. The section concludes with an overview of some of the limitations and uncertainties associated with current climate projections.

3.1 Historical Climate and Observed Changes

Kenya's complex tropical climate varies significantly between regions due to the country's variable topography and the influence of several regional and global climatic processes (MENR, 2002). Although Kenya's coastal areas, along the Indian Ocean, are warm and humid, with average daily temperatures between 27°C and 31°C (Mutimba et al., 2010, p. 23), most of its interior is arid and semi-arid: nearly 80 per cent of the country receives less than 700 millimetres of rain per year (MENR, 2002, p. 36). In some areas of northwestern and eastern Kenya, approximately 200 millimetres of rain falls per year (MENR, 2002, p. 36). More temperate conditions occur in the western and central highlands. Areas near Lake Victoria and the central highland east of the Rift Valley can receive between 1,200 and 2,000 millimetres of rain annually (MENR, 2002, p. 36), while the valleys and basins can be dry (AEA Group, 2008b).

Seasonal rainfall patterns are driven mainly by the migration of the Intertropical Convergence Zone, a narrow band of low pressure and heavy precipitation that forms near the equator. The movement of the Intertropical Convergence Zone is very sensitive to changes in the surface temperature of the Indian Ocean, but generally travels southward from October to December (the "short" rains season), and then northward between March and May (the "long" rains season) (MENR, 2002; Seitz & Nyangena, 2009; Thornton et al., 2008). Significant rainfall also occurs between June and September in the western highlands and along the coast (SEI, 2009). Rainfall in the rainy seasons varies greatly among different parts of the country and from year to year; it is particularly variable in the ASALs. Annual variations are largely due to the influence of the El Niño Southern Oscillation (ENSO) on Indian Ocean sea-surface temperatures. Higher-than-average rainfall generally occurs over most of the country during El Niño episodes, while the reverse is associated with La Niña events (Conway, 2009; D. Gikungu, personal communication, March 29, 2012).

In recent decades, changes have been observed in Kenya's climate. Mean annual temperatures have increased by 1.0°C since 1960, an average rate of 0.21°C per decade (McSweeney et al., 2009). A visible indicator of this warming trend has been the decline of the Lewis Glacier on Mount Kenya, which has lost 40 per cent of its mass since 1963 (MENR, 2002). Changes in rainfall patterns also have been noticed since the 1960s, but do not show any statistically significant trends at the national level toward wetter or drier conditions (AEA Group, 2008a). At the subnational level, greater rainfall has occurred during the short rains of October to December, particularly in northern Kenya, where the rains have begun to extend into the hot and dry months of January and February (AEA Group, 2008a; GOK, 2010). In contrast, local observations suggest that the long rains of March and April have become increasingly unreliable in locations such as Eastern Province (Awuor, 2009). Rainfall intensity has also changed, becoming more intense along the coast (MENR, 2002).

3.2 Climate Hazards: Historical Patterns and Observed Changes

Kenya is one of the most disaster-prone countries in the world (MOSSP, n.d.). Between 2000 and 2009, for instance, out of every one million Kenyans, an average of 94,526 people per year were affected by natural disasters (see Table 4) (UNDP, 2010). More than 70 per cent of natural disasters in Kenya result from extreme climatic events (GOK, 2009), the most common being floods and droughts. Major droughts occur about every 10 years, while moderate droughts or floods occur every three to four years (AEA Group, 2008a). The total number of people affected by these climate disasters increased substantially in the 1990s and 2000s (EM DAT, 2012), in part due to Kenya's population growth. Collectively, the economic cost of floods and droughts is estimated to create a long-term fiscal liability equivalent to about 2.0 per cent (SEI, 2009, p. ii) to 2.4 per cent (AEA Group, 2008b, p. 1) of GDP each year, or approximately US$500 million per year (SEI, 2009, p. ii). The floods of 1997–1998, immediately followed by the drought of 1998–2000, are estimated to have cost the Kenyan economy US$4.8 billion, or 14 per cent of GDP (AEA Group, 2008b, p. 1).

TABLE 4: POPULATION AFFECTED BY NATURAL DISASTERS* (AVERAGE PER YEAR, PER MILLION PEOPLE) (2000–2009)

GLOBAL COMPARISON			REGIONAL COMPARISON		
1	Swaziland	156,115	1	Kenya	94,526
2	Mongolia	120,113	2	Djibouti	94,144
3	Tajikistan	100,709	3	Eritrea	87,758
4	Cuba	97,163	4	Zimbabwe	75,240
5	China	96,359	5	Malawi	70,315
6	Kenya	94,526	6	Somalia	67,697
			7	Ethiopia	37,289
			8	Sudan	20,408
			9	Uganda	10,899

**Natural disasters include "droughts, earthquakes, epidemics, extreme temperatures, floods, insect infestation, storms, volcanoes and wildfires" (UNDP, 2010, p. 171)*

Derived from UNDP (2010)

Drought occurs cyclically and has historically affected the greatest number of people and posed a substantially greater risk than floods of adversely affecting GDP (Earth Institute, n.d.). For example, from 1964 to 2004 an average of 1,482,964 people were affected by each of the 11 recorded droughts, while an average of 70,795 people were affected by the 17 recorded floods. During this same period, 165 Kenyans were killed by drought and 524 by floods (Earth Institute, n.d., p. 1).

Recent major droughts occurred in 1991–1992, 1995–1996, 1998–2000, 2004–2005 and 2009 (GOK, 2006; SEI, 2009). Droughts cost an estimated 8.0 per cent of GDP every five years (AEA Group, 2008b, p. 1). As an example, the drought from 1998 to 2000 (during a strong La Niña event [SEI, 2009]) was considered the worst in 40 years, affecting people in Central, Eastern, Rift Valley, Coast and North Eastern provinces (GOK, 2006; World Bank, n.d.). Approximately 4.4 million people required food assistance (World Bank, n.d.), and the drought cost $2.8 billion (Mogaka et al., 2006; SEI, 2009), primarily due to lower industrial production, reduced hydropower generation, and lost crops and livestock (Mogaka et al., 2006). Poor rains in 2006 caused the loss of approximately 70 per cent of livestock in the ASALs and led to nearly 3.5 million people requiring food aid and other humanitarian assistance (AEA Group, 2008b, p. 1). The social consequences of drought are also significant. In pastoralist communities, for instance, consequences include undermining the social position of households, breaking up families, damaging social safety nets and increasing vulnerability to future food insecurity (Aklilu & Wekesa, 2002). Particularly in pastoral areas, drought also increases the likelihood of conflict over limited resources, which in turn can augment the social consequences.

While droughts typically affect all of Kenya, **floods** are usually more localized. They have also caused the highest level of mortality (Earth Institute, n.d.). Floods seasonally affect parts of Nyanza and Western provinces, especially around the Lake Victoria Basin, as well as the Tana River drainage basin[5] and coastal settlements (AEA Group, 2008a). The ASALs periodically experience flash floods (World Bank, n.d.). Since 1950, six serious floods have occurred in Kenya (MENR, 2002), including major floods in 1961, 1997–1998 (AEA Group, 2008b) and 2006, the last of which affected an estimated 723,000 people (SEI, 2009, p. ii). The cost of floods is estimated at 5.5 per cent of GDP every seven years (AEA Group, 2008b, p. 1). The floods of 1997–1998 (during an El Niño event), for example, affected approximately 1.0 million people and resulted in an economic loss of US$0.8 billion to US$1.2 billion due to damage to infrastructure, public health impacts and crop losses (SEI, 2009, p. ii). Only about one-eighth (or US$100 million) of the infrastructure damaged by this event was replaced, suggesting a long-term negative impact on Kenya's development (Mogaka et al., 2006, p. xvi).

Other climate-related hazards in Kenya include landslides and forest fires. **Landslides** occur mostly during the rainy season and are associated with floods. They are particularly a concern in regions of the country with steep slopes and annual rainfall of over 1,200 millimetres (UNDP, n.d.a). Therefore provinces such as Western, Nyanza and the north Rift Valley are most affected by landslides (UNDP, n.d.a). The number of landslides is reported to be increasing as forested lands are converted to agriculture, resulting in looser soils and fewer trees to slow the flow of water down slopes (UNDP, n.d.a). Statistical data on landslide destruction has not yet been quantified (World Bank, n.d.).

Forest fires are an additional hazard influenced by climatic conditions. Since about 1990, Kenya has lost an average of more than 5,700 hectares of forested land per year to forest fires (Mutimba et al., 2010, p. 25). The economic cost of this loss has not yet been calculated (Mutimba et al., 2010).

Whether or not the frequency or severity of extreme climate events in Kenya have changed over the past few decades is uncertain, as are the causes of such possible change. Based on case studies, some researchers have stated that the severity of droughts in Kenya has increased over the past 40 years due to environmental degradation caused by factors such as deforestation (UNDP, n.d.a). However, researchers at Michigan State University reviewed temperature and precipitation readings in northwest Kenya and found no indication of greater frequency or intensity of drought in the region, although local farmers felt both were increasing (Ziervogel et al., 2008). Ziervogel et al. (2008, p. 19) suggest that the observed rise in average temperatures has put additional stress on vegetation such that "it takes less extreme hot and dry spells to inflict drought like conditions."

3.3 Projected Climate and Climate Hazard Trends

The higher temperatures and potential changes in rainfall and drought patterns that have occurred in Kenya over the past couple of decades are broadly consistent with the changes in climate projected by global climate change models. Kenya is expected to experience higher temperatures in all seasons (AEA Group, 2008a). Although uncertainty remains regarding the degree of warming that will occur, most regional models suggest temperatures will typically increase by about 1°C by the 2020s and 4°C by 2100 (AEA Group, 2008a). The rate of warming will not be consistent across all parts of the country (see Figure 4). The country's plateaus and mountain ranges, for instance, could remain much cooler than the lowlands (Funk et al., 2010). By 2025, western Kenya is projected to see temperature increases ranging from 0.9°C to 1.1°C, while temperatures in the southern coastal area could increase by an average of 0.5°C; in

[5] The districts of Nyando, Kisumu, Rachuonyo and Busia are most affected by floods (World Bank, n.d.).

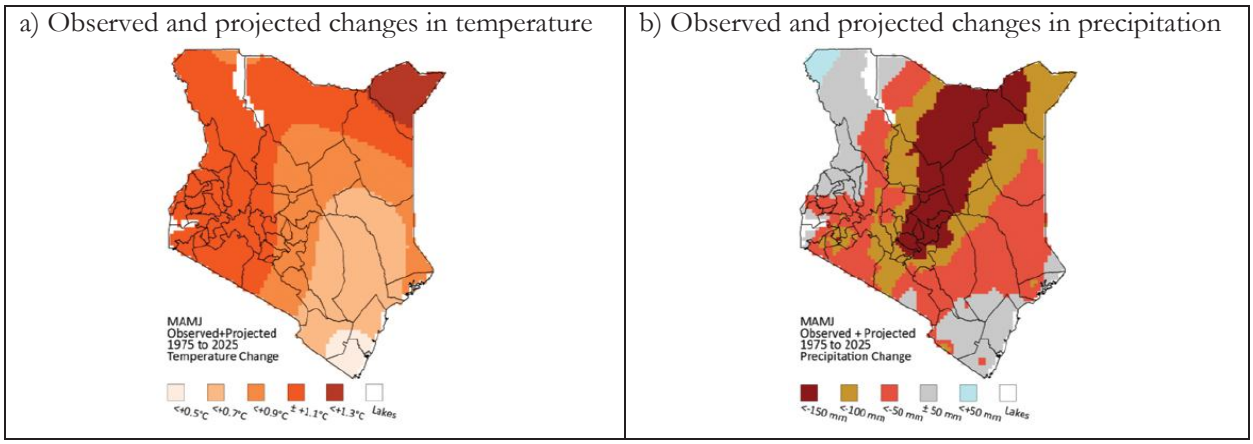

FIGURE 4. REGIONAL DISTRIBUTION OF OBSERVED AND PROJECTED CHANGES IN RAINFALL AND TEMPERATURES FOR THE PERIOD FROM 1975 TO 2025

Reprinted with permission from Funk et al., 2010, p. 2

the northern tip of eastern Kenya, temperatures could rise by 1.1°C (Funk et al., 2010). In comparison, analysis based on a regional climate model suggests that by 2100, temperatures in northwestern Kenya will rise by 1°C more than in the rest of Kenya (except perhaps in March to May), while northeastern Kenya (particularly near Wajir) will see 1°C to 2°C less warming than the national average (AEA Group, 2008a, p. 16).

Greater uncertainty persists regarding the impact of climate change on future rainfall patterns. In part this uncertainty is due to the absence of a clear understanding of the processes that affect Africa's current climatic drivers (such as ENSO) and how they may be altered in the future (Conway, 2009). At the regional level, analysis by the Intergovernmental Panel on Climate Change (IPCC) using general circulation models projects that East Africa will likely become wetter, particularly during the rainy seasons (Boko et al., 2007). Mean annual precipitation in East Africa is projected to increase by 7 per cent by the decade of 2080 to 2090, though projections range from a decline of 3 per cent to an increase of 25 per cent (Christensen et al., 2007).

Seasonal variations in rainfall patterns are also expected, with certain models projecting a mean increase in East Africa of 13 per cent from December to February and 4 per cent from June to August by the period from 2080 to 2090 (Christensen et al., 2007). These models also anticipate rainfall patterns becoming less uniform over time, with possible increases in sporadic and intense precipitation; the IPCC projects that by the end of the century, the number of extreme wet seasons in East Africa may increase by 5 to 20 per cent (Christensen et al., 2007; Seitz & Nyangena, 2009). However, the timing of rainfall seasons in the region is not expected to change in the coming decades (Boko et al., 2007).

Analysis of potential changes in Kenya's precipitation patterns presents a slightly different picture. Analysis by the KMD projects a general decrease in mean annual rainfall in Kenya (D. Gikungu, personal communication, March 29, 2012). Similarly, Funk, Eilerts, Davenport and Michaelsen (2010) project that annual average precipitation will decline by 50 to 150 millimetres throughout most of Kenya's interior by 2025, while a large part of Kenya will experience a decline in precipitation during the long rains of more than 100 millimetres (Funk et al., 2010). At the same time, wetter conditions are likely to occur during the short rains of October to December, particularly in northern Kenya, where

projections based on general circulation models suggest that rainfall could increase by as much as 40 per cent by the end of this century (AEA Group, 2008a; D. Gikungu, personal communication, March 29, 1012). This increase is likely to take the form of an increase in heavy or extreme rainfall events (AEA Group, 2008a). In contrast, runs of a regional climate model suggest that precipitation could increase slightly during the long rains, particularly in the highlands and along the coast; and precipitation could increase during the short rains only to the west of the Rift Valley and in pockets along the coast in the extreme northeast (AEA Group, 2008a).

Considerable uncertainty remains regarding the probable implications of climate change for extreme climate events such as floods and droughts, with projections varying widely (SEI, 2009). The potential for an increase in extreme rainfall events in the rainy seasons (particularly the short rains) suggests that the risk of flooding will rise (AEA Group, 2008a; SEI, 2009). Droughts are likely to continue (Boko et al., 2007), with at least one study suggesting that they will remain at least as extreme as at present, and possibly increase in intensity over this century (AEA Group, 2008a).

The process of climate change will also lead to a rise in global **sea levels** and ocean temperatures, with implications for the probability of coastal flooding and the intensity of storms. Projections suggest that by 2030, sea-level rise will result in 10,000 to 86,000 Kenyans being affected each year by coastal flooding. The loss of coastal wetlands and coastal erosion is also expected (SEI, 2009). The economic cost of sea-level rise is projected to be between US$7 million and US$58 million per year by 2030, and US$31 million to US$313 million per year by 2050[6] (SEI, 2009, p. iii).

3.4 Status of Climate and Hazard Information at the National and Regional Levels

Climate change projections such as those presented in Section 3.3 are generally based on the use of general circulation models and, to a lesser extent, regional climate models. These models, however, have several limitations. The data generated by general circulation models, for instance, is relatively crude, as they have a horizontal spatial resolution of 200 square kilometres and are therefore unable to fully account for the diversity of terrain and altitude found in places such as Kenya. General circulation models therefore are most useful when considering change over a broad area (AEA Group, 2008a). Regional climate models, on the other hand, produce estimates with a much higher resolution (up to 10 square kilometres) and provide more detailed and locally relevant information. However, they are generally based on as few as one climate model and one emission scenario, and they therefore may not represent the full range of possible future climate conditions.

Moreover, the development of climate projections for Kenya depends largely on understanding the processes that drive climatic patterns in Africa today—namely the movement of the Intertropical Convergence Zone, the formation of monsoons in the Indian Ocean, and ENSO (Conway, 2009). While understanding of these processes is growing, many questions remain regarding how they interact and will change as average global temperatures rise. An additional constraint is the lack of trained climatologists in Africa (Conway, 2009), as well as restricted modelling capacity due to human resource limitations and lack of computational capacity to expand databases. These conditions make it difficult to develop climate projections for Kenya and the East African region as a whole (Conway, 2009).

A further complication is a severe lack of local weather data in Kenya and for Africa as a whole. With about one station per 26,000 square kilometres, the density of weather stations in Africa in 2009 was one-eighth what the World Meteorological Organization recommends. Particular gaps are noted in central Africa and in the Horn of Africa

[6] Based on prices as of 2009, with no discounting (SEI, 2009).

(Conway, 2009, p. 7). The limited number of stations restricts capacity to validate climate models and therefore reduces confidence in the scenarios they generate (Conway, 2009). Kenya has only 25 official meteorological stations (Ziervogel et al., 2008, p. 43), and where they exist, weather recording may either be too short, full of gaps, or only collect information on a few climatic parameters. Kenya has recognized this challenge and has committed to rehabilitating its hydrometeorological data-gathering network by 2030 (GOK, 2007a). Notably, Kenya has an estimated 600 manned and volunteer weather stations, some with data series for the past 40 to 50 years. Collecting this data and converting it into digital form could help Kenya overcome some of its data and modelling limitations (Ziervogel et al., 2008, p. 43).[7]

Climate models also require topographic, land use cover and socio-economic information. However, baseline data regarding Kenya's diverse land forms, land uses and variable topography is insufficient, making it difficult to account for the spatial variability of microclimates. For example, only 30 per cent of Kenya's water supply is currently monitored, due primarily to inadequate staff and too few hydrometeorological stations (GOK, 2007a). As well, limited data regarding current and anticipated socioeconomic conditions restricts capacity to project climatic circumstances. For example, land-use and land-cover changes are known to significantly affect climate and to be significantly influenced by factors such as policy interventions, population dynamics and world markets. For these reasons, given that simulation models require a sizable amount of temporal and spatial data, considerable uncertainty remains regarding projections of future climatic change—and of climate risk more broadly—in Kenya.

Kenya also faces challenges with respect to the methodologies it uses to assess climate risks. The most commonly used methodology for assessing flood and drought risks, for instance, is to overlay maps of predicted climate patterns onto maps of land use/land cover or human settlements to show systems, activities and human populations at risk. While this is an acceptable method of analysis, there is a need to go further to show how different environmental components might be differentially affected under various climate scenarios. There is also a need to increase capacity to analyze the economic impacts of climate change (NEMA, 2005) and potential adaptation actions in order to ensure optimal allocation of climate risk management investments.

[7] The Global Climate Observing System initiated a pilot project on data recovery efforts across Africa in 2008 (Ziervogel et al., 2008).

4.0 Climate Risk Profile

Climate-related risks have adversely affected Kenya's development in the past and are expected to continue to do so. An examination of climate risks in relation to Kenya's critical economic sectors—water, agriculture, health, energy, industry and social services—and their implications for particularly vulnerable groups can provide a better understanding of this relationship.

4.1 Water

Of Kenya's estimated 30.7 billion cubic metres of water, 20.2 billion cubic metres are from internal renewable surface water sources. The rest is supplied by groundwater resources and transboundary rivers (WRI, 2007, p. 28). Water resources cover 1.9 per cent of the country (Mango et al., 2010, p. 5852) and include Lake Victoria, Lake Turkana, Lake Naivasha and Lake Baringo as well as numerous swamps in the Loraine Plain (Mutimba et al., 2010). These lakes and Kenya's other water resources are mostly supplied by a network of perennial rivers that originate from five water towers: Mount Elgon, the Aberdare Range, the Mau Escarpment, Cherangani Hills and Mount Kenya. Water resources are unevenly distributed, being more dense in the central and western regions; the Lake Victoria drainage basin contains 65 per cent of Kenya's renewable surface water supply (WRI et al., 2007, p. 28). Kenya's four other large drainage basins are the Ewaso Ngiro, Tana River, Rift Valley and Athi River drainage basins (WRI et al., 2007). The rivers used most for human consumption are recharged primarily by rainfall (Kandji, 2006).

Despite these resources, Kenya is one of the most water-scarce countries in Africa (Kandji, 2006; Mango et al., 2010; WRI et al., 2007). In 2004, Kenya's water availability was estimated at 936 cubic metres per capita; a country is characterized as "water scarce" when its water availability is below 1,000 cubic metres per capita (WRI et al., 2007, p. 28). Based on current population growth rates, water availability is projected to fall to 350 cubic metres per person by 2020 (WRI et al., 2007). Degradation of existing water supplies is an additional challenge, and is estimated to cost the country at least Ksh 3.3 billion (approximately US$470 million[8]), or 0.5 per cent of GDP per year (Mogaka et al., 2006, p. xiii). With demand for water projected to exceed supply, achieving Kenya's economic goals and Millennium Development Goals could become increasingly difficult (WWAP, 2006).

All sectors of the Kenyan economy depend on the availability of water. Water is the direct input for irrigated and rain-fed crop production, as well as fisheries, forest growth and food gathered in resource commons; it is the fuel for Kenya's hydroelectric power sector, is used in manufacturing processes, and is required for drinking water and sanitation—and therefore directly affects the health and well-being of Kenyans. The greatest demand (70 per cent) for renewable fresh water comes from the agricultural sector (WWAP, 2006). Livestock production, for instance, consumes high amounts of water (Dyszynski et al., 2009, p. 15), leading to livestock producers often competing with other sectors for access to limited water resources (WRI et al., 2007). On a regional basis, the highest demand for water for agricultural purposes comes from the ASALs, where high evaporation rates increase the need for irrigation (Mogaka et al., 2006). People residing in ASALs rely heavily on groundwater, the only reliable source of water (WRI et al., 2007).

Domestic water consumption accounts for the second-largest demand for water in Kenya. Only a select few in the affluent parts of the country receive piped water service, and even within this privileged service the infrastructure is

[8] Dollar values, where not provided in the references given, were calculated for the relevant year using rates provided by OANDA (www.oanda.com).

poorly maintained and rarely updated (WRI et al., 2007). Many Kenyans (29 per cent in 2003), particularly in rural areas, obtain their water supply from open water sources, which carry health risks—particularly during flood periods, when drinking water becomes polluted, increasing the chances of outbreaks such as cholera and malaria (WRI et al., 2007). An additional 32 per cent of Kenyans (based on 2003 figures) obtain their drinking water from groundwater sources (WRI et al., 2007, p. vii).

Water Policy

Kenya has adopted polices and strategies to address current and anticipated levels of water scarcity. As a whole, these policies have a greater focus on the economic benefits derived from improved access to and use of water resources, and only indirectly address climate risks. The overarching policy framework is *Kenya Vision 2030*, which aims to increase access to improved water and sanitation services in rural and urban areas through mechanisms that increase supply and conserve water sources. By 2012, Kenya plans to restore the five water towers through the Water Catchment Management Initiative, rehabilitate its hydrometeorological data-gathering network and strengthen water infrastructure (GOK, 2007a). Improved water harvesting and storage is intended to overcome the current imbalance involving excess water during the rainy seasons and little or no water in the dry seasons (Anonymous, 2008b).

In addition to the *Vision 2030* targets, Kenya's WSIP for 2008 to 2030 aims to increase urban access to safe water from 60 to 70 per cent by 2010, and to increase rural access from 40 to 65 per cent. It also aims increase urban access to improved sanitation from 55 to 70 per cent, and rural access from 45 to 66 per cent, by 2012 (Dyszynski et al., 2009, p. 20).

The strategies for reaching the WSIP targets are the *National Water Services Strategy, Irrigation and Drainage Strategy* and *National Water Resource Management Strategy* (Dyszynski et al., 2009). The aims of the *National Water Services Strategy* include providing at least half of all underserved urban populations with safe water by 2015 and improving access to basic sanitation services in rural (to 72 per cent) and urban (to 77.5 per cent) areas by 2015. The *Irrigation and Drainage Strategy* focuses on increasing agriculture yields through capacity-building and research and development to move from rain-fed crops to irrigated agriculture. The *National Water Resource Management Strategy* promotes increased access to water for all, integration of water and resource planning on a catchment basis, attraction of private investment, use of accurate water data, introduction of disaster risk management to water resources, and development of water-pricing policies to recognize water as an economic good (Dyszynski et al., 2009, p. 21). Currently, Kenya falls short with respect to achieving its safe water and sanitation targets. As well, care will need to be taken to ensure that the construction and rehabilitation of dams and canals to increase water storage does not have excessive negative socioenvironmental impacts.

Historical Impacts of Climate Risk on Water Resources

Kenya's water resources are periodically affected by droughts and floods, as well as by inter- and intra-annual rainfall variability, which primarily determines when and where water may be found in Kenya (MENR, 2002). During periods of drought, catchment areas become degraded, rivers dry up, lake levels drop, dams and pans experience increased siltation, hydroelectric power production becomes restricted, water needs to be collected from more distant locations, water quality declines as pollutants become increasingly concentrated in smaller water bodies, and conflict over scarce resources can increase. Floods also adversely affect water quality by bringing more fertilizer and pesticide residues into

water bodies, potentially leading to eutrophication (Mutimba et al., 2010). Moreover, floods damage infrastructure such as roads, railway lines, bridges and water intakes (WWAP, 2006). This damage can in turn create food shortages, power rationing and infrastructure damage, all a heavy burden on society and the economy (WWAP, 2006). The drought from 1998 to 2000, for example, caused an estimated economic loss of US$1.4 billion from reduced industrial production solely because of insufficient availability of water to generate hydroelectricity (Mogaka et al., 2006, p. xvi).

Projected Future Impact of Climate Change on the Sector

Kenya's water resources are vulnerable to climate change–induced alterations in rainfall patterns, accelerated glacier loss and sea-level rise. Although uncertainty remains regarding how precipitation patterns will change in different regions of Kenya, it may be anticipated that soil moisture, river runoff and groundwater recharge patterns will be affected both positively and negatively. For example, soil moisture is expected to decline in the ASALs and increase in moist areas (MENR, 2002). Where rainfall increases, opportunities to harvest rainwater and store clean water could expand (UNICEF, 2010), which in turn may reduce the occurrence of water-borne diseases. These impacts will also influence reservoir systems, water quality and water supply infrastructure (Githui et al., n.d.).

Higher temperatures will also lead to more rapid evaporation, which could affect access to surface water for irrigation, household use and livestock production, and by wildlife (Andresen et al., 2008; Harding & Devisscher, 2009). This effect could also lead to persistence of moisture deficits for longer periods (MENR, 2002). Changes in the pattern of Kenya's cyclical climate shocks of drought and flood could also adversely affect the availability of critical water resources. Reducing vulnerability to these and other water-related hazards would reduce risks to investments and production, and hence would contribute to poverty reduction.

Glacial melt is an additional source of concern. Mount Kenya's glaciers supply the Tana and Nzoia rivers, particularly their dry-season flows (MENR, 2002), and are melting faster than previously recorded (Voda et al., 2009). In 1900, Mount Kenya had 18 glaciers; in 2008, it had seven (Anonymous, 2008b). This process is already contributing to declines in water availability (Anonymous, 2008b; Seitz & Nyangena, 2009). Although information regarding how climate change will affect Mount Kenya's glaciers is currently limited (GOK, 2010), it is generally expected that they will disappear along with other high-altitude tropical glaciers (Voda et al., 2009).

Finally, Kenya's coastal areas are at risk of sea-level rise and the associated intrusion of salt water, particularly if accompanied by a decline in rainfall (MENR, 2002). This process has negative implications for availability of freshwater resources for domestic, industrial and agricultural use, as well as for coastal ecological systems. Some studies on the implications of sea-level rise for coastal cities have been undertaken, mostly focused on Mombasa (Awuor et al., 2008; Kebede et al., 2010; Owour & Froeken, 2009). Mombasa plays an important economic role in Kenya's economy and is one of the largest port cities in Eastern Africa. It is projected that 17 per cent of Mombasa will be submerged with a sea-level rise of only 30 centimetres, leading to displacement of people due to flooding, water-logged soils and reduced crop production caused by salt stress (Awuor et al., 2008). A study by the Tyndall Centre, based on the A1B sea-level and socioeconomic scenario, suggests that a 1-in-100-year extreme water event (e.g., storm surge) would currently affect 190,000 people and US$470 million in assets, and that this exposure will increase to over 380,000 people and US$15 billion in assets by 2080 due to socioeconomic and, to a lesser extent, climatic factors (Kebede et al., 2010).

4.2 Agriculture

Agriculture is the backbone of Kenya's economy, continuing to be of critical importance in terms of employment, food security, livelihoods and economic development (De Wit, 2006; ROK, 2010; Wong et al., 2005). The sector directly generates about 26 per cent of annual GDP and indirectly creates 25 per cent of GDP through links to agro-based manufacturing, transport, and wholesale and retail trade (GOK, 2008; Harding & Devisscher, 2009; ROK, 2010). Further, it constitutes 65 per cent of total exports and employs 18 per cent of the formal sector (ROK, 2010, p. 1). In rural Kenya, 70 per cent of the population derives its economic activities from agriculture, namely subsistence farming (primarily maize, wheat, rice, sorghum, millet, cassava, Irish and sweet potatoes, bananas, and other fruits and vegetables), livestock and fishing (IFAD, 2007; Wong et al., 2005, p. 11). Despite aggregate growth over the past decade, growth in Kenya's agriculture sector remains low due to factors such as inadequate access to improved seeds, fertilizers, market information and an adequate network of rural roads, as well as legal and policy barriers. The sector's potential to promote rural development and alleviate poverty has not been fully achieved (Deutsche Gesellschaft fur Internationale Zusamenarbeit, n.d.).

The agricultural sector in Kenya comprises four important subsectors, namely crop production, livestock production, fisheries and forestry. **Crop production** takes place within a limited proportion of Kenya's total area; only 17 to 20 per cent of Kenya is arable, primarily because of low and unevenly distributed rainfall (Harding & Devisscher, 2009; IFAD, 2007; Kandji, 2009). High-potential arable lands are generally found in areas 1,200 metres above sea level (De Wit, 2006; ETC, 2006). Overall, it is estimated that about 15 per cent of Kenya receives sufficient rainfall (about 762 millimetres per year) to support growth of maize and other non-drought-resistant crops in four out of every five years (WRI et al., 2007, p. 27). Approximately 13 per cent of Kenya receives 508 to 762 millimetres of rain per year, meaning that special dry farming or irrigation is needed to cultivate crops. The remaining 72 per cent of the country (the ASALs) lacks sufficient rainfall for reliable crop production (WRI et al., 2007, p. 27) and is generally used for rangeland (Kabubo-Marianra & Karanja, 2007).

As presented in Table 5, crop production in Kenya can be divided into three main categories: industrial crops, food crops and horticultural production. While industrial crops (e.g. cotton, vanilla beans and palm oil) contribute a more moderate share to Kenya's agricultural GDP, they are a substantial source of export revenue. Horticultural production, including growth and export of flowers, fruits and vegetables, is the fastest-growing component of Kenya's agricultural sector and generates more than US$300 million per year (Mutimba et al., 2010). As with other agricultural subsectors, its success depends on a variety of economic and climatic factors.

TABLE 5. RELATIVE CONTRIBUTION OF KENYA'S AGRICULTURE SUBSECTORS TO AGRICULTURAL GDP AND EXPORTS

AGRICULTURE SUBSECTOR	CONTRIBUTION TO AGRICULTURAL GDP (%)	CONTRIBUTION TO AGRICULTURAL EXPORTS (%)
Industrial crops	17%	55%
Food crops	32%	0.5%
Horticulture	33%	38%
Livestock	17%	7%

Data source: ROK (2010, p. 1)

Nearly all of Kenya's crop production (98 per cent) depends on rain (WRI et al., 2007, p. 34), making rain-fed agriculture Kenya's major source of national food supply (Dyszynski et al., 2009). Irrigated agriculture currently occurs on about 105,000 hectares of the estimated 539,000 hectares suitable for irrigation (ROK, 2010, p. 27). Of these systems, 42 per cent are operated by smallholder farmers for fruit and vegetable production, 40 per cent by larger commercial farms, and 18 per cent by publicly owned systems (ROK, 2010). Sixty-five per cent of irrigated lands are used for horticultural production (such as cut flowers, fruits and vegetables) while the remainder is used for the production of other crops, including cereals, cash crops, root crops and fodder (WWAP, 2006, p. 90). In this respect, irrigation contributes to 3 per cent of GDP and constitutes about 18 per cent of the total value of agricultural production (Dyszynski et al., 2009, p. 15).

The **livestock** sector is also important to Kenya's economy, being responsible for 5 per cent of GDP (IFAD, 2007, p. 2). Eighty-four per cent of rural Kenyan households and 66 per cent of all Kenyans own livestock (AfDB, 2007). Nearly half (45.5 per cent) of Kenya's livestock production (Dyszynski et al., 2009, p. 15) occurs in the ASALs, where the sector accounts for 90 per cent of employment and 95 per cent of pastoralists' household income (an estimated 3 million Kenyans benefit from pastoralism) (IFAD, 2007, p. 2). The livestock subsector may be further divided into milk and milk products (dairy industry) and beef production (beef industry). Dairy production occurs primarily in medium- to high-rainfall areas, involves an estimated 3.5 million head of cattle (ROK, 2010, p. 14) and is primarily undertaken by small-scale producers (OPC, n.d.). Kenya is currently self-sufficient in milk production (ROK, 2007; ROK, 2010). The beef industry involves approximately 9 million beef cattle that are largely raised in the ASAL rangelands (ROK, 2010). The industry primarily provides beef for local consumption, but potential for growth of the export sector is high (OPC, n.d.). As with crop production, both of these subsectors are affected by rainfall shortages. Moreover, resource conflicts are on the rise as farmers compete with livestock-holders/pastoralists for increasingly scarce resources (ETC, 2006; Kandji, 2006).

The **fisheries sector** is an important source of economic activity and food security in Kenya. It contributed 0.5 per cent of GDP in 2006 (MOFD, 2011) and provides food to about 11.2 million Kenyans (Mogaka et al., 2006, p. 23). The bulk of the sector (about 90 per cent) relies on freshwater bodies, particularly Lake Victoria. On this lake, total annual catches increased during the 1980s and 1990s, but have since declined due to overharvesting associated with greater commercialization of fish production (MOFD, 2011). The marine fishery primarily occurs inshore, with an estimated 6,500 artisanal fishermen harvesting about 4 per cent of Kenya's national fish production. Aquaculture is the source of another 4 per cent and is undertaken primarily at the subsistence level; few commercial fish farms have been established in Kenya (MOFD, 2011).

Forestry provides both economic and ecosystem services to Kenya. Although canopy forest covers only 2 per cent of the country, it provides climate regulation and water supply (Kandji, 2006, p. 18). It also provides food, wood fuel, fodder, pasture and medicines (Mutimba et al., 2010), and thereby serves as a safety net, particularly for poor households. Officially the forest sector contributes about US$141 million (or 1.3 per cent) of GDP (WRI et al., 2007, p. 95). This figure, however, does not include forestry's contribution to energy generation or production of timber and non-timber products used for subsistence purposes or traded in local markets (MENR, 2005; WRI et al., 2007). Due to various socioeconomic stresses, including illegal logging, conversion to agriculture and unsustainable charcoal production (Mutimba et al., 2010), about 55,000 hectares of woodlands and bush lands per year are being converted to other land uses (Mogaka et al., 2006). This process is leading to a greater risk of floods and droughts (Harding & Devisscher, 2009).

Although it is Kenya's major economic activity, the agriculture sector faces several challenges, including a skewed landholding system, poor infrastructure, inefficient land policies and legislation, low value addition, government corruption, and vulnerability to climatic variability and shocks (ETC, 2006; FAO, 2011; Ikiara et al., 2009; ROK, 2010). Land-ownership disparities, in particular, are a grave problem (World Bank, 2009). About three-quarters of Kenyans live in the medium- to high-potential agricultural areas of the country, which is leading to greater pressure on the land as populations grow (World Bank, 2009). Landholdings on a per capita basis have declined from 7.2 hectares per person in 1960 to 1.7 hectares per person in 2005 (UNEP, 2009). On a household basis, landholdings have fallen from an average of 2.44 hectares in 1997 to 2.32 hectares in 2007 (Kibaara et al., 2008, p. 5). Currently, 98 per cent of landholdings in Kenya are smaller than 10 hectares, and 83 per cent of these are smaller than 2 hectares (Anonymous, 2008b). The average size of landholdings varies by region, with households in the high-potential maize zone owning an average of 4 hectares, and households in the western and central highlands owning between 0.8 hectares and 1.2 hectares (Kibaara et al., 2008, p. 5). Despite the limited size of their holdings, small-scale farmers account for 75 per cent of total agricultural output (Anonymous, 2008b). Intensive production on these small plots, however, is leading to soil degradation (ETC, 2006), and these households frequently experience food shortages as they are unable to produce enough from their land to meet family nutritional needs (Anonymous, 2008b).

Agricultural Policy

In the last decade the government has introduced several policies and programs to improve the productivity of Kenya's agricultural sector. In 2004 the government launched the *Strategy for Revitalizing Agriculture*, which set a target of achieving a 3.1 per cent rate of growth during the period from 2003 to 2007, and over 5 per cent annual growth by 2007 (ROK, 2010, p. xii). This target was exceeded when the agricultural sector grew by 6.1 per cent in 2007 (ROK, 2010, p. vii).

To continue the momentum of the *Strategy for Revitalizing Agriculture*, the government introduced the *Agriculture Sector Development Strategy*, 2010–2020 (ASDS). The ASDS is aligned to *Kenya Vision 2030*, in which the government set a goal of establishing an "innovative, commercially oriented and modern agriculture, livestock and fisheries sector" (GOK, 2007a, p. 13). Specific targets in *Vision 2030* related to agriculture include increasing crop and livestock productivity; promoting specialization of smallholder agriculturalists through efforts such as improving market access; opening up 1.2 million hectares of land to cultivation, in part through expansion of irrigation in the ASALs; transforming key institutions; and introducing new land-use policies (GOK, 2007b).

The goal of the ASDS is to generate 10 per cent annual sectoral growth through the introduction of new technologies and methods that will increase productivity, commercialization and competition at all levels (ROK, 2010). The ASDS has identified the following additional targets to be achieved by 2015: reduce the number of people living under the poverty line to less than 25 per cent; lower food insecurity by 30 per cent; boost agricultural output to more than KES 80 billion (approximately US$960 million) per year; work with the private sector on production, processing and marketing; and improve and streamline agricultural services such as research, extension, training and regulatory institutions (ROK, 2010, p. xiii).

The ASDS seeks to provide systematic support to small-scale farmers through extension, training, research, and regulatory services, and also aims to change the sector's regulatory framework to encourage a shift from subsistence farming to market-oriented production (GOK 2008; GOK, 2010). It identifies climate change as one of the main constraints on the future development of Kenya's agricultural sector.

The 2007 *National Policy for Sustainable Development of Arid and Semi-arid Lands of Kenya* also influences development of the agricultural sector in this region of the country. It seeks to improve the socioeconomic situation found in Kenya's ASALs by promoting a market-oriented economic process; diversifying incomes to reduce reliance on livestock; improving management of natural resources following a review of existing land-use policies and tenure systems; promoting ecosystem conservation to improve pastoral production; promoting access to markets, financial services and social services for nomadic pastoralists; and mitigating climatic risks such as droughts and floods (GOK, 2007c). Climate risk is specifically identified as a concern.

Agriculture's vulnerability to climate change is also addressed in the government's National Climate Change Response Strategy (ROK, 2010). This strategy promotes integrating meteorological information into farming activities; building sand dams to increase access to water resources; and increasing use of drought-tolerant, early-maturing and disease- and pest-resistant crops. For the fisheries sector, the government says it will develop country-wide maps indicating areas that require shore-protection measures, undertake research on marine ecosystems and encourage coastal resource management. Lastly, the government seeks to introduce livestock-insurance schemes, promote research on improved breeds, and encourage diversified economic activities coupled with raising awareness on land-resource management (GOK, 2010).

Regarding forestry, Kenya's constitution obliges the state to work to achieve and maintain a tree cover of at least 10 per cent of land area. The Kenya Forest Service, as part of the implementation of the *Forest Act 2005*, has put in place ten forest conservation committees and enlisted 355 community forest associations to strengthen participatory forest management. Conservation and rehabilitation of the five water towers is a flagship project under *Vision 2030*, and industrial forest plantations have been established to help meet demand for timber. In addition, Kenya is developing its REDD+ (reducing emissions from deforestation and forest degradation) national strategy and implementation framework.

Historical Climate Risks

Kenya's agricultural sector is vulnerable to climate variability and extreme weather events such as droughts and floods, the impacts of which have led to food shortages, rising food prices and damage to the national economy. This vulnerability stems in part from the country's considerable inter- and intra-annual variability in rainfall and dependency on rain-fed agricultural production. Vulnerability of the sector to climate risks could be reduced through investments in water storage, rainwater harvesting and irrigation infrastructure—as committed under the *Agriculture Sector Development Strategy*, 2010–2020 (ROK, 2010)—as well as more efficient water use in light of current and projected water shortages. Intensification of irrigation could lead to an estimated fourfold increase in crop production (ROK, 2010), not accounting for the implications of climate change.

The historical economic impact of drought on Kenya's agricultural sector has been significant. For example, drought from 1998 to 2000 caused US$370 million in agricultural losses (Mogaka et al., 2006, p. xvi), including the death of an estimated 2 million sheep and goats, over 900,000 cattle and 14,000 camels (Aklilu & Wekesa, 2002, p. 2). In the aftermath, the government needed to provide US$10.5 million in emergency assistance to affected livestock communities to recover lost production (Wong et al., 2005, p. 13). In the ASALs, expanding populations and intensification of land use has exacerbated vulnerability to drought (Kandji, 2006). Drought also encourages deforestation as people increasingly clear forests for agricultural lands, use forested lands for grazing, and produce

charcoal for their energy and economic needs (Mogaka et al., 2006). Forest fires also become more frequent, with adverse economic consequences in terms of lost timber and the cost of fire suppression. During the drought of 1999, for example, forest fires cost the government between KES 25.8 million and KES 28.6 million (approximately US$0.34 million and US$0.40 million) (Mogaka et al., 2006, p. 38).

Floods are also a concern for both crop and livestock production. The 1997–1998 floods, for instance, caused more than US$230 million in damages to Kenya's agricultural sector (Kandji & Verchot, n.d.), and an outbreak of Rift Valley fever in the wake of these floods killed 80 per cent of the livestock in northern Kenya (Kandji & Verchot, n.d.).

Future Climatic Impacts

Kenya's agricultural sector, and particularly its smallholder farmers, is vulnerable to the impacts of climate change due to its high dependence on rain-fed production (Harding & Devisscher, 2009; Kandji, 2006). However, due to agriculture's diversity of subsectors and its geographical expanse, it is challenging for researchers to present a holistic understanding of precisely how this sector might be affected (Kandji & Verchot, n.d.; SEI, 2009). Generally speaking, climate change is anticipated to affect the availability, accessibility, utilization and system stability of food production in Kenya (GOK, 2007c). Crop yields are expected to decline due to excessive or insufficient availability of water, more losses to pests and diseases, and more competition with weeds. In the livestock sector, production might decline due to lack of pasture, restricted access to water and heat stress (Thornton et al., 2009b). Changes in the prevalence of livestock diseases (such as Rift Valley fever) are also possible, although how climate change will affect the spread of livestock diseases is "basically unknown," and these consequences are expected to be "muted" over the next 20 to 30 years (Thornton & Gerber, 2010, p. 172).

Current studies conclude that the impacts of climate change will vary among agroecological zones. For example, one study (Kabubo-Mariara & Karanja, 2007) projects that a 3.5°C mean temperature increase and a 20 per cent change in precipitation by 2030, as projected using the Canadian Climate Change Model, will result in a 1 per cent increase in production in high-potential areas (or an increase of US$3.54 per hectare), but a 21.5 per cent decrease in production in medium- and low-potential areas (or a loss of US$54 per hectare). In contrast, should temperatures increase by 4°C and precipitation change by 20 per cent by 2030, as projected by the Geophysical Fluid Dynamics Laboratory model, Kabubo-Mariara & Karanja (2007) have estimated production losses in high-potential areas equal to US$32 per hectare, and to US$178 per hectare in medium- and high-potential agricultural areas (Kabubo-Mariara & Karanja, 2007, p. 3).

In the cooler highlands, temperature rise could create an environment more conducive to growth of crops such as maize (Andresen et al., 2008), potentially leading to a 20 per cent increase in food production (Sivakumar et al., 2005). This benefit, however, will be experienced in only a fraction of the country. In contrast, the ASALs are estimated to receive the heavy burden in temperature increase and declining precipitation (Kabubo-Mariara & Karanja, 2007), with projections suggesting that they could encounter a 20 per cent decrease in production should mean temperatures increase by 2.5°C.

In terms of how specific crops may be affected by climate change, research indicates that a long-term decrease in the production of key crops such as maize may occur (Kandji & Verchot, n.d.; Sivakumar et al., 2005). It is estimated that maize production could decline by 90,000 metric tons by 2055 (Kandji & Verchot, n.d.) Similarly, Thornton, Jones, Alagarswamy and Andresen (2009a) simulated yield changes to 2050. The outcomes of the study suggest that maize production could decrease by 20 per cent or more in the semi-arid regions of Kenya while increasing in the highland

areas of central and western Kenya. The study also looked at the production of beans and found reductions were widespread, but that substantial increases in bean yields were possible in Kenya's western highlands (Thornton et al., 2009a, p. 61).

Another study looked at the impact of both extreme dry and wet scenarios on the agricultural sector. Under a drought scenario in which the drylands are severely affected and the humid highlands relatively modestly so, it was estimated maize production would decline dramatically and the total value of agricultural land would be reduced by one-third (SEI, 2009, p. iv). Under a wetter scenario, it was projected that no change in production would occur in the highlands, but that production would increase in the central zones, resulting in an overall 10 per cent increase in the value of agricultural lands (SEI, 2009, p. iv).

Contrasting with the studies previously described, Funk et al. (2010) project that maize production in central Kenya will *increase* by about 40 per cent compared with current levels. This projection is based on extending an observed increase in maize production in this part of Kenya despite a historical increase in dryness and temperatures. The authors also suggest that the potential negative impact of climate change on agricultural production could be overcome in the short term by a modest green revolution (Funk et al., 2010).

Overall, understanding of how climate change might affect crop production in Kenya is limited. Despite this, some adaptation measures have been identified that are likely to improve the capacity of this sector to cope with projected impacts. These include:

- *Improve smallholder crop production*. Introduce drought- and flood-resistant crops, use soil conservation strategies, promote appropriate water conservation measures, diversify crop production, introduce appropriate harvesting techniques, improve storage and enhance transportation networks (De Wit, 2006; Funk et al., 2010; Kabubo-Marianra & Karanja, 2007; Nganga, 2006).
- *Improve management of water resources*. Conserve and rehabilitate water catchments and riverine basins; promote more efficient water use; increase water availability through rainwater harvesting, sand dams and similar techniques; and ensure sustainable irrigation practices in drought-prone zones.
- *Reduce economic risks*. Diversify income generation opportunities and expand the availability of insurance for crop and livestock production.[9]
- *Create an enabling environment*. Improve the dissemination of climate change monitoring and information to increase farmers' capacity to take advantage of favourable conditions to maximize production. Improve extension services and increase capacity within the government to implement policies and plans.

Kenya's forest sector will likely also be adversely affected by climate change. Rainfall patterns currently determine the distribution of forested areas in Kenya (Mutimba et al., 2010). As these patterns change, forests could be exposed to more invasive species, pathogens and fire risk (Mutimba et al., 2010). The resulting changes in their composition, growth and regeneration patterns would reduce their capacity to provide economic and environmental services (Mutimba et al., 2010). Little assessment appears to have been undertaken regarding the potential impact of climate change on Kenya's forestry sector. Similarly, understanding of the potential consequences of climate change for Kenya's fisheries sector is limited.

[9] Index-based livestock insurance is currently being piloted in Marsabit District, northern Kenya. The project is working with over 2,000 households and uses satellite imagery to determine when insurance payments are needed in light of potential losses of livestock forage (Karaimu, 2010).

4.3 Health

Kenya faces a heavy disease burden. About 30 per cent of this burden is due to malaria, which is ranked as the number-one cause of disease and mortality in both adults and children (WHO, 2010; Yanda et al., 2006), with 5 per cent of deaths per year being due to malaria (ROK, 2009, p. 3). As well, an estimated 7.4 per cent of Kenyans have HIV/AIDS, with about 1.4 million people HIV positive (ROK, 2009, p. 3) and approximately 85,000 annual HIV/AIDs-related deaths, which have cumulatively left behind 2.4 million orphans (GOK, 2008). In addition, tuberculosis is again on the rise, despite past improvements. It is speculated that this resurgence is due to the combination of the disease with HIV/AIDS, in addition to multiple-drug resistance (GOK, 2008; Ochieng & Makoloo, 2009). Non-communicable diseases are also a burden, causing the deaths of 729 people per 100,000 in 2004 (UNDP, 2010). Malnutrition affects 54 per cent of children under the age of five, and three out of five children demonstrate underdeveloped growth due to long-term nutritional deficiency (GOK, 2008).

Kenya's capacity to provide an equitable and effective health care system is limited by poverty and inequality within the country (World Bank, 2009), and most Kenyans lack access to quality health care. Although the total cost of health care "has escalated well beyond the financing capacity" of the government (MOH, 2006), Kenya's expenditure on health per person per year is low, being US$10.90 in 2007 (GOK, 2008). This funding is not distributed evenly, with significant disparities among and within provinces (MOH, 2006). As one indicator, only 30 per cent of Kenya's total health care budget was allocated to rural areas in 2007 (GOK, 2008), although 70 per cent of Kenyans continue to live in these areas (World Bank, 2011). Moreover, spending in health services is lopsided toward the highest quartiles, with the poor receiving less-than-proportional benefits from total public spending (World Bank, 2009). The lack of access to quality health care, combined with poor water and sanitary services, affects preventive measures in rural and urban areas (World Bank, 2009).

Parallel to a lack funds and an inefficient administration, Kenya has a limited number of qualified medical personnel—which has contributed to minimizing progress related to infant and maternal health. Between 2000 and 2009, there was an average of one physician for every 10,000 Kenyans. Furthermore, the number of hospital beds per 10,000 people has remained at 14 over the last decade. Infant mortality in 2008 was 81 per 1,000 live births, and mortality of children under the age of five was 128 per 1,000 live births (UNDP, 2010), with wide disparities among provinces. For example, in Central Province infant mortality was an estimated 54 per 1,000 live births, while in North Eastern and Nyanza provinces it was estimated at 163 and 206, respectively (GOK, 2008, p. 98). Maternal mortality was approximately 560 out of 100,000 live births (UNDP, 2010), with about 60 per cent of births occurring outside hospitals, and only 40 per cent attended by skilled medical personnel (GOK, 2008). An estimated 14,700 women die each year due to pregnancy-related complications (GOK, 2008).

Health Policy

Through *Kenya Vision 2030* and the *First Medium Term Plan*, the government aims to create a health care system that is efficient and of improved quality. In these documents, the government has committed to achieving its Millennium Development Goals[10] and shifting from a curative to a preventive system by refining its first-level and district medical

[10] Through its *First Medium Term Plan*, the government sets the following targets to help pursue its Millennium Development Goals (GOK, 2008, p. ix): reducing mortality among children under the age of five from 120 to 33 per 1,000, reducing maternal mortality from 410 to 147 per 100,000, increasing skilled personnel in birth delivery from 42 to 95 per cent, increasing the proportion of immunized children below the age one from 71 to 95 per cent, lowering the number of cases of tuberculosis from 888 to 444 per 100,000, and lowering the proportion of inpatient malaria fatalities to 3 per cent and of HIV/AIDS to less than 2 per cent.

centres. This latter process is underway through the decentralization of funds and management from the Ministry of Public Health and Sanitation (MOPHS) to the communities and to district medical officers (GOK, 2008). It is intended that through decentralization, the MOPHS will focus primarily on policy creation, leaving programming at the community level. This bottom-up approach in turn focuses on the individual lifestyles of community members and targets equal access to health care (GOK, 2008).

In addition, the government seeks to scale up the output-based approach system, which enables poor women of reproductive age to access medical care more effectively. It aims to accomplish these goals by creating a public-private partnership to increase efficiency in access and delivery of health, water and sanitation (GOK, 2007a). (Currently, out of 6,194 health facilities, 51 per cent are public; the rest are operated by faith-based organizations and the private sector [GOK, 2008]). The government has also stated that it plans to establish a mandatory national health insurance scheme to provide equitable health care financing to all Kenyans (GOK, 2008). Currently, Kenyans earning a salary are required to make compulsory contributions to the National Hospital Insurance Fund, while the informal and self-employment sectors can make voluntary contributions (NHIF, n.d.). The vast majority of people in the informal sector cannot make these contributions and are left out of the fund. The intention of the new scheme is compulsory contributions for all, while subsidizing those who cannot make regular payments (MOH, 2005).

The foundation work toward revamping the Kenyan health care system started in 2005 through the country's *Second National Health Sector Strategic Plan of Kenya* (NHSSP II) (2005–2010). The plan introduces community-owned resource persons and community health extension workers to deliver community-level health services (MOH, 2005). Implementation of the NHSSP II is supported by the community health strategy (MOH, 2006), whose overall goal is to enhance communities' access to health care and their role in health care delivery by implementing life cycle–focused health actions. Its objectives include improving services at the community level, enhancing the capacity of community health extension workers, strengthening links between communities and health facilities, and enabling community members to ensure accountability of facility-based health services (MOH, 2006).

The Ministry of Public Health and Sanitation's strategic plan for 2008 to 2012 further articulates plans for strengthening Kenya's health care system (MOPHS, 2008). Its five priority areas focus on improving equitable access and the quality, responsiveness and efficiency of public health and sanitation services; fostering partnerships; and improving financing (MOPHS, 2008). The plan specifically includes commitments to establishing new health facilities, recruiting technical staff, promoting the use of treated water by households, and developing key health sector policies, such as the third National Health Sector Strategic Plan. It also aims to reduce malaria incidence to 15 per cent "by utilizing cost effective control measures such as long-lasting insecticide treated nets and indoor household spraying." While the plan recognizes climate change as a potential health threat, specifically with respect to the extension of malaria endemicity, climate risks are not strongly integrated.

Kenya has prepared a *Comprehensive National Health Policy Framework, 2011–2030*, which aims to "[attain] the highest possible standards of health in a manner responsive to the population needs" (MOPHS, 2011, p. 2). The primary objectives of this policy include reducing the burden of communicable diseases until they are no longer a major public health concern; ensuring that the burden of such diseases does not increase; guaranteeing the provision of "affordable, equitable, accessible and responsive" medical services; increasing health-promotion efforts; and strengthening links with sectors that influence health, such as education, sanitation, housing and food security (MOPHS, 2011, p. 3). Overall, the government's current health plans are steps in the right direction to improve inefficiencies and inequalities in its health sector; however, considerable challenges remain to be overcome.

Historical Links Between Climate and Health

Climatic factors such as temperature and precipitation patterns directly and indirectly affect the health and well-being of Kenyans today. These impacts are caused both by extreme weather-related events and by changes in average climate conditions on a daily, seasonal or annual basis. Many health–climate links are also influenced by forms of environmental degradation such as rapid deforestation, loss of biodiversity and degradation of water resources. While these processes can lead to emergence of diseases, they can also reduce capacity to treat health ailments. A significant number of Kenyans still rely on traditional medicines gathered from the surrounding ecosystem. Climatic events, such as drought, and environmental degradation reduce capacity to access these traditional medical treatments.

Vector- and water-borne diseases in particular are directly influenced by climatic patterns, including ENSO events and surface temperatures in the Indian Ocean. Of these diseases, malaria and cholera are of particular concern. An estimated 25 million people are at risk of malaria every year in Kenya, and 40,000 die annually from the disease (KEMRI, n.d.; Yanda et al., 2006). Moreover, the economic burden of malaria is estimated at US$45 million to US$99 million annually in terms of direct costs. When full economic cost are considered, this increases to between US$18 million and US$144 million (including disutility from pain and suffering) (SEI 2009, p. iv; Wandiga, 2006; WHO, n.d.).

Malaria outbreaks generally occur between July and September and are influenced by temporal variations in maximum temperature and rainfall (Wandiga et al., 2010). Outbreaks have been found to occur when high temperature anomalies are followed by substantial rainfall a month later (Wandiga et al., 2010). For example, high precipitation and temperature levels associated with El Niño events (1982–1983 and 1997–1998) were followed by malaria outbreaks (Wandiga et al., 2010; Yanda et al., 2006). Historically, malaria has been more prevalent in lowland areas of Kenya (Yanda et al., 2006); however, research conducted in Kenya and the Lake Victoria basin has found that malaria has become more widespread in the highlands in recent decades, due to greater climatic variability coupled with environmental changes (such as deforestation) and changes in cropping patterns, and their influence on mosquito breeding and survival (Ochieng & Makoloo, 2009; SEI, 2009; Wandiga et al., 2010; Yanda et al., 2006). To illustrate, the highland districts of Bomet, Uasin Gishu, Kisii, Gucha, Nyeri, Kiambu and Nyandarua were malaria-free in the 1960s, but by the 1980s, malaria cases were being reported in all seven districts (Ochieng & Makoloo, 2009).

Cholera also poses a heavy health burden in Kenya. Along the Lake Victoria basin, cholera outbreaks have emerged through consumption of contaminated water and food and through poor hygiene practices (Yanda et al., 2006). In addition, high rainfall and seasonality of sea-surface temperatures are correlated with cholera outbreaks (Yanda et al., 2006). Like malaria outbreaks, cholera is also sensitive to ENSO patterns during the short rains of October to December (Olago et al., 2007; Yanda et al., 2006).

Apart from climatic variability, socioeconomic factors also influence the vulnerability of poor households to malaria and cholera. Income-generation capacity is correlated with the ability of households to invest in health coping mechanisms, such as food and medicines (Olago et al., 2007; Wandiga, 2006; Wandiga et al., 2010; Yanda et al., 2006). Moreover, poverty coupled with an inadequate health care system handicaps poor households' capacity to cope with health-related risks. For example, although district and provincial hospitals are equipped with inpatient capacity to treat malaria-affected people, many of those affected live far from these facilities, and their first level of contact is with local health centres. These centres lack qualified personnel and have inadequate diagnostic facilities, which can limit their capacity to deal with malaria cases and increase the likelihood of misdiagnosis (Olago et al., 2007; Wandiga et al., 2010).

Due to the challenges Kenya faces, its capacity to respond to climate-inflicted diseases is low, and most times it responds too late (Yanda et al., 2006). Kenya's curative and preventive programs for malaria and cholera are not comprehensive and rely heavily on external assistance and funding—the latter of which means that the long term-sustainability of health centres is not always guaranteed (GOK, 2007a; Wandiga et al., 2010; Yanda et al., 2006). This creates a heavy burden on the government and a challenge when developing national and community-based adaptive strategies.

Future impact of climate change

Within the constraints of current knowledge, the government has identified malaria, Rift Valley fever, malnutrition, water-borne diseases (such as cholera and typhoid), scabies, chiggers and lice infestations as some of the health impacts that are likely to grow due to climate change (WHO, 2010). Of these concerns, the vast majority of completed research concentrates on the Lake Victoria basin and focuses specifically on malaria and, to a lesser extent, cholera.[11] Based upon this research, temperature and precipitation increases in higher elevations are projected to result in malaria spreading to new locations. Specifically, in the highlands the number of people at risk is projected to increase between 36 and 89 per cent by the 2050s, meaning an extra 2.8 to 7.0 million people could be affected. The direct economic burden of this increase in malaria prevalence has been estimated at US$48 million to US$99 million per year by the 2050s (SEI, 2009, pp. 15–16). This projection assumes a temperature rise of between 1.2°C and 3°C, and a population that remains at 2009 levels (SEI, 2009).

For a better understanding of the relationship between climate change and health in Kenya, further research is paramount. Kenya would benefit from additional studies on health-related risks other than malaria and cholera, such as heatstroke, malnutrition and HIV/AIDS. Kenya also needs to develop sustainable adaptive strategies and early-warning systems to combat future climate challenges. As health-related outbreaks have a number of causes, adaptive programs at the national and community levels should consider demographic trends and socioeconomic factors that affect land use, as these in turn can influence the degree to which climate change will impact Kenya's health sector (Wandiga et al., 2010).

4.4 Energy

Energy production and consumption are instrumental to Kenya's development. At present, energy from all sources is primarily used by the residential sector (77.6 per cent), followed by transportation (14.7 per cent), industry (5.9 per cent), agriculture and forestry (0.8 per cent), commercial and public services (0.5 per cent), and others (0.6 per cent) (Karekezi et al., 2008, p. 16). The dominance of the residential sector in part reflects the fact that over 85 per cent of Kenyans continue to rely on traditional energy sources such as wood, charcoal, dung and agricultural residues. These fuels are primarily used for cooking and heating; firewood is used for cooking by 68.3 per cent of households (80 per cent of rural households and 10 per cent of urban households) and charcoal is used by 13.3 per cent of households. Other households rely on kerosene, including 44.6 per cent of those in urban areas (ROK, 2011, p. 13).

Reliance on these traditional sources has adverse health implications for women and children, because of smoke in poorly ventilated indoor conditions as well as the time burden associated with collecting wood and agricultural residues. As these energy resources are primarily derived from forests and farmlands, their use also contributes to deforestation

[11] See Wandiga et al. (2006); Wandiga et al. (2010); and Yanda et al. (2006).

and its associated negative impacts on soil and water resources (Mogaka et al., 2006; Wong et al., 2005). Loss of forest cover, rising populations, existing land tenure arrangements and inefficient utilization have combined to create persistent and increased scarcity of fuelwood (Mugo & Gathui, 2010).

An estimated 23 per cent of Kenyans have access to grid electricity (ROK, 2011, p. 13), and the majority of these reside in urban areas; only 3 per cent of rural Kenyans have access to electricity (MENR, 2005, p. 44). This limited access is one factor contributing to Kenya's relatively low per capita consumption of electricity, estimated to be 474 kilograms of oil equivalent per capita in 2009 (World Bank, 2010), compared with other countries in Africa. A second factor is the higher cost of electricity compared with that found in neighbouring countries (Karekezi et al., 2008). Most electricity is provided through large hydropower stations (51.2 per cent, or 732.2 megawatts of effective capacity), followed by diesel thermal plants (31.4 per cent)[12] and geothermal plants (13.2 per cent). Most hydropower comes from the dams on the Tana and Turkwel rivers (Anonymous, 2008b). Small amounts of electricity (1 per cent or less) are provided through biomass cogeneration, small hydro and wind (ROK, 2011, p. 17). Collectively, Kenya's electricity supply is 1,429 megawatts "under normal hydrology," while demand is currently 1,191 megawatts, leaving a small margin (ROK, 2011, p. 16). Demand is rising significantly due to population growth and economic expansion (ROK, 2011). Peak load for electricity is projected to increase to 2,500 megawatts by 2015 and 15,000 megawatts by 2030 (ROK, 2011, p. 17). To meet this demand, the country is expected to need installed capacity for electricity production of 19,169 megawatts by 2030 (ROK, 2011).

The availability of domestically produced energy in Kenya is directly influenced by environmental and climatic factors. Loss of forest cover due to demand for fuelwood and charcoal has led to significant reductions in the amount of water flowing through rivers during the dry seasons (Mogaka et al., 2006), greater siltation of reservoirs (also caused by heavy floods) (GOK, 2010) and reduced capacity for electricity generation (GOK, 2010; MENR, 2005). Siltation alone, for example, has led to a reduction in the storage capacity of the Kindaruma Dam from 16 million cubic metres to 11 million cubic metres (GOK, 2010, p. 40).

Droughts and declines in rainfall also directly influence the electricity sector, as they lower reservoir levels, reducing hydropower production and resulting in load-shedding (ROK, 2011). During the 1999–2000 drought, for example, reduced industrial productivity caused in part by less access to electricity resulted in Kenya's GDP declining by 0.6 per cent in 2000 compared with the previous year. The Kenya Power and Lighting Company's revenue dropped by KES 4.1 billion or US$20 million (GOK, 2010, p. 40; Kandji, 2006, p. 18; Mogaka et al., 2006). Power cuts have since become an annual occurrence (Mutimba et al., 2010). As hydropower generation has become increasingly unreliable, the proportion of Kenya's electricity produced via expensive thermal power plants has increased, leading to higher prices for consumers. Drought also influences the traditional energy sector, as people's reduced capacity to purchase kerosene and electricity leads to greater demand for charcoal and fuelwood (Mogaka et al., 2006). The loss of industrial production and higher energy prices caused by drought has historically resulted in greater economic costs than has resource degradation (Dyszynski et al., 2009).

The adverse effects of climatic events on energy production in Kenya are projected to grow due to climate change. Climate change could alter forest growth patterns, further shrinking the availability of wood for energy and reducing hydroelectric power potential by lowering the amount of water in rivers (particularly during the dry seasons) and

[12] All petroleum and coal used in Kenya is imported (International Energy Agency, 2009), accounting for 25 per cent of Kenya's imports. This dependency imposes a heavy economic burden (World Bank, 2011, p. vi).

promoting reservoir siltation (GOK, 2010). The cost of these changes could be significant, with projected revenue in the hydroelectric sector falling to between US$86 million per year (low climate change projection) and US$71 million per year (high projection) by 2050, compared with the current US$90 million per year (Dyszynski et al., 2009, p. 46).

At the same time, climate change is also anticipated to lead to rising energy demand. Higher temperatures will likely increase demand for air conditioning and refrigeration, while reduced precipitation and expanding populations could lead to a greater need for irrigation (GOK, 2010). The cost associated with greater demand for air conditioning in Mombasa, for instance, is expected to increase by 240 to 340 per cent by the 2050s (SEI, 2009, p. v).

To address the historical and projected future vulnerability of Kenya's energy sector to climate risks while expanding production given rising demand, the government has introduced a number of new policies and strategies to strengthen the sector. The ruling legislation for the energy sector is the *Energy Act* of 2006, which is enforced by the Energy Regulatory Commission. Rural energy production is regulated by the Rural Electrification Authority, which manages rural programs and funding. In *Vision 2030*, the government directs its efforts to generating "more energy at lower cost and increased efficiency in energy consumption" (GOK, 2007a, p. 8). More specifically, through its *First Medium Term Plan*, the government aims to extend power supply to one million households between 2008 and 2012 at a cost of KES 84 million (approximately US$1.0 million) (GOK, 2008, p. xi). It also seeks to integrate Kenya into the Southern African Power Pool, through Tanzania, and looks at promoting geothermal, solar and wind power.

In support of *Vision 2030* and the *First Medium Term Plan*, the Energy Regulatory Commission developed its *Strategic Plan 2008–2012*, whose main objective was to generate "reliable, cost effective and high quality energy in an environmentally friendly manner" (Energy Regulatory Commission, 2008, p. 24), and which functions as a guide for the commission. Under the National Climate Change Response Strategy, the government has also announced plans for a green energy development program that will promote renewable energy sources such as geothermal, wind, solar and biofuels (GOK, 2010). Geothermal power, which has the potential to generate an estimated 7,000 megawatts to 10,000 megawatts of power (ROK, 2011), is being promoted because of its greater reliability (as it is less vulnerable to climate risks), lower cost and long plant life. Kenya has already established several geothermal plants, including the Olkaria geothermal power stations, which are presently being expanded to produce 280 megawatts (Rajab, 2012). The Kenya Electricity Generating Company has also established a 5.1 megawatt wind farm in Ngong, and plans to establish a second 10 megawatt farm in the same area. A 300 megawatt, privately owned wind farm is also being constructed in Turkana (Gathanju, 2010).

The National Climate Change Response Strategy also calls for additional research to be undertaken on the potential vulnerability to climate change of renewable energy sources such as solar and wind and of its power-transmission infrastructure. It further recommends controlling upstream water abstraction to increase the availability of water for downstream hydropower production, and promoting effective cookstoves to reduce pressure on available wood sources (GOK, 2010). Kenya's energy sector could also be strengthened by improving power transmission and distribution, increasing electricity infrastructure in rural areas, reducing energy costs, and enhancing public awareness of energy conservation needs (Anonymous, 2008b; Kenya Institute for Public Policy Research and Analysis, 2007).

4.5 Industry and Service Sectors

Kenya's industrial and service sectors are also important contributors to its current and expected future development. Kenya's industrial sector is one of the largest in sub-Saharan Africa (MENR, 2005; World Bank, 2011) and includes the production of refined petroleum products, cement, soft drinks and textiles; the milling of grains and sugar; and light manufacturing (USDS, 2011). Generating about 16 per cent of GDP in 2010 (CIA, 2011), the sector was expected to grow by 3.4 to 5.3 per cent in 2010—down from a rate of 7.1 per cent in 2007 (World Bank, 2011). Most industrial activity takes place in Nairobi and Mombasa. Nairobi is the hub for international flights and for the financial and telecommunications industries, and it hosts a number of corporate regional offices (World Bank, 2011). Mombasa has seen a 10 per cent increase per year in container imports since 2005—despite problems arising from the need for infrastructure improvements at the port of Mombasa (World Bank, 2011).

The service sector constituted 62 per cent of the Kenyan economy in 2010 (CIA, 2011). Tourism forms a large part of this sector, as Kenya's coastal rainforests, marine ecosystems, and wildlife, as well as Mount Kenya, make it one of the top tourist destinations in the world (WRI et al., 2007). A significant proportion of wildlife conservation occurs in Kenya's ASALs, where tourism is the major economic activity (WRI et al., 2007). Between 2004 and 2009, tourism generated US$737 million in revenues (World Bank, 2011, p. 13). Following a decline after the post-election violence of 2008, the sector grew by 15 per cent between 2009 and 2010 and generated an estimated KES 73.68 million (approximately US$0.88 million) in earnings (Ministry of Tourism, n.d.).

Expansion of the industrial and service sectors forms a significant part of Kenya's economic development strategy. As stated in *Vision 2030*, Kenya aims to become a rapidly industrializing middle-income country by 2030 (GOK, 2007a). Strategies to achieve this goal include promoting investment in key agro-processing industries, becoming a provider of basic manufactured goods for Eastern and Central Africa, supporting local industries that use local raw materials, and adding value to imports that can then be re-exported (GOK, 2007a). The primary goal of the *First Medium Term Plan* is to increase growth in manufacturing, wholesale and trade from 5 per cent to 10 or 12 per cent by 2012. This goal is to be achieved by expanding Mombasa and Kisumu's manufacturing sectors, establishing at least five small- and medium-enterprise industrial parks and specialized economic zones (GOK, 2008, p. viii), and creating a least 10 wholesale hubs and 1,000 to 1,500 producer business groups (GOK, 2007a).

In the services sector, Kenya intends to position itself among the top 10 long-haul tourist destinations in the world (GOK, 2007a) and to make its financial services globally competitive (GOK, 2007b). The first goal is to be achieved by developing two new resort cities, improving existing parks, creating new high-value niche products, attracting high-end international hotel chains, and investing in new conference facilities (GOK, 2007a). By 2012, Kenya wants to increase tourism's contribution to GDP to more than KES 200 million (US$2.3 million), expand the number of visitors to the country to 3 million per year and increase average visitor spending to at least KES 70,000 (US$805) (GOK, 2007a; GOK, 2008).

Continued expansion of the transportation and communications sector is also envisioned, and is expected to support achievement of Kenya's industrial and service sector goals. This sector experienced strong growth in recent years, rising from 3.5 per cent in 2003 to 10.8 per cent in 2006 (GOK, 2007a, p. 2). By 2030, the country aims to have a firmly interconnected network of roads, airports, railroads, ports and telecommunications (GOK, 2007a). In the near

term, targets for the period from 2008 to 2012 include establishment of a national spatial plan to coordinate public and private sector investments, and development of a free port in Mombasa (GOK, 2008). *The Vision 2030* flagship project, construction of a port in Lamu that will be linked to Ethiopia and south Sudan, was announced in March 2012.

To achieve Kenya's goals related to the industrial, service, and transportation and communications sectors, exposure to climate risks will need to be managed. Historically, these sectors have been adversely affected by extreme weather events like the rains and ensuing floods of 1997–1998. This event caused US$1 billion in damages to transportation and telecommunications infrastructure (GOK, 2010), led to the closure of park roads for extended periods (Viner & Agnew, 1999), and damaged coral reefs near Mombasa that are a major tourist attraction (SEI, 2009). Environmental degradation and climate variability and change has also affected the tourism sector in recent years, causing receding of the glaciers on Mount Kenya; reduced numbers of flamingos in Lake Nakuru due to lower lake levels, migration of wildlife across the Mara River due to reduced water flows, and diminishing of beaches along the coast (GOK, 2010). These changes are occurring against a loss of an estimated 3 per cent of Kenya's large wildlife per year; the country has lost 60 to 70 per cent of its large wildlife since 1977 (ROK, 2010).

In the future, infrastructure such as roads, railways, buildings and ports may experience greater damage from extreme weather events such as rainstorms and floods, as well as from sea-level rise (GOK, 2010). These impacts will in turn indirectly affect industrial production. As well, the industrial sector could be directly affected by water scarcity and reduced reliability of hydroelectric power. Industrial installations along the coast may also be damaged by sea-level rise (Awuor et al., 2008). The tourism sector may be affected by greater water scarcity, with implications for tourist facilities, wildlife populations and natural attractions such as lakes and shorelines; shrinkage of the wildlife population; electricity shortages (WRI et al., 2007); greater demand for energy as temperatures rise, with associated higher costs (SEI, 2009); and movement of wildlife populations, with potential implications for the appropriateness of existing park boundaries and conflicts between humans, livestock and wildlife (Viner & Agnew, 1999).

The National Climate Change Response Strategy presents some strategies for addressing these concerns. It notes the need to "climate proof" new infrastructure investments to ensure their resilience over their lifespans and suggests mechanisms for doing so (GOK, 2010), including establishing a maintenance fund to address damage from extreme weather events; ensuring structures are able to withstand higher temperatures, stronger winds and rising sea levels; and undertaking research to better understand the potential impact of climate change on national infrastructure (GOK, 2010). It also proposes that the Kenya Wildlife Service develop a national wildlife adaptation strategy, in partnership with stakeholders such as the World Wildlife Fund and the tourism industry.

4.6 Vulnerable Groups

While climatic events affect many Kenyans annually, poor households' restricted access to and control over resources leaves them less able to cope with shocks and stresses (Kimani & Kombo, 2010). In extremely vulnerable parts of the country, minor hazards tend to become humanitarian emergencies due to a lack of local coping capacity (ROK, 2009). Particularly vulnerable to the impacts of climatic events are members of female-headed households, orphans, people living with HIV/AIDS, the disabled, internally displaced people and international refugees.

While all of these groups are at greater risk of being adversely affected by climatic extremes, analysis has thus far focused primarily on the vulnerability of women. Kenyan women are acknowledged to be particularly vulnerable to climate impacts due to their household responsibilities and greater dependence on weather-sensitive livelihoods

(Mutimba et al., 2010). They manage over 40 per cent of Kenya's smallholder farms and provide up to 80 per cent of farm labour for crop production (AfDB, 2007, p. vi). About 80 per cent of Kenyan women spend about one to five hours per day per household looking for fuelwood (AfDB, 2007, p. vi), and in some rural locations (particularly in the ASALs), they spend 3 to 5.25 hours a day collecting water (AfDB, 2007, p. 20). Climate disasters can increase women's household responsibilities and cause disproportionate economic losses (Mutimba et al., 2010). During periods of drought, especially in the ASALs, women and children need to walk greater distances to fetch water and fuelwood (Nampinga, 2008). The household responsibilities of women can also increase, even more so if the able-bodied male members of a household leave in search of economic opportunities (Mutimba et al., 2010; Nampinga, 2008). Greater resource scarcity can also increase the likelihood of women and children being affected by conflict and violence (Mutimba et al., 2010; Omolo, n.d.; UNICEF, 2010). Women are at greater risk as well during periods of flood, when the occurrence of malaria, cholera and dysentery—to which pregnant women and children are more vulnerable—can increase, particularly in areas where access to health care is inadequate (ICPAC, 2007; Nampinga, 2008).

Women's vulnerability is accentuated by their more restricted access to resources (Nampinga, 2008; Omolo, n.d.). Most women do not have full access to or control over the land they farm (women own 1 to 5 per cent of land titles in Kenya [AfDB, 2007]), nor to capital or agricultural credit (Kimani & Kombo, 2010). Therefore, compared with men, they are less able to implement agriculture measures that could reduce their vulnerability to climatic events. They also have less capacity to seek off-farm income-generation opportunities. On the other hand, women also have capabilities as natural resource managers and community leaders that can increase their capacity to cope with various climate hazards (Mutimba et al., 2010).

Climate change could compound the vulnerability of women, children and other marginalized groups. Changes in average and extreme weather patterns could result in greater destruction of infrastructure, such as schools, critical to poverty reduction; reduce crop yields, causing an increase in childhood malnutrition; and lead to greater conflict over scarce water resources and migration to urban centres whose social, water and sanitation systems are already overburdened (UNICEF, 2010). These changes would further limit marginalized groups' economic opportunities and potentially deepen their level of poverty.

Addressing poverty and reducing disparities in wealth distribution are priority goals of *Kenya Vision 2030*, in which the government aims to achieve "equality in power and resource distribution between the sexes, [and] improved livelihoods for all vulnerable groups" (GOK, 2007a, p. 21). Particular attention is to be given to marginalized groups in the ASALs, urban slums and pockets of extreme poverty in other areas. *Vision 2030* outlines plans to improve access by disadvantaged groups to business opportunities and health and educational services (GOK, 2007a). To help achieve this goal, the government aims to mainstream gender considerations into government policies, plans and budgets during the period from 2008 to 2012 (GOK, 2008). It also plans to increase the availability of gender-disaggregated data; develop an integrated data system for tracking vulnerable groups; establish a consolidated social protection fund to support orphaned and vulnerable children, the disabled, and other vulnerable groups; establish a disability fund; establish a national drought contingency fund; introduce an affirmative action policy to ensure that at least 30 per cent of civil service recruitments, promotions and appointments at all levels go to women; continue the Women Enterprise Fund; increase the efficiency of the legal system in order to reduce gender-based violence; and develop a national policy on aging and the elderly (GOK, 2008).

Kenya's *National Gender and Development Policy* was passed in 2000 and provides a framework for the country's efforts to promote the advancement of women and the mainstreaming of gender into development (ROK, 2000). The policy focuses on the economy, poverty and sustainable livelihoods, the law, political participation and decision-making, education and training, health and population, and the media (ROK, 2000). The National Commission on Gender and Development, established in 2004, is supporting implementation of this policy (AfDB, 2007). The commission's mandate is to advise the government on gender concerns and coordinate efforts to mainstream gender into national development (Mutimba et al., 2010).

Despite these efforts, Kenya's progress with respect to integrating gender considerations into national sectoral policies appears to be limited, and capacity-building is needed in this area (see, for example, AfDB, 2007; GWA & IEW, 2009). A study in the water sector, for example, suggests that while the importance of mainstreaming is recognized, inadequate knowledge of gender issues among government staff is a barrier to acting upon this understanding (GWA & IEW, 2009). This finding is reflected in Kenya's National Climate Change Response Strategy, which identifies significant adaptation measures in various sectors of the economy but lacks gender-sensitive targets and indicators.

Capacity-building also appears to be needed with respect to climate change and its implications for achieving Kenya's gender and development targets. Climate risk management efforts could be strengthened by improving understanding of the implications of climate change for Kenyan women and other vulnerable groups, deepening analysis of how to develop and implement adaptation measures that minimize adverse impacts on these groups, and integrating this knowledge into policy and program implementation. Creation of this understanding will likely need to be supported by greater research and by awareness-raising with policy-makers.

4.7 Summary

As illustrated by the preceding sections, Kenya's economy and people are vulnerable to climate-related risks due to their high degree of dependency on natural resources. Historically, this dependency has led to climate hazards having significant adverse economic consequences, in addition to the loss of human lives. Projections suggest that these negative consequences will increase in the future due to climate change. The additional economic cost of climate change, over and above current losses due to climate variability, could equal 2.6 per cent of GDP each year by 2030—not taking into account the cost of future extremes (floods and droughts) and potential effects on ecosystem services (SEI, 2009, p. iii). The implications of this projection for achievement of Kenya's development goals as articulated in *Vision 2030* are profound and suggest the need to directly address the country's sources of vulnerability and improve management of current and future climate risks.

5.0 Climate Risk Management Profile

Given the significant proportion of the Kenyan population affected by climate hazards each year and the profound negative impact of these events on the country's economy and local livelihoods, effective management of climate risks is required if Kenya is to achieve its sustainable development objectives. Climate risk management involves the systematic use of climate information in development decision-making to minimize the potential harm or losses associated with climate variability and change.[13] For climate risk management efforts to be successful, an effective policy framework must be in place, institutions must enable effective communication between different stakeholders, high-quality climate data and information must be available, and sufficient resources (human, technical and financial) must be available to use information effectively (Hellmuth et al., 2007). This section examines the extent to which these requirements for successful climate risk management are present in Kenya today—and therefore the country's capacity to cope with the greater complexity and uncertainty of climate risks in the future due to climate change.

5.1 Institutional and Policy Arrangements for Addressing Disaster Risk Reduction and Climate Change Adaptation

Climate risk management is most prominently undertaken as part of efforts to facilitate disaster risk management and climate change adaptation. Despite their interconnectedness, in Kenya, as in many developing countries (UNDP, 2002a), different institutions and policies support disaster risk management efforts and adaptation to climate change.

Disaster Risk Management

Disaster risk management, including the management of climate risks, is presently the responsibility of the Ministry of State for Special Programmes (MOSSP) in collaboration with the National Disaster Operation Centre in the Office of the President. The MOSSP was established within the Office of the President in 1994 (GOK, 2009). Its overall objective is to promote the establishment of comprehensive disaster management in Kenya, including disaster prevention, mitigation, preparedness, response and recovery (MOSSP, n.d.). Its functions include the development and implementation of comprehensive disaster management policies and programs, and coordination of resources mobilized to manage disasters (MOSSP, n.d.).

The National Disaster Operations Centre (NDOC), established in 1998, focuses primarily on emergency response. Composed of officers from different ministries and departments (Ngethe, 2010), it is responsible for executing decisions of the National Disaster Coordination Committee, an inter-ministerial committee formed when major disasters occur that is composed of permanent secretaries and chaired by the permanent secretary for the MOSSP (Mutimba et al., 2010; Sana 2007). The NDOC coordinates rapid-onset disaster-response efforts by liaising with, coordinating and mobilizing responsible ministries/departments and donors. Further responsibilities of the NDOC include monitoring, collecting and disseminating relevant information before, during and after a disaster on a year-round basis, collaborating with other stakeholders, sensitizing the public and preparing an inventory of resources (NDOC, n.d.; Ngethe, 2010).

Disaster management is further facilitated by the National Disaster Management Executive Committee, which falls under the Cabinet office and is responsible for developing disaster intervention programs, and district disaster management committees responsible for managing disasters within their jurisdictions (Sana, 2007). As well, a National Platform on Disaster Risk Reduction was established in 2004 to support implementation of the Hyogo

[13] Definition adapted from Hellmuth et al. (2007) and the definition of risk management included in UNISDR (2009).

Framework of Action 2005–2015. The Platform provides a forum for stakeholder engagement and coordinates the integration of disaster risk reduction into development (MOSSP, n.d.; ROK, 2009). Various ministries, governmental bodies, non-governmental organizations (NGOs), multilateral organizations and the private sector have roles in these and other initiatives related to disaster management. These organizations include the KMD, which is active in providing timely information regarding climate hazards, and the media, which communicates these warnings to communities (KNPDRR, 2011).

As part of its disaster risk management efforts, Kenya established a national drought management system about 20 years ago (Zwaagstra et al., 2010). This coordination and response system includes the Kenya Food Security Structure, which is composed of the Kenya Food Security Meeting—an advisory group chaired by MOSSP that brings together national stakeholders and key bilateral and multilateral donors on a monthly basis—and the Kenya Food Security Steering Group, a subcommittee of the Kenya Food Security Meeting (MOSSP, n.d.; Mutimba et al., 2010; ROK, 2009; Zwaagstra et al., 2010). The latter coordinates the monitoring of key agricultural, livestock, economic, social and climatic indicators (Sana, 2007) to identify early signs of pending food emergencies; develops and manages coordinated response mechanisms to food insecurity and drought stress; and provides technical advice (ROK, 2009).

To enhance this system, the Drought Management Authority, housed within the Ministry for Development of Northern Kenya and other Arid Lands, was established in November 2011 (NCLR, 2011). The mandate of the Drought Management Authority is to, "either on its own or in association with other authorities or persons, establish mechanisms to ensure that drought does not become famine and the impacts of climate change are sufficiently mitigated." Responsibilities of the Drought Management Authority include ensuring efficient operation of existing drought early-warning systems, supporting drought-related policy formation, raising awareness and coordinating the implementation of risk-reduction activities, coordinating the preparation and regular updating of drought contingency action plans at all levels, developing clear criteria for the national Drought Contingency Fund and other financing mechanisms, and coordinating various drought-response initiatives (Ministry for the Development of Northern Kenya and other Arid Lands, n.d.; NCLR, 2011). Coordination of existing drought-management efforts with those focused on adapting to climate change has also been recommended (Zwaagstra et al., 2010).

Current disaster risk management efforts in Kenya are mostly focused on reactive, short-term emergency or relief responses, as opposed to comprehensive disaster management (IRIN, 2010; MOSSP, n.d.). They are also impeded by the absence of a coordinated institutional framework that enables systematic preparation for and response to disasters (MOSSP, n.d.; Zwaagstra et al., 2010). This situation has resulted in slower and less coordinated responses to disasters, and in additional costs (IRIN, 2010; Ngethe, 2010). For example, in an assessment of the costs associated with responding to the 1999 to 2001 drought, it was estimated that US$171 million would have been required—as opposed to actual expenditures of about US$343 million—had an effective disaster management system been in place (IRIN, 2010).

To help address this situation, the *National Disaster Management Policy* has been drafted (GOK, 2009). Creation of this policy was initiated in early 1999 (GOK, 2009), and its content has evolved over the years in response to the emergence of new issues like climate change (IRIN, 2010) and the need to align it to Kenya's new constitution (KNPDRR, 2011). A final draft of the policy was presented to Cabinet in 2010 (KNPDRR, 2011), but has not yet been approved.

The draft *National Disaster Management Policy* establishes a framework for institutionalizing and coordinating disaster risk management across sectors and actors, placing equal emphasis on prevention, preparedness and recovery (GOK, 2009). Its overall goal is to prevent disasters and their impacts on people, infrastructure and the environment; increase

the resilience of families and communities affected by disasters; ensure responses to emergencies that are "fast, well coordinated, effective and appropriate"; and ensure timely recovery from disasters (GOK, 2009, p. 9). Under the proposed policy, the institutional framework for disaster management would be streamlined by repositioning existing institutions (e.g. MOSSP and the National Platform on Disaster Risk Reduction) and establishing new ones (e.g. a national disaster executive committee and a national disaster coordination committee [GOK, 2009]).

The draft policy also specifically recognizes the links between disaster risk management and climate change adaptation. Acknowledging that climate change is likely to increase the frequency and unpredictability of climate-related hazards, climate change adaptation is presented as a "foundational concept" of the draft policy (GOK, 2009, p. 10). The MOSSP is expected to have greater responsibilities related to climate change adaptation, including undertaking research; advising the National Environment Management Authority (NEMA) and the Ministry of Environment on measures "to safeguard the environment based on hazard risk analysis and climate change research"; advising line ministries on how to reduce natural hazard risks, including those linked to climate variability and change; and providing information to communities about the potential impacts of climate change and ways to increase their resilience (GOK, 2009, p. 29).

The *Disaster Risk Reduction Strategy for Kenya 2006–2016* has also been prepared. It aims to "lay a firm foundation to sustain community resilience to disaster events," support an integrated approach to disaster management, and provide guidance on the mainstreaming of disaster risk reduction into development programming, planning and implementation (GOK, 2006, p. 49). The strategy sets out seven goals, including enhancing the legal and policy framework for disaster management, establishing a focal point for disaster management activities, and reducing the impacts of climate change. With respect to the latter, the strategy seeks to support local adaptation, build capacity to use climate forecasts and risk assessments to develop plans, mainstream adaptation into development planning, and integrate climate change projections into disaster management efforts (GOK, 2006).

Climate Change Adaptation

A number of different government bodies, ministries and organizations are involved in supporting adaptation to climate change in Kenya. Prominent among these is the National Climate Change Activities Coordinating Committee (NCCACC), composed of 25 representatives from several ministries as well as municipalities, public universities, the private sector and NGOs (Mutimba et al., 2010; Ogola, n.d.). Established in 1992, the NCCACC is instrumental in coordinating the government's activities on climate change (Mutimba et al., 2010). It also aims to facilitate research on climate change impacts and possible adaptation measures, establish a database on climate change impacts and response strategies, and provide policy advice on climate change (Ogola, n.d.).

In addition, the Climate Change Coordination Unit was established in the Office of the Prime Minister in 2008 to "provide high level political support for climate change activities in Kenya" (Mutimba et al., 2010, p. 43). Now named the Environment and Climate Change Coordination Unit, it also supports coordination of activities and the mainstreaming of climate change into the work of different ministries (Matiru, 2009; Mutimba et al., 2010). The Office of the Prime Minister has been removed under Kenya's new constitution, enacted in August 2010. This office will not exist after the national elections expected in March 2013. The status of the Coordination Unit after this date has not yet been determined.

The ministries directly involved with the implementation of climate change efforts are the Ministry of the Environment and Mineral Resources (MEMR) and the Ministry of Forests and Wildlife (Mutimba et al., 2010). The latter is primarily involved in efforts to reduce greenhouse gas emissions through forestry activities (Mutimba et al., 2010). MEMR is

the focal point for climate change and has lead responsibility for coordinating and supervising climate change efforts (adaptation and mitigation) across all sectors (Mutimba et al., 2010). This work is coordinated through the Climate Change Secretariat, established in 2010. NEMA and the KMD also support climate change action (Mutimba et al., 2010).

The Ministry of State for Planning, National Development and Vision 2030 has developed the Threshold 21 Model (T21), which is strengthening institutional capacity for integrating climate change adaptation into the national development planning process. This planning tool for climate adaptation integrates analysis of the risks and impacts of climate change across the major sectors in the economy, society and environment in order to inform coherent national development policies that encourage sustainable development, poverty eradication and increased well-being of vulnerable groups, especially women and children, in the context of *Vision 2030*. The multisectoral team developing the model is drawn from a number of key government departments and agencies, including the Meteorological Department, Ministry of Energy, Department of Resource Surveys and Remote Sensing, and Ministry of State for Development of Northern Kenya (Ministry of State for Planning, National Development and Vision 2030, 2011).

A number of other ministries and government agencies are also engaged in climate change–related projects and programming. These include the ministries of Land, Water and Irrigation; Northern Kenya and Other Arid Lands; Fisheries; Tourism; Public Health and Sanitation; Agriculture; and Energy (Mutimba et al., 2010). As well, the Kenya Agriculture Research Institute has established a climate change unit with the principle objective of providing leadership, information and technologies that will support climate change adaptation.[14] In addition, the Kenya Forestry Service has been designated as the focal point for REDD+ (reducing emissions from deforestation and forest degradation) activities.

At the policy level, Kenya released its National Climate Change Response Strategy in 2010. The strategy was developed in part to address a perceived shortcoming in *Vision 2030*, in that the latter does not fully recognize the potential for climate change to hamper achievement of Kenya's ambitious development goals (GOK, 2010). Within the context of achieving "climate smart" development, the main focus of the strategy is to ensure the integration of climate change adaptation and mitigation into "all government planning, budgeting and development objectives" (GOK, 2010, p. 12). It proposes key adaptation measures for the sectors of health, agriculture, water, fisheries, tourism and wildlife, livestock and pastoralism, physical infrastructure, and social amenities (which include human settlements). It also recommends modernizing and enhancing Kenya's national meteorological services and strengthening the county's capacity to plan for, cope with and recover from climate disasters (GOK, 2010).

The government has acted upon recommendations included in the NCCRS, including establishment of the Climate Change Secretariat within MEMR, responsible for overseeing all climate change issues and programs (GOK, 2010). The secretariat is currently spearheading development of a climate change action plan. The action plan process, to be completed in 2012, will include sections on adaptation, mitigation, financing, policies and laws, monitoring and review, technology, and capacity-building. The adaptation work includes examination of options for adaptation and drafting of a national adaptation plan. The MEMR is also encouraging the establishment of climate change focal points in all ministries to better enable effective facilitation of climate change adaptation activities at the ministry level. To further strengthen Kenya's institutional system for managing climate change, the NCCRS suggests that the NCCACC continue to perform an advisory role while a new national climate change steering committee be established to support coordination of climate change activities (GOK, 2010).

[14] For more information, see http://www.kari.org/?q=content/official-launch-climate-change-unit

The government has acted to improve its climate change institutions, yet action remains somewhat uncoordinated, leading to duplication of efforts in certain cases (Mutimba et al., 2010). Other concerns include the absence of sufficient human and physical resources and capacity within the MEMR and Climate Change Coordination Unit to effectively fulfill their responsibilities (Mutimba et al., 2010).

Concluding Assessment

Kenya has considerable experience responding to climate-related disasters, including droughts and floods, and has established systems for monitoring their occurrence and communicating warnings of pending climate hazards to vulnerable populations (KNPDRR, 2011). It has also made positive strides toward establishment of an enabling environment for addressing climate change. However, despite these accomplishments, institutional arrangements for managing disaster risk management and climate change adaptation could be enhanced.

Policy frameworks and institutional arrangements must be strengthened to enhance their capacity to promote collective action and knowledge-sharing. In disaster risk management, for example, the absence of a national policy has been cited as constraining budgetary allocations for disaster risk reduction efforts and leading to uncoordinated interventions. The result is limited capacity to rapidly respond to disasters, particularly at the community level, and reduced accountability (KNPDRR, 2011; Ngethe, 2010). As well, research on the nature of past disasters has been inadequate, and a comprehensive disaster risk assessment has not been completed, both of which impede planning (Ngethe, 2010). Integration of climate concerns into national planning processes has been limited by weak institutional capacity to execute current responsibilities (Matiru, 2009).

The deficiencies in the current system have been acknowledged by the government, including in *Kenya Vision 2030*, which aims to "enhance disaster preparedness in all disaster-prone areas and improve the capacity for adaptation to global climatic change" (GOK, 2007b, p. 19). The government is making progress toward implementation of recommended policy and institutional changes. Signs of this progress include development of the Climate Change Secretariat, establishment of the T21-Kenya team in the Planning Department, a review of policies and laws, and the development of an action plan. The action plan process is working to improve inter-ministerial coordination and integrate climate change considerations into national planning processes.

Over and above the limited coordination among actors engaged in disaster risk management and climate change adaptation, an integrated response to these twin concerns is also absent. While the need to link disaster risk management and climate change adaptation is acknowledged in the draft *National Disaster Management Policy, Disaster Risk Reduction Strategy for Kenya 2006–2016* and the NCCRS, clear institutional guidance appears to be lacking regarding how this goal might be accomplished. This gap in policy and institutional structure will need to be filled if Kenya is to effectively engage in climate risk management.

5.2 Climate and Hazard Information

Effective management of climate risks requires the availability of sufficient and accurate climate data as well as its effective communication to end users. It further requires access to complementary information that can inform risk analysis, such as the location and characteristics of vulnerable groups that may be exposed to particular hazards, topographic and soil data, and economic development projections.

In Kenya, climate information is provided through the Intergovernmental Authority on Development Climate Prediction and Analysis Centre (ICPAC) and the KMD. Headquartered in Nairobi, ICPAC supports the national and regional climate risk reduction strategies of seven countries in the Greater Horn of Africa (Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan and Uganda), and facilitates access to climate information by Burundi, Rwanda and Tanzania. The regional centre collects, processes, stores and offers access to climate and remote-sensing data, provides early warning of climate-related hazards, identifies climate change adaptation options, and supports capacity-building in the generation and application of climate tools and information. It monitors past climate parameters (including temperature and rainfall) in the Horn of Africa on 10-day, monthly and seasonal time scales in order to detect historic anomalies, and it monitors and assesses current climatic conditions and predicts conditions based on statistical models for these same time scales. A key activity of the centre is hosting an annual forum, the Greater Horn of Africa Climate Outlook Forum, at which major climate centres from around the world agree upon seasonal climate forecasts for the region. ICPAC disseminates the information it collects to national meteorological and hydrological services, including KMD (ICPAC, n.d.).

Housed within the MEMR, KMD is Kenya's primary source of national and subnational climate information. Along with maintenance of historical records since 1896 (NEMA, 2005), the department provides access to daily weather forecasts, four-day forecasts, seven-day forecasts, monthly forecasts, and seasonal climate forecasts that cover the next three to six months (KMD, n.d.). Developments in weather and seasonal rainfall predictions have increased the accuracy and reliability of KMD's seasonal forecasts in recent years (Ndegwa et al., 2010); its seasonal forecasts, as well as daily, four-day and seven-day forecasts, are generally accurate (Mwangi, n.d.). KMD also provides forecasts for extreme events (floods and droughts) and undertakes monitoring, assessment, modelling and communication of the extent to which climate change is occurring in the country (KMD, n.d.).

BOX 2: ENHANCING RESILIENCE TO DROUGHT THROUGH IMPROVED ACCESS TO CLIMATE INFORMATION

Agriculture in Kenya's ASALs is being adversely affected by increasingly unpredictable weather, compounding farming communities' vulnerability to food insecurity and declines in human and animal health. These conditions present a growing challenge for development in these regions.

To enhance the resilience of ASAL farmers to drought, a pilot project was launched in 2006 in the community of Sakai, located in Mbooni East District. One of its objectives was to improve the provision of downscaled weather information to farmers through a partnership between ICPAC, KMD, the government's Arid Lands Resource Management Project and the Centre for Science and Technology Innovations. In the past, KMD had delivered information in a manner that farmers were not able to understand. Through the partnership, projections regarding the likely onset, cessation and distribution of the rains, and whether rainfall levels would be above normal, normal or below normal, were translated into agronomic advice for rural farmers (e.g. crop selection, timing of planting and spacing of seeds). This information was delivered to Sakai farmers through radio, printed brochures and agricultural extension workers in an understandable language and in a way that was relevant to their agronomic needs. As a result, farmers were able to make more informed farming decisions and successfully apply climate risk management strategies to cope with weather variability.

Based on the successful Sakai experience, a farmers' handbook tailored to the region's agroecological conditions was created. In addition, the Ministry for the Development of Northern Kenya and other Arid Lands now requires that all of the arid and semi-arid areas of Kenya receive downscaled weather forecasts as part of Kenya's drought-early-warning activities.

Sources: IISD (2009; 2011)

To understand the vulnerability of populations to the climate hazards monitored and analyzed by ICPAC and KMD, environmental, topographic, economic and social data must also be accessible. In Kenya, this information has been consistently collected by organizations such as the Central Bureau of Statistics and the Department of Resource Surveys and Remote Sensing (WRI et al., 2007). Remote sensing and geographical information system data collected by the Department of Resource Surveys and Remote Sensing, for example, can be used to map the distribution of natural resources and livelihood strategies; variability in poverty densities; land use and land cover; distribution of humans, livestock and wildlife; and disaster-risk areas (see, for example, WRI et al., 2007). As well, to facilitate information-sharing related to climate risks, MOSSP has created a "one-stop-shop data centre" that provides access to a national inventory of resources and capabilities available in all national, private, NGO, community-based and individual institutions (MOSPP, n.d., p. 22).

Kenya has considerable capacity to collect, analyze and disseminate climate information and data. Yet some challenges remain. KMD, for instance, is understaffed and has limited resources to collect and disseminate data, and its products are not as widely used by institutions, sectors and the public as is desirable (Matiru, 2009). The number of professionals with meteorological expertise in Kenya is also limited (Matiru, 2009). Furthermore, climate forecasts prepared by KMD, particularly for some high-impact weather events like floods, could be improved through greater access to real-time data collection and transmission (Mwagi, n.d.).

Collection of socioeconomic data by different public and private sector institutions also could be improved. Data collection remains uncoordinated, and data gaps exist in terms of "comprehensiveness, interval of collection, coverage and the general form in which the data may be available, its accuracy and the extent of accessibility" (GOK, 2008, p. 41). For example, limited information is available regarding key natural ecosystems such as major water catchment areas and how they might be affected by climate change (GOK, 2010). Similarly, the agricultural sector requires greater sharing of data among stakeholders, as well as enhanced monitoring and evaluation (GOK, 2008). Within the health sector, limited information is available for monitoring of health goals, and capacity must be developed to improve data generation and management (GOK, 2008). Furthermore, collection methodologies, storage and access to data related to the environment and natural resources must be harmonized (GOK, 2008). Finally, gender-disaggregated data has not been collected in the past, which limits capacity to engage in appropriate planning, monitoring and evaluation (AfDB, 2007; GWA & IEW, 2009). The absence of such data also means that women's contribution to their households is mostly unidentified in national statistics (AfDB, 2007), and their contribution to the economy is therefore largely unrecognized.

In response to these concerns, Kenya's *Vision 2030* includes the Meteorological Systems Modernisation Programme, the objective of which is to improve the country's disaster preparedness and promote "awareness among vulnerable communities and decision-makers" (GOK, 2007a, p. 15). A component of the program includes enhancing capacity for dynamic modelling for weather forecasting and climate projections (GOK, 2007a). As well, as part of its *First Medium Term Plan*, Kenya has stated its intention to rehabilitate its hydrometeorological data-gathering network and build capacity to collect records and monitor data-acquisition instruments; create data profiles of the poor across the country and their needs; establish a geographical information system–based land information management system to enhance the delivery of services to Kenyans, particularly the poor; strengthen the Health Management Information System; and prepare a national spatial plan to collect and continually update data on land use (GOK, 2008). The NCCRS also recommends periodic assessments of how climate change might affect Kenya's people, economy and environment (GOK, 2010).

5.3 Current Major Climate Risk Management Activities

Kenyans who live in risky environments employ a rich variety of strategies to reduce their exposure to climate hazards (Kandji, 2006) and cope in times of crisis. Common strategies used to minimize the adverse consequences of (climate) shocks are to, "in order of importance, [spend] cash savings, sell assets (animals), work longer hours, reduce food consumption and receive help from family and friends" (World Bank, 2009, p. xvii). Migration—either temporary or permanent, and either within Kenya or to another country—is also a widely used strategy. Remittances provide an additional, important social safety net (USDS, 2011).

To strengthen these indigenous coping strategies at the community level and enhance capacity to manage climate risks at a national level, a number of dedicated projects and programs have been initiated in Kenya. These initiatives are being undertaken by a range of actors, with significant adaptation projects being implemented by different government ministries with funding support from international donors. Ministries engaged in implementation of climate adaptation projects include Agriculture, Development of Northern Kenya and other Arid Lands, Environment, Energy, Fisheries Development, Forestry and Wildlife, Lands, Livestock Development, Public Health and Sanitation, Special Programmes, Tourism, and Water and Irrigation (Matiru, 2009; Mutimba et al., 2010). Several parastatal organizations, such as NEMA, the Kenya Agriculture Research Institute, the Kenya Forest Service and the Kenya Wildlife Service, are also implementing climate change adaptation projects (Matiru, 2009; Mutimba et al., 2010).

Other organizations engaged in climate change adaptation actions in Kenya include:

- Multilateral organizations like the United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP) and World Bank.
- International research institutes such as the International Livestock Research Institute and the World Agroforestry Centre.
- NGOs, including international NGOs (e.g. Action Aid, Birdlife International, CARE, International Union for the Conservation of Nature and World Wildlife Fund), national NGOs (e.g., African Centre for Technology Studies, Centre for Science and Technology Innovations, Forest Action Network, and Nature Kenya), local NGOs, and community-based organizations (Matiru, 2009).
- Consulting organizations such as Camco Advisory Services and the Conservation Development Centre.

These and other organizations are also engaged in supporting disaster risk management action in Kenya, including MOSSP, UNDP, United Nations International Strategy for Disaster Reduction, United Nations Office for the Coordination of Humanitarian Affairs, World Food Programme, Intergovernmental Authority on Development, Kenya Red Cross Society, ActionAid, Oxfam, World Vision and various universities (KNPDRR, 2011).

Technical and financial assistance for climate change adaptation projects has been provided by a number of different sources, most prominently through the Japan-funded, UNDP-implemented Africa Adaptation Program, and the Climate Change Adaptation in Africa program, which was supported by the United Kingdom's Department for International Development and the International Development Research Centre (Hove et al., 2011). Funding is also being provided by the Rockefeller Foundation, Special Climate Change Fund, UNDP and World Bank, and through bilateral assistance from Germany, the Netherlands, Norway, Sweden, Switzerland and the United Kingdom (Hove et al., 2011).

Most current adaptation projects in Kenya address needs related to agriculture and, to a lesser extent, freshwater resources, disaster risk management, pastoralism and coastal zone management (Hove et al., 2011). These projects support implementation of a variety of climate risk management strategies in different sectors, such as:

- *Water resources*. Rainwater harvesting; building sand dams; constructing water dams and reservoirs; drilling boreholes; expanding irrigation systems, including drip and bucket irrigation; building water-retention ditches and terraces; constructing upstream infiltration ditches that collect water upslope and feed croplands downslope; instituting measures to enhance water efficiency; and strengthening regulatory arrangements.
- *Agriculture*. Strengthening drought early-warning systems; improving management of soil and water resources to enhance soil fertility, reduce soil erosion and increase soil moisture; developing and promoting drought-tolerant and early-maturing crop varieties as well as those that can withstand higher temperatures and resist pests and diseases; promoting conservation agriculture; establishing index-based insurance schemes for crops[15] and livestock; strengthening Kenya's agricultural extension service; diversifying rural livelihoods; improving animal husbandry; and promoting the safe movement of pastoralists across national boundaries.
- *Health*. Improving national and local health-delivery systems as part of broader development activities, including actions such as rehabilitation of health clinics and dispensaries, strengthening disease-outbreak monitoring, and distributing insect repellents and mosquito nets.
- *Energy*. Reducing dependency on hydropower production and remaining forest resources by promoting energy-efficient cookstoves and the development of alternative energy sources such as geothermal and solar energy systems.
- *Tourism*. Improving understanding of the vulnerability of wildlife to climate change through detailed research, and promoting participatory rangeland management.
- *Disaster risk reduction*.[16] Climate-proofing development initiatives in key sectors; providing training in disaster reduction and recovery to ministries and districts; conducting risk assessments, hazard mapping and vulnerability mapping; providing access to national disaster information; strengthening dikes in flood-prone areas; constructing dams for upstream storage; and enhancing awareness and strengthening early-warning systems through, for instance, the use of community radio.
- *Awareness*. Providing the public and key decision-makers with greater information regarding climate risks and possible management strategies.

Many of these ongoing adaptation projects focus on the ASALs and other rural areas (Hove et al., 2011).

Early lessons from the implementation of dedicated climate change adaptation projects highlight the need for greater capacity and coordination. While awareness has been raised regarding the need to respond to the threat posed by climate change, the capacity of people and organizations to act upon this knowledge and integrate these concerns

[15] For example, the program Kilimo Salama enables small-scale farmers to obtain micro-insurance against drought or excess rain. Under this system, trained agro-dealers use a camera phone to scan a special bar code on each bag of seed or other input purchased by a farmer, which automatically registers it. An insurance payment is triggered if data transmitted from one of 30 weather stations indicates that climatic conditions extreme enough to damage crop production have been experienced. Farmers receive insurance payments automatically (ScienceDaily, 2010).

[16] From KNPDRR (2011).

into their mandates remains limited. As well, NGOs and other organizations are not significantly engaged in sharing experience and knowledge gained through implementation of current adaptation projects. Factors contributing to this situation include lack of time for overworked personnel to write up and share lessons learned, the format in which reports are made available, and competition among organizations for limited financial resources (Matiru, 2009). Moreover, few projects and programs involve collaboration among a diverse range of stakeholders (Matiru, 2009), further limiting the opportunity for knowledge-sharing and capacity-building. In particular, greater collaboration is required between agencies focused on research that supports climate risk management and those implementing measures at the community level (Matiru, 2009).

Limited coordination among current initiatives is also a concern. The presence of multiple actors within and outside of government actively engaged in climate risk management activities provides a considerable base upon which to take action. However, in the absence of effective coordination, efforts may be duplicated, and financial and human resources may be used inefficiently (Matiru, 2009). The establishment of the Climate Change Coordination Group by donors and the Kenya Climate Change Working Group by civil society aims in part to address this challenge, but the success of each depends on the degree to which participants have the capacity and willingness to share information and coordinate efforts (Matiru, 2009). A further concern is the lack of clarity regarding the mandate of different agencies within the government with respect to climate change, which has led to confusion and conflict (Matiru, 2009; Mutimba et al., 2010).

Overall, numerous efforts by multiple actors are underway in Kenya and helping to reduce vulnerability to climate risks. However, to effectively engage in climate risk management, capacity must be enhanced in different sectors and at different levels of jurisdiction, lessons learned must be shared, and implementation must be coordinated.

5.4 Capacity Needs Assessment for Climate Risk Management

Kenya has identified a number of needs that must be met if its capacity to manage climate risks is to increase. Processes used to identify these needs have included completion of a national capacity needs self-assessment related to climate change in 2005, with the support of UNDP; a national capacity needs self-assessment for implementation of multilateral environmental agreements in 2007, with the support UNEP; and a technology needs assessment for the United Nations Framework Convention on Climate Change in 2005, which is being revisited in 2011–2012. Additional needs were identified in the NCCRS, and these may be elaborated through completion of the Kenya's climate change action plan (including its adaptation component). Kenya's 2011 report on progress toward implementation of the Hyogo Framework lists still others. Capacity needs identified in these reports include:

- *Strengthening national strategies and policy frameworks*. Recommended actions include establishing a coordinated framework to facilitate oversight of climate risk management and to guide integrated, multisectoral efforts (GOK, 2010; NEMA, 2005); developing consensus-based strategies, programs and action plans for climate change (NEMA, 2005); increasing capacity to integrate climate change into decision-making, particularly within the natural resource sectors (NEMA, 2005) and municipal governments (GOK, 2010); and increasing capacity to evaluate barriers to the implementation of specific policies (NEMA, 2005). Several of these needs are currently being addressed through Kenya's efforts to strengthen its institutional capacity related to disaster risk management and climate change, as described in section 5.1.

- *Strengthening government institutions*. Mechanisms identified include defining institutional mandates and responsibilities more clearly (NEMA, 2005); possibly establishing a facility responsible for sectoral coordination, financing and supporting the private sector related to adaptation to climate change (SEI, 2009); enhancing coordination among government and civil society actors (Marimba et al., 2010); and strengthening the capacity of the NCCACCC (NEMA, 2005). Further, there is a need to put in place district-level disaster management officers and provide them with training (KNPDRR, 2011) and to ensure that disaster risk reduction is managed through establishment of institutions with clear responsibilities and contact points (GOK, 2010). The need to increase capacity to analyze the economic impacts of climate change and adaptation measures has also been recognized (NEMA, 2005). Although the Kenya Adaptation to Climate Change in Arid Lands project and research by SEI has contributed to this understanding, better economic information is needed to ensure efficient allocation of limited resources.
- *Improving research, systematic observation and data management*. Steps towards this goal could include increasing the number of people with specialized training related to systematic observation (NEMA, 2005), use of georeferenced demographic and socioeconomic data, and, more generally, climate science and policy (GOK, 2010); investing in climate information systems to modernize Kenya's national meteorological service, improve weather monitoring and forecasting (SEI, 2009), enhance downscaled climate models (GOK, 2010), and increase access to climate data (NEMA, 2005)—in part through the Meteorological Systems Modernisation Programme; establishing institutions dedicated to climate change–related research (NEMA, 2005) and a national knowledge-management system (SEI, 2009); establishing national standards for undertaking multi-hazard risk assessments (KNPDRR, 2011); completing hazard assessments to inform planning and development decisions (KNPDRR, 2011); increasing access to completed risk assessments, which are presently disaggregated and scattered among different institutions; consolidating and sharing findings of research undertaken by various NGOs, UN bodies and universities (KNPDRR, 2011); ensuring that data is gender disaggregated; and enhancing information about critical natural ecosystems, how climate change might impact them, and the implication of these changes for society, the economy and the environment (GOK, 2010).
- *Enhancing implementation of projects and programs*. Strategies identified include building capacity to evaluate adaptation projects, identify adaptation options, undertake vulnerability assessments, engage in scenario development and carry out adaptation planning (NEMA, 2005); ensuring that incentive systems within government promote project development (Matiru, 2009); developing systems for assessing whether resources allocated for adaptation are being used effectively (Matiru, 2009); and ensuring more equitable regional distribution of resources and projects undertaken by NGOs and development assistance organizations (KNPDRR, 2011).
- *Improving communication and increasing awareness among the public and policy-makers of the potential impacts of climate change and climate risk management strategies*. Action could include developing communication tools for use from local to national levels (GOK, 2010); improving coordination, monitoring and exchange of information among stakeholders engaged in climate risk management, such as scientists, government policy-makers, NGOs and civil society organizations (GOK, 2010; Marimba et al., 2010; NEMA, 2005); and developing science–policy networks (SEI, 2009).

Restricted access to financial resources, including at the district level, also has been identified as a constraint to effective implementation of climate risk management (NEMA, 2005).

While some of the capacity needs identified in reports such as the 2005 *National Capacity Needs Self-Assessment* are beginning to be addressed, a number of gaps remain (Mutimba et al., 2010). The government has identified the need to establish a capacity-building framework as a strategy for overcoming these challenges (GOK, 2010).

5.5 Assessment of Climate Risk Management Capacity

An assessment of Kenya's capacity to manage climate risks may be informed by application of the National Adaptive Capacity Framework developed by the World Resources Institute. The Framework evaluates national capacities against five adaptation "functions," namely (WRI, 2009):

- *Assessment*. The extent to which information is available to guide decision-making, as measured by the degree to which national assessments have been completed, existing efforts have been systematically inventoried, climate risks have been integrated into national planning documents and assessments are regularly updated.
- *Prioritization*. The extent to which national climate risk priorities have been identified and are systematically reviewed on a periodic basis.
- *Coordination*. Whether processes are in place to enable multiple stakeholders within and outside government to implement climate risk management activities in a manner that avoids duplication and gaps.
- *Information management*. The extent to which information is gathered, analyzed and disseminated to the public in a way that is useful, accessible and relevant.
- *Climate risk reduction*. How measures to address specific risks in priority areas have been identified, assessed and implemented.

In Kenya, a range of assessments have examined the country's exposure to climate impacts and their possible socioeconomic implications. These assessments have focused primarily on vulnerability to climate change, and have been used to inform policy responses such as the NCCRS. They have been completed by the government, research institutes, NGOs and others, and have looked at a number of sectors (particularly agriculture) in different regions (particularly the ASALs). While these assessments provide a strong basis for going forward, some key knowledge gaps remain. Understanding of the potential impacts of climate change on some sectors (such as freshwater fisheries, infrastructure and tourism), and on vulnerable groups, remains limited. As well, a comprehensive assessment of Kenya's disaster risk has not yet been completed. Nor has a consolidated national assessment of Kenya's vulnerability to climate change been prepared. Ongoing efforts to systematically inventory adaptation risks and responses in conjunction with the development of the national adaptation plan should help address this latter concern.

At the policy level, Kenya has identified climate change and disaster risk management as concerns within *Vision 2030* and has identified priority needs through the NCCRS. Completion of the national adaptation plan will further these positive steps. Kenya has also made clear progress toward integration of adaptation considerations into national policies such as the *Agriculture Sector Development Strategy, 2010–2020*, the *National Policy for the Sustainable Development of Arid and Semi Arid Lands of Kenya*, and the draft *National Disaster Management Policy*. Challenges persist with

respect to establishing a national disaster management policy and implementing a coordinated, comprehensive and integrated disaster prevention, mitigation, preparedness, response and recovery system. As well, better coordination between adaptation and disaster risk management efforts would enhance national capacity to engage in coherent and comprehensive climate risk management. A process for routinely reviewing climate risk management needs and priorities also needs to be established.

The government has established processes for coordinating climate risk management efforts vertically, horizontally and with actors outside government, such as through the National Disaster Operations Centre, National Platform on Disaster Risk Reduction, Kenya Food Security Steering Group, National Climate Change Activities Coordinating Committee (NCCACC), Climate Change Secretariat and Climate Change Working Group. Despite this clear progress, vertical coordination continues to be limited for both climate change adaptation and disaster risk management, with most efforts taking place at the national level; coordinated provincial, district and community action is limited. As well, some overlap in mandates exists, authority in the area of disaster risk management is hampered by the absence of an enacted policy framework, and implementation is impeded by financial, human resource and capacity limitations. These factors can limit the capacity of existing coordination mechanisms to function effectively. Finally, coordination between risk management and adaptation institutions remains limited, and this may lead to duplication of efforts.

One of Kenya's strengths is its capacity to collect, assess and disseminate climate information. While the government has identified areas for improvement related to weather forecasts and climate projections, the climate observation and monitoring systems of KMD and ICPAC are well-established, well-maintained and kept updated. Data is also gathered through government bodies like the Central Bureau of Statistics, Department of Resource Surveys and Remote Sensing and National Disaster Operations Centre. Gaps remain, however. Notably, information is limited about key natural ecosystems, progress toward health goals, and gender-disaggregated data, and more research needs to be done on the causes and consequences of natural disasters. Coordination of the collection and sharing of socioeconomic data between public and private sector institutions must also be improved (GOK, 2008).

Overall, Kenya has vibrant institutions that provide the basis for creating a more coherent and stronger climate risk management system. It has also demonstrated a clear commitment at the policy level to addressing climate risks through development of the National Climate Change Response Strategy and draft *National Disaster Management Policy*. However, a recent assessment concluded that "Kenya is not adequately adapted to deal with existing climate risks" (SEI, 2009, p. ii), and is therefore more vulnerable to future climate change. To overcome this deficit, Kenya will need to build on its assets to address gaps in policy, institutional coordination, vulnerability assessments and information access that impede its capacity to actively engage in climate risk management.

6.0 Conclusions and Recommendations

Kenya is currently in transition as it implements the provisions of its new constitution, strengthens its system of governance and revitalizes its economy. The country has articulated an ambitious development agenda through *Kenya Vision 2030* and is developing and implementing a myriad of policies, strategies and programs to support achievement of its goals. The country will need to effectively manage climate risk in order to achieve these goals, particularly given the high vulnerability of key sectors to climate variability and change. This review suggests areas in which Kenya has made progress toward successfully managing climate risks and areas in which further action is needed.

6.1 Major Findings

Kenya's exposure to climate risk is high. It is already one of the most disaster-prone countries in the world (MOSSP, n.d.), experiencing major droughts about every 10 years and moderate droughts or floods every three to four years (AEA Group, 2008a). These two types of extreme events have created a long-term fiscal liability for the country estimated to equal about 2.0 to 2.4 per cent of GDP each year (AEA Group, 2008b; SEI, 2009). The burden imposed by climate risks on Kenya's economy is likely to increase in the future as global climate change progresses. Already, mean annual temperatures in Kenya have increased 1.0°C since 1960, and rainfall patterns have changed—most notably greater rainfall during the short rains of October to December (GOK, 2010). One estimate suggests that the additional net economic cost due to climate change could equal 2.6 per cent of GDP per year by 2030, over and above current losses due to climate variability. This estimate is likely conservative, as it does not account for the cost of future floods and droughts or potential impacts on ecosystem services (SEI, 2009).

Kenya's exposure to climate risk stems from a variety of factors. Kenya is already one of the most water-scarce countries in Africa, and access to water is likely to become further constrained due to population growth, economic expansion, and changes in rainfall patterns. Within the economically important agricultural sector, nearly all crop production in Kenya (98 per cent) is rain-fed (WRI et al., 2007), and about half of all livestock production occurs in the ecologically and climatically sensitive ASALs (IFAD, 2007). Production capacity at the large hydropower stations that generate over half of Kenya's electricity has fallen in recent years due to drought and poor rains, resulting in annual power shortages (Mutimba et al., 2010). The country's large tourism industry relies on natural attractions such as wildlife, marine ecosystems and the glaciers of Mount Kenya. This sector, as well as the industrial sector, requires reliable infrastructure such as electricity, roads and water supplies. Malaria, outbreaks of which are highly influenced by changes in temperature and rainfall, is responsible for 5 per cent of all deaths in Kenya annually (ROK, 2009, p.3), making it the number-one cause of disease and mortality among children and adults (WHO, WMO & UNEP, 2003; Yanda et al., 2006). These climate risk factors affect all Kenyans, but disproportionately affect those living in flood- and drought-prone areas and members of poor households, including women, children, the disabled, people living with HIV/AIDS, internally displaced people and international refugees.

The degree to which climate change will augment these climate risks is uncertain. General scientific consensus is that mean annual temperatures will continue to rise, potentially by about 1°C by the 2020s and 4°C by 2100 (AEA Group, 2008a), that coastal areas will increasingly be affected by sea-level rise of an uncertain amount, and that Kenya's glaciers will largely be lost. Uncertainty is greater regarding how rainfall patterns will change. While models suggest that Kenya's mean annual rainfall will decrease, differences are expected at the regional level and between seasons.

This scientific uncertainty in turn is reflected in limitations on knowledge of how climate change will influence individual sectors. To date, more research has examined projected changes to the agricultural sector, including changes in productivity in different regions and for individual crops. These studies suggest that productivity might increase in the highlands while decreasing in the ASALs. Significant research has also studied the potential for the number of malaria-endemic areas in Kenya to increase, particularly in the highlands. Uncertainty remains, however, regarding the extent to which the observed increase in malaria prevalence in the Kenyan highlands is due to climatic factors or to changes in socioeconomic and environmental factors. While these studies provide guidance regarding the potential consequences of climate change and areas of concern for climate risk management, a number of research questions remain unanswered.

Although gaps in understanding persist, it is clear that current and future climate risks have profound implications for achieving the goals in *Vision 2030*. Over and above the costs climate change is expected to impose on the economy, goals within individual sectors may become more challenging. Efforts to expand tourism opportunities and increase this sector's contribution to GDP, for example, could be jeopardized by the loss of tourist attractions (such as coral reefs and wildlife) and damage to infrastructure (such as roads, electricity and water supply). Similarly, plans to expand Kenya's agro-processing industries may be undermined by changes in the yield and reliability of individual crops. So too could plans to increase agricultural productivity by increasing reliance on irrigated agriculture, particularly when rainfall in the ASALs is likely to decline. Export trade growth could be endangered, as well, if expansion of Mombasa's port facilities does not take into consideration the risks associated with climate change. Moreover, understanding remains limited regarding how urban centres, which are expected to become increasingly important hubs for economic growth, will be influenced by climate change.

The government has acknowledged its vulnerability to climate risks, including climate change, in *Vision 2030* and other policy documents. In recent years it has also acted to strengthen its capacity to manage climate change and disaster risks. In the area of climate change, it has established institutional structures to support the integration of climate change into policy and programming, and to promote coordinated action among ministries. These structures include the NCCACC, the Environment and Climate Change Coordination Unit, the Climate Change Secretariat within MEMR, and the T21-Kenya team. The government also prepared the NCCRS in 2010, which provides guidance on how *Vision 2030* could be achieved while also mitigating and adapting to climate change (GOK, 2010). Ongoing efforts to develop an action plan to facilitate implementation of the NCCRS will further this progress. In addition, Kenya has begun to integrate climate change considerations into key sectoral policies, including the *Agriculture Sector Development Strategy, 2010–2020* (ROK, 2010), the *National Policy for the Sustainable Development of Arid and Semi Arid Lands of Kenya* (GOK, 2007b), and plans to reduce dependency on hydroelectric power production by expanding use of other renewable energy sources, particularly geothermal.

In the area of disaster risk management, Kenya is working to build upon existing capacity such as the National Disaster Operations Centre, National Platform on Disaster Risk Reduction, Kenya Food Security Steering Group and the MOSSP. It has drafted (but not yet implemented) the *National Disaster Management Policy*, which establishes a framework for institutionalizing and enhancing coordination. The policy also seeks to move Kenya toward a more comprehensive approach that addresses disaster prevention, preparedness and recovery equally. Current efforts to enhance disaster risk management are guided by the *Disaster Risk Reduction Strategy for Kenya: 2006–2016*.

While these are positive steps, some challenges remain. Notably, current policy action related to climate change and disaster risk management has been undertaken largely at the national level; less progress has been made toward building response capacity at the district and provincial levels. For example, trained disaster management officers are needed at the district level (KNPDRR, 2011). Strengthening of vertical action and coordination is likely to become of greater importance in the future given provisions in Kenya's new constitution to devolve responsibility to new county governments, bringing decision-making closer to the people and making governments more accountable for provision of services (World Bank, 2011).

Gaps also remain with respect to consideration of climate risks in key policies. Examples include Kenya's WSIP, the *Second National Health Sector Strategic Plan of Kenya*, and the *National Gender and Development Policy*. Moreover, progress with respect to improving Kenya's disaster risk management capacity is limited by the delayed finalization of the draft *National Disaster Management Policy*. Its absence has been cited as constraining budgetary allocations for disaster risk management efforts and for limiting capacity to implement measures that would improve coordination within and outside of government (KNPDRR, 2011; Ngethe, 2010). As a result, disaster risk management remains largely focused on reactive, short-term emergency or relief responses and is slower, less coordinated and more costly than is desirable (IRIN, 2010; MOSSP, n.d.; Ngethe, 2010; Zwaagstra et al., 2010).

The need to strengthen links between climate change adaptation and disaster risk management has been recognized in key documents like the NCCRS and the *Disaster Risk Reduction Strategy*. So too has the need for greater integration of response strategies and coordination among ministries, institutions, international donors and NGOs to make climate risk management efforts more effective. Kenya is responding to these recommendations, with progress being made toward improving interministerial coordination on climate risk. The climate change action plan process brings together representatives from relevant government departments, the private sector and civil society. Consultations at the county level undertaken as part of this process will help raise awareness at the local level. The T21-Kenya process has also improved interdepartmental coordination. Focused on the implementation of the NCCRS, the tool helps policy-makers identify the impacts of climate change on national development policies and programs, and should lead to decision-making that is better informed about climate risks.

Climate risks must be considered in policy planning and in budgetary processes. More work is needed, for example, to ensure the budgetary process properly considers climate change issues, as technical, financial and human resource constraints in different ministries continue to limit their capacity to effectively execute current responsibilities and develop and share knowledge (Matiru, 2009; Mutimba et al., 2010). Planning for Kenya's next medium-term plan presents an important opportunity for the integration of climate risks into national decision-making.

Beyond these concerns related to policy and institutions, climate risk management in Kenya also faces a number of information and capacity constraints. While ICPAC and KMD generally provide accurate and reliable climate forecasts, their capacity to support climate risk management could be enhanced by continuing to address human resource constraints, better enabling the collection and dissemination of information, and improving access to real-time data collection and transmission (Mwagi, n.d.). The collection, analysis and dissemination of socioeconomic data could also be improved. In particular, data is presently collected and stored by scattered institutions; the efforts of these different actors need to be better coordinated so as to identify and overcome data gaps while minimizing duplication of efforts (GOK, 2008). Furthermore, known data gaps could be addressed, such as the availability of information regarding key natural ecosystems (GOK, 2010) and gender-disaggregated information (AfDB, 2007; GWA & IEW, 2009). Plans

such as those to establish a geographic information system–based land information management system, implement the Meteorological Systems Modernisation Programme and prepare a national spatial plan should help overcome these shortcomings.

A broad array of technical and human capacity constraints also impedes climate risk management efforts in Kenya. These include capacity to assess risk and develop options for managing risk; capacity to design, fund and implement projects and programs; awareness among the public and policy-makers of climate change, its potential consequences and its possible ramifications for Kenya's development goals; and capacity to systematically collect lessons learned and disseminate information among a wide range of stakeholders in different sectors and jurisdictions. Gaps in knowledge exist at all levels regarding how to prepare for and respond to climate risk—from the national to the community levels and from technical capacity to knowledge coordination and dissemination.

A multiplicity of actors within and outside the Kenyan government are actively engaged in climate risk management. To further these efforts, Kenya needs to establish clear policy frameworks; strengthen the capacity of existing institutions to implement well-defined mandates in coordination with others; undertake additional research to answer critical, outstanding questions; and build capacity to assess, plan for and respond to climate risks. The government is working to address these needs by strengthening interministerial coordination and integrating climate change considerations into planning processes. These efforts should help Kenya transition from reactively responding to climate risk and addressing immediate needs to proactively tackling the underlying socioeconomic and ecological causes of climate risk and preparing for anticipated events.

6.2 Recommendations for Policy- and Decision-Makers

We make the following recommendations to strengthen scientific and socioeconomic understanding of the potential climate risks facing different economic sectors and improve institutional capacity to mitigate and respond to these risks:

Sector-specific recommendations to address knowledge gaps

- *Crop production*. Conduct deeper analysis regarding the potential impacts of climate change on a broad range of agricultural crops in different regions of the country to ensure food security and this sector's continued contribution to the national economy.
- *Livestock production*. Further analyze how to build herders' capacity to cope with more arid conditions and the potential for more intense droughts, including investigating opportunities for livelihood diversification (Aklilu & Wekesa, 2002; Kabubo-Mariara & Karanja, 2007).
- *Fisheries*. Perform a full assessment of how Kenya's freshwater fisheries sector will be affected by climate change, given its important role in food security and the provision of local livelihoods.
- *Forestry*. Improve understanding of the status of existing forests in Kenya, within and outside of gazetted areas, particularly their location, composition, contribution to the provision of ecosystem services, rehabilitation requirements, and trends in growth, yields and quality. Further research is also needed regarding potential changes in forest characteristics and their exposure to fire, pests, diseases and invasive species.

- *Water*. Improve comprehension of how climate change will affect Kenya's five water towers and other watersheds, particularly those in areas already experiencing water stress. A catchment-basin-by-catchment-basin study could be undertaken that accounts for not only potential changes in climatic conditions but also potential increases in demand due to population growth and economic development (Mogaka et al., 2006). Greater understanding of appropriate policies and measures for achieving sustainable and efficient use of water is also needed.
- *Tourism*. Perform an economic analysis of the myriad potential consequences of a changing climate on Kenya's tourism sector, and how these impacts might be ameliorated. Greater understanding is needed of possible changes in habitat distribution, composition and function, wildlife abundance and migration patterns, and tourism demand. Completion and implementation of the national wildlife adaptation strategy should contribute to achieving this objective.
- *Coastal zones*. Research how Kenya's coastal areas could be affected climate change, including the impact of sea-level rise on the loss of low-lying areas, saltwater intrusion into freshwater resources, and potential damage from future storm surges. Additional analysis of potential impacts on coastal resources such as coral reefs and inshore fisheries would also enhance capacity to manage future climate risks.
- *Energy*. As recommended in the NCCRS, assess the vulnerability of renewable energy sources such as solar, bioenergy and wind to climate change, as well as the vulnerability of Kenya's energy transmission infrastructure (GOK, 2010).
- *Infrastructure*. Deepen understanding of the vulnerability of critical infrastructure, including ports, roads, railways and telecommunication networks, to the impacts of climate change. As well, awareness, capacity, tools and (as appropriate) legal requirements are needed to ensure that new infrastructure is "climate proofed" and therefore able to withstand higher temperatures, more intense rains, stronger winds and rising seas (GOK, 2010).
- *Health*. Enhance knowledge of the relationship between climate change and a range of health-related risks. Along with continued research on the implications of climate change for malaria and cholera, more research is needed on concerns such as malnutrition, heatstroke and HIV/AIDS. Health early-warning systems also need to be strengthened (Wandiga et al., 2010).
- *Disaster risk*. To inform future planning, expand research on the nature of past disasters, along with undertaking a comprehensive disaster risk assessment (Ngethe, 2010).
- *Urban areas*. Improve understanding of urban vulnerability and climate risk reduction options, as centres such as Nairobi and Mombasa are expected to play a vital role in Kenya's future economic development, and with more than half of all Kenyans projected to live in urban areas by 2033 (World Bank, 2011). Little research appears to have been undertaken on the vulnerability of Kenya's urban centres to the impacts of climate change.
- *Vulnerable communities*. Conduct new research to increase comprehension of the potential implications of climate change for groups such as women, children, the disabled, internally displaced people and international refugees. The differential effects of climate change on specific groups in Kenya appear to be understudied.

General recommendations to strengthen response capacity

- *Climate projections*. Improve understanding of projected changes in climatic conditions, particularly rainfall patterns, at the subnational level. Achieving this understanding will require fulfilling commitments to rehabilitating Kenya's hydrometeorological data-gathering network and implementing the Meteorological Systems Modernisation Programme, as well as further developing regional climate models, providing greater access to real-time data collection and transmission, and addressing human resource constraints.
- *Capacity at the subnational level*. Enhance knowledge and capacity to manage climate risks at the subnational level, establish appropriate horizontal and vertical coordinating bodies, and put in place the technical, financial and human resources needed to support climate risk prevention, response and recovery. Efforts so far to strengthen institutional and human capacity to manage and coordinate climate risks have largely focused on the national level. Less capacity has been built at the provincial and district levels, limiting implementation of climate risk management actions. Importance of this issue will increase with the devolution of power to the counties, as set out in the new constitution.
- *Adaptive planning*. Strengthen communication between climate scientists and policy-makers to better ensure that decisions consider potential climate risks. Recognizing the considerable uncertainty that remains regarding the types of climate risks Kenyans will face in different regions of the country, and the ongoing evolution of knowledge in this area, emphasis should be placed on iterative planning methods that respond to changes in the availability of information.
- *Gender integration*. Give greater attention to understanding how climate risks differ between men and women, and incorporate this knowledge into planning and programming. Although the Government of Kenya aims to mainstream gender considerations into government policies, plans and budgets, progress to date has been limited. Increasing the availability of gender-disaggregated data would further support progress on this issue. As well, the National Commission on Gender and Development appears to have the potential to play a stronger role in raising awareness of the links between gender and climate risks.
- *Data collection and sharing*. Centralize the availability of relevant socioeconomic, environmental and topographic data currently scattered among different institutions, and harmonize collection methodologies, storage and access to data related to the environment and natural resources (GOK, 2008).
- *Integration of climate considerations into policy and programming*. Continue to ensure that climate risks are integrated into relevant policies and programs. Examples of current and future initiatives into which climate risk considerations could be integrated include the Water Catchment Management Initiative, the WSIP and the National Spatial Plan. Continued efforts to raise awareness of policy-makers regarding climate risks and response options would facilitate these efforts.
- *Coordination between climate change and disaster risk management*. Address the need for a more integrated approach within current efforts to strengthen the institutions and policy frameworks guiding these areas. Although key documents have acknowledged the links between climate change adaptation and disaster risk management, the institutional framework needed to foster collaboration between these elements of climate risk management remains unclear.

- *Vision 2030*. Ensure achievement of relevant components of this document, which puts forward an ambitious development plan for Kenya—one that identifies concrete goals related to the three pillars of economic, social and political performance. Some of the commitments in this document, such as implementation of the Meteorological Systems Modernisation Programme, directly support climate risk management. Many others, though, indirectly help reduce vulnerability to climate risks. These include establishing a consolidated social protection fund to support orphaned and vulnerable children, the disabled and other vulnerable groups; strengthening Kenya's health system, particularly in rural areas; and diversifying Kenya's energy supply system—moving away from large-scale hydroelectric power and toward decentralized, renewable energy sources.
- *Technical and human capacity to manage climate risks*. Continue to build climate risk management capacity through a diversity of action in different sectors aimed at various actors from the national to the community level. For instance, training can enhance capacity to assess climate risks, increase capacity of local communities to reduce climate risks, and enable scientists to undertake required research and development in the field of climate risk management (GOK, 2010). Priority capacity building needs are expected to be identified in the new climate change action plan.
- *"Climate proofing" the medium-term planning process and Kenya's budgetary process*. "Climate proof" these key national processes by mainstreaming climate change into their development and implementation. This process could be supported by use of the T21-Kenya model, which provides a substantive step toward incorporating climate risks into the planning process. In undertaking this process, priority could be given to ensuring implementation of the priority adaptation actions identified in Kenya's new climate change action plan.

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