Republic of Kenya

Kenya

Second National Communication to the United Nations Framework Convention on Climate Change

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FOREWORD

On behalf of the Government of Kenya, it is a privilege and a great honour for me to present Kenya's Second National Communication (SNC) to the Conference of Parties to the UNFCCC. This Communication represents the commitment of the Government of Kenya and its people to address global warming and climate change. At the heart of this Communication is our conviction that all countries must do their part to achieve steep reductions in greenhouse gas emissions and thereby strive to avoid the dangerous, and perhaps catastrophic, impacts associated with climate change. With this report, Kenya takes an important step toward meeting our international obligations and ensuring that climate change is considered in our country's policies, activities, and investment plans.

Recognising the problems posed by climate change and the importance of taking the necessary action to mitigate climate change impacts, the Government of Kenya ratified the UNFCCC in 1994. Though Kenya is a minor emitter of greenhouse gases (GHG), the country is negatively impacted by climate change in nearly all its economic sectors, such as agriculture, tourism, transport, industry and forestry. As a developing country that is highly vulnerable to the impacts of climate change, Kenya believes that meeting the climate change challenge lies in sustainable development initiatives that promote strong, clean and climate-resilient economic growth. Adaptation is a necessity for Kenya; and strengthened institutional and human resources are needed to improve capacity to adapt to the impacts of climate change. Kenya has mitigation potential in several sectors like energy, transport, forestry and waste management. Lack of funding limits the exploitation of opportunities to address adaptation and mitigation.

This second national communication assesses Kenya's national circumstances and responses to climate change. This follows the Initial National Communication that was prepared and submitted to the UNFCCC in 2002. The SNC is the basis for future action in research and offers opportunities for policy development and refinement. The document serves as a useful tool upon which to base decisions concerning climate change and future national development. We look forward to building upon the plans discussed in this Communication in the spirit of global cooperation.

The report contains the greenhouse gas inventory for Kenya and examines potential measures to abate the increase of greenhouse gas emissions. The report also reviews the main findings on the likely impact of climate change and the vulnerability of various economic sectors in the country to these impacts. Finally, possible adaptation measures are presented in the report.

This national effort marks a significant milestone towards capacity building and institutional strengthening, as well as improving national climate information and understanding. However, we are aware and have identified in our Communication the constraints and gaps, and the related capacity building needs. Addressing these constraints will help to further improve future National Communications and enable continuous reporting on a consistent basis and in accordance with the applicable guidelines.

It is the responsibility of my Ministry of Environment, Natural Resources and Regional Development Authorities (MENRRDA) as the national climate change focal point to ensure the full implementation of the strategies and measures for curbing the adverse impacts of climate change and variability on all the sectors of economic growth, and to promote sustainable economic growth and development. However, this requires collective efforts among all stakeholders in the public and private sector organisations, including non-governmental organizations (NGOs), civil society, the donor community, and local communities. The Government will provide the necessary support required for the successful implementation of the strategies and measures spelled out in this Second National Communication.

Despite the many challenges encountered during the preparation of this report, valuable experience was gained, national capacity on climate change issues was further developed and many lessons were learnt. A foundation has been laid for sustainability in preparing successive national communications.

On behalf of the Government of Kenya, I would like to express my sincere gratitude to the Global Environment Facility (GEF), and the United Nations Environment Programme (UNEP) as its implementing agency, for their support throughout the preparation of this SNC.

I congratulate all those who have contributed directly and indirectly in towards this Communication.

Prof. Judi Wakhungu, CBS
Cabinet Secretary,
Ministry of Environment, Natural Resources and Regional Development Authorities

PREFACE

Kenya ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, and since then the country has been working towards the achievement of the objectives of the convention. As a Party to the United Nations Framework Convention on Climate (UNFCCC), Kenya is required to periodically report to the Convention through a National Communication that accounts for common but differentiated responsibilities and specific national and regional development priorities, objectives and circumstances.

Like all parties to the convention, Kenya is obligated to submit national communications as required by the UNFCCC. To fulfil this obligation, Kenya prepared its First National Communication (FNC) to the Conference of the Parties in 2002. This Second National Communication (SNC) is the second assessment of Kenya's situation with regard to national circumstances and responses to climate change. The SNC reflects relevant aspects of Kenya's Vision 2030 and a number of other national sector-specific policy documents. The communication provides an overview of climate change issues for key stakeholders at local, national, regional and international levels.

The communication was prepared through a national effort and contributions of various stakeholders from government, civil society and the private sector in Kenya organised in three broad thematic working groups (TWG). The participatory process involved numerous institutions and stakeholders, with the TWGs overseeing the implementation of the work programme. The Communication was prepared in accordance with the provisions of the Articles 4.1 and 12.1 of the Convention and the guidelines contained in 17/CP.8 of the Conference of Parties (COP). Preparation of the SNC included numerous technical consultations as well as stakeholder consultations through national workshops. The Government views the process of preparing Kenya's SNC as an opportunity to enrich and enhance the country's capabilities in identifying constraints, gaps, and related financial, technical and capacity needs to adequately fulfil our obligations under the UNFCCC. As well, the process has helped to identify opportunities, as well as threats, that arise as a result of the changing climate.

The SNC builds on the National Climate Change Action Plan, 2013-2017 (NCCAP) and the draft National Adaptation Plan, among others. The updated and improved information brings out the projected high regional and sectoral variability and vulnerability in the country. A high standard of scientific rigour and data quality has been maintained throughout the process. The exercise was coordinated by the National Environment Management Authority (NEMA) on behalf of the Government of Kenya.

The structure of the Communication is based on the guidelines for preparation of national communications from Parties not included in Annex I to the Convention (Decision 17/CP.8). The SNC comprises, as required, information on national circumstances, greenhouse gas (GHG) inventory and measures to mitigate climate change, vulnerability and adaptation to climate change, and other information relevant to the achievement of the objective of the convention, including research, education and systematic observation specific to climate change.

The Communication highlights Kenya's efforts to address climate change. As well, it provides a solid foundation for further work on scientific and policy issues and clearly defines the climate change-related concerns within the national context and identified potential areas for further action.

The SNC notes that Kenya needs to strengthen the coordination, networks and information flows between ministries, different levels of government, civil society, academia and the private sector to have a more efficient integration of climate change variables into poverty reduction and development strategies. It aims to alert policy makers on the importance of mainstreaming climate change issues in policy and legal frameworks. The SNC will help to enhance the capacity of the scientific and research communities to formulate and implement mitigation and adaptation policies, options and actions. The report further highlights the need for awareness raising among stakeholders and decision-makers.

Chapter 1 of the SNC covers Kenya's national circumstances including its governance structures, geographic location, climate, economy, demography, natural resources and biodiversity.

Chapter 2 provides information on Kenya's greenhouse gas (GHG) inventory. The chapter reports greenhouse gas emissions and removals by sinks for the year 2000, as well as additional years between 1995 and 2010.

Chapter 3 provides an analysis of climate change scenarios and impacts, the vulnerabilities of the various regions to the predicted impacts and the proposed adaptation measures. This chapter borrows heavily from the work to develop the NCCAP and Adaptation Plan.

Chapter 4 provides information on climate change mitigation opportunities for Kenya in the various economic sectors. The chapter borrows heavily from the top-down methodology developed and applied in the mitigation analysis of the NCCAP, albeit with updated data.

Finally, Chapter 5 reports on any other information that Kenya considers relevant to the achievement of the objective of the Convention, looking at mainstreaming efforts, technology transfer, research and systematic observation and capacity building.

I express my gratitude to the officials and experts of NEMA, Ministry of Environment and Natural Resources, other related government departments, civil society organizations, members of the TWGs, the consulting team and individuals for their dedication and commitment in the preparation of the SNC through a participatory process, which included a series of workshops, seminars and meetings involving all key stakeholders.

Finally, I request all officials, experts and stakeholders to make their best efforts to utilise the information and knowledge of this document for our national, regional and global benefit.

Dr. Richard L. Lesiyampe, MBS
Principal Secretary,
Ministry of Environment, Natural Resources and Regional Development Authorities

ACKNOWLEDGEMENT

This SNC has been prepared in fulfilment of Kenya's reporting commitments under the UNFCCC's articles 12.1 and 4.1. The Communication was prepared through the collaborative effort of local and international resource persons. The National Environment Management Authority (NEMA), on behalf of the Ministry of Environment and Natural Resources and the Government of Kenya, acknowledges the assistance received from various institutions and individuals during the preparation and finalisation of Kenya's SNC for submission to the CoP of the UNFCCC.

The preparation of the SNC to the Conference of the Parties was funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Programme (UNEP), for which we are very grateful.

Special gratitude goes to the consulting team, led by ClimateCare, who worked tirelessly to guide the process and to prepare the SNC. Tom Owino of ClimateCare led the consulting team. Seton Stiebert carried out the GHG inventory work and updated the mitigation analysis. Jackie Nyaoro led the preparation of the chapters on Kenya's national circumstances and other issues related to the implementation of the Convention, while Deborah Murphy carried out the final review of the chapters.

Several NEMA staff members were involved in the preparation of the SNC. Special acknowledgement goes to Dr. Kennedy Ondimu for leading the project steering team, Dr. Anne N. Omambia and Maurice Otieno for their efforts to ensure the process did not stall despite the many challenges encountered, as well as spearheading, managing and coordinating the preparation process. In Alphonse Omollo is acknowledged for managing the book of accounts throughout the project cycle. Further, The Late Anne Sirengo played a very significant role in coordinating this project before she met her untimely death on 21st June 2014. Special thanks also goes to Felix Mugambi for the layout and Computer Graphic Design.

Members of the Thematic Working Groups, various national institutions, government departments, academic institutions, private sector organisations, civil society organizations and development partners provided expertise and data for the preparation of the SNC. Their contributions are greatly appreciated. Special acknowledgement goes to the International Institute for Sustainable Development (IISD) and the Energy Research Centre of the Netherlands (ECN) for developing the methodology applied for the mitigation chapter of the SNC, and the Climate Change Secretariat at the Ministry of Environment and Natural Resources for leading the preparation of the draft National Adaptation Report which provided invaluable input for the vulnerabilities and adaptation section of this communication.

We gratefully acknowledge the Global Environment Facility (GEF), United Nations Environment Programme (UNEP) and all other contributors for their steadfast support and assistance.

Prof. Geoffrey Wahungu
Director General, National Environment Management Authority

ABBREVIATIONS:

ASALs	Arid and Semi-Arid Lands
ATAR	Adaptation Technical Analysis Report
CDKN	Climate Development Knowledge Network
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CoP	Conference of Parties
DoE	Directorate of Environment
DRSRS	Department of Resource Surveys and Remote Sensing
FNC	First National Communication
GCM	General Circulation Model
GEF	Global Environment Facility
GHG	Greenhouse Gas
GoK	Government of Kenya
HFCs	Fluorinated Hydrocarbons
ICPAC	IGAD Climate Prediction and Applications Centre
IGAD	Intergovernmental Authority for Development
IMTR	Institute for Meteorological Training and Research
IPCC	Inter-Governmental Panel on Climate Change
ITCZ	Inter Tropical Convergence Zone
IUCN	International Union for the Conservation of Nature
KMD	Kenya Meteorological Department
LECB	Low Emission Capacity Building
LULUCF	Land-Use, Land-Use-Change and Forestry
MDG	Millennium Development Goals
MENRRDA	Ministry of Environment, Natural Resources and Regional Development Authorities
N_2O	Nitrous Oxide
NAMAs	Nationally Appropriate Mitigation Actions
NAP	Draft National Adaptation Plan
NCCAP	National Climate Change Action Plan
NCCRS	National Climate Change Response Strategy
NCCS	National Climate Change Secretariat
NEMA	National Environment Management Authority
NMVOC	Non-Methane Volatile Organic Compounds
NO_x	Nitrogen Oxides
PHC	Primary Health Care
RCM	Regional Climate Model
SNC	Second National Communication
SO_2	Sulphur Dioxide
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Climate Change is the most serious global challenge of our time. Kenya signed the United Nations Framework Convention on Climate Change (UNFCCC) on 12 June 1992, and ratified it on 30 August 1994. It also ratified Kyoto Protocol on 25 February 2005 which entered into force on 26 May 2005. As a Party to the Convention, Kenya has implemented initiatives to meet its obligations and commitments, including the development of its First National Communication (FNC) that was prepared in 2002 with support from the Global Environment Facility (GEF) through the United Nations Environment Programme (UNEP).

The FNC included preparation of a Greenhouse Gas (GHG) Inventory for the reference year 1994 in compliance with Articles 4 and 12 of the UNFCCC and in accordance with the Intergovernmental Panel on Climate Change (IPCC) Guidelines of 1996. While the FNC provided a good description of the country's circumstances and a basis for future studies on climate change, gaps in and paucity of data significantly constrained the quality of the GHG inventory work for the base year 1994. The FNC also reported the results of initial studies on the country's vulnerability to climate change.

Kenya's 2010 National Climate Change Response Strategy (NCCRS) recognized the impact of climate change on Kenya's development. The National Climate Change Action Plan (NCCAP) 2013-2017, launched in 2013, was a logical follow up to the NCCRS. Additionally, Kenya has prepared a draft National Adaptation Plan (NAP), which is expected to be finalized in 2015. Through the implementation of these plans, Kenya plans to reduce vulnerability to climate change and improve the country's ability to take advantage of the opportunities offered by climate change. Among other things, the NCCAP identifies priority mitigation and adaptation measures and provides with information on how to integrate these options in national development plans. In addition, the NCCAP explores financial instruments and sources available, such as public and private sector funding, multilateral initiatives, carbon markets and other sources of funding.

Kenya commitments as a Non-Annex I Party to the UNFCCC include the preparation of this Second National Communication (SNC). This SNC reports GHG emissions and removals by sinks for the year 2000, as well as additional years between 1995 and 2010, following IPCC guidelines. This Communication has borrowed heavily from prior work in the NCCAP and the draft NAP. While the mitigation report of this Communication has applied the top-down approach of the NCCAP, the data used has been updated.

This Communication was supported by the Global Environment Fund (GEF) through the United Nations Environment Programme (UNEP). The funds received allowed the improvement of the emissions inventory, and supported the Consultant's work in the preparation of the reports, and the stakeholder reviews and validation of the work that was necessary to deliver a good quality SNC. The National Communication process included individual and public consultations with representatives from government institutions, academia, the private sector and non-governmental organizations, in order to capture their opinions and ensure inclusiveness.

National Circumstances

The Republic of Kenya is a unitary state with a multi-party devolved two tier government system consisting of a national government and 47 county governments. While the Government of Kenya (GoK) has the overall responsibility for ensuring that programmes are put in place to deliver its obligations under the UNFCCC, all the administrations under the national and county governments play a part in meeting these obligations.

Kenya has a total area of 582,646 km^2, consisting of 11,230 km^2 of water surface and 571,416 km^2 of land area. About 85 per cent of the land area is classified as Arid and Semi-Arid Lands (ASALs) with a fragile ecosystem and where land use is largely pastoral. The country is situated between 5^{o}N and 5^{o}S latitude and 34^{o}E and 42^{o}E longitude with varied landforms types that are divided into plains, escarpments, hills, and low and high mountains. It is bordered by landmass to the north, west and east with the Indian Ocean to the southeast.

Kenya is a lower middle-income country with an estimated national Gross Domestic Product (GDP) US$ 60.9 billion in 2014. After years of stagnant economic growth in the 1980s and 1990s, the GDP growth peaked in 2007 at 7.1 per cent. Post-election violence in early 2008 compounded with drought, high global energy and food prices, among other challenges, reduced GDP growth to 1.5 per cent in 2008. The economy rebounded in 2010 with GDP showing growth rates of about 6 per cent, with a slight decline to 4.7 per cent in 2013. The natural resource sectors account for 42 per cent of GDP while the services sector contributes about half of the GDP. The industry sector contributes the remaining 10 per cent. Most of the sectors are highly sensitive to the consequences of climate change because of their dependence on the natural environment.

Kenya's population, having grown from 37.7 million in 2009 to 41.8 million in 2013, is projected to reach 46.7 in 2017. About 67.7 per cent of the country's population resides in the rural areas and relies predominantly on an ever-degrading environment and scarce natural resources for their livelihoods. However this situation is changing with an increase in rural-urban migration. The urban population increased from 5.4 million in 1999 to 12.2 million in 2009 and is projected to reach 17.64 million in 2017. Equally the country has a high population density that increased from 66.4 to 71.2 persons per km^2 between 2009 and 2012, and is projected to reach 80.3 persons per km^2 by 2017. The increase has led to a substantially increased pressure on land for settlement and support for livelihoods. Despite the government efforts to reverse the poverty situation, in 2012, 49.8 per cent of the total population was living below the poverty line (below 1 USD a day), with the level being higher in rural areas at 55.0 per cent than in urban areas estimated at 35.5 per cent. The poor continue to lack critical services such as access to quality healthcare, water supply and education. Economic gains have largely benefited the wealthiest quantile contributing to the country's social and economic gap (inequality) with great disparities between the rural and urban. The bulk of those living below poverty line are more vulnerable to climate change.

Kenya's climate varies considerably across the country. It is hot and humid at the coast, temperate inland, and very dry (of arid nature) in the north and northeast parts of the country. The climate is strongly influenced by the circulation system of Inter Tropical Convergence Zone (ITCZ) and its geographic location. This has shaped the occupation of its land and partly contributes to its socioeconomic differences. The western, central and coastal regions, which are primarily rain fed, and comprised of productive agricultural land occupies less than

20 per cent of the country's land area and carries the majority (approximately 90 per cent) of the country's population. The ASALs, occupying 80 per cent of land area, are sparsely populated carrying the remaining 10 per cent of Kenya's population.[1]

The natural resource base, mainly forests, wetlands, dry lands, and aquatic and marine resources are under stress due to a variety of forces such as population pressure, deforestation, coastal modification, ongoing degradation of the eco-systems, unsustainable use and poor governance of these resources. The stresses are beginning to threaten vulnerable habitats, biodiversity and even livelihoods and long-term food security for a large proportion of Kenyans.

Partly due to El Niño and La Niña episodes, Kenya is prone to cyclical prolonged droughts and serious floods, with climate change increasing the intensity and frequency of these events. These repeated patterns of droughts and floods have large negative impacts and high economic costs. The potential impacts of such events have been exacerbated by socio-economic trends as much as climate. A significant part of the damage from floods is attributed to the increase in population, urbanization, and value assets in flood-prone areas. Changes in the terrestrial system, such as deforestation and loss of natural floodplain protection, also contribute to economic losses.

Biodiversity: Kenya is endowed with an enormous diversity of wildlife and, according to the International Union for Conservation of Nature (IUCN), the country ranks second in Africa in terms of mammalian species diversity. Wildlife-based tourism contributes about 70 per cent of the gross tourism earnings, 25 per cent of GDP and 10 per cent of total formal employment, underpinning its importance to the economy. Wildlife-based tourism forms a vital part of Kenya's economy and will be challenged by climate risks particularly changes in wildlife migration patterns and species diversity.

Forests: Kenya's national forest cover increased from 5.9 per cent in 2000 to about 7 per cent in 2010 as noted in the country's National Forest Policy, 2014. This trend begins to reverse with the decrease from 7.9 per cent to 5.9 per cent experienced between 1990 and 2000 and represents good progress towards the Constitution's target of 10 per cent forest cover.

Forests play a vital role, serving as source of wood products and an important wildlife habitat. Forests also provide important ecosystem services such as reducing soil erosion, climate regulation, natural pest control, preserving water availability and quality, food, wood fuel, fodder, pasture and medicines. Over 80 per cent of Kenyans rely on wood biomass for their energy requirements and forests also provide other goods to support their livelihoods. Forest therefore serves as a safety net, particularly for poor households. A 2013 study for the Ministry of Environment Water and Natural Resources determined that Kenya has a wood supply potential of 31.4 million m^3 against a national demand of 41.7 million m^3 with a current deficit of 10.3 million m^3.

The decreasing forest cover, between the years 1990 to 2000, was attributed to unsustainable utilization and conversion of forest land to other land uses. The sector is vulnerable to climate change, which is expected to have marked effects on composition, growth rates, and regenerative capacities with the associated implications on livelihoods and human development.

Water: Kenya was categorised as a water scarce country in 1992 with available water resources of $647m^3$ per capita, which was below the international acceptable threshold of 1,000 m^3. The country's water scarcity index has worsened with rapid population growth, and is expected to fall from approximately 586 m^3 per capita in 2010 to as low as 293 m^3 per capita by 2050. As a water-scarce country, Kenya is critically exposed to the adverse effects of climate change. This has serious implications for Vision 2030 flagship projects particularly in the tourism, agriculture and industry sectors which will require additional water.

Agriculture: The agricultural sector is the primary source of livelihoods for the majority of Kenyans and a backbone of the economy. The sector consistently contributes an average of 24 per cent to the national GDP. Due to a scarcity of potential agricultural land, the sector has come under pressure from population increase leading to subdivision of land into small-scale rain-fed farms that are difficult be run sustainably. 75 per cent of the total agricultural output is produced on these small-scale farms rendering the sector highly vulnerable to extreme weather events and the changing climatic conditions of shifting rain patterns and drought. Climate change is adversely affecting the stability of the sector.

Energy: Energy is a key component for the Kenyan economy and its population's standard of living. The country's economic growth and better quality of life for its citizens require an adequate and reliable supply of energy. Currently, there are constraints in energy supply, which include low access to modern energy services, high cost of energy, irregular supply and high cost of energy investments. Biomass (including wood fuel, charcoal, and agricultural waste), petroleum and electricity are the three main sources of energy in the country. About 87 per cent of the country's domestic energy demand is met by biomass particularly wood fuel, which provides 90 per cent and 85 per cent of rural and urban households' energy requirement, respectively. The need for wood has led to substantial deforestation and land degradation. Access to modern energy services is required to reduce the wood fuel dependency.

Hydropower, which constitutes over half of the total effective grid connected electricity, is highly vulnerable to variations in hydrology and climate. This is a big challenge for Kenya because poor rains result in hydroelectricity shortfalls, leading to more costly and GHG-intensive electricity generation through diesel. Geothermal accounts for 12.2 per cent of the electricity mix and the remaining 29.7 per cent is predominantly petroleum-based thermal generation. Kenya's National Energy Policy 2014, which has been formulated within the framework of Vision 2030, encourages diversification of electricity sources. The policy states the GoK's intention to increase electricity generation capacity by an additional 5,000 MW from the current 1,664MW by 2016. The new capacity will mainly be developed from geothermal 1,646MW, natural gas 1,050MW, wind 630 MW and coal 1,920MW. This new plan, despite potentially increasing GHG emissions from coal, aims to improve energy security and reduce the recent trend of oil thermal comprising the largest portion of new capacity.

Health: Kenya has made progress in health care especially in tackling communicable diseases such as HIV-AIDs, tuberculosis and malaria, and improving access to maternal health services. About 52 per cent of the country's population has access to basic health services within 5 km. Access to basic Primary Health Care (PHC) and referral services, however, still remains a significant challenge. Significant disparities in service availability exist between rural and urban areas and in hard to reach areas. Maternal deaths and child malnutrition remain major challenges in the country. Climate change has potential negative impacts on the sector. The GoK identified malaria, Rift Valley fever, malnutrition, water borne diseases (such as cholera), scabies, jiggers and lice infestations as some of the negative impacts likely to grow due to climate change.

Education: Education in the country has had a remarkable increase in access and participation rates. Primary education recorded the highest progress, while access rates at pre-primary, secondary and tertiary education remain low relative to sub-Saharan average of 7%. The GoK plans to address issues related to access, focusing on addressing low enrolment in areas below the national average, retaining students in school up to 18 years, providing education more effectively through a digital platform, and matching education and training with the demand for the skills required in the workplace.

National Greenhouse Gas (GHG) Inventory

Kenya's GHG emissions and removals by sinks for the year 2000, as well as additional years between 1995 and 2010 have been reported in accordance with the recommendations of the IPCC.

In October 2002, Kenya submitted its first inventory with Kenya's FNC. The FNC inventory was prepared for the reference year 1994 in compliance with Articles 4 and 12 of the UNFCCC and in accordance with the IPCC Guidelines of 1996.

A description of the appropriate methodologies used and an analysis and interpretation of the data generated on anthropogenic greenhouse gas emissions and sinks, on a sector-by sector basis, for Kenya is provided in the SNC. The greenhouse gas Inventory was conducted on an individual sector basis for the Energy, Industrial Processes, Solvent and Product Use, Agriculture, Land Use, Land-Use Change and Forestry (LULUCF), and Waste Sectors. The greenhouse gases included are Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O) and partially fluorinated hydrocarbons (HFCs) not covered under the Montreal Protocol. Indirect greenhouse gases including Non-Methane Volatile Organic Compounds (NMVOC), Carbon Monoxide (CO) Nitrogen Oxides (NO_x) and Sulphur Dioxide (SO_2) are also reported as they have an important influence on chemical reactions in the atmosphere.

The *IPCC Revised 1996 Guidelines for National Greenhouse Gas Inventories* (Volumes 1, 2 and 3) and the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* were used as the basis to undertake the necessary calculations on GHG Emissions and Removals. The use of these IPCC Guidelines for all years fulfills the objective of the COP for the use of comparable methodologies. In accordance with the guidelines, CO_2 emissions from international bunkers and burning of biomass are not included in the national totals, but are reported separately as memo Items in the inventory.

The calculation of emissions was assisted using UNFCCC's Non-Annex I National Greenhouse Gas Inventory Software (version 1.3.2). For purposes of verification and transparency, the inventory for Kenya includes the completed relevant IPCC Worksheets for all sectors, in addition to the Summary Report Sheets, used to prepare the Inventory Report (provided as appendices to this report). Complete documentation of methods, activity data and emission factors along with references of all data sources are provided in individual sector reports. This level of documentation greatly assists in the transparency of the inventory and will aid in the preparation of future inventories.

While reporting the GHG inventory, care has been taken to include consideration of the methodology used, the quality assurance/ quality control (QA/QC) measures applied, the results of the key source analysis and Tier 1 quantification of uncertainties associated with the estimates.

The summary of GHG emissions by sectors and type of gas in 2000 is shown in Table 1 below.

Table 1: Emission Patterns by Sector and GHG Type

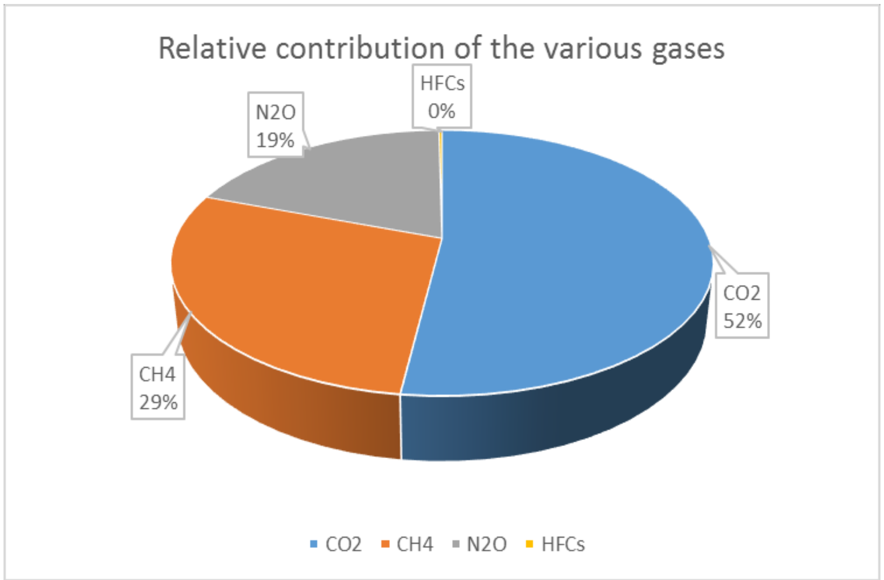
No.	Sector	2000 Emissions (CO2e - Gg)				TOTAL	TOTAL as %
		CO2	CH4	N2O	HFCs		
2	Energy sector	7,227	1,932	601		9,760	17.76
3	Industrial process sector	694			118	812	1.48
4	Solvent and other product use					-	-
5	Agriculture sector	-	13,041	9,498		22,539	41.01
6	Land use, land-use change and forestry	20,571	57	9		20,637	37.55
7	Waste	7	697	502		1,205	2.19
	TOTAL	**28,499**	**15,726**	**10,611**	**118**	**54,955**	**100**

In 2000, Kenya's total GHG emissions were 54,955 Gg CO_2 equivalent (approximately 55 million tons of CO_2 eq.) coming from all the UNFCCC sectors apart from solvents and other product use sector, which had no GHG emissions.

The LULUCF sector was a net emitter in 2000, contributing approximately 20,000 Gg CO_2 equivalent (or approximately 20 million tons of CO_2 equivalent) or 37.55 per cent of the total emissions.

The total amount of CO_2, CH_4, N_2O and HFCs emitted were 28,499 Gg, 15,726 Gg, 10,611 Gg and 118 Gg respectively, totalling to 54,955 Gg CO2 equivalent. The industrial process also emitted 118 Gg CO_2 eq. GHG emissions. The above table also gives the relative contribution of the various gases to the total CO_2 equivalent emissions from the country.

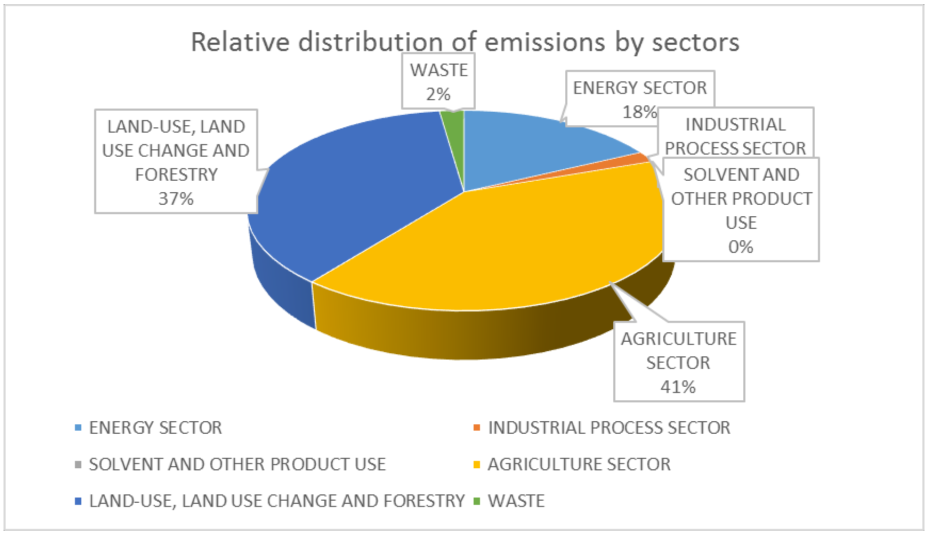
Figure 1: Relative contribution of the various gases



The energy sector emitted 9,760 Gg of CO_2 eq., contributing 17.7 per cent of the total GHG emissions in 2000. The agriculture sector emitted 22,539 Gg CO_2 eq, which was 40.9 per cent of the total GHG emissions. The LULUCF emitted 20,637 Gg CO_2 eq, which was 37.4 per cent of the total GHG emissions. The industrial sector emitted 1020 Gg CO_2 eq., or 1.85 per cent of the total. The waste sector emitted 1205 Gg CO_2 eq in 2000, which was 2.19 per cent of the total GHG emissions.

Figure 1 shows the relative contributions of the GHG emissions by gas type while Figure 2 shows the relative contributions of the GHG emissions by sector.

Figure 2: Relative distribution of emissions by sectors



The relative emissions of CO_2 from LULUCF to the total GHG emissions excluding LULUCF was by far the largest in 2000. CO_2 was 99 per cent of the total emissions from the LULUCF sector. Emissions of CH_4 and N_2O originated mainly from the agriculture sector – 82 per cent of total CH_4 and 89 per cent of the total N_2O emitted in 2000 were from the agriculture sector. The synthetic gases (HFCs) were entirely emitted from the industrial processes.

Assessment of Vulnerability and Adaptation

Although Kenya has little historical or current responsibility for global climate change, and emissions are insignificant relative to the global emissions, the country is highly vulnerable to its impacts.

Kenya, being a developing country with a majority of the population dependent on climate-sensitive sectors, has low adaptive capacity to withstand the adverse impacts of climate change. The situation is further aggravated by poor infrastructure facilities, weak institutional mechanisms, and lack of financial resources. Therefore adaptation to climate change is the main priority of the country.

The chapter on Assessment of Vulnerabilities and Adaptation to Climate Change in Kenya, assesses past climate trends and the possible future climate scenarios in the country, and summarizes the risks and vulnerabilities associated with the trends. Adaptation actions are then proposed.

Climate Change Scenarios

Observed temperature trends indicate an increase in the mean annual temperature by approximately 1°C since 1960. The average number of hot days per year has increased by approximately 15.6 per cent between 1960 and 2003, with the rate of increase being highest in March to May. The average number of hot nights per year has increased by approximately 31 per cent for the same period, with the rate of increase being highest from September to November. The average number of cold days and nights has decreased by 4.4 per cent and 11.5 per cent respectively. The rate of decrease of cold days is highest in September to November while the rate of decrease of cold nights is highest from December to February.

Observations of rainfall for Kenya as a whole do not show statistically significant trends linked to climate change. Observed climate trends show that on average, northern parts of the country have become wetter, while southern Kenya has become drier. This is largely due to variations in the 'short rains' that fall from October to December, although this is subject to considerable uncertainty.

Based on climate model output, Kenya may see a general trend towards warmer, wetter conditions in the coming decades.

It is projected that mean annual temperature may increase by between 0.8 and 1.5°C by the 2030s and 1.6°C to 2.7°C by the 2060s. The frequency of hot days is projected to increase by 19-45 per cent, and the frequency of hot nights by 45-75 per cent by the 2060s. Projections suggest a decrease in the number of days and nights that are considered 'cold' in the current climate. Cold days and nights are expected to become very rare.

GCMs suggest that there may be increases in average annual rainfall in Kenya by the 2060s. However there is considerable model disagreement with a range of projections varying from a 5 per cent decrease to a 17 per cent increase by the 2030s and no change to a 26 per cent increase by 2060s. The increase in total rainfall is projected to be largest from October to December.

RCMs suggest that during the 'long rains', Kenya could experience a significant increase in rainfall with the largest increase occurring over the highland districts and the coastal region. During the 'short rains' an increase in rainfall could predominantly affect the region to the west of the Rift Valley. The rest of the country could experience slightly decreased rainfall in isolated pockets. This is in contrast to the GCM average results, which suggest wetter conditions during the 'short rains'. The northeast of the country is projected by the RCM to become significantly drier on an annual basis. This is in contrast to the GCM projections that suggest that the north of the country may become wetter, but is in line with observed rainfall trends since 1960.

Climate Change Impacts and Vulnerability

Kenya is extremely susceptible to climate-related effects and extreme weather events pose serious threats to the socio-economic development of the country. The key drivers of the economy are primarily natural resource based and are climate sensitive. The cumulative impacts of climate change over the next two to three decades have the potential to reverse much of the progress made towards the attainment of the Millennium Development Goals (MDGs) and Vision 2030. The costs of climate change impacts, especially droughts and floods, could be equivalent to 2.6 per cent of Kenya's annual GDP by 2030, with devastating consequences on the environment, society and the wider economy.

While floods are generally associated with higher damage to public infrastructure assets, the burden of drought falls more heavily on people, communities and the private sector.

The climate change impacts and risks to Kenya's economy for particular sectors are summarized below.

Water Resources: This is already affected by inter-and intra-annual rainfall variability, including the extremes of flooding and drought. Climate change may further reduce the availability of water resources through altered rainfall patterns, higher evaporation, lower lake levels, accelerated loss of glaciers and rising sea level.

Food Security: The agriculture, livestock and fisheries sector is key for Kenya in terms of employment, food security, livelihoods and economic development. Climate change has the potential to significantly affect agriculture-based livelihoods by challenging the sustainability of current arable, pastoral and fishing practices.

Coastal Zones: Increases in sea surface temperature, sea level rise and coastal erosion are likely to put additional pressure on coastal ecosystems, including islands, estuaries, beaches, coral reefs and marine biodiversity. Coral reef ecosystems are particularly vulnerable to climate change impacts, with associated consequences for the livelihoods of millions of people depending on those ecosystems for food, income and shoreline protection. In coastal locations, ports and transport infrastructure is particularly exposed due to flooding, together with tourism assets and settlements situated close to the coast.

Human Health: Climate change is expected to put human health at risk by exacerbating the magnitude and occurrence of existing impacts, such as heat stress, air pollution, asthma, vector-borne diseases (such as malaria, dengue, schistosomiasis – also referred to as swimmer's itch or snail fever – and tick-borne diseases), water-borne and food-borne diseases (such as diarrhoeal diseases).

Forestry and Wildlife: Anticipated impacts of climate change on biodiversity include shifting of ecosystem boundaries, change in natural habitats and sharp increases in extinction rates for some species.

Urban and Housing: Climate change is likely to make rural livelihood strategies and living conditions increasingly challenging and as a result is likely to exaggerate the current rural-to-urban migration trend. Specific risks and challenges for communities, especially those living in urban environments and particularly the most vulnerable, include river and flash flooding, with flood-related fatalities constituting 60 per cent of disaster victims in Kenya. Extreme events also have indirect impacts through water scarcity and quality issues and food insecurity.

Arid and Semi-Arid Lands: Over the past few decades, transformations in the ASALs have impacted the livelihoods of the pastoralists. The migration of rural communities from the congested high-potential areas and the dry arid areas to cities has contributed to overpopulated slums and settlements that lack basic services. Implications for women included the additional burden of sustaining household food, water and human security. School attendance rates for children has decreased, child labour increased and conflicts over resources have intensified.

Tourism: Climate variability and climate change, partnered with broader environmental degradation, has the potential to significantly affect the tourism sector, including wildlife tourism. With its close connections to the environment and climate itself, tourism is considered to be a highly climate-sensitive industry.

Manufacturing, Transport and Trade: Impacts to critical supporting infrastructure, such as energy, water, communications and transport, have the potential to reverberate into the private sector, with consequences for business continuity, revenue, workforce and associated supply chains. Climate-induced changes affecting productivity and crop diversity, in the tea, coffee and horticulture sectors, have implications for exports and imports.

Infrastructure (for Energy and Transport): Climate change has the potential to compromise infrastructure design, function and performance across a range of settings. In coastal locations, ports and transport infrastructure is particularly exposed. Riverine flooding and landslides have the potential to cause significant damage to physical infrastructure such as roads, bridges, water pipelines and power lines.

Adaptation

The development of the draft National Adaptation Plan (NAP) included the development of criteria used to identify priority actions under each Medium Term Plan theme. The criteria were weighted to ensure actions addressing existing vulnerabilities scored highly, while also giving emphasis to preparing for continuing climatic change, impacts and risks. Projected changes will be, addressed through, for example, no and low regrets measures, and incorporation of climate knowledge into decisions regarding long-lived fixed assets, and where a long lead-in decision timeline is required.

The draft NAP recommends the development of an adaptation monitoring and evaluation (M&E) system. This system will help to ensure that the benefits of interventions aimed at building adaptive capacities and enhancing resilience are being realised. A feedback mechanism will ensure that learning is used to improve the adaptation planning in GoK sector plans and programmes.

The Adaptation section of this SNC includes tables setting out adaptation priorities identified through the NCCAP process. The draft NAP is expected to be completed in 2015 and will include more details on the identified priorities.

Mitigation of GHG Emissions

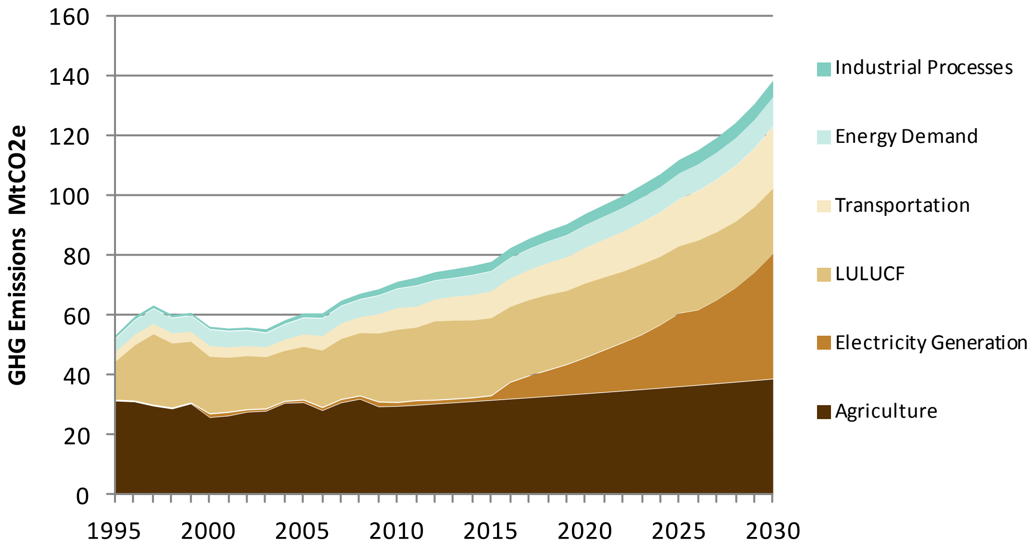
Although developing countries are not required to take on emission reduction commitments, Kenya views climate change mitigation as a means to sustainable development. Low-carbon analysis facilitates the implementation of mitigation projects, strengthening of institutional and human capacity-building and the prioritisation and evaluation of social, economic and environmental programmes.

The chapter on mitigation of GHG emissions describes the low-carbon assessment undertaken in the six mitigation sectors: energy, transport, industry, agriculture, forestry and waste management. Detailed scenario analysis of the sectors was carried out during the NCCAP process in 2012. Therefore, this report does not undertake new low-carbon development scenarios, but improves the NCCAP analysis by applying updated data.

Methodology for Mitigation Assessment

The last official GHG emissions inventory for Kenya was completed for the year 1994 and used in the FNC in 2002. The mitigation analysis for the SNC therefore started with the development of an inventory of historical greenhouse gas emissions for 2000 to 2010. Emissions were then projected out to 2030 to form the reference case. Illustrated in Figure 3 below, emissions to increase from 52 million tonnes of carbon dioxide equivalent ($MtCO_2e$) in 1995 to 138 million $MtCO_2e$ in 2030. This reference case forms the baseline against which abatement potential is estimated for the six mitigation sectors.

Figure 3: Emission Baseline Projection for Kenya (MtCO2e)



The analysis of low-carbon development opportunities looked at mitigation potential, costs and sustainable development benefits. The analysis concluded with the identification of priority actions that can enable low-carbon development.

The low-carbon (mitigation) options were then assessed and those options that offered the greatest opportunity for emissions reductions, aligned with Government of Kenya priorities, and offered significant sustainable development benefits were prioritized. The mitigation options in each sector were analyzed in detail to create a wedge analysis, which demonstrated how these low-carbon options could help to bend down emissions.

The technical mitigation reports of the NCCAP provide full details of a range of mitigation actions. The choice of actions has not been affected by the updated data; however, the mitigation potentials of the actions have been adjusted by applying updated data to the model. The identified big wins are expected to have a significant impact on sustainable socio-economic development, adaptation and mitigation in Kenya. They include:

- Restoration of forests on degraded lands and reforestation of degraded forests
- Geothermal power generation
- Climate smart agriculture and agroforestry
- Improved cookstoves
- Mass rapid transit system in Nairobi, including bus rapid transit with light rail transit corridors

These 'big win' opportunities capture over two-thirds of the mitigation potential out to 2030.

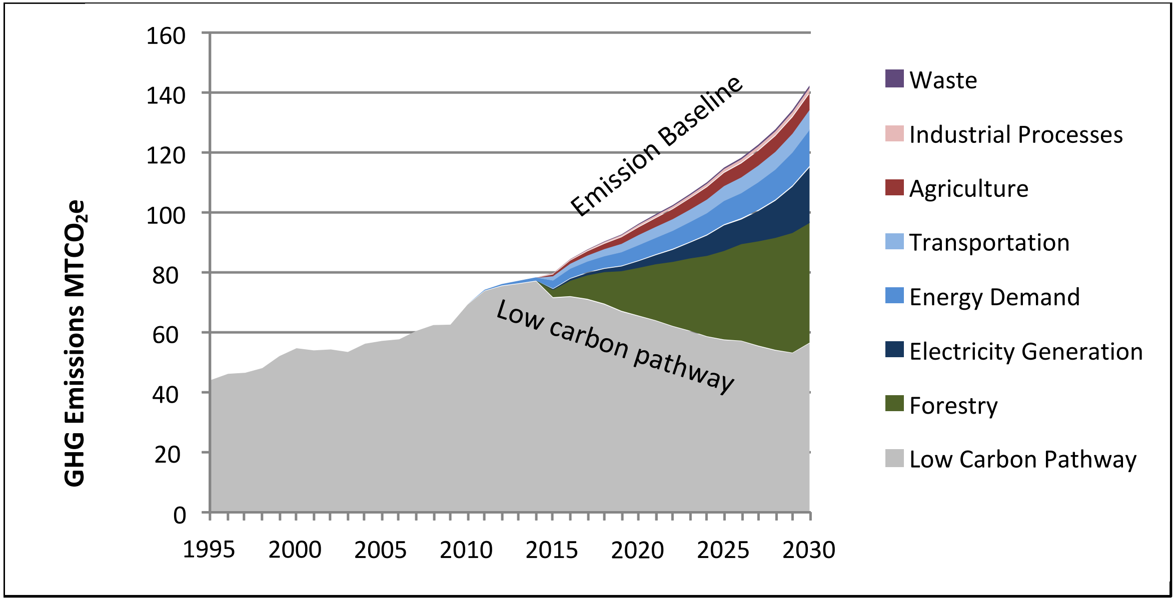
Emission Baseline Projection

Projections of the baseline emissions to 2030 for each sector, illustrated in Figure 3 above, are used as the baseline case against which it is possible to demonstrate the expected abatement potential in each of the six major mitigation sectors (with energy examined from two perspectives: electricity supply and energy demand). In the reference case, emissions increase up until 2030 in all sectors except LULUCF.

Mitigation Scenarios

Figure 4, indicates the composite mitigation abatement potential of the low-carbon development opportunities in six sectors. The biggest mitigation potential by 2030 is in the forestry sector followed by electricity generation.

Figure 4: Composite abatement potential for all sectors for Kenya (technical potential) in MtCO2e



Energy: The analysis of six low carbon development options for electricity supply indicated that geothermal power has by far the largest abatement potential (14 MtCO2e per year) in 2030, with other technologies varying between 0.5 and 1.4 MtCO2e. Geothermal power can provide low-cost base load generation, facilitate economic activity and development, as well as reduce the current reliance on hydropower thereby improving climate resilience.

In regard to energy demand, direct fuel combustion of biomass from wood sources, such as fuelwood and charcoal, is the dominant fuel source in Kenya (for domestic usage) accounting for almost 70 per cent of primary, non-electricity, non-transport energy demand. Eight low carbon development options were analysed in the energy demand sector. Improved cookstoves that reduce the volume of biomass required for cooking have the largest potential for GHG emission reductions, 5.22 Mt CO2e a year in 2030. Replacing kerosene lamps with renewable lighting technologies, using liquefied petroleum gas (LPG) instead of fuelwood for cooking, and cogeneration of heat and power in agriculture were also found to have significant abatement potentials of over 1.64 MtCO2e a year in 2030.

Transport: Seven low carbon development options were analysed for the transport sector. The option with the largest mitigation potential is the development of an extensive mass transit system for greater Nairobi in the form of bus rapid transit (BRT) corridors, complemented by light rail transit (LRT) in high thoroughfare corridors. This public transport system has an abatement potential of approximately 2.8 MtCO2e a year by 2030. The second largest mitigation potential is the introduction of biodiesel, with a 10 per cent blend requirement having a potential of approximately 1.2 MtCO2e a year in 2030. The abatement potentials for the other low-carbon development options vary between 0.5 and 0.8 MtCO2e a year in 2030.

Industrial Processes: 95 per cent of industrial process emissions in Kenya are created by two industries: cement manufacturing (1.9 MtCO2e in 2010) and charcoal manufacturing (0.8 MtCO2e in 2010). Process emissions from cement manufacturing can be reduced by replacing clinker in the cement mix with alternative materials. The most significant low carbon development opportunity is the introduction of more efficient kilns for charcoal production, with an abatement potential of 1.56 MtCO2e per year in 2030. Sustainable development benefits include reduced fuelwood demand leading to lower levels of deforestation and increased productivity.

Agriculture: Agricultural emissions (the largest source of GHG emissions in Kenya) are likely to increase from 30 MtCO2e in 2010 to 35 MtCO2e in 2030 (Figure 5.6), largely driven by livestock methane emissions and land use change.

Agricultural low carbon development options have the potential to abate in the order of 5.54 MtCO2e per year in 2030. The most significant reduction can be achieved through agroforestry, which has an abatement potential of 4.16 MtCO2e per year in 2030. Other low carbon development options include conservation tillage and limiting the use of fire in range and cropland management, with abatement potentials of over 1.09 and 0.29 MtCO2e per year in 2030, respectively.

Forestry and Other Land Use: Forestry and other land use related emissions accounted for 21.1 MtCO2e in 2010, or about 32 per cent of national emissions. Emissions primarily originate from deforestation, where forests are cleared for fuelwood and charcoal production or to create agricultural land. Emissions are expected to increase to 26 MtCO2e in 2015 and then decline to 22 MtCO2e by 2030.

The most significant abatement potential can be achieved through restoration of forests on degraded lands. Abatement potential of 32.56 MtCO2e per year by 2030 is likely through conservation and sustainable forest management interventions. Restoration of degraded forests has an abatement potential of 6.06 MtCO2e per year by 2030, and reducing deforestation and forest degradation potentially can abate 1.57 MtCO2e per year by 2030.

Waste: Landfills and sewage treatment plants generate GHG emissions through the production of methane. Waste-related GHG emissions are expected to increase from 2 MtCO2e per year in 2010 to 4 MtCO2e in 2030.

Landfill gas methane capture, with an abatement potential of 0.78 MtCO2e in 2030, is the main low carbon development opportunity.

Other Information

This chapter of the SNC provides other information considered relevant for the implementation of the UNFCCC in Kenya.

The following are discussed in the chapter:

- Steps taken to integrate climate change into the relevant social, economic and environmental policies
- Key policies containing measures to mainstream climate change
- Technology Transfer
- Research and Systematic Observation
- Education Training and Awareness
- Capacity Building
- Constraints, Gaps and Related Financial, Technical and Capacity Needs in Implementation of the Convention.

Steps taken to integrate climate change into relevant policies

The Government of Kenya, recognising the growing threat that climate change poses for its near- and long-term development agenda, has improved its capacity to mitigate and adapt to the impacts of climate change. A policy and institutional framework to guide the country toward a low carbon climate resilient development pathway is under development. Kenya's governance structure has been informed by the global and regional commitments and obligations, such as UNFCCC (1992), Africa's African Climate Change Strategy, (2011) and East Africa's Climate Change Policy, Strategy and Master Plan (2011).

The first national policy document on climate change, the National Climate Change Response Strategy (NCCRS), has improved understanding of the issue and has guided policy decisions since its launch in 2010. To operationalize the NCCRS, Kenya prepared the National Climate Change Action Plan 2013-2017 (NCCAP).

The NCCAP views climate change as a crosscutting issue to be mainstreamed in national planning and development processes, and in policy decisions across all sectors of the economy. The NCCAP sets out priority adaptation and mitigation actions that will help Kenya move toward a low carbon climate resilient development pathway. Effective implementation will be supported through the establishment of an enabling governance structure including a climate change policy and law, a funding mechanism and investment framework, a capacity development and management framework, and a national a national performance and benefit measurement system.

The Government of Kenya has moved to implement a number of actions in the NCCAP, including improved drought management and promotion of renewable energy.

The Ministry of Planning and Devolution (MOPD) has included indicators to track progress in mainstreaming climate change in its Second Handbook of National Reporting, which helps the government monitor progress toward the goals of the Second Medium Term Plan of Vision 2030.

A Climate Change Bill is expected to be enacted into law in 2015. This Bill includes establishment of a National Climate Change Council that has responsibility for coordination of climate change actions, including mainstreaming

Key policies containing measures to mainstream climate change

Other relevant national policies and legislation that contain measures that enable mainstreaming of climate change are included in Table 2 below.

Table 2: Key National Policies and Initiatives

Policies	Measures to mainstream climate change
Constitution of Kenya (2010)	A clean and health environment (Articles 42, 69 and 70) is a fundamental right under the Bill of Rights. The Constitution establishes the right to food security while emphasizing sustainable and productive management of land and natural resources, such as a goal of tree cover of 10 per cent of the country's land area.
Vision 2030 (2008)	Encapsulates flagship programmes and projects with aspects of adaptation and mitigation.
National Policy for the Sustainable Development of Northern Kenya and other Arid Lands (2012)	Focuses on climate resilience requiring government to find solutions to address climate challenges and to come up with measures to manage drought and strengthen livelihoods.
National Disaster Management Policy, 2012	Aims to increase and sustain resilience of vulnerable communities to hazards.
Environmental Management and Coordination Act (1999)	Provides the framework for the management of the environment.
Kenya Forestry Master Plan (1995-2020)	Recognises the environmental role of forests including water values, biodiversity values, climate change values through carbon sequestration and other environmental services.
Water Act (2002)	Provides the overall governance of the sector, and recognises the climate change implications on health, sanitation and water.

Agricultural Sector Development Strategy (2010-2020)	Provides framework for transforming agriculture into a modern and commercially viable sector. Notes that addressing food security will require addressing the challenge of over-dependence on rain fed agriculture.
Energy Policy and Act (2004)	Encourages implementation of indigenous renewable energy sources to enhance the country's electricity supply capacity. The policy is implemented through the Energy Act of 2006, which provides for mitigation of climate change, through energy efficiency and promotion of renewable energy.
Integrated National Transport Policy (2010)	Provides for transport solutions that have relevance to climate change mitigation

Technology Transfer

Kenya's climate change technology needs are diverse and their deployment requires a range of activities. Kenya has undertaken two Technology Needs Assessments (TNAs), in 2005 and 2013. The latter prioritised Environmental Sustainable Technology (EST) needs for mitigation and adaptation and developed their technology action plans (TAPs). The TNAs determined that priority technologies have high socio-economic or sustainable development benefits, and target the energy, waste, agriculture and water sectors in rural communities. The key technologies are: solar home systems, solar dryers, bio-digesters, drought resistant sorghum, roof-surface water harvesting and drip irrigation.

The priority technologies have been deployed Kenya, yet widespread diffusion has been limited by such barriers as:

- High cost of purchase, installation and maintenance
- Weak policies and lack of standards
- Limited information and awareness.

Successful diffusion requires robust outreach and awareness raising through training and knowledge transfer systems.

Research and Systematic Observation

Various institutions in Kenya undertake systematic observation and coordinate climate and climate change-related research activities and programmes in the country. The Kenya Meteorology Department (KMD), working closely with Africa's IGAD Climate Prediction and Applications Centre (ICPAC) and the Institute for Meteorological Training and Research (IMTR), has the overall mandate to carry out climate and climate change-related research. The country hosts a number of observational stations and an extensive communication network covering a Regional Telecommunications Hub (RTH) that collects observational data originating from its own and associated National Meteorological Centres (NMCs) and relaying such data directly to the global Main Telecommunication Network (MTN). Despite Kenya's extensive observational network, a lean meteorological budget means that quantity and quality are considered inadequate to cover the country effectively. Climate monitoring networks in the ASALs – an area with high need - are extremely limited. Funding is required to establish an adequate observational infrastructure.

Education, Training and Public Awareness

Climate change issues receive minimal consideration in Kenya's formal education system. The level of awareness of climate change issues and impact is low across the country. The NCCAP recommends increasing awareness and mainstreaming of climate change issues in education curriculum, but action in this area has not progressed. In addition, high quality scientific research is needed to update available knowledge and build confidence in mainstreaming climate change information in decision making. The

MENR is in the process of developing a Climate Information Centre, which is expected to begin to fill information gaps when operational.

Capacity Building

Numerous capacity building initiatives in climate change have been undertaken in Kenya, including through the GEF and the UNDP Low Emission Capacity Building programme. The areas of focus include: institutional strengthening; establishment of national focal points; national climate change programmes; greenhouse gas inventories; and vulnerability and adaptation assessments, amongst others. The NCCAP recommended the development of a National Framework for Climate Knowledge Management and Capacity Development to improve coordination and implementation of capacity building initiatives.

Constraints, Gaps and Related Financial, Technical and Capacity Needs

Improved capacity to prepare and improve National Communications (NCs) on a continuous basis is a key need. This includes improved monitoring networks and data capture systems. Throughout the second NC process, and especially during the development of the GHG inventory, data availability and quality were a major concern. Adequate funding is a key need to enable staff training and improve organizational arrangements.

Other important gaps and constraints include the need for improved predictions of potential climate change at smaller scales, the development of appropriate impact simulation models, and improved forecasting and early warning systems. Improved communication among scientists, journalists, policy-makers and other stakeholders can help to improve awareness.

The Government of Kenya has improved its capacity to manage climate change and is working to improve legal and institutional framework. With the passing of the Climate Change Bill, funding and capacity building will be required to enable the MENR and other institutions such as NEMA to effectively fulfil their expanded mandates.

CHAPTER 1

Kenya National Circumstances

TABLE OF CONTENTS

INTRODUCTION

This chapter, provides information on Kenya's national circumstances, based on which, the country would be addressing the challenges due to climate change. These are important as they determine Kenya's ability to mitigate and adapt to climate change while developing sustainably.

The chapter starts by providing an overview of Kenya's government structure and includes brief descriptions of the country's geographic and climatic characteristics. This is followed up with the current status, prospects and plans for the different environmental, economic and social sectors within the country. The information includes indication of any associated climate change impacts, vulnerabilities, and risks and including brief reviews of a sector contribution to GHG emissions if of significance and where data is available. It culminates with details on the country's environmental and climate change governance.

GOVERNMENT PROFILE

The Republic of Kenya (hereinafter referred to as 'Kenya') is a unitary State with a multi-party political system. Kenya became independent on 12 December 1963 as a multi-party state, becoming a one party state in 1982 and reverting back to multi-partism in 1992. In 2010, the Government of Kenya (GoK) enacted a new constitution (hereinafter referred to as 'the Constitution') which created a devolved two tier government consisting of a national government and county governments. The new government structure came into effect following a general election in March 2013.

The Constitution and the new government structure has brought in 47 constitutionally autonomous county governments that have defined spheres of power and functions; a bicameral legislature;[2] separation of powers between the three arms of government (the Executive, Legislature and Judiciary) and more stringent requirements for transparency and accountability for holders of public office at all levels.

The established devolution plays a major role in service delivery through the County Governments Act, 2012[3]. The Act states that a county government shall plan within a framework that integrates economic, physical, social, environmental and spatial planning. The framework protects and develop natural resources in a manner that aligns national and county government policies. As such while the GoK has overall responsibility for ensuring that programmes are put in place to deliver its obligations under the United Nations Framework Convention on Climate Change (UNFCCC), all the administrations under the national and county governments play a part in meeting this through the policies available to them. Climate change, because of its crosscutting and multi-sectoral nature, is a function of the national and county governments and requires concurrent jurisdiction across both levels. Further information about the institutional arrangements and responsibilities for environment and climate related policies, plans and strategies is set out in Section IX below.

In July 2008, Kenya launched Vision 2030, the national long-term development blueprint. It aims to transform Kenya into a newly industrialising, middle-income country providing a high quality of life to all its citizens by 2030, in a clean and secure environment. Vision 2030 is comprised of economic, social and political pillars. The economic pillar seeks to improve the prosperity of all regions of the country and all Kenyans by achieving an average 10 per cent Gross Domestic Product (GDP) growth rate per annum beginning in 2012. The social pillar seeks to create just, cohesive and equitable social development, in a clean and secure environment, through investment in the people of Kenya and improvement of the quality of life for all Kenyans. The political pillar aims to realise an issue-based, people-centred, result-oriented and accountable democratic system. The three pillars are anchored on the foundations of macroeconomic stability which include infrastructural development, science, technology and innovation, land reforms, human resources development, security and public sector reforms.

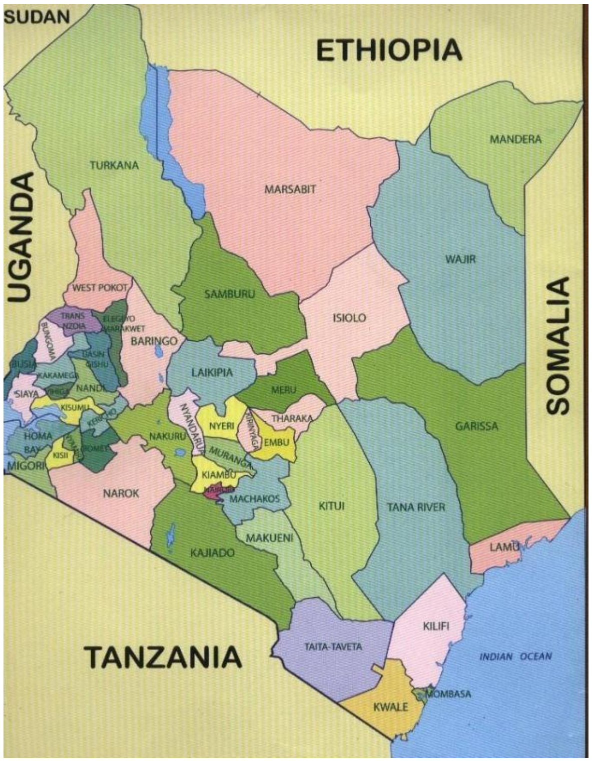
Vision 2030 is implemented in successive five year Medium-Term Plans (MTP), through a number of flagship projects. The first MTP covered the period 2008 – 2012 and the second MTP covers the period 2013-2017. Kenya's response as a signatory of the UNFCCC has included preparation of the First National Communication (FNC) in 2002, development of the National Climate Change Response Strategy (NCCRS) in 2010, launch of the National Climate Change Action Plan (NCCAP) in 2013 and submission of a Climate Change Bill to Parliament in 2014. The Ministry of Environment and Natural Resources (MENR) has designated a Climate Change Secretariat to guide its climate change response, and several sectoral ministries have designated climate change units.

GEOGRAPHICAL PROFILE

Location

Kenya, which is almost bisected by the Equator, extends between latitudes 5^{o}N and 5^{o}S and longitudes 34^{o}E and 42^{o}E. It is bordered by South Sudan and Ethiopia to the north, Uganda to the west, Somalia to the east, Tanzania to the southwest and Indian Ocean to the southeast (Figure 5). It spans a territorial area of 582,646 km^2 consisting of 11,230 km^2 of water surface and 571,416 km^2 land area. Of the total land area, approximately 490,000 km^2 (about 85 per cent) is classified as arid and semi-arid land (ASALs).[4,5]

Figure 5: Map of Kenya

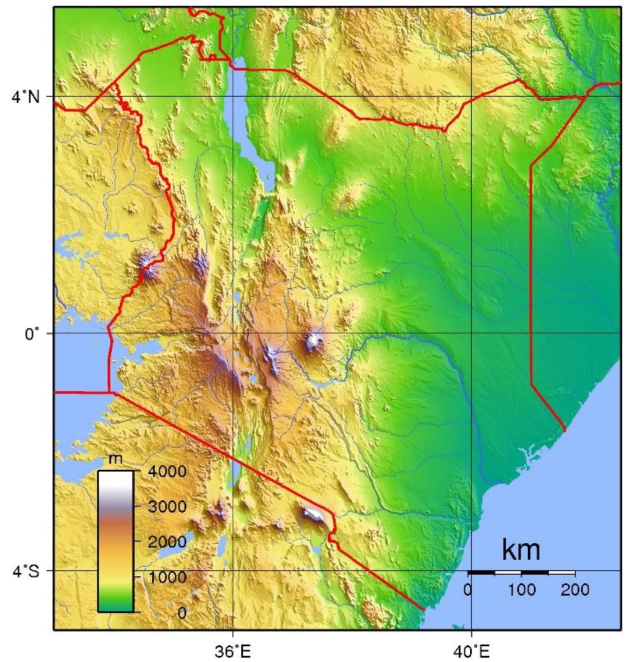


Source: Commission on Revenue Allocation (CRA) - 2013; Government of Kenya

Topography

Kenya's landscape relief stretches from sea level to about 5,200m above sea level at the peak of Mount Kenya.[6] Its topography is described as simple and diverse. The simplicity is due to its relief being easily separated into lowlands and uplands while termed diverse because of its varied landforms types which are divided into plains, escarpments, hills with low and high mountains and breaks.[7] Figure 6 shows that from the coastline in the southeast, one comes to a narrow low-lying plain. The altitude then gradually changes to low plateaus, mainly of semi-arid nature that spread in the eastern and northern parts of the country and sparsely populated. From the low plateaus the terrain runs to an elevated plateau and mountain region in the southwest (forming the Kenyan highlands).

Figure 6: Topography of Kenya



Source: Wikipedia, the free encyclopedia

The highlands contain the bulk of the country's population and farmland. The highlands are cool and agriculturally rich. Both large and small-holder farming is carried out here. Major cash crops are tea, coffee, flowers, vegetables, pyrethrum, wheat and maize. Livestock farming is also practised. Much of the highlands lie 1,500 to 3,000 m above sea level and are dotted by extinct volcanoes. The Great Rift Valley bisects the highlands into east and west forming a steep sided trench of 30 to 40 miles (48 to 64 km) wide and 600 to 900 m deep.[8] Mount Kenya the highest mountain in the country is found on the eastern side while Mount Elgon is to the western side on the border of Kenya and Uganda.

CLIMATIC PROFILE

Kenya's climate varies considerably across the country. It is hot and humid at the coast, temperate inland, and very dry in the north and northeast parts of the country. The climate is heavily influenced by its variable topography and the N-S migration of zonal arm of the Inter Tropical Convergence Zone (ITCZ). Its geographic location also makes the country prone to cyclical droughts and floods with climate change expected to make such types of climate driven events increase in intensity and frequency.

Temperature

Kenya's temperatures vary dramatically, with the highlands experiencing considerably cooler temperatures than the coastal and lowland regions. According to the climate risk assessment undertaken during the NCCAP - observed temperature data for the country shows a distinct warming trend. Observed climate data for Kenya shows a distinct warming trend since the 1960s.[9] From the early 1960s, Kenya has experienced generally increasing temperature trends over vast areas. Over the inland areas, the trends in both minimum (night/early morning) and maximum (daytime) temperatures depict a general warming (increasing) trend with time. However, the increase in the minimum temperatures is steeper than in maximum temperatures. The result of the steeper increase in Tmin and a less steep increase Tmax is a reduction in the diurnal temperature range (difference between the maximum and minimum temperatures) – Figures 34-39 depict these trends for some selected representative locations in the country. (Refer to Figures 33-38 in Chapter 3; Climate Change Scenarios; Present Climate Change (Trends and Baseline) from page 98.)

Temperatures in Kenya, since 1960, have exhibited an incremental trend. The annual mean increase has been estimated at 1^0C with an average rate of 0.21^0C per decade.

Temperature Projections

The country's temperature projections are based on General Circulation Models, (GCMs), also known as Global Climate Models. The A1B (medium) scenario described in this SNC is one of the four main groups of emissions scenarios used by the Intergovernmental Panel on Climate Change (IPCC). The A1B describes a future world of very rapid economic growth, a population that peaks in mid-century and declines thereafter with a rapid introduction of new and more efficient technologies with balance across all energy sources.

The data indicates that the following temperature trends are considered likely, relative to the baseline period 1961-1990:[10]

- Mean annual temperature is projected to increase by between 0.8 and 1.5°C by the 2030s and 1.6°C to 2.7°C by the 2060s;
- An increase is projected in the frequency of hot days and hot nights. Projections indicate that hot days could occur on 19-45 per cent of days by the 2060s and 26-69 per cent of days by the 2090s. Hot nights are projected to increase more quickly, occurring on 45-75 per cent of nights by mid-century and 64-93 per cent of nights by the end of the century;
- Projections suggest a decrease in the number of days and nights that are considered 'cold' in the current climate. Cold days and nights are expected to become very rare.

Under the same emissions scenarios GCM projections suggest that there will be no cold days or nights by the 2090s.[11]

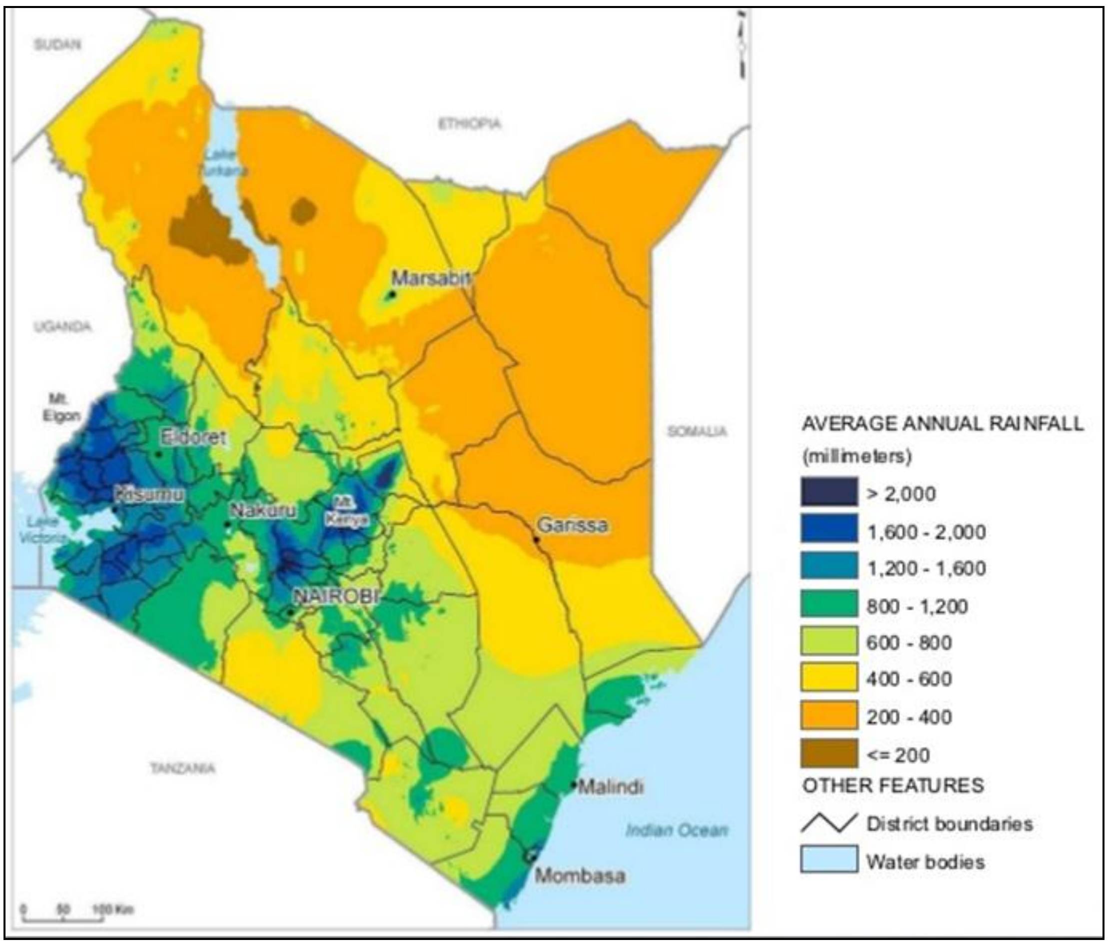
Precipitation

Kenya's average annual precipitation is typically 680 mm, ranging from less than 250 mm in the northern ASALs areas to about 2,000 mm in the western region (Figure 7).[12] The high rainfall zone, which receives more than 1,000 mm of annual rainfall is the productive agricultural land. It occupies less than 20 per cent of the country's land area and carries approximately 80 per cent of the population.[13] The ASALs with annual rainfall of less than 750mm occupies more than 80 per cent of the land area, and support about 20 per cent of Kenya's population and 70 per cent of the livestock production.[14]

On an annual basis, precipitation in the country is governed primarily by the movement of the ITCZ which migrates south through Kenya in October to December and returns northwards in March to May. The rainfall distribution, therefore, depicts very strong seasonality The ITCZ brings wet weather to the region resulting to most parts of Kenya having two distinct wet periods(bimodal rainfall distribution): The 'Long Rains' (March to May) and the 'Short Rains' (October to December). The 'Long Rains' are abundant over most parts of the country and contribute significantly to the annual rainfall totals. The "Short Rains" are more abundant and reliable in the South-eastern lowlands and parts of the eastern highlands. The two distinct rainfall seasons are separated by two dry periods that occur in mid-December to mid-March (hottest and driest period) and June to September (cool season) in most areas.

Some areas near large water bodies, receive rainfall throughout the year (mean monthly rainfall > 50mm for all the twelve months. In addition, some areas in western Kenya extending to parts of central Rift Valley exhibit a tri-modal rainfall distribution (Three peaks) with the third rainfall peak occurring in July/August period.

Figure 7: Distribution of mean annual rainfall



Source: World Resources Institute (2013)

Kenya's rainfall also varies over longer time periods.[15] Annual variation in rainfall is influenced by factors such as surface temperatures patterns of the Indian Ocean and the upper level wind regimes. Warmer than average sea surface temperatures in the equatorial eastern and Central Pacific Ocean – El Niño episodes – usually result in above average rainfall in the short rainfall season, whereas colder than average sea surface temperatures in the same region – La Niña episodes – bring depressed (below average) rainfall in the same season.[16] As the 'short rains' are most affected by the presence of El Niño conditions, they account for the majority of the inter-annual rainfall variability (estimated at about 74 per cent). [17] Although the current available evidence suggests little overall change in precipitation, there is significant geographical diversity in observed rainfall trends. Rainfall trends in Kenya since 1960 have shown the following specific characteristics:[18]

- Some evidence shows that northern areas of the country have become wetter, and southern areas drier, although this is subject to considerable uncertainty; [19]
- Trends in extreme rainfall events based on daily rainfall data are mixed. They show a generally increasing trend in the proportion of heavy rainfall events;[20]
- Trends for one day rainfall maxima and five day rainfall maxima also show inconsistent trends;
- Periodic droughts occur in Kenya relatively frequently. Moderate drought events have been recorded on average every three to four years and major droughts affect the country every ten years on average. Prolonged droughts have become more common since 2000.

Precipitation projections

GCM data indicates that the following trends may be seen for rainfall in Kenya. The statistics are for an A1B (medium) emissions scenario unless otherwise stated:[21]

- There may be increases in average annual rainfall in Kenya by the 2060s. However there is considerable model disagreement with a range of projections varying from a 5 per cent decrease to a 17 per cent increase by the 2030s and no change to a 26 per cent increase by 2060s;
- The increase in total rainfall is projected to be largest from October to December (-6 mm to +29 mm per month by 2030s and 0mm to 30 mm by the 2060s) and proportional changes largest in January and February (-14 per cent to +50 per cent by 2030s and -6 per cent to +60 per cent by the 2060s). The broad span of projections indicates high levels of model disagreement;
- The proportion of annual rainfall that occurs in heavy events will increase. The range of increase varies from 2 to 11 per cent by the 2060s and 2 to 12 per cent by the end of the century;
- There is relatively good model agreement that 1 and 5-day rainfall annual maxima will increase. The range of predicted increase for 5-day events is between 2 to 19mm by the 2060s and 2mm to 24mm by the end of the century.

Disasters and extreme climatic events

More than 70 per cent of natural disasters in Kenya result from extreme climatic events[22] the most common being floods and droughts. Recent major droughts occurred in 1991–1992, 1995–1996, 1998–2000, 2004–2005 and 2009.[23] Major floods occurred in 1997/98 and 2006. There are indications that these have intensified in recent episodes reflecting a changing climate.

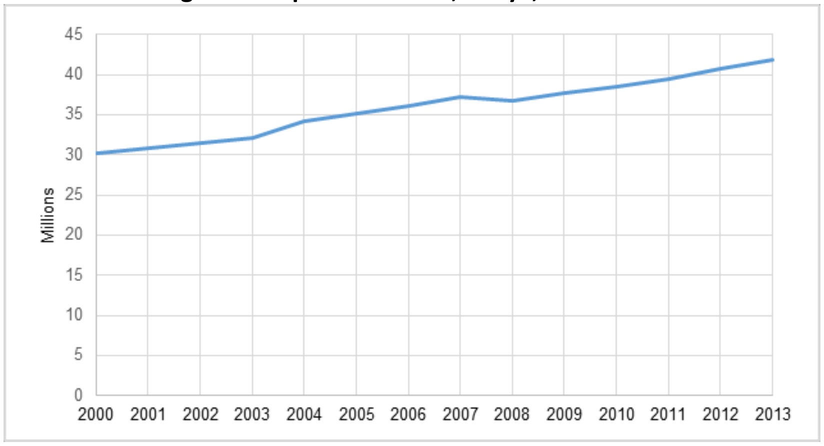
The repeated pattern of droughts and floods has large impacts and high economic costs. Droughts cost an estimated 8 per cent of GDP every five years[24]. For instance the 1998 to 2000 drought was estimated at US$ 2.8 billion from the loss of crops and livestock, forest fires, damage to fisheries, reduced hydropower generation, reduced industrial production and reduced water supply.[25] The impacts of such events are exacerbated by socio-economic trends (see Box 1 for a description of flood damage). For example, a significant part of the flood damage has been attributed to the increase in population, urbanisation, and value assets in flood-prone areas. Changes in the terrestrial system, such as deforestation and loss of natural floodplain storage, also contribute to increased flooding and damage.[26]The continued annual burden of these events leads to large economic costs (possibly as much as $0.5 billion per year, equivalent to around two per cent of GDP) and reduces long-term growth.[27]

POPULATION PROFILE

Kenya is characterised by a rapidly growing population, rapid urbanisation and increasing urban poverty, water scarcity, declining food production and low resilience to climate change. The combined effects of climate change and rapid population growth increase food insecurity, environmental degradation and poverty levels in in the country.

Kenya's population was 37.7 million in the 2009 national census, a 9 million person increase from the 28.7 million reported in the 1999 census. The population is estimated to have increased to 41.8 million in 2013 and is projected to reach 46.7 million by 2017.[28] Figure 8 illustrates this population trend, an increase of one million per year.[29] This growth is largely a result of past high fertility, which peaked at 8.1 children per woman in 1978 and declined to 4.6 children per woman in 2008[30]. The 2009 census reported a population density of 66.4 persons per square km in 2009], and this is expected to increase to 80.3 persons per square km by 2017.[31] A high percentage of the population density is concentrated in the non-ASALs areas (about 15 per cent of land area). This puts pressure on natural resources causing substantial environmental degradation, particularly deforestation, and constraining the country's ability to development in a sustainable manner. Addressing both population growth and climate change should be a top priority.

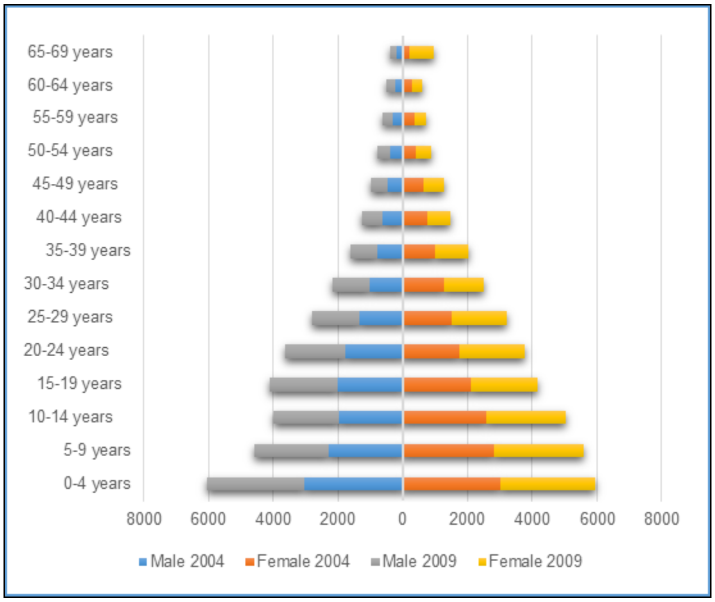
Figure 8: Population trend, Kenya, 2000-2013



Source: derived from The Kenya National Bureau of Statistics data

Kenya is in the second stage of general demographic transition models, illustrated in Figure 9. This situation is characterised by declining birth and mortality rates, although the birth rate is higher than the mortality rate leading to an increasing 'youth bulge'.[32] Youth comprise about 36 per cent of the national population but worryingly 61 per cent of them remain unemployed.[33] The reasons are mainly attributed to a lack of vocational or professional skills demanded by the job market (about 92 per cent fall in this category).[34] The unemployment challenge is further compounded by a low transition to and low completion rates in secondary education. In addition, youth face limited opportunities for technical and vocational skills training.

Figure 9: Population pyramid for Kenya, 2004 compared with 2009



Source: Derived from the Kenya National Bureau of Statistics data

A narrowing of the pyramid particularly for 50+ years indicates a shorter life expectancy. Females outnumber males at older ages (65-69 years) reflecting a higher life expectancy of females. Women represent 51 per cent of the country's population.[35]

The majority of the Kenyan population (about 67.7 per cent) resides in rural areas. However this situation is changing with an increase in rural-urban migration.[36] The 2009 census showed that the urban population increased from 5.4 million in 1999 to 12.2 million in 2009. Close to half of all Kenyans are projected to be urban residents by 2050[37]. Kenya's urban population is growing at four per cent per annum.[38] The increase in urban population and limited affordable housing has resulted in informal settlements with limited housing, sanitation, water, energy and waste disposal. The growth of urban population, and the accompanying urban poverty (in Kenya about 55 percent of urban residents currently live in poverty in informal settlements) presents a major development challenge. Residents in informal settlements are highly vulnerable to climate change impacts such as flooding, fires, and landslides and often lack basic amenities and proper sanitation. Better urban planning and reforms could help Kenya make the most of the socioeconomic benefits of urbanisation and reduce reliance on natural resources such as agricultural land.

About 46 per cent of the population is under the national poverty line.[39,40] Table 3 shows the prevalence of poverty in rural areas (49.1 per cent) compared to urban areas (33.7 per cent). There are wide variations across counties. Counties in the ASALs such as Kitui, Marsabit, Mandera, Samburu, Tana River, Turkana and West Pokot have poverty levels above 70 per cent. These counties are very dry but and characterised by relatively weak infrastructure and poor access to public services.

Table 3: Poverty and inequality in Kenya (per cent), 1993-2006

		1992	1994	1997	2000	2006
Urban		29.3	29.0	49.2	51.5	33.7
Rural		46.0	46.8	52.9	59.6	49.1
Total (urban and rural)		41.8[41]	40.0	52.3	56.8	45.9
Inequality* (per cent)		56.9	44.3	41.9	-	45.2

***Based on Gini coefficient representation of Kenya's population income distribution**
Source: Modified from UNEP. (2014). Green Economy Assessment Report – Kenya

Despite government efforts to reverse the poverty situation, Kenyans below the poverty line continue to lack critical services such as access to quality healthcare services, water supply and education. Economic gains have largely benefited the wealthiest quintile contributing to the country's social and economic gap (inequality) with great disparities between the rural and urban areas.

The poverty and inequality situation expose Kenyans to climate risk hazards rendering them vulnerable to climate change. According to the IPCC Working Group II (WGII) 5th Assessment Report (AR5) poverty and inequality are the most salient conditions that shape climate-related vulnerability. Poverty affects livelihood options and creates conditions where people have few assets to buffer extreme events. Climate change is an additional burden to the poor.

NATURAL RESOURCES PROFILE

Biodiversity

Kenya is endowed with a rich biodiversity due to the abundance of species within the country's varied ecosystems. It is home to five globally important biodiversity hot spots and includes 62 Important Bird Areas (IBAs)[42] among others. The International Union for Conservation of Nature (IUCN) ranks Kenya second in Africa in terms of mammalian species diversity.[43] Kenya is famous for its diverse group of large mammals like the leopard, buffalo, black rhinoceros, African elephant, and African lion (also known as the big five). Wildlife based tourism contributes about 70 per cent of the gross tourism earnings, demonstrating the importance of biodiversity to the economy.[44] The country's existing protected area (PA) system takes care of most of its biodiversity, but still fall short. Kenya's State of Environment report 2010 identifies threats to the country’s biodiversity in the PAs and beyond: human-wildlife conflict; poaching; overexploitation and human encroachment (human settlements and expansion of their livelihood activities of agricultural and livestock development) due population increase.

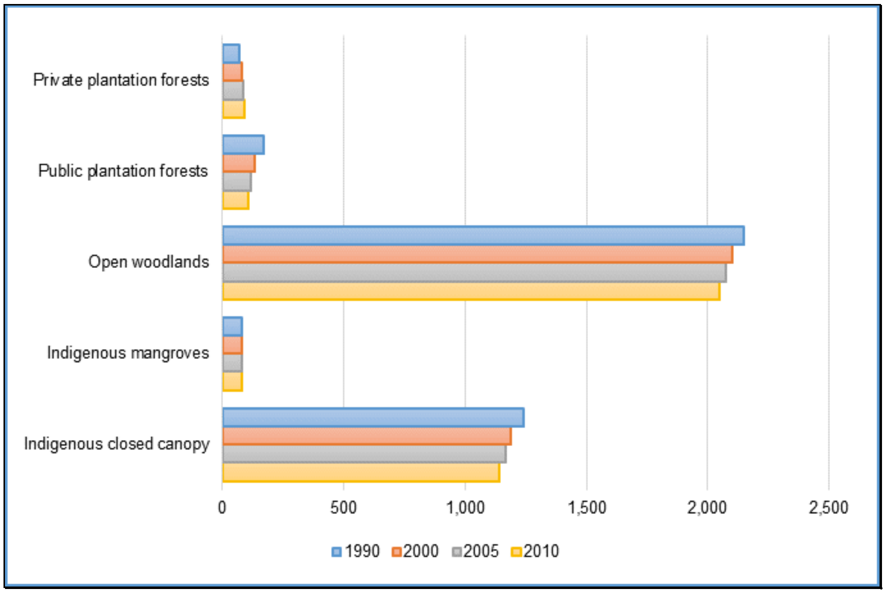
Notwithstanding the human-wildlife conflicts, climate change has a direct link with biodiversity and species diversity loss. Biodiversity is habitat specific; whenever there are changes in climate particular species disappear from their current habitats and new species appear leading to ecosystem changes. Observed changes in Kenya include the drying up of rivers and migration of species to new habitats.[45] Kenya Wildlife Service (KWS) researchers confirmed that climate change and ecological disturbances caused an observed increase of infectious diseases leading to deaths in wildlife populations. Birds and mammals have been the worst affected, with climate change blamed for the sudden mass death of flamingos around Lake Nakuru in the Rift Valley in 2006. Hence climate change poses serious threats to biodiversity in Kenya both in aquatic and terrestrial ecosystems. The tourism industry is heavily dependent on biodiversity conditions and quality, and climate change is expected to have profound impacts on biodiversity.

Forestry

Forests are of high value in Kenya, having critical ecological, social, cultural, and economic functions. Over 75 per cent[46] of Kenya's renewable surface water originates from the country’s water towers and catchments. The critical water role of forests is important for the population’s livelihoods, irrigated agriculture, and production of hydro-electric power. Forests contribute directly and indirectly to national and local economies through revenue generation and wealth creation. Forestry contributes an estimated 3.6 per cent of Kenya's GDP, excluding charcoal and direct subsistence uses.[47]

Forest classification in the country is based on definitions set out by the Food and Agriculture Organization (FAO). Forest is defined as a group of trees featuring a tree canopy cover of over 10 per cent, with crowns that are largely contiguous. There are five distinct classes:[48] indigenous closed canopy forests, indigenous mangroves, open woodlands, public plantation forests and private plantation forests.

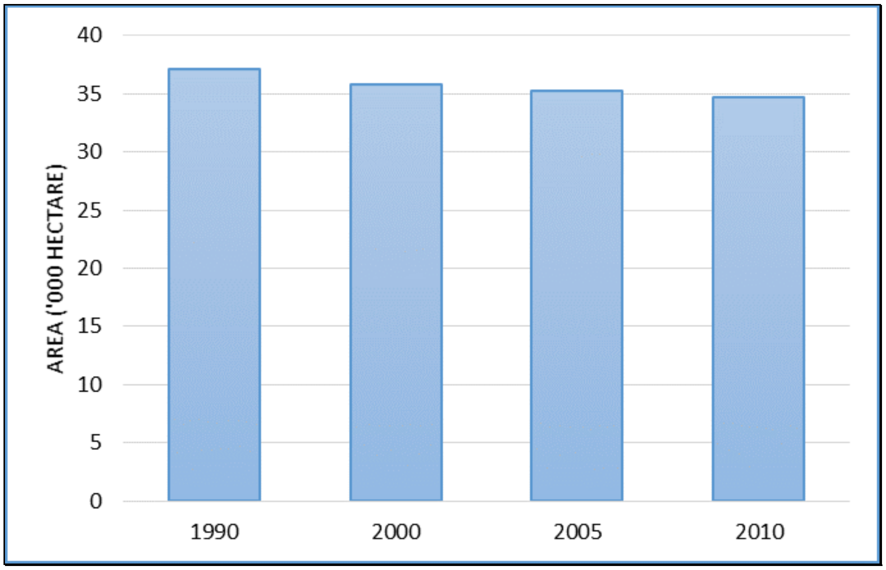
Figure 10: Forest classes' area trend, Kenya, 1990 – 2010



Source: Global Forest Resource Assessment Country Report FAO, page 9 cited in the NCCAP Mitigation Chapter forestry analysis

Figure 10 shows the area of each of the forestland classes in total land area from 1990 to 2010. Forestry cover comprises mainly open woodlands, encompassing approximately 59 per cent of the country's forest area. Indigenous closed canopy is the second largest class at approximately 33 per cent, with public and private plantations and mangroves making up the remaining share.

Figure 11: Forest area trend, Kenya, 1990-2010



Source: Global Forest Resource Assessment Country Report

Kenya has experienced a decline in forest cover (Figure 11). At independence in 1963, Kenya's forest cover stood at about 11 per cent.[49] Approximately 12,000 hectares of forest a year have been lost through deforestation.[50] Between 1990 and 2010, for instance, forest cover fell from 12 per cent in 1990 to 6 per cent in 2010.[51] The drivers of deforestation are mainly unsustainable utilisation and conversion of forest land to other land uses.[52] About 80 per cent of Kenyans rely on wood biomass[53] for their energy requirements and forests also provide other goods to support their livelihoods such as timber materials. The livelihood needs exerts considerable pressure on forest resources. In addition, the technologies used for wood conversion for timber manufacturing and charcoal production are obsolete and wasteful leading to overharvesting of trees to meet the demand. As a result deforestation in Kenya has been high, with a yearly loss to the economy of over USD 19 million.[54]

The situation is reversing with forestry cover estimated as 6.99 per cent as noted in the country's National Forest Policy, 2014. The increase is an improvement from 6 per cent in 2010 and represents good progress toward the Constitution's target of 10 per cent forest cover.

Climate changes is expected to further increase forest degradation possibly resulting in desertification.[55] This will have adverse impacts on the economic benefits and livelihoods derived from this sector, as well as biodiversity and other environmental services. GoK is working to address these challenges, including the development of a national strategy for Reducing Emissions from Deforestation and Forest Degradation and fostering conservation, sustainable management of forests, and enhancement of forest carbon stocks (REDD+). The strategy seeks to incentivise activities to help meet the tree cover goal of the Constitution and Vision 2030. The country has gained experience in REDD+ through the Kasigau Wildlife Corridor Project, the first activity in Africa to issue voluntary forestry carbon credits. Other REDD+ projects are under development, including the Mikoko Pamoja mangrove restoration project in Kwale and a second phase of the Kasigau Corridor project. The National Forest Policy 2014 and the Forests Act 2005 are the main policy and legislative instruments in this sector, and encourage progress toward the 10 per cent forest cover through industrial plantations, agroforestry, urban forestry and activities implemented by local forest authorities.

Water Resources

The water sector in Kenya underpins its main economic sectors of agriculture, livestock, tourism, manufacturing and energy. The country is divided into six major drainage basins (Figure 12) consisting of: Lake Victoria North (18,374 km^2); Lake Victoria South (31,734 km^2); Rift Valley (130,452 km^2); Athi (58,639 km^2); Tana (126,026 km^2); and Ewaso Ng'iro North (210,226 km^2).[56]

Its drainage system is dense with many ephemeral streams and perennial rivers of which a small number are permanent. The permanent rivers are; Tana, Athi, Sondu, Yala, Mara, Nzoia and Nyando. Several of these are damned upstream to provide hydroelectricity, irrigation and water for domestic use. The main rivers drain radially from the central highlands into the rift valley, eastward into Indian Ocean and westward into Lake Victoria. Those north of Mount Elgon and from the highlands along South Sudan-Ethiopia border drain mainly into Lake Turkana. The country's five water towers - Mount Kenya, Aberdares Ranges, Mau Complex, Mount Elgon and Cherangany hills - are the source of these rivers. These valuable towers are under continuous threat from human encroachment which has contributed to the drying up of some of the rivers and streams.[57]

In 1992, Kenya was categorised as a water scarce country with per capita available water resources of 647 m^3 per person, below the internationally acceptable threshold of 1000 m^3. This was reduced to 586 m^3 in 2010 (Table 4) limited availability is further aggravated by rapid population increase and climate variability. The scarcity has serious implications for the key sectors of tourism, agriculture and industry, as well as Vision 2030's flagship projects which rely heavily on water availability.

Figure 12: Kenya water catchment areas

Source: JICA Team - National Water Master Plan 2030

Table 4: Renewable and available water resources

Item	2010	2030	2050
Precipitation (P) *(BCM/y)	400.1	441.6	479.1
Evapotranspiration € **(BCM/y)	358.0	397.3	425.9
Renewable WR (P-E) (BCM/y)	42.1	44.3	46.0
Renewable SW (BCM/y)	20.6	24.9	26.7
GW Recharge (BCM/y)	21.5	19.4	19.3
Sustainable Yield of GW*** (BCM/y)	1.9	1.7	1.7
Available Water Resources (BCM/y)	22.5	26.6	28.4
Population Projected (million)	38.5	67.8	96.9
per Capita RWR (m3/y/capita)	1,093	653	475
per Capita Available WR (m3/y/capita)	586	393	293

Source: JICA Team - National Water Master Plan 2030

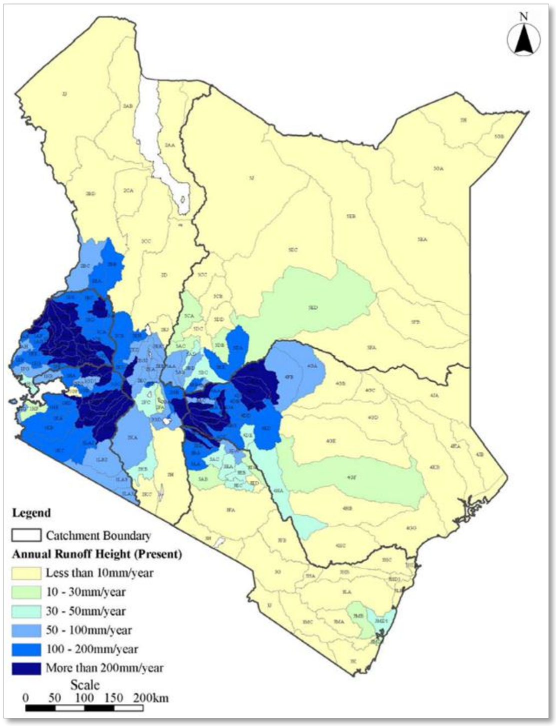
Note: * Multi-model ensemble analysis of 11 GCMs for 2030 and 2050

**** Estimation by FAO Penman-Monteith method**

***** 10% of GW recharge excluding river and riparian areas**

Figure 13 gives the distribution of renewable surface water resources while Figure 14 illustrates the available surface and ground water yields. Both show uneven distribution across the five basins.

Figure 13: Distribution of renewable surface water resources

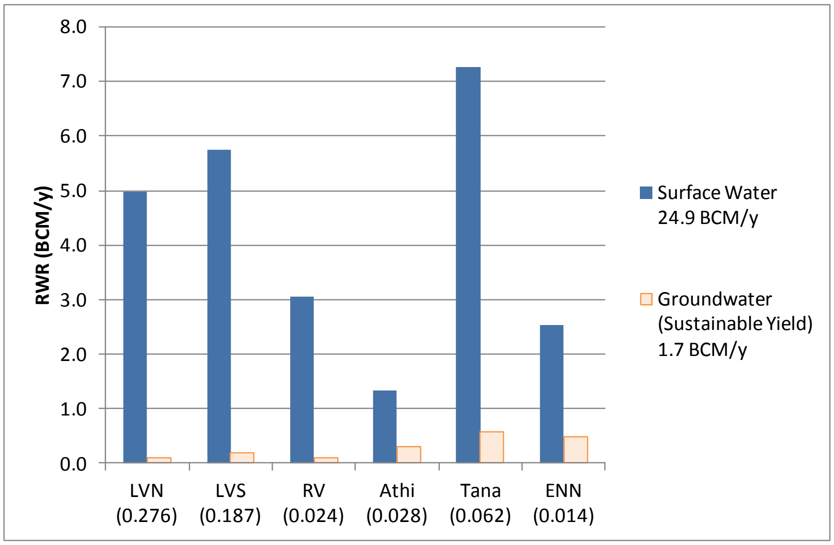


Sources: Water bodies (FAO 2000a), permanent and intermittent rivers (NIMA 1997) and major drainage areas (MoWD and JICA 1992a).

On an annual basis, precipitation in the country is governed primarily by the movement of the ITCZ which migrates south through Kenya in October to December and returns northwards in March to May. The ITCZ brings wet weather to the region resulting to Kenya's two distinct wet periods: The 'long rains' (March to May) and the 'short rains' (October to December). The 'long rains' bring approximately 70 per cent of Kenya's total rainfall with the 'short rains' contributing a further 20 per cent.[58] The remaining six months of the year are typically dry, contributing just 10 per cent of the country's total rainfall.[59]

The Tana and Lake Victoria basins are those with the most renewable surface water resources. Athi has the least renewable water sources and is the catchment serving the two main cities: Nairobi and Mombasa. The uneven distribution across the basins is a big challenge for water resource management.

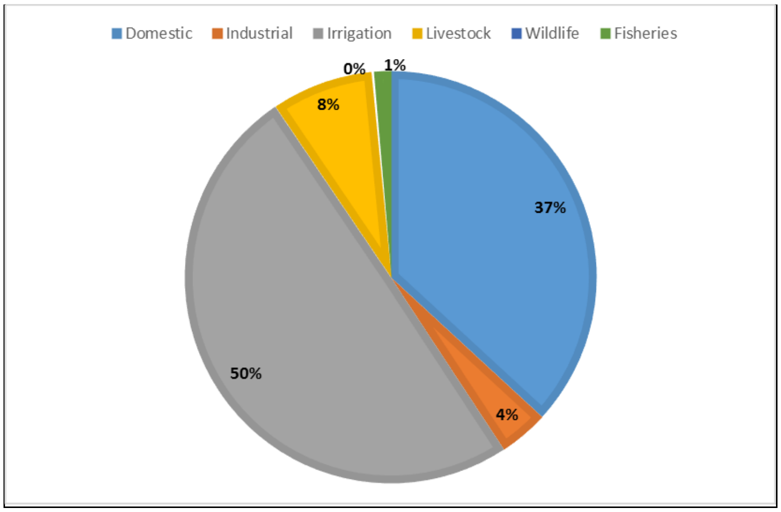
Figure 14: National Water Master Plan 2030 available surface and groundwater water yields



Source: JICA Team - National Water Master Plan 2030

Kenya's water scarcity is expected to be more severe in the future due to an overwhelming increase of water demands against a substantially reduced per capita availability of 393 m^3 by 2030 (see Table 5). Figure 15 shows that water demand in 2010 was driven by irrigation (50 per cent), domestic use (37 per cent) and livestock (8 per cent). Industrial, and inland fisheries demand also contributed to the rise in water use, although to a lesser degree. The demand from irrigation will increase further as Vision 2030 seeks to expand irrigable land by 1.2 million ha.[60] The demand will be greatest in the Tana and Ewaso Ng'iro catchments that serve the ASALs region.

Figure 15: Kenya's water demand 2010



Source: JICA Team - National Water Master Plan 2030

Increased demand from domestic, livestock and industrial activities is also expected due to the population growth, as well as implementation of Vision 2030 flagship projects.

Climate change is likely to cause changes in water availability in terms of quantity and quality, and increasing frequency of floods and droughts is expected to impact the state of the available freshwater resources. Competition for the resource is expected to increase, resulting in water resource conflicts between upstream and downstream users and between agriculturalists and pastoralists.

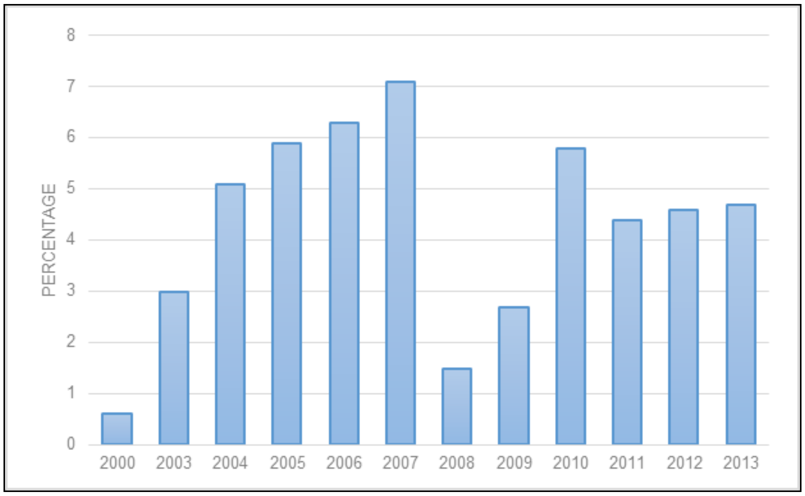
The governance framework in the water sector is based on the National Water Policy Sessional Paper No. 1 of 1999, which was operationalised by the enactment of the Water Act in 2002. The reforms have aimed at improving service delivery, increasing community participation, increasing investments and implementing Integrated Water Resources Management (IWRM). IWRM has intensified activities on forestry, soil conservation, and improved land use and water catchment management. To properly develop and manage resources in the country, the GoK formulated the National Water Master Plan in 1992 (NWMP) and updated National Water Master Plan 2030 (NWMP 2030). The NWMP 2030 factors in new circumstances particularly increasing water demand, impacts of climate change, population growth, and also social and economic developments.

ECONOMY, INDUSTRY AND SERVICES PROFILE

Economy

Kenya is a lower middle-income country with an estimated national GDP of US$ 60.9 billion in 2014.[61] Figure 16 gives a visualisation of Kenya's GDP trend from 2000-2013, demonstrating that Kenya's economic performance has varied.

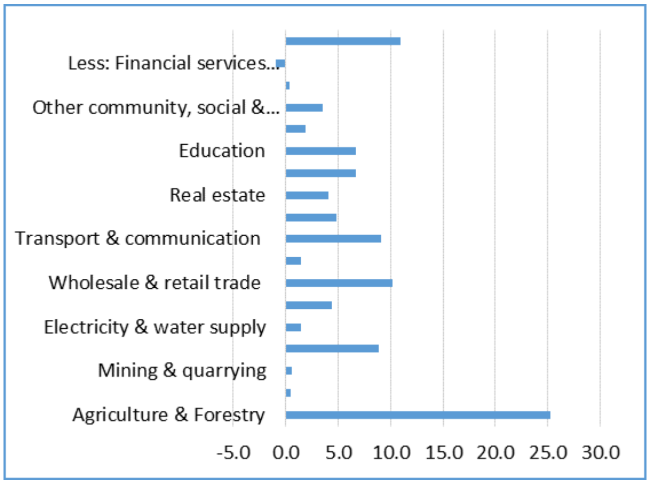
Figure 16: National GDP growth rates



Source: Derived from the Kenya National Bureau of Statistics data (Data for 2001 and 2002 not available from source)

GDP growth rates peaked in 2007 at 7.1 per cent per annum. Post-election violence in early 2008 compounded with drought, high global energy and food prices together with the effects of the global financial crisis on remittance and exports, reduced GDP growth to 1.5 per cent in 2008.[62] The economy rebounded in 2010 with GDP growth rates at about six per cent, with a slight decline in 2011 and 2012.

Figure 17: Sector contribution to Kenya's GDP



Source: Authors derivations of data from the Kenya National Bureau of Statistics

Figure 17 shows the different sectors' contributions to GDP in the country. Approximately 42 per cent of Kenya's national GDP is derived from its natural resource sectors (namely agriculture, forestry, fishing, tourism, water supply and energy). The services sector, (which includes transport and communication, wholesale and retail trade, financial and other services) accounts for about half of GDP. The industry sector (manufacturing, construction, mining and quarrying) contributes the remaining 10 per cent.[63]

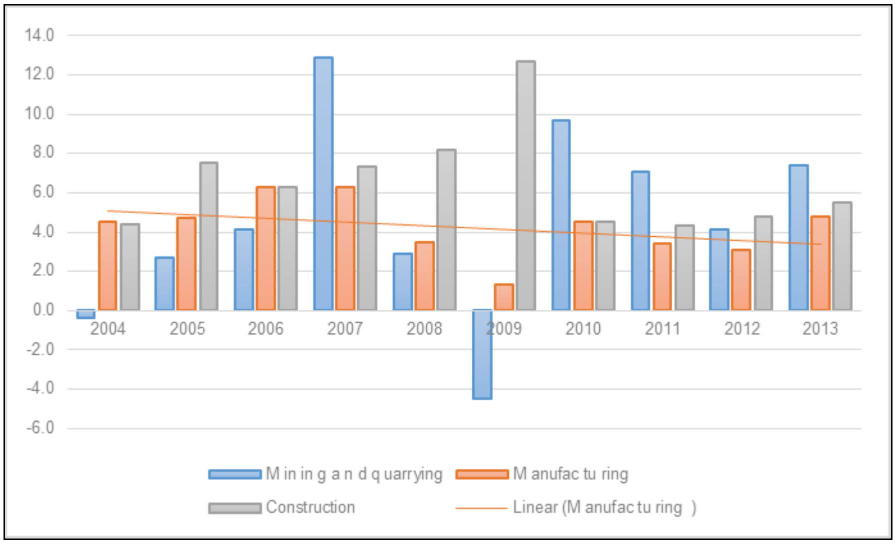
The informal sub-sector (also known as 'Jua Kali') accounts for about 80 per cent of total recorded employment.[64] The sector covers all unregulated small-scale activities largely undertaken by those self-employed. An estimated 10 million people were engaged in the informal sector in 2012, up from 6 million and 9 million in 2004 and 2010, respectively.[65] The informal sub-sector is generally characterised by low productivity, vulnerability of employment, and low incomes.[66]

In addition to concerns about an expanding informal economy, the labour market is also beset with under-employment. In 2013, Kenya's unemployment was estimated at 36 per cent, with those for youth (15-35 years) constituting the highest, at 61 per cent. The rate of unemployment varies across the country, with the highest in the north-eastern regions at about 23 per cent (2012) and the lowest in Nyanza and the western regions, estimated at 4.8 per cent and 5.2 per cent (2012), respectively.[67]

Industry

The industrial sector comprises the manufacturing, construction, mining and quarrying sub-sectors. The contribution of the sector to GDP in 2013 was 4.8 per cent for manufacturing accelerating from 3.2 per cent in 2012; 5.5 per cent for construction compared to 4.8 per cent in 2012; and 7.4 per cent for mining and quarrying an increase from 4.1 per cent in 2012.[68]

Figure 18: Industry sector growth rate, Kenya 2004-2012



Source: Authors derivations of data from the Kenya National Bureau of Statistics

Figure 18 shows a negative trend line in the industry growth rate between 2004 and 2013. The National Industrialisation Policy Framework (2011-2015) attributes this to high capital investment; intermediate and capital goods industries that are relatively underdeveloped, high energy costs, and environmental concerns. The sector has experienced a weak enabling policy environment because past industrial policies have been contained in many disparate policy documents that have lacked harmonised and clearly defined national industrialisation policy. The sector is also characterised by low value addition, low employment and low capacity utilisation. A new National Industrialization Policy (2014) is expected to provide a stronger and more robust institutional framework within which to synchronise and coordinate the various policies, strategies and activities. Expansion of the industrial sector forms a significant part of Kenya's economic development strategy. The strategies to achieve this include but are not limited to:[69]

- Promoting investment and expansion in key climate sensitive agro-processing industries;
- Becoming a provider of basic manufactured goods for eastern and central Africa consequently expanding the country's export base;
- Supporting local industries that use local raw materials, and adding value to imports that can then be re-exported.

Climate change will need to be managed to achieve these goals. Historically, the sector has been adversely affected by extreme weather events such as rains and ensuing floods, which have impacted infrastructure such as roads, railways, buildings and ports. These impacts indirectly affect industrial production.[70] Low rainfall has resulted in low water quantities leading to interruptions in electricity supply given that most electricity is hydro-generated. In addition, the cost of electricity rises in times of drought as diesel generators are used to make up the shortfall. The availability of agricultural raw materials needed by industries is also adversely affected by recurring drought.

Mining, Quarrying and Oil and Gas Extraction

The country has economically viable quantities of coal, iron ore, fluorspar, titanium gypsum, limestone, soapstone, gemstones, soda ash, diatomite, lead, gold, silicon oxide and marble. Recent discoveries of oil, gas and rare earth minerals suggest that these will be potentially important resources for Kenya going forward. The mining and quarrying sector registered a growth of 7.4 per cent in 2013, a substantial increase from 4.1 per cent in 2012.[71] The sector accounted for only one per cent of GDP and three per cent of total export earnings in 2014.[72] There has been very little exploitation of these resources, and development of the mining and quarrying sector is expected to support resource based industries such as iron and steel, cement, building and construction, chemical and ornamental industries, among others. The Oil and other mineral resources sub-sector has been identified as an additional priority sector under the Economic Pillar of Vision 2030. Developments and decisions could impact on Kenya's GHG emission profile, with use of domestic coal expected to increase emissions in the electricity supply sector. Vulnerability to climate change in the sub-sector depends on the mining method. Surface mining might be particularly affected by high rainstorms and floods.[73]

Manufacturing

Medium and large industries constitute less than five per cent of the total number of enterprises but contribute over 60 per cent of the manufacturing sector's GDP contribution. Micro and small enterprises comprise about 95 per cent of total enterprises (the informal sector) but contribute only about 20 per cent to the manufacturing sector's GDP contribution. Formal employment with medium and large industries grew by five per cent in 2012 while informal employment (discussed above) grew by 17 per cent in the same period.[74] The sub-sector GDP growth rate was 4.8 per cent in 2013, an increase from 3.2 per cent in 2012. The sub-sector is highly import dependent, and faces high energy costs and environmental concerns. The unreliable supply of electricity means that most manufacturers operate standby or diesel emergency power systems. Others such as cement manufacturers are exploring coal as an alternative electricity supply source, which could lead to a rise in GHG emissions. The First and Second MTPs both give attention to growth and diversification in the manufacturing sub-sectors with the aim of increasing the sector's contribution to GDP and foreign exchange earnings. To achieve this, three special economic zones targeting manufacturing were established in Mombasa, Kisumu and Lamu. Other planned initiatives include building clusters for meat and leather products; a stronger dairy sector; and the development of industrial and SME parks in the 47 counties that will provide linkages to other sectors like agricultural and services. Climate change may affect the sub-sector in a number of ways. First, climate change affects primary sectors such as Agriculture and in turn prices and quality and quantity of manufacturing inputs. Second, the supply chain particularly logistics is affected leading to delays and in turn increase in cost of services.

Services

Trade

The trade sector is a key driver for the achievement of national development goal. Trade provides linkages with other sectors by creating markets through which goods and services reach the consumer. The trade sector in Kenya operates on two levels: domestic and international.

Domestic trade encompasses mainly wholesale and retail trade, contributing an average 10.1 per cent to GDP. It accounts for about 16 per cent and 60 per cent of recorded formal and informal employment, respectively. Kenya has recorded a rapid growth in wholesale retail and distribution, particularly in the supermarkets and hypermarkets which realised a growth of 32 per cent between 2000 and 2010,[75] with some of these expanding to regional markets. The exponential growth of supermarkets has been driven by changing consumer lifestyles, increased urbanisation, and economic growth.[76]

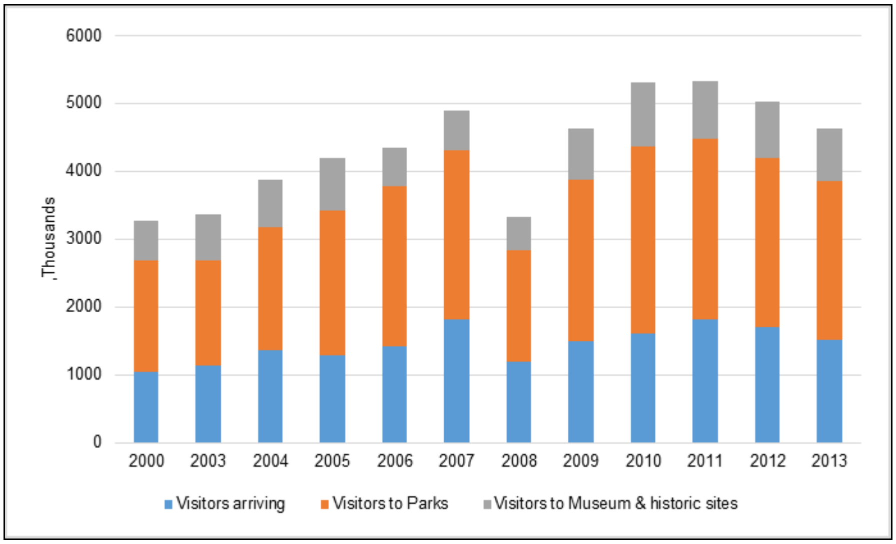
International Trade: Kenya's external trade is highly skewed towards agricultural commodity exports. The value of total merchandise exports was 45 per cent in 2013 while imports were 81.1 per cent in the same year.[77] A high percentage of imports over exports has led to a widening of the country's trade balance. Most of the imports are capital goods or raw materials (e.g. petroleum products, motor vehicles, electric equipment, food, metals and plastics) for industrial production. The exports consist mostly of agricultural products particularly tea, coffee and horticultural produce. The East African Community, the country's largest market, accounts for about 27 per cent of Kenya's total exports, followed by Asia and Europe.[78] The country also exports clothing and apparel to the United States through the African Growth and Opportunity Act (AGOA). The export base has remained largely the same since Independence; inferring that the country has been unsuccessful in diversifying the export base. To reduce the trade balance and diversify its export base the GoK is actively seeking to enlarge export market by integrating external trade as part of foreign policy.

The trade sector depends on services and products offered by other sectors such as energy, agriculture and transport. The sector is vulnerable to climate change, subject to changes in rainfall reliability and extreme weather events such as drought, floods. Climate change impacts affect yields, production costs, prices, and, in macroeconomic terms, Kenya's trade balance. Climate change also affects the value chain particularly warehouse and transport facilities (road, rail, sea). Transport infrastructure suffered substantial damage in the 1997 -1998 El-Niño rains which caused economic losses of US$ one billion mainly from reduced trade activities.[79]

Tourism

Kenya has a wide diversity of natural assets, including over 500 km of year-round warm sandy coastal beaches, marine ecosystems, abundant wildlife, a rich and diverse cultural heritage, and Mount Kenya's glaciers. The tourism sector contributes approximately 10 per cent to overall GDP, making it the third most important sector after agriculture and manufacturing and Kenya's third largest foreign exchange earner after tea and horticulture.[80]

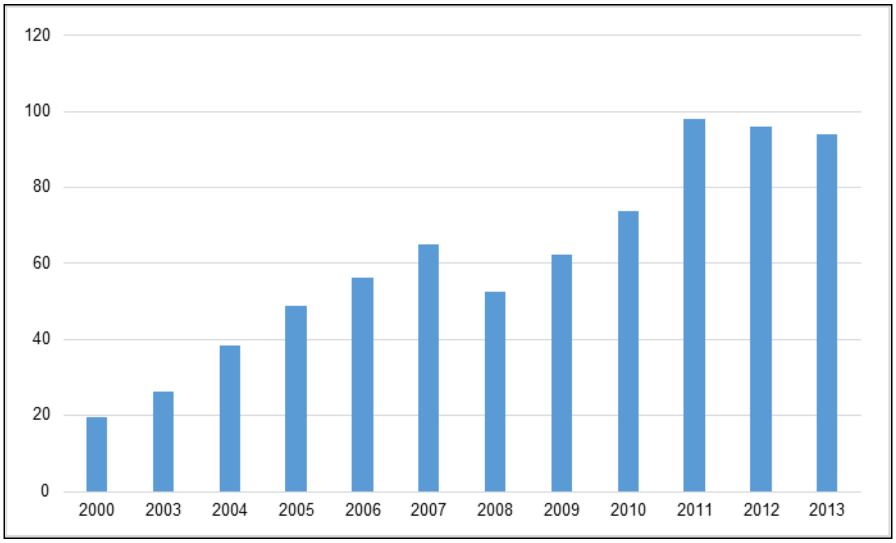
Figure 19: Tourism numbers



Source: Authors derivations of data from the Kenya National Bureau of Statistics

Figure 19 shows tourist arrivals were approximately 1.5 million in 2013 a decrease from 1.7 million in 2012. The earnings declined from KSh. 96 billion in 2012 to KSh. 94 billion in 2013 (Figure 20). The slowdown in tourist arrivals in 2013 is attributed to the global economic slowdown, especially in Europe, and negative publicity related to security in the country. Vision 2030 seeks to position Kenya among the top 10 long-haul tourist destinations in the world by providing a high-end, unique and varied experience for visitors. Internal insecurity and climate change impacts could pose challenges to achieving this goal.

Figure 20: Tourism earnings



Source: Authors derivations of data from the Kenya National Bureau of Statistics

Climate change impacts tourism, which relies on a natural resource base. The NCCAP showed that climate change may already be affecting a wide range of the environmental resources that are critical attractions for tourism, such as wildlife productivity and biodiversity, and water levels and quality. Noted observed impacts include a reduction in the volume of the Mara River (due to climatic variations and the destruction of the Mau catchment) which has taken a toll on migration of wildebeests between the Serengeti National Park (Tanzania) and the Maasai Mara Reserve (Kenya). In addition, flash floods have at times rendered some tourist destinations (e.g. Maasai Mara in 2011) inaccessible due to the destruction of the road infrastructure. Other impacts include wildlife human conflicts especially in Northern Kenya where longer and more frequent droughts have ravaged pastoralist populations in recent decades, increasing the pressure on the limited resources available, which have to be shared with wildlife.[81] Increases in deaths in wildlife populations from infectious diseases. Are impacted by climate change Birds and mammals have been the worst affected, with climate change blamed for the sudden mass death of flamingos around Lake Nakuru in the Rift Valley in 2006. [82]

Information Communications and Technology (ICT)

Information and Communication Technology (ICT) has been identified as a key enabler to the attainment of the goals and aspirations of the Vision 2030, helping to transform Kenya into a knowledge and information based economy by enabling access to quality, affordable and reliable ICT services in the country. The Government has undertaken various measures aimed at developing the ICT sector, such as putting in place a national broadband strategy.

The growth in ICT-enabled services has opened a new window for Kenya. The Vision 2030 identified Business Process Outsourcing (BPO) – IT enabled - as a priority sector. By 2012 Kenya had witnessed growth of key BPO companies such as KenCall, Safaricom, Kentech and Horizon.[83] Growth has also been witnessed in other related industries such as computer hardware manufacturing and the acquisition and use of computers, mobile phones and television sets. ICT growth has led to computers and the internet being common across businesses in all sectors, with mobile phones in particular becoming an essential part of Kenya's population daily lives.

ICT has been one of the main drivers of Kenya's economic growth over the last decade. Since 2000, ICT has been responsible for 0.9 of the 3.7 per cent annual GDP growth, and for all of Kenya's GDP per capita growth (World Bank). The ICT sub-sector is expected to contribute over 10 per cent to GDP by 2017. To achieve this goal, the GoK is implementing various initiatives that include improving universal access to IT, promotion of BPOs, capacity building, development of digital content, roll out of e-government services, establishment of an information technology (IT) knowledge based centre (Konza Techno City) and promotion of ICT-based industries.

From a climate change perspective ICT has an important role to play in the development of capacity for adaptation and mitigation.[84] For adaptation ICT can facilitate the processes of knowledge integration and learning. An example is the Kilimo Salama partnership between Syngenta Foundation, UAP Insurance and Safaricom that offers insurance policies to farmers who plant on as little as one acre of land to shield them from significant financial losses when drought or excess rain negatively impact their harvests. Payments to farmers are made through a mobile enabled platform (known as MPesa). ICTs could play an important mitigation role through "smart" applications such as smart metering to promote energy efficiency. Additionally ICT growth is expected to lead to increased electricity demand and disposal challenges will result from a high rate of obsolete ICT equipment due to technological change.

Transport

Kenya's rapidly growing transport sector accounts for about 10 per cent of GDP.[85] Vision 2030 identifies transport is a key enabler of sustainable growth. Reliable and efficient road, rail, air and water transport infrastructure facilitates smooth and faster movement of goods and services and national and regional integration. This, boosts trade within and across Kenyan borders, promotes economic development, and contributes to poverty reduction and wealth creation. .

The sector has seen significant enhancements to improve the movement of people and goods, including the building of the Nairobi-Thika superhighway; the modernising of the Mombasa-Nairobi highway; expanding the international airport in Nairobi, upgrading of the port of Mombasa; developing a port in Lamu; and upgrading the railway track between Mombasa and Nairobi.

The road transport, subsector has experienced significant growth, with the vehicle population (excluding motorcycles) having increased from 600,000 in 2000 to 2.2 million in 2013. The high growth of registered vehicles in Nairobi, coupled with underdeveloped infrastructure has led to severe traffic congestion, especially during the extended peak hours, contributing to local air pollution and resultant health impacts and significant economic losses as much time and fuel is spent in the traffic congestion. To reduce traffic congestion in Nairobi, the government has developed plans to introduce a Mass Rapid Transport (MRTS) system that includes both a Bus Rapid Transit (BRT) system complemented by commuter rail,

An estimated 47 per cent of Nairobi residents and the majority of rural residents rely on transport by foot. Public transport services are comparably expensive or in some case inadequate to meet demand, and private cars are out of the financial reach of the majority of citizens.[86] Public transport is relatively under-developed and is dominated by minibuses (matatus). The government has identified the mobility needs of Kenya's rural inhabitants and has stated its commitment to the promotion of Intermediate Means of Transport (IMTs) as a strategy for poverty alleviation.

The vast majority of freight transport, including transit freight headed to other countries, is served by trucks. About 30 per cent of the cargo handled at the port of Mombasa is transit cargo destined for such countries as Uganda, Rwanda and Burundi. Railway transport of freight is expected to increase with the construction of a standard gauge railway line linking Mombassa to Malaba in Uganda; and development of a new transport corridor linking Lamu Port with South Sudan and Ethiopia. Most petroleum products are transported from Mombasa to the hinterland via a pipeline.

International and domestic air transport has been growing and plays a key role in supporting some of Kenya's leading foreign exchange earners, namely tourism and horticulture.

The transport sector is a significant and growing contributor of greenhouse gas emissions. The NCCAP reported that emissions from the sector are expected to triple between 2010 and 2030, from a baseline of six million tonnes of CO_2-equivalent in 2010. The road-subsector is the main source of emissions, responsible for about 99 per cent of emissions from non-aviation transport.[87] Rail systems improvements and development of an MRT in Nairobi are mitigation actions that will improve road safety and facilitate regional trade.

The transport sector is also impacted by climate change, including heavy rains and sea level rise. Due to the importance of transport in the development of Kenya and the region, and as recommended in the NCCAP, Kenya will aim to mainstream climate change into the development of port facilities, roads, railways and bridges to account for rising sea levels, flooding and the increased occurrence of extreme weather events. Addressing climate change in the in the transport sector means working to reduce greenhouse gas emissions while encouraging development of transport infrastructure that accounts for flooding, extreme weather events and other effects of climate change.

AGRICULTURE PROFILE

The agricultural sector directly contributes about 25.4 per cent of Kenya's GDP[88] and another 27 per cent indirectly via linkages to agro-based industries and the service sector, giving an overall 52 per cent contribution to Kenya's GDP. The crops (horticulture, food crops and industrial/cash crops), livestock and fisheries subsectors are the main components of the agricultural sector, respectively contributing about 78 per cent, 20 per cent and 2 per cent of agricultural GDP.[89] Growth of the national economy is highly correlated to growth and development in agricultural sector, indicating the sector's importance for the stimulation of overall economic growth (Figure 21). Agriculture is the primary source of livelihoods for the majority of Kenyans, accounting for 18 per cent and 60 per cent of the formal and total employment respectively. It accounts for 65 per cent of Kenya's total exports.[90]

Areas of high to medium agricultural potential (food crop production, cash crops and dairy farming) cover less than 15 per cent of land area and supporting about 80 per cent of the country's population (NEMA, 2010). Population increase and scarcity of land in the high to medium production areas has led to subdivision of land resulting in small uneconomic farms that cannot be run sustainably. Farming in the country is largely small-scale, with 75 to 80 per cent of total agricultural production from rain-fed farms that average 0.2 to 3 hectares in size.[91] The problem is expected to increase with population growth.

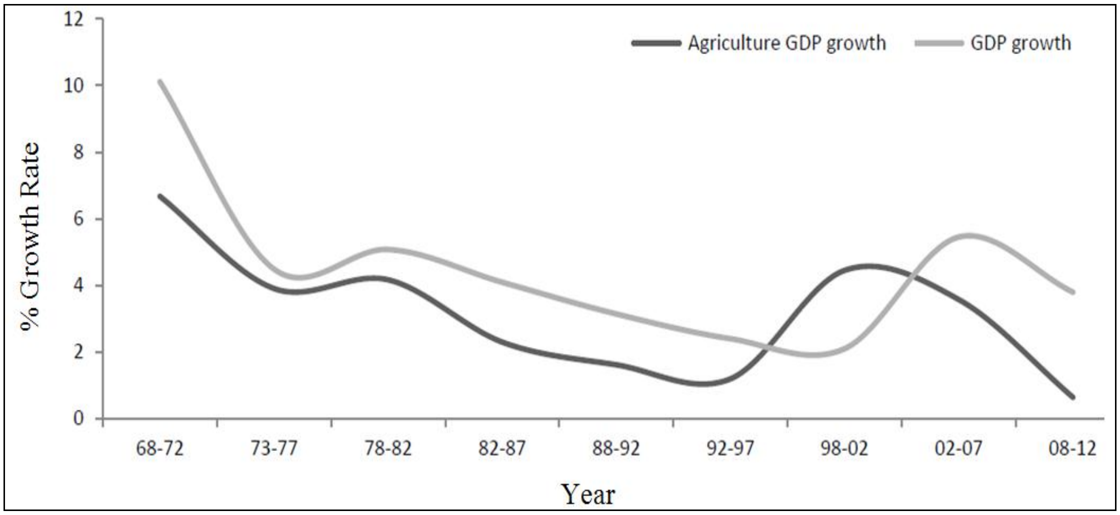
The **crops subsector** includes maize, rice, wheat, sorghum, potatoes, cassava, vegetables and beans. Kenya's agriculture is 98% rain-fed and predominantly small-scale, especially in the medium to high-potential areas. Changes in precipitation either in quantity and/or timing have a great impact on production. Limited rainfall also contributes to the production pressures, which are compounded by high input costs especially fertilizers, poor marketing chains, low level of mechanisation and high transport costs.. Production of the main food crops – maize, wheat and rice – has generally been below the country's consumption requirements thus contributing to food insecurity.[92]

The key cash crops in Kenya are tea, coffee, sugar cane, pyrethrum, and tobacco. Tea is one of the leading foreign exchange earners in the country. The horticulture industry is the second most important foreign exchange earner. Its products include cut flowers, vegetables, fruits, nuts, herbs and spices.

The **livestock subsector,** including beef, dairy, sheep and goats, camel, poultry and pigs, plays an important economic and socio-cultural role in many Kenyan communities. Dairy cattle are mainly kept in the medium to high-rainfall areas. Beef is produced on rangelands with dairy cattle culls contributing significantly to supply. Kenya ranks second in the East Africa region after Sudan in both animal product yields and value.[93] Sheep and goats play a key role in the food security and incomes of pastoral households due to their short generation intervals, high adaptability and versatile feeding habits. Pig rearing has withstood periodic fluctuations and is now relatively well established. Camels are reared mainly in the arid areas, and their high versatility in drought periods means their rearing is gradually extending to the South Rift region and is expected to expand to other parts of the country.

Production in the **fisheries subsector** is fairly minimal with aquaculture commercial enterprises increasingly taking shape.

Figure 21: Agricultural GDP Growth Rate vs. National GDP Growth Rate (% change), 1968-2012



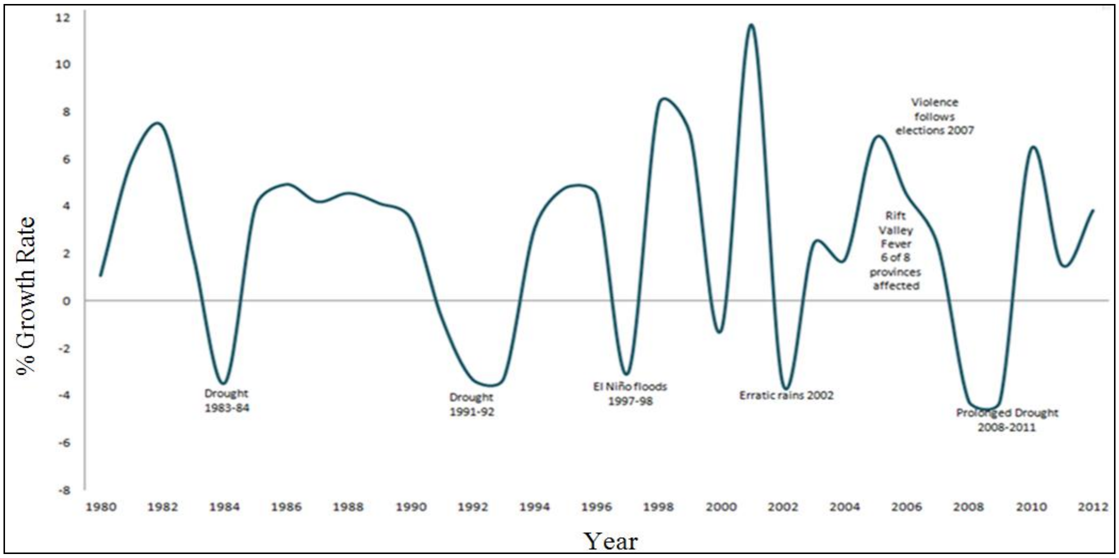
Source: World Bank, 2014

The agricultural sector is highly vulnerable to climate change. Growth rates in the agricultural sector are correlated with flood and drought events, and historically negative growth indices have been associated with extreme weather events (see Figure 22). A study by the Adaptation to Climate Change and Insurance (ACCI) project[94] reported the occurrence of 41 flood events and 12 drought events between 1970 and 2013, noting that flooding tends to be more frequent but more localized, while drought is less frequent but more systemic. The cycle of drought is becoming shorter, more frequent and more intense.

Agricultural sector productivity is directly influenced by emerging and projected changes in climatic patterns, including increased variability of seasonal rains. National trends indicate an increase in temperature and highly variable rainfall where first season rains are lower in amounts and more variable, while second season rains have increased in amount.

The frequency and intensity of the extreme weather and climate events such as drought and floods are also on the increase. These weather events result in increased soil erosion, deforestation, loss of soil fertility and reduced productivity. The increasing frequency and magnitude of extreme weather events has contributed to a decline in the annual growth rate in agricultural "value added" (Government of Kenya, 2014)[95].

Figure 22: Agricultural growth index and major extreme events in Kenya 1980 – 2012



Source: World Bank, 2014

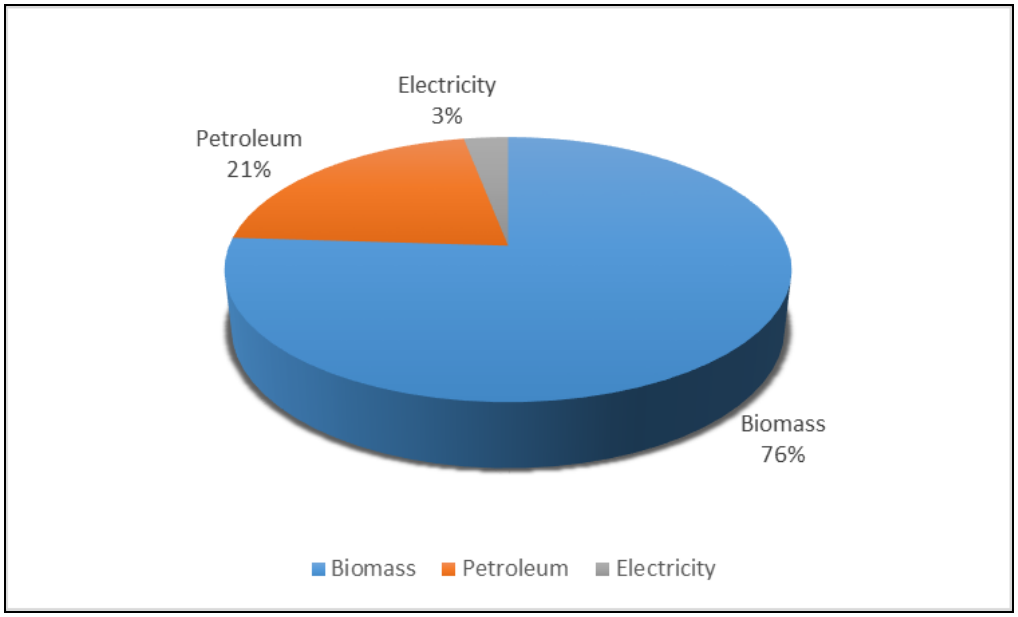
ENERGY PROFILE

Energy is a critical component for the Kenyan economy and its population's standard of living. Vision 2030 identifies energy as a key foundation and one of the "enablers" upon which the economic, social and political pillars will be built. The GoK recognises that the successful implementation of its flagship projects will greatly depend on supply of adequate, reliable, clean and affordable energy. As a result the demand for electricity will increase as the numerous economic activities implemented and new county governments take shape. In particular will be the energy intensive activities such as mining; production of iron and steel products; irrigation of large tracts of land for food security; operation of petroleum pipelines for both crude and refined fuel oils amongst others. The level and intensity of commercial energy use in the country will certainly be a key indicator of the degree of its economic growth and development.

Kenya faces serious constraints in energy supply, including low access to modern energy services, high cost of energy, irregular supply and high cost of energy investments[96]. Biomass (wood fuel, charcoal, and agricultural waste), petroleum and electricity are the main sources of energy in the country. They account for 76 per cent, 21 per cent, and 3 per cent, respectively, of the country's total energy consumption (Figure 23).

Wood fuel is the most important source of energy in the country. About 80 per cent of the population depends on it for their domestic needs, providing 90 per cent and 85 per cent of rural and urban households' energy requirement, respectively.[97] Current wood harvesting is unsustainable leading to deforestation and land degradation in the country.[98]

Figure 23: Kenya Energy Sources



Source: Derived from data based on Ellis K. et al, 2013

Petroleum is imported and mainly used in the transport, commercial and industrial sectors. Kenya's import of petroleum accounted for about 16 per cent of the total import bill in 2012 and 17.9 per cent in 2013 and consumed about 31 per cent and 55 per cent of the country's foreign exchange earnings from merchandise exports in 2012 and 2013, respectively.[99] Kenya currently relies on imports for all petroleum requirements. However, with the discovery of oil in the country, this trend is expected to change with time.

In 2013, electricity in Kenya was generated mainly from hydropower, geothermal and thermal sources. Figure 25 and Figure 26 show the electricity generation by sources in 2013. The total installed electricity generation capacity in Kenya was 7,890 GWh.

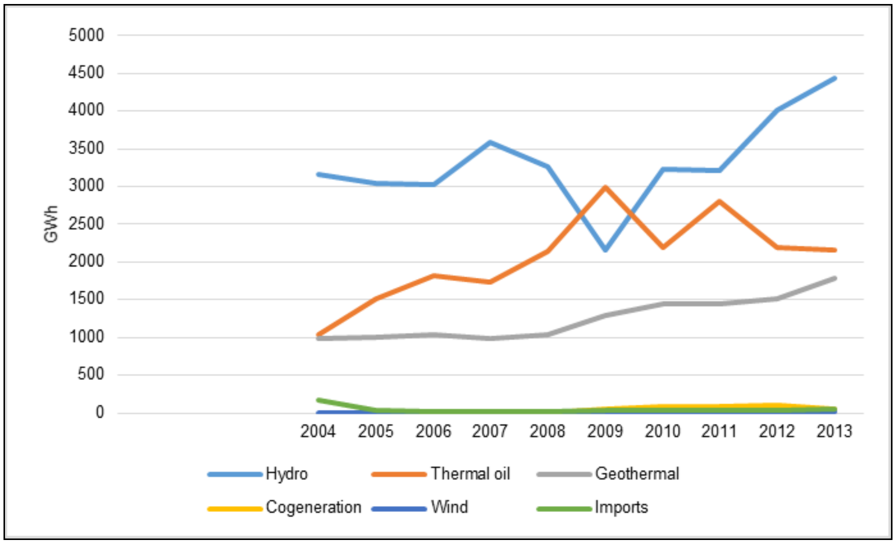
Figure 24 shows the electricity generation by sources for the period 2004 to 2013. Hydropower, the main source of electricity, reduced considerably in 2009 due to reduced rainfall and reduced hydrology in the main catchment areas of the major rivers on which generating dams are constructed. This was aggravated by the destruction of water catchment areas leading to dry water levels and siltation in the dams.[100] Droughts and declines in rainfall have led to lower reservoir levels reducing hydropower production.[101]

Geothermal power is increasingly becoming a key player and may take over from hydropower as the leading source of electricity in the country. Other renewable energy sources such as wind, solar and biomass (cogeneration) are also becoming important alternative sources of electricity although these remain insignificant in the country's overall energy mix. Programmes for their increased development and use have been formulated such as the revised Feed-in-Tariff (FiT) policy in 2010.

The electricity mix is projected to change in order to drive the achievement of Vision 2030 and in light of recent resource discoveries and long-term plans. Kenya's National Energy Policy 2014, which has been formulated within the framework of Vision 2030, considers diversification of electricity sources. Through it, the GoK has developed a plan to raise electricity generation capacity by an additional 5,000 MW from the current 1,664 MW that will total to 6,762 MW by 2016. The new capacity will mainly be developed from geothermal 1,646 MW, natural gas 1,050 MW, wind 630 MW and coal 1,920 MW. This new plan will not only improve Kenya's energy security but also reduce dependency on hydropower and imported fuels.

Only about 25 per cent of the total population in Kenya are connected to the grid.[102] About 60 per cent of all the generated electricity is consumed by the commercial and industrial sectors and only about 25 per cent is used by households.[103]

Figure 24: Electricity generation sources for the period 2004 -2013



Source: Authors derivations of data from the Kenya National Bureau of Statistics

The key challenges in the electricity sub-sector in the country include:

- Inadequate power generation capacity
- Major power outages that cost the country up to two per cent of GDP and that have led to about 70 per cent of the country's firms investing in their own generation compared to only 10 per cent of firms in South Africa[104]
- High electricity costs

Climate change will exacerbate the situation, as prolonged drought leads to a reduction of water levels in dams. The low October to December 2013 rainfall resulted in reduced water levels in the hydroelectric power generation dams, leading to power shortages and electricity rationing.[105] Flooding has led to siltation of dams, and the resultant reduction of water storage and hydroelectricity generation capacity.[106] The adverse effects of climate variability and change on hydropower are projected to grow.[107]

HEALTH PROFILE

Vision 2030 emphasizes making progress on universal access to health care, prevention and primary health care, clean water, management of communicable disease, maternal and child health, and non-communicable diseases. It also seeks to invest in medical research, pharmaceutical production and health tourism as a means of diversifying external revenue sources and serve as a regional hub for health services. The GoK allocates about 4.6 per cent of the national budget to health, which remains below the Abuja target of 15 per cent.[108]

Kenya has made progress to improve health care especially in tackling communicable diseases such as HIV-AIDs, tuberculosis and malaria. About 52 per cent of Kenya's population has access to basic health services within 5 km, [109] although significant disparities in service availability exist between rural and urban areas. The ASALs remain the most disadvantaged in the provision of health services especially, the distribution of health facilities and availability of health personnel. Mortality rates remain high. The main causes of mortality include: HIV/AIDS (29.3 per cent), perinatal conditions (9 per cent), lower respiratory infections (8.1 per cent), tuberculosis (TB) (6.3 per cent), diarrhoea (6.0 per cent) and malaria at (5.8 per cent).[110]

Climate change will negatively impact progress in the health sector. For example, rising temperatures and erratic rainfall may lead to an increased spread of various diseases, such as malaria because of an increase in mosquito breeding habitats. Historical incidences of increased temperature and rainfall, such as during the El Niño events of 1982 to 1983 and 1997 to 1998, coincided with malaria outbreaks[111] In addition the reduction of surface water will increase the exploitation of ground water which will lead to more people suffering from diseases such as fluorosis, diabetes and hypertension.[112] This is because ground water in some areas such as the Rift Valley have been found to contain specific compounds such as high fluoride levels, high sodium levels and low chromium levels which are directly associated with the increased emergence of these diseases.[113]

The environment, water, health and sanitation sectors are interconnected. Climate change impacts in the environment and water sectors also affect the health and sanitation sector; and actions in these sectors need to be looked at holistically in order to avoid mal-adaptation.

EDUCATION PROFILE

Kenya has had a remarkable increase in access and participation rates in the education sector as reflected in indicators of the enrolment rate and gender parity across all levels of education. However, disparities still exist, and access and participation rates remain below national average in the ASALs. The disparities at county level are further aggravated by inefficient utilisation of available resources, as manifested through teacher absenteeism and limited emphasis on monitoring of actual performance.

Primary education recorded the highest progress, while access rates at pre-primary, secondary and tertiary education remain below the sub-Saharan average of 7%. Learning outcomes at the secondary school are still weak, with about 70 per cent of candidates failing to achieve the minimum grade for admission to university. Equally, the literacy level has remained low.

The GoK has developed plans to address issues related to access, equity, quality, relevance, service delivery, curriculum, teacher development and management, as well as training in the areas of technology and entrepreneurial skill development.

Table 5: National education indicators

	2009	2010	2011	2012
Pre-Primary GER	60.6	60.9	65.6	66.3
Pre-Primary NER	49	50	52.4	53.3
Primary GER	110	109.8	115	115.8
Primary NER	92.9	91.4	95.7	95.3
Secondary GER	45.3	47.8	48.8	49.3
Ministry of Education Budget (%)	16	15.6	13.5	11.4
Primary teacher/ Student ratio (public)	1:52	1:54	1:57	1:56
Secondary teacher/ Student ratio (public)	1:30	1:31	1:31	1:32

Source: Authors derivations of data from the Kenya National Bureau of Statistics

INSTITUTIONAL PROFILE

This section provides information on GoK institutions, policies, plans, strategies and initiatives that provide a governance framework for implementing climate change responses.[114]

The Government of Kenya is developing a policy and institutional framework to guide the country toward a low carbon climate resilient development pathway. Kenya's governance structure has been informed by the global and regional commitments and obligations, such as UNFCCC (1992), Africa's African Climate Change Strategy (2011) and East Africa's Climate Change Policy, Strategy and Master Plan (2011).

The first national policy document on climate change, the National Climate Change Response Strategy (NCCRS), has improved understanding of the issue and has guided policy decisions since its launch in 2010. To operationalize the NCCRS, Kenya prepared the National Climate Change Action Plan 2013-2017 (NCCAP). The action plan is delivered through eight sub-components:

- Long-term National Low Carbon Climate Resilient Development Pathway
- Enabling Policy and Regulatory Framework
- Adaptation Analysis and Prioritisation
- Mitigation
- Technology
- National Performance and Benefit Measurement
- Knowledge Management and Capacity Development
- Finance

The Government of Kenya has moved to implement a number of actions in the NCCAP, including improved drought management and promotion of renewable energy. The Ministry of Planning and Devolution (MOPD) has included indicators to track progress in mainstreaming climate change in its Second Handbook of National Reporting. A Climate Change Bill is expected to be enacted into law in 2015. This Bill includes establishment of a National Climate Change Council that has responsibility for coordination of climate change actions, including mainstreaming climate change in national and county budgets, plans and programs. A draft Climate Change Framework Policy and a National Policy on Climate Finance are expected to provide guidance on mainstreaming to national departments and country governments.

National Policies and Legislation

Other relevant national policies and legislation that contain measures that enable mainstreaming of climate change are included in Table 6 below.

Table 6: Key National Policies and Legislation

Policies	Measures to mainstream climate change
Constitution of Kenya (2010)	A clean and health environment (Articles 42, 69 and 70) is a fundamental right under the Bill of Rights, providing a rationale for the formulation of adaptation and mitigation legislation, policies and strategies. The Constitution establishes the right to food security while emphasizing sustainable and productive management of land and natural resources, such as a goal of tree cover of 10 per cent of the country's land area.
Kenya Vision 2030	The national development blueprint has many plans and programs that factor in aspects of adaptation and mitigation. Its flagship projects include irrigation expansion, geothermal development and slum rehabilitation.
National Policy for the Sustainable Development of Northern Kenya and other Arid Lands	Focuses on climate resilience requiring government to find solutions to address climate challenges and to come up with measures to manage drought and strengthen livelihoods. The establishment of the National Drought Management Authority (NDMA), the National Disaster Contingency Fund and the Council for Pastoralists education are provided for in the policy.
National Disaster Management Policy, 2012	Mainstreams disaster risk reduction in the country's development initiatives, and aims to increase and sustain resilience of vulnerable communities to hazards.
National Environment Policy (2013)	Provide a framework for an integrated approach to planning and sustainable management of Kenya's environment and natural resources.
Environmental Management and Coordination Act (1999)	Provides the framework for the management of the environment, including the establishment of NEMA which is a regulator in matters of environment, the Designated National Authority (DNA) for the CDM and the National Implementing Entity (NIE) for the Adaptation Fund.
Kenya Forestry Master Plan (1995-2020)	Provides an overarching framework for forestry development and recognises the environmental role of forests including water values, biodiversity values, climate change values through carbon sequestration and other environmental services.
Second National Environment Action Plan (2009-2013)	Provides a broad framework for the coordination of environmental activities by the private sector and Government to guide the course of development activities, with a view to integrating environment and development for better management of resources.
National Water Master Plan 2030	Assesses and evaluates the availability and vulnerability of country's water resources up to around 2050 taking climate change into consideration.
Water Act (2002)	Provides the overall governance of the sector, and recognises the climate change implications on health, sanitation and water.
Agricultural Sector Development Strategy, 2010-2020	Provides the framework for transforming agriculture into a modern and commercially viable sector. Notes that addressing food security will require addressing the challenge of over-dependence on rain fed agriculture.
Energy Policy and Act (2004)	Encourages implementation of indigenous renewable energy sources to enhance the country's electricity supply capacity. The policy is implemented through the Energy Act of 2006 (revised 2014), which provides for mitigation of climate change, through energy efficiency and promotion of renewable energy.
The Feed in Tariffs (FiTs) Policy (2008,revised 2012)	**P**romotes generation of electricity from renewable sources. It applies to geothermal, wind, small hydro, solar and biomass.
Integrated National Transport Policy (2010)	Provides for transport solutions that have relevance to climate change mitigation.

Lead Government institutions for climate change

Table 7 shows the lead institutions and responsibilities with regard to climate change at the time of preparing the Second National Communication for Kenya

Table 7: Lead institutions and responsibilities with regard to Climate Change

Ministry/Agency	Description
Ministry of Environment, Natural Resources and Regional Development Authorities (MENDDRA)	The mandate of the Ministry is to monitor, protect, conserve and manage the environment and natural resources through sustainable exploitation for socio-economic development aimed at eradication of poverty, improving living standards and ensuring that a clean environment is sustained now and in the future. The Ministry is also responsible for making policy on climate change and for the coordination of climate change response in the country. The National Climate Change Secretariat (NCCS) is a department of the Ministry and spearheads the development and implementation of climate change policies, strategies and action plans. These include: National Climate Change Action Plan (2013-2017) which implements the National Climate Change Response Strategy (2010). The Ministry is the national focal point for the UNFCCC. In addition to the NCCS, the Ministry comprises of the following departments and institutions, which also play a role in the national climate change response: • National Environment Management Authority (NEMA) – This is a state corporation established by the Environmental Management and Coordination Act No.8 of 1999 whose mandate is to supervise and coordinate all matters related to the environment. With regard to climate change, NEMA serves as the Designated National Authority for the Clean Development Mechanism and the National Implementing Entity for the Adaptation Fund. NEMA is also the technical entity that produces the National Communications to the UNFCCC • Kenya Meteorological Department (KMD) • Department of Resource Surveys and Remote Sensing (DRSRS)
Ministry of Devolution and Planning	This Ministry is responsible for national development planning, leadership and coordination of devolution; and associated monitoring and evaluation in Kenya. It leads the process to mainstream climate change into the national plans including the 5 year mid-term plans under Vision2030. It also works with the MENR to analyse the risks and impacts of climate change to national development.
The National Treasury	The Ministry is charged with the responsibility of formulating financial and economic policies as well as the management of revenues, expenditures and borrowing by the GoK. In relation to climate change, the Ministry is responsible for the allocation of funds from the exchequer and is the National Designated Authority to the Green Climate Fund
Ministry of Energy and Petroleum	The Ministry is mandated to facilitate provision of clean, sustainable, affordable and secure energy for national development while protecting the environment. The Ministry has a department of renewable energy

	and other associated relevant institutions which include: Rural Electrification Authority (REA), Geothermal Development Company (GDC), Kenya Electricity Generation Company (KENGEN), Kenya Power and the Kenya Electricity Transmission Company Limited (KETRACO), Centre for Energy Efficiency and Conservation (CEEC).
Ministry of Agriculture, Livestock & Fisheries	The Ministry of Agriculture is mandated to promote and facilitate production of food, livestock and fisheries and agricultural raw materials for food security and incomes; advance agro-based industries, and agricultural exports; and enhance sustainable use of land resources as the basis for agricultural enterprises. Due to the sensitivity of agriculture to climate change, the Ministry has established a climate change unit that coordinates climate related issues across the agriculture sector. The Ministry is also implementing various climate change programmes and projects.
National Council for Science & Technology (NCST)	The NCST is an advisory institution on matters of Science, Technology, Innovation and Research in Kenya for national social economic development.
National Drought Management Authority (NDMA)	Established by Legal Notice in late 2011, the core mandate of the NMDA is to exercise general supervision and coordination over all matters relating to drought management in Kenya, and to be the principal instrument of Government in ensuring the delivery of all the policies and strategies that relate to drought management and climate change adaptation.
Climate Change Units/Desk Offices	Climate Change Units and Desk Offices have been established in most Government of Kenya institutions including: Kenya Agricultural Research Institute (KARI), Kenya Forest Service (KFS), Kenya Wildlife Service (KWS), and Kenya Forestry Research Institute (KEFRI).
County Governments	The Kenya Constitution 2010 establishes 47 constitutionally autonomous county governments that have defined spheres of power and functions. *The County Governments Act, 2012* states that a county government shall plan within a framework that integrates economic, physical, social, environmental and spatial planning, and protect and develop natural resources in a manner that aligns national and county government policies. Climate change is a function of the national and county government and requires concurrent jurisdiction across both levels. Various functions assigned to county governments are integral to fulfilment of actions required to address climate change.

Source: Kenya's National Climate Change Action Plan

The National Environment Management Authority (NEMA), a semi-autonomous government agency in the MENR, is responsible for the overall coordination and management of the process of preparation of Kenya's national communications.

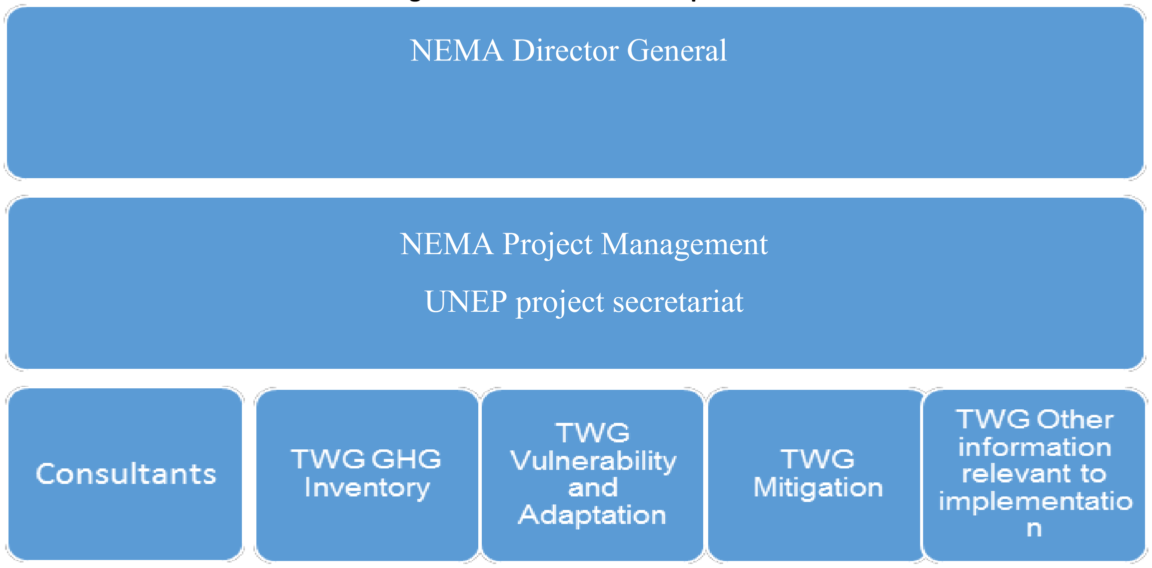
NEMA was established under the Environmental Management and Co-ordination Act No. 8 of 1999 (EMCA) in 1999. The EMCA mandates the Authority to exercise general supervision and coordination over all matters relating to the environment and to be the principal instrument of the GoK in the implementation of all policies relating to the environment. NEMA's work is guided by provisions in Articles 42 and 70 of Kenya's Constitution 2010. Article 42 states that every person has the right to clean and healthy environment. Article 70 provides the right to have environment protected for the benefit of present and future generations through legislative and other measures. In addition

NEMA work links closely with the Vision 2030 goal of a clean secure and sustainably managed environment. NEMA has been assigned leading roles in the flagship projects of Waste management; Education for Sustainable Development (ESD); securing wildlife corridors through the EIA process; clean development mechanisms among other projects. The Authority also advises the GoK on various Multilateral Environmental Agreements (MEAs) that should be ratified, domesticated and implemented for the benefits of the country. In addition the Authority chairs the inter-ministerial committee overseeing performance contracts required by GoK from the Ministries Departments and Agencies (MDAs) to report on Environmental sustainability on a quarterly basis and annually.

The above platforms strengthen NEMA's mandate as the lead institution in spearheading the national communications process and conducting inter-ministerial coordination.

The Second National Communication (SNC) work has built on the work done under the First National Communication (FNC), NCCRS, NCCAP, the draft NAP and Kenya's Vision 2030. Figure 25 below shows the current institutional set up for the preparation of the SNC. The future proposed institutional framework for addressing Climate Change, including meeting international commitments under the UNFCCC is addressed under the Climate Change Bill, 2014.

Figure 25: Structure for Preparation of SNC



The NEMA Project Management Team (PMT) is composed of a Project Coordinator and Project Steering Committee chaired by the NEMA Director General or his appointee. PMT worked hand in hand with the UNEP project secretariat. The consultants were responsible for compiling the relevant data for the chapters working with the Technical Working Groups (TWGs), who reviewed and approved the outputs of the consultants. The four TWGs involved the key sector stakeholders and experts from other government Ministries, civil society and the private sector. TWGs also acted as advisory groups, supporting access to information for the consultants, providing inputs, review and analysis of work and results.

KENYA'S ON-GOING RESPONSES TO CLIMATE HANGE

The GoK and other stakeholders are implementing many interventions that have direct and/or indirect relevance to climate change adaptation and mitigation.
Examples include:

- *Agriculture:* promoting irrigated agriculture, promoting conservation agriculture, value addition to agricultural products, developing weather indexed crop insurance schemes, support for community-based adaptation including provision of climate information to farmers, enhanced financial and technical support to drought resistant crops.
- *Livestock and Pastoralism:* Breeding animals tolerant to local climatic conditions, weather indexed livestock insurance, establishment of fodder banks, documenting indigenous knowledge, provision of water for livestock and humans, early warning systems for droughts and floods, and vaccination campaigns.
- *Water Resources:* Enforcement and/or enactment of laws for efficient water resource management, increasing capture and retention of rainwater, water quality monitoring, de-silting rivers and dams, protecting and conserving water catchment areas, investing in decentralized municipal water recycling facilities, campaigns on water harvesting, developing hydrometric network to monitor river flows and flood warning.
- *Forestry:* Intensified afforestation, promoting agroforestry-based alternative livelihood
- systems, promoting alternative energy sources, community forest management, REDD+ initiatives and reduced mono-species plantation stands.
- *Energy:* promoting the use of alternative energy including geothermal, wind, solar and
- mini hydropower generation; and the promotion of improved cook stoves and solar systems.
- *Transport:* construction of a standard gauge rail line, improvements to the port of
- Mombasa, and road improvements and construction, including the Thika superhighway.

CONCLUSION

Social economic and environment indicators show minimal progress in addressing the effects of climate change especially over the past decade (Table 8). The annual emissions per capita (without LULUCF) gradually decreased from 1.5 tCO2e in 1996 to 1.3 tCO2e in 1998, where it stabilised until 2012. A similar trend was observed for the GHG emissions per capita including LULUCF.

The challenge of climate change is likely to compound these trends. There is increasing evidence that climate change is directly affecting the social, economic and environmental status of the country. The World Bank affirms that "poverty and vulnerability to climate change remain the most critical development challenges facing Kenya."[115]

Table 8: National economic indicators

Indicator	1996	1998	2012
Population (millions)	28	28.7	41.8
Annual GHG emissions per capita (excluding LULUCF) in tCO_2	1.5	1.3	1.3
Annual GHG emissions per capita (including LULUCF) in tCO_2	2.0	1.9	1.8
Estimated share of informal sector in GDP(percentage)	6.1	8.2	25
Relevant area (square kilometres)	582,646	582,646	582,646
Share of manufacturing industry in GDP (percentage)	13.8	16	8.9
Share of services in GDP (percentage)	59	60.2	48
Share of agriculture in GDP (percentage)	25	26	26
Land area used for agricultural purposes (million square kilometres)	52,047	52,047	52,047
Urban population as percentage of total	29	33.6	32 (2012)
Livestock population (000)	29,961	29,961	67,454
Forest area (square kilometres)	20,310	20,310	20,509 (2010)
Population in national absolute poverty (percentage)	48	48.02	46
Life expectancy at birth (years)	59.9 (1989)	59.5 (1989)	60.37 (2011)
Literacy rate (percentage)	73.4	78	74 (2007)

Sources: 1st NC; Economic Report 2013; 2nd MTP; NCCAP; State of Environment Report 2009; Planning Commission, 2007; Kenya National Human Development Report 2013

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CHAPTER 2

Kenya National Greenhouse Gas Inventory

TABLE OF CONTENTS

INTRODUCTION

All parties to the United Nations Framework Convention on Climate Change (UNFCCC) are required to update and report periodically on their inventory of anthropogenic emissions and removals of greenhouse gases (GHGs). In October 2002, Kenya submitted their first inventory with Kenya's First National Communication (FNC). The FNC inventory was prepared for the reference year 1994 in compliance with Articles 4 and 12 of the UNFCCC and in accordance with the Intergovernmental Panel on Climate Change (IPCC) Guidelines of 1996.

This chapter presents Kenya's greenhouse gas (GHG) emissions and removals by sinks for the year 2000, as well as additional years between 1995 and 2010 in accordance with the recommendation of the Intergovernmental Panel on Climate Change (IPCC). The greenhouse gas Inventory was conducted on an individual sector basis for the Energy; Industrial Processes; Solvent and Product Use; Agriculture; Land Use, Land-Use Change and Forestry (LULUCF); and Waste Sectors. The greenhouse gases included are Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O) and partially fluorinated hydrocarbons (HFCs) not covered under the Montreal Protocol. Indirect greenhouse gases including Non-Methane Volatile Organic Compounds (NMVOC), Carbon Monoxide (CO) Nitrogen Oxides (NOx) and Sulphur Dioxide (SO_2) are also reported as they have an important influence on chemical reactions in the atmosphere.

The IPCC *Revised 1996 Guidelines for National Greenhouse Gas Inventories* (Volumes 1, 2 and 3) and the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* were used as the basis to undertake the necessary calculations on GHG Emissions and Removals. The use of these IPCC Guidelines for all years fulfils the objective of the Conference of the Parties for the use of comparable methodologies. In accordance with the Guidelines, CO_2 emissions from International Bunkers and burning of biomass are not included in the national totals, but are reported separately as Memo Items in the Inventory. Complete documentation of methods, activity data and emission factors along with references of all data sources are reported in Kenya's National GHG Inventory Report 2010.

The calculation of emissions was assisted using UNFCCC's Non-Annex I National Greenhouse Gas Inventory Software (version 1.3.2). Annex A of the SNC presents the standard reporting tables for the years 2000, 2005 and 2010.

The chapter starts with energy sector for which the methodology, the activity data, the GHG emissions and the indirect GHG emissions are discussed. The other sectors follow with discussions under the same topics after which, the inventory gaps, needs and recommendations are presented. The chapter then analyses the key sources, uncertainty and improvements between the FNC and the SNC. It concludes with a summary of the GHG emissions and removals.

SUMMARY OF GREENHOUSE GAS EMISSIONS AND REMOVALS

This section provides an overall summary of greenhouse gas emissions for Kenya between 1995 and 2010. Greenhouse gas emissions are expressed as CO_2e (Carbon Dioxide Equivalent) by IPCC sectors. The carbon dioxide equivalent is calculated using the 100 year global warming potentials for specific gases that are identified for use with the *Revised 1996 IPCC Guidelines*.

Figure 26 and Figure 27 indicates the relative contribution of the four main greenhouse gases (i.e., CO_2, CH_4, N_2O and HFCs) to total emissions for each of the inventory years 1995, 2000, 2005 and 2010.

Figure 26: Total Greenhouse Gas Emissions expressed in CO_2e Excluding LULUCF (Gg)

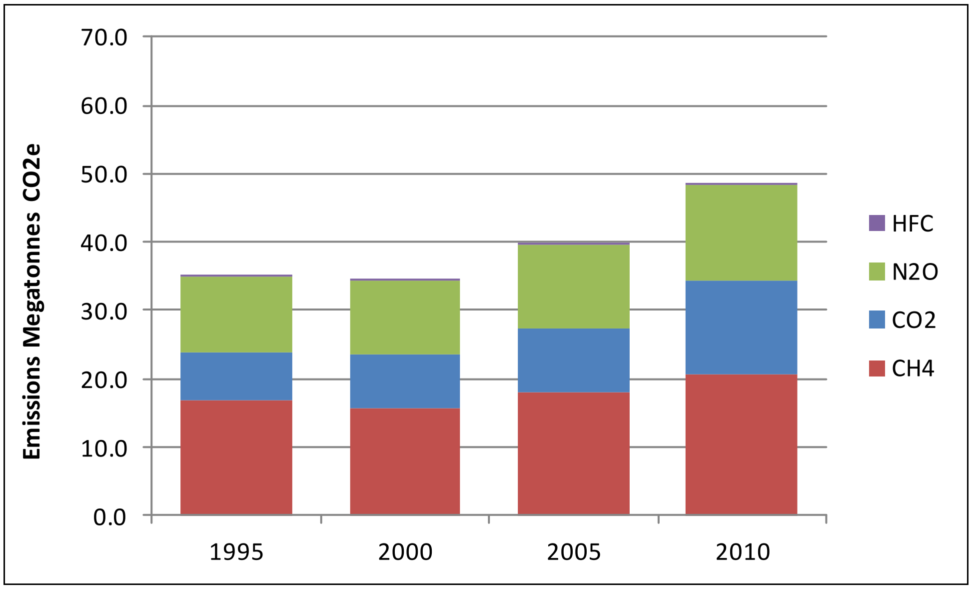
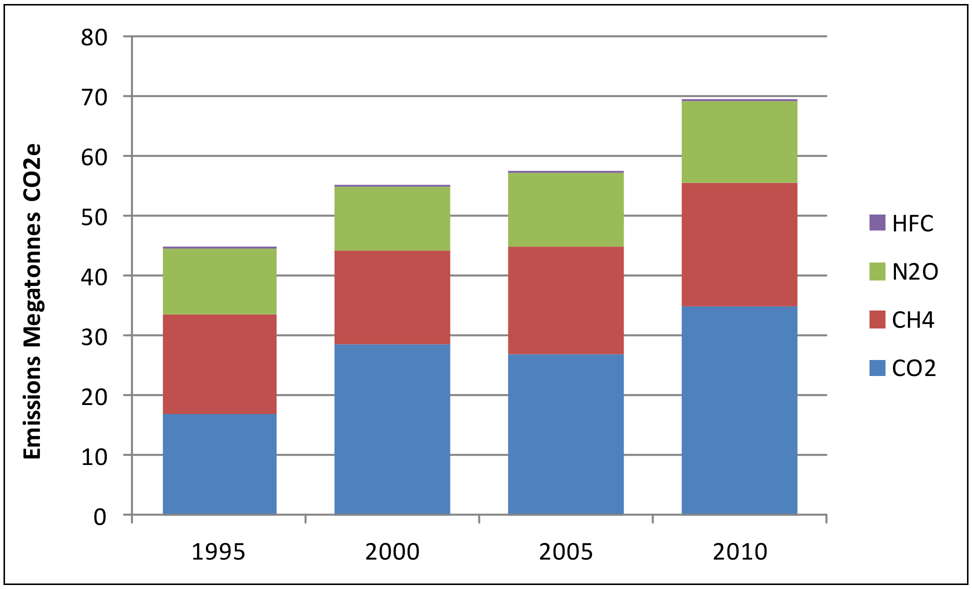


Figure 27: Total Greenhouse Gas Emissions expressed in CO_2e Including LULUCF (Gg)



Overall greenhouse gas emissions in Kenya have increased over the past fifteen years but not at a rate above the average economic growth of 3.5% (World Bank, 2014). Average annual growth in emissions excluding LULUCF was 2.2% per year, with LULUCF it was 3.0% per year.

Total CO_2e emissions for the year 2010 are estimated to be 48.4 megatons (Mt) without the contribution from LULUCF. This is an

increase from 1995 of 13.5 Mt or 38%. With the LULUCF sector, total CO_2e emissions rise to 69.5 Mt in 2010, an increase from 1995 of 25 Mt or 56%. Emission growth is primarily driven by increased demand for fossil fuels in the energy sector and by increased emissions in the LULUCF sector. Energy emissions grew at an average rate of 4.1% per year while LULUCF emissions grew at an average rate of 5.3% per year between 1995 and 2010. Agriculture emissions grew much more slowly at an average rate of 1.3% per year. Waste and industrial process emissions account for less than 6% of overall emissions and grew at an average annual rate of 2.3% and 6.1% respectively between 1995 and 2010.

Trends in total CO_2e emissions for each IPCC category for the complete time series 1995 to 2010 are shown in Figure 28 excluding the LULUCF sector. Figure 29 identifies the emissions profile with the LULUCF sector.

Figure 28: Greenhouse Gas Emissions in $MtCO_2e$ excluding LULUCF (1995-2010)

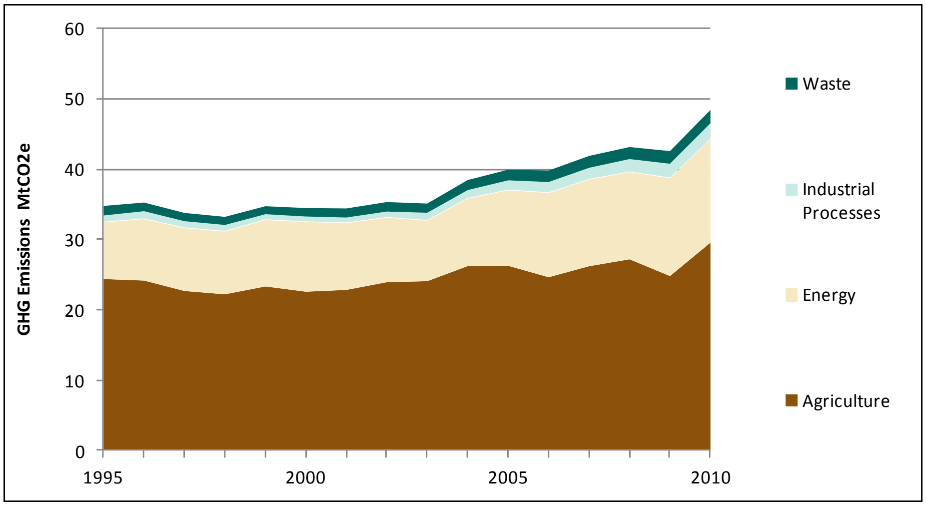
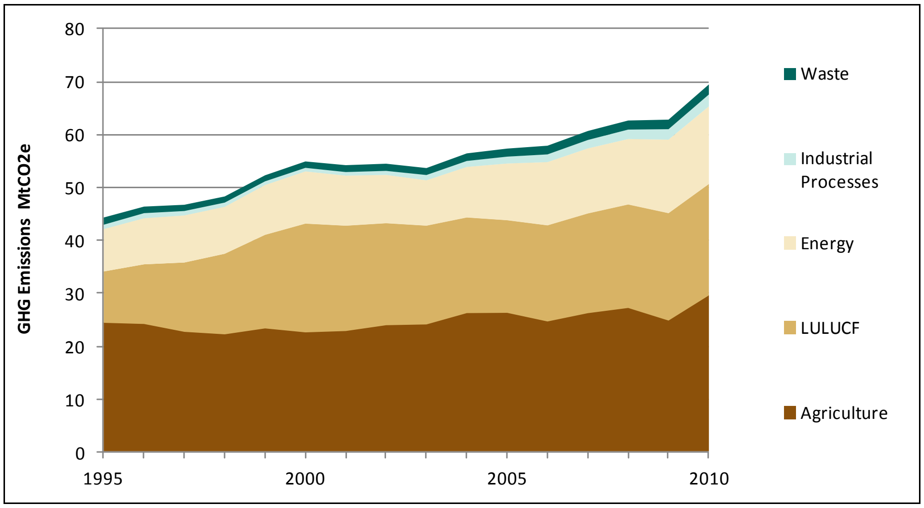


Figure 29: Greenhouse Gas Emissions in $MtCO_2e$ including LULUCF (1995-2010



Greenhouse gas emission contributions by sector and greenhouse gas are summarized in Table 10 for the year 2010. The percent share of emissions by sector is shown in the last column of the table. Detailed results by sector and source categories for each of the 1995, 2000, 2005 and 2010 inventories are provided in the standard reporting tables in Annex A.

Table 1: Summary of Greenhouse Gas Emissions and Removals in 2010 by Sector (Gg)

Sector	Emissions (Gg)					Percent Share (%)
	CO_2	CH_4	N_2O	HFC	Total in CO_2e	
Energy	11,755	109	2.23	-	14,735	30.4%
Industrial Processes	2,127	-	-	0.027	2,210	4.6%
Agriculture	-	815	40.2	-	29,577	61.1%
Waste	8.3	58.4	2.14	-	1,898	3.9%
Excluding LULUCF	**13,890**	**982**	**44.6**	**0.027**	**48,421**	**100%**
LULUCF	21,090	2.7	0.03	-	21,156	30.4%
Total Emissions and Removals	**34,980**	**985**	**44.6**	**0.027**	**69,577**	**100%**

GREENHOUSE GAS EMISSIONS BY SECTOR

Energy Sector

The Energy sector includes direct and indirect greenhouse gas emissions from oxidation of carbon contained in fossil fuels during combustion, whether when generating other forms of energy, such as electricity, or in final consumption. In the case of biomass fuels (firewood, charcoal and agricultural residues), CO_2 emissions are not accounted for in total energy sector emissions. Renewable fuels do not generate net emissions and emissions associated with the non-renewable part are included in the Land-Use Change and Forestry sector.

CO_2 emissions from combustion of fuels supplied for international water-borne navigation and international aviation (the so-called bunker fuels) are reported in accordance with Decision 17/CP.8, but not accounted for in total energy sector emissions.

The Energy sector also includes fugitive emissions from fossil fuel production, transportation and processing. In Kenya's case this includes emissions from the refining of crude oil into petroleum products, as well as, NMVOC emission from the storage and handling of crude oil.

Kenya did not have primary fossil fuel production before 2010 but has had an active refinery that manufacturers secondary petroleum products from imported crude. Additional fuels for consumption are imported including coal from South Africa. Demand for petroleum fuels has steadily increased since 2000 at an average annual rate of 3.4%. The highest growth in demand was related to the transportation sector. Electricity generation has also grown at a similar pace over the same timeframe and renewable resources such as hydro and geothermal that are not estimated to generate significant greenhouse gas emissions represent an average of about 70% of total generation between 2000 and 2010. However, the electricity generation mix can fluctuate as hydro generation has varied substantially in recent years due to unreliable water levels.

The national consumption of fossil and biomass fuels is identified in Table 11. Data on fossil fuels was provided primarily by the Ministry of Energy. Estimates of biomass consumption were based on a number of different studies and are consistent with an *Integrated Assessment of the Energy Policy* conducted by Kamfor Consultants completed in 2006.

Table 2: Domestic Consumption of Fuels (1000's tonnes of product) (1995-2010)

Type	Fuel	2003	2004	2005	2006	2007	2008	2009	2010
Primary Fossil Fuels[1]	Crude Oil	1,382.6	2,043.8	1,774.0	1,643.2	1,598.7	1,687.7	1,610.1	1,551.5
	Bit. Coal[3]	92.4	108	89.3	119.7	109.5	108.8	94.6	165.2
Secondary Fossil Fuels[1]	LPG	40.9	41.7	49.4	64.6	77.4	84.4	74.6	87.8
	Gasoline	327.9	326.4	333.7	358.2	367.1	381.3	461.7	599.2
	Aviation Gasoline	1.5	1.8	2	2	2.2	2.5	1.4	2.5
	Jet Kerosene	487.3	521.1	559.1	593.3	638.5	559.2	570.9	539.6
	Illuminating Kerosene	190	236.1	307	279.2	265.2	244.7	332.8	316
	Light diesel oil	649.6	789.4	892.4	1,035.6	1,116.5	1,141.1	1,416.1	1,517.3
	Heavy diesel oil	24.4	25.2	25.5	40.7	40.1	30	23.9	25
	Fuel Oil	407	432.8	546.7	664.6	614.8	690	729.4	680.3
	Refinery Usage	64.4	80.6	81.3	93.3	96.5	91.3	92.4	101.4
	Bitumen	10.7	6.5	20.4	17.4	16.6	12.4	0.3	15.9
	Additives	0.4	0.5	0.8	24.3	40.5	58.6	78.8	82.3
	Lubricants [3]	28.1	32.1	27.2	34.6	29.1	28.8	23.3	27.5
Biomass Fuels [5]	Fuelwood	11,738	11,680	11,700	11,719	11,739	11,759	11,778	11,798
	Charcoal	1,844	1,800	1,837	1,876	1,915	1,954	1,995	2,036
	Agricultural Residues	3,767	4,397	4,545	4,698	4,857	5,021	5,190	5,366
Type	**Fuel**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Primary Fuels	Crude Oil	1680.3	1412.9	1833.7	2157.7	1132.6	2,452.3	1,965.6	1,493.4
	Bit. Coal[4]	96.8	89.2	91.5	73.2	71.5	66.1	66.1	98.6
Secondary Fuels[1]	LPG	31.2	31.2	30.7	31.3	32.2	33.4	35.5	40.5
	Gasoline	378.7	399.3	390.6	395.8	384.6	365.7	374.3	365.8
	Aviation Gasoline	5.7	4.6	4.1	3.2	2.5	2.2	2.4	1.8
	Jet Kerosene	433.7	444.6	431.9	419.4	418.7	432.2	417.3	470.2
	Illuminating Kerosene	243.1	253.8	267.6	318.2	406.8	383.7	306.1	273.6
	Light diesel oil	603.1	646.3	615.9	607.5	601.7	712.8	663.7	627.3
	Heavy diesel oil	23.5	26.6	47.6	26.4	25.4	28.1	27.7	28
	Fuel Oil	347.5	424.2	386.9	397.3	439.4	490	558.1	498.7
	Refinery Use-age	92.7	102.8	93.6	94.1	90.2	96.3	81.3	77.4
	Bitumen	12.3	12.3	13.7	18.9	23.6	21.5	22.3	16.4
	Additives	6.0	4.8	2.7	0.6	0.6	0.8	0.6	0.4
	Lubricants [3]	13.3	15.1	16.1	17.9	19.9	22.5	23.3	25.1
Biomass Fuels [5]	Fuelwood	10,884	11,610	12,336	12,193	12,052	11,913	11,854	11,796
	Charcoal	1,724	2,026	2,328	2,206	2,090	1,981	1,934	1,888
	Agricultural Residues	1,138	1,178	1,219	1,522	1,899	2,370	2,766	3,228

Sources: [1] Ministry of Energy and Petroleum. Economic Survey 2000 to 2011. Kenya National Bureau of Statistics.

[2] Biomass estimates derived from Ministry of Energy (2002). Study on Kenya's Energy Demand, Supply and Policy Strategy for Households, Small scale Industries and Service Establishments. Kamfor Consultants, Nairobi, Kenya and UNEP (2006). Kenya: Integrated assessment of the Energy Policy With focus on the transport and household

energy sectors

1 Lubricants from 2004 to 2010 from Petroleum Institute of East Africa (PIEA) website. Kenya Petroleum Sales Data. Accessed January 14, 2015 at http://www.petroleum.co.ke/index.php?option=com_content&view=article&id=48&Itemid=112. Lubricants before 2004 based on fraction in 2004 and changes in transportation fuel consumption.

Notes: [4] Bituminous Coal values are in 1000's Tonnes Oil Equivalent
[5] Biomass fuels are reported in 1000's of tonnes of dry matter (dm).

In order to estimate consumption by sector an analysis was conducted to determine fuel consumption that relate to the defined IPCC source categories (energy industries, manufacturing industries and construction, transport, commercial/institutional, residential and agriculture, forestry and fishing). Activity data provided by the Ministry of Energy & Petroleum in Table 12 was the basis of the allocation of secondary fossil fuel consumption by different sectors. Table 3, Table 4 and Table 5 present combustion and fugitive emissions for CO_2, CH_4 and N_2O based on the sectoral approach.

Table 3: Sectoral Energy Consumption (1000's of tonnes of product)

Fuel	2003	2004	2005	2006	2007	2008	2009	2010
Agriculture	57	58.1	35.7	34.8	56.5	37.1	26.3	33.9
Retail Pump outlets and road transport	1,061.1	1,269.0	1,344.5	1,542.4	1,570.4	1,609.3	2,054.5	2,362.5
Rail transport	24.2	20.8	17.9	20.5	16.4	13.5	8.5	0.2
Tourism	8.4	8.5	17.1	8.9	11.6	8.1	8.3	7.4
Marine (excluding natural forces)	0.5	7.5	1.3	0.9	0.7	0.8	7.3	16.1
Aviation (excluding government)	486.4	520.9	549.4	588	635.7	567	592.4	625.1
Power generation	151.5	204.2	319.3	386.6	399.9	360.4	373.2	300.3
Industrial, Commercial and others	280.3	291.2	362.4	405.9	408.8	482	570	414.6
Government	11.9	39.9	57.8	31.2	8.3	12.5	18.9	15.8
Balancing Item	47.4	45.4	10.4	19	13.5	42.3	47.5	10.2
Total	**2,128.7**	**2,374.6**	**2,715.9**	**3,038.2**	**3,121.8**	**3,133.0**	**3,610.8**	**3,765.7**

Source: Ministry of Energy and Petroleum (2014). Personal Communication provided by Ministry of Energy and Petroleum on 11-Aug-2014 in response to energy data request.

Table 4: Total Energy CO_2 Emissions (Gg) Sectoral Approach

Source	Energy Sub-Sector	CO_2 Emissions (Gg)				Change 1995-2010
		1995	2000	2005	2010	
Combustion Emissions	1 Energy Industries	773	978	1,188	1,253	+62%
	2 Manufacturing Industries & Construction	876	948	1,117	1,604	+62%
	3.a Civil Aviation	360	348	447	433	+20%
	3.b Road Transportation	3,069	3,357	3,821	6,830	+123%
	3.c Railways	10	11	14	24	+140%
	3.d Navigation	47	56	51	50	+6.4%
	4.a Commercial/Institutional	279	402	399	496	+78%
	4.b Residential	685	1,059	878	952	+39%
	4.c Agriculture/Forestry/Fishing	51	68	79	111	+118%
Fugitive Emissions	**Refining and Storage**	**-**	**-**	**-**	-	0%
TOTAL ENERGY EMISSIONS		**6,149**	**7,228**	**7,994**	**11,755**	**+91%**

Table 5: Total Energy CH_4 Emissions (Gg) Sectoral Approach

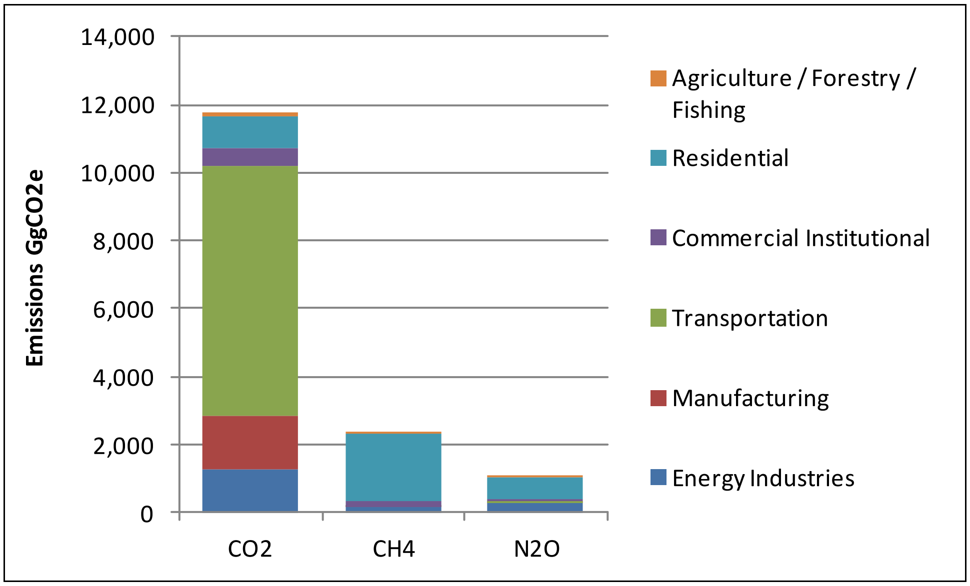
Source	Energy Sub-Sector	CH_4 Emissions (Gg)				Change 1995-2010
		1995	2000	2005	2010	
Combustion Emissions	1 Energy Industries	5	6	6	6	+15%
	2 Manufacturing Industries & Construction	0	0	0	1	+62%
	3.a Civil Aviation	0	0	0	0	+20%
	3.b Road Transportation	0	0	0	1	+84%
	3.c Railways	0	0	0	0	+152%
	3.d Navigation	0	0	0	0	+6%
	4.a Commercial/Institutional	6	7	7	7	+15%
	4.b Residential	66	79	81	168	+154%
	4.c Agriculture/Forestry/Fishing	0	0	0	0	0%
Fugitive Emissions	**Refining and Storage**	**0.06**	**0.09**	**0.07**	**0.06**	**0%**
TOTAL ENERGY EMISSIONS		**78**	**93**	**95**	**109**	**40%**

Table 6: Total Energy N_2O Emissions (Gg) Sectoral Approach

Source	Energy Sub-Sector	N_2O Emissions (Gg)				Change 1995-2010
		1995	2000	2005	2010	
Combustion Emissions	1 Energy Industries	0.73	0.81	0.78	0.84	**+15%**
	2 Manufacturing Industries & Construction	0.05	0.05	0.05	0.11	**+62%**
	3.a Civil Aviation	0.00	0.00	0.00	0.00	+20%
	3.b Road Transportation	0.03	0.03	0.03	0.05	+114%
	3.c Railways	0.00	0.00	0.00	0.00	+151%
	3.d Navigation	0.00	0.00	0.00	0.00	+6%
	4.a Commercial/Institutional	0.08	0.09	0.09	0.10	+15%
	4.b Residential	0.80	0.96	1.00	1.17	+42%
	4.c Agriculture/Forestry/Fishing	0.00	0.00	0.00	0.00	+117%
Fugitive Emissions	**Refining and Storage**	**-**	**-**	**-**	**-**	**0%**
TOTAL ENERGY EMISSIONS		**1.69**	**1.96**	**1.96**	**2.23**	**32%**

The road transportation sub-sector generates the largest proportion of CO_2 emissions (58%). CH4 and N_2O emissions are largest for the residential sub-sector accounting for more than half of these emissions. Figure 30 illustrates the contribution of emissions from different energy sub-sectors for each of the greenhouse gases. Emissions are expressed in carbon dioxide equivalent (CO_2e) so that the relative importance of emissions of CO_2, CH_4 and N_2O can be easily compared.

Figure 30: Energy Sector Greenhouse Gas Emissions in 2010 expressed in CO_2e (Gg)



Emissions from international bunker fuels are summarized in Table 6.

Indirect greenhouse gas emissions are presented in Table 7.

Table 7: Total GHG Emissions from Bunker Fuels in (Gg)

Sector / Fuel	Greenhouse Gas	Emissions from Bunker Fuels (Gg)				Change 1995-2010
		1995	2000	2005	2010	
Aviation Jet Kerosene	CO_2	1,027	1,023	1,324	1,277	+24%
	CH_4	0.007	0.007	0.009	0.009	+29%
	N_2O	0.009	0.009	0.011	0.011	+22%

Table 8: Total Energy Indirect Emissions (Gg) Sectoral Approach

Indirect Greenhouse Gas Emission	Emissions (Gg)				Change 2000-2010
	1995	2000	2005	2010	
Nitrogen Oxides (NO_X)	84	97	103	139	+65.5%
Carbon Monoxide (CO)	1,744	2,027	2,028	2,392	+37%
Non methane volatile organic compounds (NMVOC)	172	199	203	252	+47%
Sulphur Dioxide (SO_2)	106	124	125	144	+36%

Industrial Processes Sector

The Industrial Processes Sector includes anthropogenic emissions from production processes in industry that are not a result from fuel combustion, since the latter are reported in the Energy sector.

The sub-sectors of importance in Kenya include mineral products, pulp and paper, food and beverage and consumption of HFCs. Other industrial processes sub-sectors such as chemical industry and metal production were determined to have no significant production activities leading to greenhouse gas emissions.

Direct greenhouse gas emissions of CO_2 are a result of cement production, lime production and soda ash production. HFC emissions are related to the import of HFCs into Kenya through products and through bulk imports.

Mineral production data that were used to estimate emissions are presented in Table 18.

Table 9: Domestic Industrial Production for Select Minerals (tonnes of product) (1995-2010)

Mineral Production	2003	2004	2005	2006	2007	2008	2009	2010
Cement	1,658,000	1,873,300	2,123,200	2,405,900	2,615,100	2,829,600	3,320,300	3,709,800
Lime [2]	1,400	1,400	50,000	50,000	50,000	50,000	45,000	47,000
Soda Ash	352,560	353,835	360,161	374,210	386,598	513,415	404,904	473,689
Bitumen	10,700	6,500	20,400	17,400	16,600	12,400	300	15,900
Asphalt [3]	107,000	65,000	204,000	174,00	166,00	124,000	3,000	159,000
Mineral Production	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Cement	1,566,000	1,816,000	1,506,000	1,426,000	1,204,000	1,146,000	1,085,000	1,229,000
Lime	12,000	15,000	15,000	16,000	4,473	1,282	1,100	1,100
Soda Ash	218,450	223,000	257,640	242,910	245,680	238,190	297,780	304,110
Bitumen	26,200	12,700	12,000	19,800	20,300	21,500	22,300	16,400
Asphalt	262,000	127,000	120,000	198,000	203,000	215,000	223,00	164,000

Sources: [1] Kenya National Bureau of Statistics. Economic Reviews 2000 to 2014.

[2] Lime data was gathered from US Geological Survey Minerals Yearbook 2002 and from Kenya Country profile accessed on August 12, 2014 at http://minerals.usgs.gov/minerals/pubs/country/2009/myb3-2009-ke.pdf.

3 Asphalt production is based on assumption that there is 10% bitumen content in asphalt produced and that all Bitumen is used in asphalt production for road paving.

Kenya does not manufacture HFCs; however, emissions from the consumption of HFCs is related to bulk imports of HFC gases that are used to recharge refrigeration and air conditioning products, as well as the stock of HFCs that- is imported within refrigeration and air conditioning, aerosols and other products. Emissions are estimated assuming that they are equal to the amount of HFCs that are imported in the country. An assumption is made that there is no destruction of HFCs. Total HFC bulk imports between 2009 and 2012 are summarized in Table 10.

Table 10: HFC Imports in kg (2009 - 2012)

HFC Type	2009	2010	2011	2012	Average per capita (g / capita)
HFC 134A	5,461	4,080	28,045	1,300	0.249
HFC 404A	2,233	1,655	15,457	3,260	0.145
HFC 407c	791	9,244	226	1,610	0.076
HFC 410a	56	-	2,041	1,725	0.024

Source: NEMA. Spreadsheets of Import and export ODS Data provided by NEMA Jan 13, 2015.

Note: Per capita estimates for years between 2000 and 2009 are based on the average import per capita between 2009 and 2011. Per capita estimates are used for 2010 estimates and then extrapolated to 1995 assuming that imports per capita are 90% lower in 1995. This declining factor is used because before 1995 there was limited use of HFCs in air conditioning and refrigeration products.

Table 11 and Table 12 present industrial process emissions for CO_2 and HFC.

Cement production accounted for more than 80% of greenhouse gas emissions in the industrial sector based on carbon dioxide equivalent (CO_2e).

Table 11: Total Industrial Process CO_2 Emissions in 2010 (Gg)

Source	Sub-Sector	CO_2 Emissions (Gg)				Change 1995-2010
		1995	2000	2005	2010	
Mineral Products	1 Cement Production	781	571	1,058	1,849	+137%
	2 Lime Production	9	1	38	35	+289%
	4. Soda Ash Production and Use	112	122	184	243	+117%
TOTAL INDUSTRIAL PROCESS EMISSIONS		**901**	**694**	**1,280**	**2,127**	**+136%**

Table 12: Total Industrial Process HFCs Emissions in 2010 (Gg)

Source	Sub-Sector	HFC Emissions (Gg)				Change 1995-2010
		1995	2000	2005	2010	
Consumption of HFCs	1 Bulk Import Emissions	0.0014	0.0062	0.0124	0.0202	+1340%
	2 Product Emissions	0.0024	0.0039	0.0148	0.0339	+1310%
TOTAL INDUSTRIAL PROCESS EMISSIONS		**0.0038**	**0.0107**	**0.0271**	**0.0541**	**+1320%**

Note: The estimated average global warming potential of all HFC species for product emissions is 1,540. Product emissions are assumed to be all HFC134a which corresponds to a global warming potential of 1,300.

Indirect greenhouse gas emissions of NMVOC and SO_2 are the result of road paving with asphalt and food and beverage production. Table 13 and Table 14 identify these emissions over time.

Table 13: Total Industrial Process NMVOC Emissions (Gg)

Source	Sub-Sector	NMVOC Emissions (Gg)				Change 1995-2010
		1995	2000	2005	2010	
Mineral Products	6 Road Paving with Asphalt	84	69	65	51	-39%
Other Production	2. Food and Drink	160	254	168	229	+43%
TOTAL INDUSTRIAL PROCESS EMISSIONS		**244**	**323**	**233**	**280**	**+15%**

Table 14: Total Industrial Process SO_2 Emissions in (Gg)

Source	Sub-Sector	SO_2 Emissions (Gg)				Change 1995-2010
		1995	2000	2005	2010	
Mineral Products	1. Cement Production	0.47	0.34	0.64	1.11	+136%
Other Production	1. Pulp and Paper	1.98	1.98	0.57	0.54	-73%
TOTAL INDUSTRIAL PROCESS EMISSIONS		**2.45**	**2.32**	**1.21**	**1.65**	**-33%**

Solvent and Other Product Use

The use of solvents and certain products can lead to significant sources of emissions of non-methane volatile organic compounds (NMVOCs). Estimations of NMVOC emissions were generated for products where import data was available for paints. NMVOC emissions from household product use (e.g., personal care products, adhesives, automotive products) were also estimated based on typical use of these products estimated in other countries.

Indirect greenhouse gas emissions of NMVOC are estimated for the application of paints and for domestic household product use. Table 15 identifies these emissions over time. Emissions related to other solvent and product use categories such as degreasing, dry-cleaning and chemical products were not estimated due to insufficient data availability.

Table 15: Total Solvent and Other Product Use NMVOC Emissions (Gg)

Source	Sub-Sector	NMVOC Emissions (Gg)				Change 1995-2010
		1995	2000	2005	2010	
Solvent and Other Product Use	A Paint Application	1.07	1.10	2.43	3.05	+186%
	D. Household Product Use	1.48	1.69	1.94	2.21	+49%
TOTAL SOLVENT AND OTHER PRODUCT USE EMISSIONS		**2.55**	**2.79**	**4.37**	**5.26**	**+106%**

Agriculture

As an overall percentage of Kenya's Gross Domestic Product (GDP), the agriculture sector has contracted between 1995 and 2010. Agriculture represented 36% of GDP in 1995 and 24% in 2010. Despite Agriculture's declining proportion of the overall economic activity in Kenya, livestock numbers and crop production have increased. The cattle population has increased marginally by 8% in that time, but other livestock populations including sheep, goat and camels have increased by more than 40%. Production of wheat and maize crops have increased by 64% and 103%, respectively.

Agricultural activities contribute to greenhouse gas emissions through a variety of different processes. CH_4 and N_2O are the only significant greenhouse gases emitted by the Agriculture Sector. CH_4 emissions arise from enteric fermentation and manure management associated with livestock, as well as, rice cultivation and prescribed burning of savannah and crop residues. N_2O Emissions arise primarily from synthetic and natural fertilizers (i.e., manure, crop residues) applied to cultivated soils and are based on IPCC assumptions regarding atmospheric deposition and leaching from soils. Other N_2O emission sources include rice cultivation and prescribed burning of savannah and crop residues and are based on land areas or production quantities combined with default IPCC emission factors. Populations of livestock were provided by the State Department of Livestock, Ministry of Agriculture Livestock and Fisheries and are presented in Table 16. Crop production data is presented in Table 17 below. The amount of synthetic fertilizers applied to agricultural soils is presented in Table 18. Table 19 and Table 20 present agricultural emissions for CH_4 and N_2O.

Table 16: Historic livestock population (head of livestock) (1995-2010)

	1995[(2)]	1996[(2)]	1997[(2)]	1998[(2)]	1999	2000	2001	2002
Dairy Cattle	3,449,951	3,391,302	3,054,985	3,027,597	3,101,506	3,369,417	3,288,327	3,505,678
Non-Dairy Cattle	9,550,049	9,387,698	8,456,715	8,380,903	8,585,494	8,075,377	8,187,534	8,434,299
Sheep	8,208,000	7,657,758	7,616,194	7,043,582	8,521,111	7,939,546	7,609,086	9,288,633
Goats	10,396,000	10,229,985	10,856,261	9,674,381	10,967,320	10,004,367	10,804,245	11,319,430
Camels	787,700	795,600	791,600	799,500	845,561	717,524	819,123	846,555
Donkeys	314,000	425,000	358,000	339,000	352,134	416,136	478,818	521,289
Swine	230,600	302,042	313,100	358,462	317,115	310,647	332,512	336,161
Poultry	27,296,000	28,332,000	29,296,000	29,718,000	26,446,153	26,291,238	27,030,572	27,871,224
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Dairy Cattle	3,473,421	3,448,270	3,497,563	3,298,347	3,579,437	3,403,346	3,310,898	3,673,212
Non-Dairy Cattle	9,057,903	9,574,142	9,521,486	9,117,924	9,320,907	10,119,119	8,238,117	10,307,309
Sheep	8,157,048	10,298,464	10,033,881	8,276,848	9,428,666	9,907,304	9,261,531	10,835,364
Goats	11,945,492	13,390,504	13,882,605	10,210,434	13,966,023	14,478,257	13,871,840	18,178,379
Camels	895,094	1,193,618	931,308	1,058,330	1,006,337	1,132,476	1,163,090	1,535,473
Donkeys	423,980	515,045	716,614	785,071	631,895	786,804	751,661	989,389
Swine	415,194	379,797	320,020	318,547	304,161	330,020	272,105	342,585
Poultry	28,282,792	25,905,570	26,856,693	27,771,847	27,495,209	29,614,970	27,538,493	30,207,795

Source: [1] State Department of Livestock, Ministry of Agriculture Livestock and Fisheries. Personal Communication by email on 20-Aug-2014. Summaries of Livestock Population Statistics (excel spreadsheet).

[2] FAOSTAT Database. Food and Agriculture Organization of the United Nations. Accessed 12-Aug-2014 for 1995 to 1998.

Table 17: Production quantity of Crops (1995 – 2010)

	1995	1996	1997	1998	1999	2000	2001	2002
Wheat	312,644	315,000	252,000	270,810	211,788	204,232	257,255	307,523
Rice	44,000	50,620	41,075	41,829	52,711	52,349	44,996	44,996
Maize	2,698,863	2,160,000	2,214,000	2,464,101	2,322,140	2,160,000	2,757,620	2,411,007
Sugarcane	4,550,000	4,650,000	4,450,000	4,661,361	4,415,781	3,941,524	3,550,792	4,501,363
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Wheat	379,034	397,005	365,696	358,061	354,249	336,688	219,301	511,994
Rice	40,498	49,290	57,942	64,840	47,256	21,881	42,202	44,468
Maize	2,713,561	2,454,930	2,918,157	3,247,777	2,928,793	2,369,569	2,442,823	3,464,541
Sugarcane	4,204,055	4,660,995	4,800,820	4,932,839	5,204,214	5,176,670	5,610,702	5,475,180

Source: State Department of Agriculture, Ministry of Agriculture Livestock and Fisheries. Personal communication in national stakeholder workshop for the National Climate Action Plan held 7-Nov-2014 in Nairobi.

Table 18: Consumption of Synthetic Fertilizer (t N/yr.) (1995 – 2010)

	1995	1996	1997	1998	1999	2000	2001	2002
Consumption of Synthetic Fertilizer	33,000	63,000	51,000	53,000	54,200	69,911	80,014	62,724
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Consumption of Synthetic Fertilizer	68.061	64,724	72,514	77,667	79,441	73,071	67,372	70,788

Source: FAOSTAT Database. Food and Agriculture Organization of the United Nations. Accessed 16-Aug-2014

Table 19: Total Agriculture CH4 Emissions (Gg)

Source	CH_4 Emissions (Gg)				Change 1995-2010
	1995	2000	2005	2010	
A. Enteric Fermentation	567	512	605	692	**+22%**
B. Manure Management	20	18	22	26	**+30%**
C. Rice Cultivation	7	9	11	13	**+86%**
E. Prescribed Burning of Savannas	79	79	79	79	**0%**
F. Field Burning of Agriculture Residues	4	3	4	5	**+25%**
TOTAL AGRICULTURE EMISSIONS	**677**	**622**	**721**	**815**	**+20%**

Table 20: Total Agriculture N_2O Emissions (Gg)

Source	N_2O Emissions (Gg)				Change 1995-2010
	1995	2000	2005	2010	
B. Manure Management	0.62	0.59	0.67	0.73	**+18%**
D. Agricultural Soils	30.88	29.01	34.17	38.36	**+24%**
E. Prescribed Burning of Savannas	0.98	0.98	0.98	0.98	**0%**
F. Field Burning of Agriculture Residues	0.08	0.06	0.08	0.10	**+25%**
TOTAL AGRICULTURE EMISSIONS	**32.5**	**37.7**	**35.9**	**40.2**	**+24%**

The enteric fermentation sub-sector generates the largest proportion of CH_4 emissions (85%). Enteric fermentation is the production of methane by herbivores as part of the digestive process where carbohydrates are broken down by micro-organisms in simple molecules for absorption into the bloodstream.

N_2O emissions are largest for the Agricultural Soils sub-sector accounting for 95% of these emissions. Figure 31 illustrates the contribution of emissions from different agricultural sub-sectors for each of the greenhouse gases. Emissions are expressed in carbon dioxide equivalent (CO_2e) so that the relative importance of emissions of CH_4 and N_2O can be easily compared.

Indirect greenhouse gas emissions of NOX and CO are the result of prescribed burning of savannahs and field burning of agricultural residues. Table 20 and Table 21 identify these emissions over time.

Figure 31: Agriculture Sector Greenhouse Gas Emissions in 2010 expressed in CO_2e (Gg)

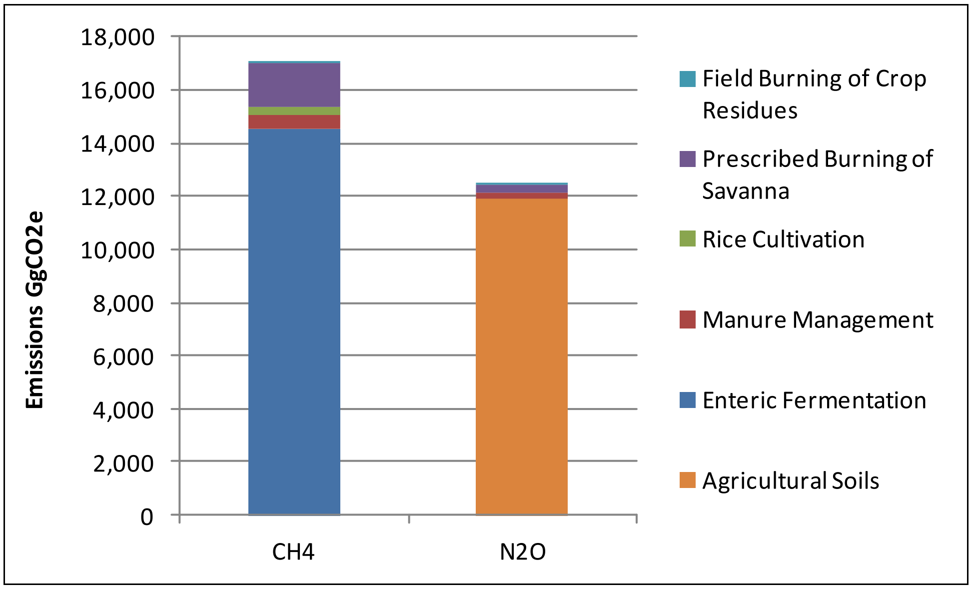


Table 21: Total Agriculture NO_X Emissions (Gg)

Source	NOx Emissions (Gg)				Change 1995-2010
	1995	2000	2005	2010	
E. Prescribed Burning of Savannahs	35.5	35.5	35.5	35.5	**0%**
F. Field Burning of Agriculture Residues	2.7	2.2	3.0	3.5	**+30%**
TOTAL AGRICULTURE EMISSIONS	**38.2**	**37.7**	**38.5**	**39.0**	**+2%**

Table 22: Total Agriculture CO Emissions (Gg)

Source	CO Emissions (Gg)				Change 1995-2010
	1995	2000	2005	2010	
E. Prescribed Burning of Savannahs	2,083	2,083	2,083	2,083	**0%**
F. Field Burning of Agriculture Residues	76	62	83	99	**+30%**
TOTAL AGRICULTURE EMISSIONS	**2,159**	**2,145**	**2,166**	**2,182**	**+1%**

Land-Use, Land Use Change and Forestry

The LULUCF sector includes estimates of emissions and removals of greenhouse gases associated with increases or decreases of carbon in living biomass as land-use changes occur over time, for example, in the conversion of a forest area to cropland, or when establishing new forest lands through reforestation or afforestation.

As recommended by the *2003 Good Practice Guidance for LULUCF*, estimations are provided for emissions and removals from land that did not undergo any land-use change, reflecting increase or loss of carbon under the same type of use (e.g. carbon increase in secondary vegetation or even in primary vegetation in managed areas), as well as, conversions of land between the six IPCC land-use categories (Forestland, Cropland, Grasslands, Wetlands, Settlements and Other Lands).

Kenya's forest cover has been substantially reduced over the last 50 years and it is currently estimated that the country forest cover is less than 6%, signalling that there may be an overall downward trend in carbon biomass stocks.

The predominant gas in this sector is CO_2, but there are also emissions of other greenhouse gases such as CH_4 and N_2O from imperfect burning of wood left in the field, in case of forest conversion to other uses.

Methodology

A global land-use data approach is the basis for consistent representation of land areas. The dataset that is employed is from the Food and Agricultural Organization (FAO) of the United Nations *Global Forest Resource Assessment 2010 for Kenya*. This method is described as Approach 1 in the *2003 IPCC Good Practice Guidance for LULUCF*.

The general method for calculating fluxes of CO_2 to or from the atmosphere and biomass carbon pools is the same as outlined in the *1996 Revised IPCC Guidelines*. These fluxes are estimated using a state and transition model that parameterizes and defines changes in land-use, land-use management and disturbances like wildfire to estimate annual fluxes over a twenty year historic period between 1990 and 2010. The inventory considers all forests in Kenya as managed forest where forest management is defined as the process of planning and implementing practices for stewardship and use of the forest aimed at fulfilling relevant ecological, economic and social functions of the forest.

The carbon pools represented in the model are consistent with IPCC Guidelines and include above-ground biomass, below-ground biomass, soil organic matter and the atmosphere. More detail on the modelling is provided in Kenya's 2010 Greenhouse Gas Inventory Report.

Land Representation and Activity Data

The *FAO Global Forest Resource Assessment for Kenya* presents land-use data that has consistent representation over a twenty year time period and is complete and covers all of the land area within Kenya. Although the data is not country derived or spatially explicit it is publicly available and transparent. Land-uses identified can be mapped at a high level to the six IPCC land-use categories (forest land, cropland, grassland, wetlands, settlement and other land). Land-use types and historic areas are presented in Table 22 below.

Table 23: Areas of different land-use categories and State Classifications between 1990 and 2010

FAO Land-Use Categories	Modelling Land-Use State Classifications (IPCC Class)	Area (000 hectares)				Change in Area (000 hectares) from 1990 to 2010
		1990	2000	2005	2010	
Indigenous Closed Canopy	Forest (Forest land)	1,240	1,190	1,165	1,140	-100
Indigenous Mangroves	Mangrove (Forest land)	80	80	80	80	0
Open Woodlands	Woodland (Forest land)	2,150	2,100	2,075	2,050	-100
Plantation Forests – Public	Plant Public (Forest land)	170	134	119	1,381	-32
Plantation Forests – Private	Plant Private (Forest land)	68	78	83	94	26
Bush-land	Bushland (Grassland)	24,800	24,635	24,570	24,510	-290
Grasslands – Other Land	Grassland (Grassland)	6,438	6,291	6,210	6,210	-228
Grasslands – Other Wooded Land	Grassland (Grassland)	3,863	4,194	4,140	4,140	-137
Settlements	Settlement (Settlements)	8,256	8,192	8,152	8,202	-54
Farms	Farms (Cropland)	9,420	10,020	10,320	10,385	965
Inland Water Bodies	Other Land (Other land)	1,123	1,123	1,123	1,123	-
Total Area for Country		**58,037**	**58,037**	**58,037**	**58,037**	**-**

Source: Food and Agriculture Organization of the United Nations (2010). Global *Forest Resources Assessment 2010 Country Report Kenya*. Forestry Department. Rome.

In order to estimate annual land-use changes between 1990 and 2010 initial areas in 1990 were compared to final areas in 2010. Since the net land-use change is almost all to farms which gained 960,000 ha in 20 years, all land classes that lost area were assigned to farms with the exception of some land converted from public plantation to private plantation. A non-spatially explicit land-use change matrix as described in the *2003 IPCC Good practice Guidance for LULUCF* was developed and is presented in Table 23. Wood removals between 1990 and 2010 for fuelwood, charcoal production and commercial uses were estimated based on a number of sources identified in Table 24. Forest fire activity data are highly variable year to year, but were found on average to be approximately 9,000 ha per year between 1980 and 2011.

Table 24: Areas Land-Use Changes between 1990 and 2010 (ha)

Final \ Initial	Forest	Mangrove	Woodland	Plant Public	Plant Private	Bushland	Grassland	Settlement	Farms	Other Land	Final Area
Forest	1,140,000										1,140,000
Mangrove		80000									80,000
Woodland			2,050,000								2,050,000
Plant Public				138000							138,000
Plant Private				26,000	68,000						94,000
Bushland						24,510,000					24,510,000
Grassland							10,350,000				10,350,000
Settlement								8,202,000			8,202,000
Farms	100,000		100,000	6,000		290,000	380,000	54,000	9,420,000		10,350,000
Other Land										1,123,000	1,123,000
Initial Area	1,240,000	80,000	2,150,000	170,000	68,000	24,800,000	10,730,000	8,256,000	9,420,000	1,123,000	**58,037,000**
Net Change:	-100,000	0	-100,000	-32,000	26,000	-290,000	-380,000	-54,000	930,000	0	0
Annual Change:	**-5,000**	**0**	**-5,000**	**-1,600**	**1,300**	**-14,500**	**-19,000**	**-2,700**	**46,500**	**0**	**0**
Annual Change (%)	**-0.42%**	**0.00%**	**-0.24%**	**-1.04%**	**1.63%**	**-0.06%**	**-0.18%**	**-0.03%**	**0.47%**	**0.00%**	

Note: Land-use changes over a twenty year period are indicated in yellow cells

Table 25: Estimated Wood Removal (t dm)

Year	Wood Removal (t dm)				
	Fuelwood [2,3,4]	Charcoal Production [2,3,4]	Poles and Posts [1,4]	Paper and Paper Board [1,5]	Industrial Wood [1,4]
1990	9,389,306	9,130,148	781,800	69,169	623,133
1991	9,670,192	9,560,124	806,711	72,519	632,622
1992	9,965,015	10,017,547	832,416	76,031	642,256
1993	10,259,838	10,474,969	858,940	79,714	652,036
1994	10,571,814	10,982,708	886,309	83,575	661,966
1995	10,883,790	11,490,446	914,550	87,623	672,047
1996	11,609,895	13,505,223	944,766	91,867	682,281
1997	12,336,000	15,520,000	975,981	96,316	692,671
1998	12,193,250	14,706,504	1,008,227	100,981	703,219
1999	12,052,152	13,935,649	1,041,538	105,872	713,928
2000	11,912,686	13,205,198	1,075,950	111,000	724,800
2001	11,854,084	12,893,001	1,074,367	116,274	744,140
2002	11,795,769	12,588,184	1,072,787	121,799	763,996

2003	11,737,742	12,290,574	1,071,209	127,587	784,382
2004	11,680,000	12,000,000	1,069,633	133,649	805,312
2005	11,950,424	12,030,276	1,068,060	140,000	826,800
2006	12,227,110	12,060,628	1,066,488	146,423	845,715
2007	12,510,201	12,091,057	1,064,920	153,141	865,062
2008	12,799,847	12,121,563	1,063,353	160,166	884,852
2009	13,096,198	12,152,146	1,061,789	167,515	905,094
2010	13,399,412	12,182,806	1,060,227	175,200	925,800

Sources:

[1] **Ministry of Environment and Natural Resources (2004).** ***Kenya Forestry Master Plan*****. Nairobi.**

[2] **Ministry of Energy (2002).** ***Study on Kenya's Energy Demand, Supply and Policy Strategy for Households, Small scale Industries and Service Establishments*****. Kamfor Consultants, Nairobi, Kenya**

[3] **United Nations Environment Programme (2006).** ***Kenya: Integrated assessment of the Energy Policy With focus on the transport and household energy sectors*****. In conjunction with Ministry of Ministry for Planning and National Development.**

[4] **Ministry of Environment, Water and Natural Resources (2013).** ***Analysis of Demand and Supply of Wood Products in Kenya*****. Study carried out by Wanleys Consultancy Services. Nairobi, Kenya.**

[5] **Mbugua, D. (2006).** ***Kenya Forestry Assessment Report*****. Forest Outlook Studies in Africa.**

Greenhouse Gas Emissions

Table 25 provides a summary of CO_2 emissions or removals that relate to different land-use categories, carbon pools and IPPC Guideline LULUCF categories. Table 26 identifies LULUCF non-CO_2 emissions related to vegetation fires.

Table 26: Total LULUCF CO_2 Emissions (Gg)

Land-Use Category [3]		Carbon Pool	Sector in IPCC Guidelines [1]	Annual Change in Carbon Stocks CO_2 (Gg) [2]			
Initial Land Use	Land Use during Reporting Year			1991 to 1995	1996 to 2000	2001 to 2005	2006 to 2010
FL	FL	Above-ground	5A	4,733	9,919	9,848	12,584
		Below-ground	5A	1,613	3,517	3,354	4,237
Sub-Total For Forest Land				**6,346**	**13,437**	**13,202**	**16,821**
CL	CL	Above-ground	5A	-947	2,914	773	945
		Below-ground	5A	60	-37	-519	-458
		Soil	5D	128	127	129	128
FL	CL	Above-ground	5B	2,359	2,316	2,186	2093
		Below-ground	5B	872	858	812	780
GL	CL	Above-ground	5B	179	179	172	168
		Below-ground	5B	502	501	482	471
SL	CL	Above-ground	5D	42	41	40	39
		Below-ground	5D	10	10	10	9
Sub-Total For Cropland				**3,204**	**6,910**	**4,084**	**4,175**
GL	GL	Above-ground	5A	**47**	**57**	**59**	**40**

		Below-ground	5A	**158**	**185**	**190**	**139**
Sub-Total For Grassland				**205**	**242**	**250**	**179**
Sub-Total For Wetlands				**0**	**0**	**0**	**0**
SL	SL	Above-ground	5A	**-46**	**-19**	**-16**	**-75**
		Below-ground	5A	**-3**	**3**	**4**	**-10**
Sub-Total For Settlements				**-49**	**-15**	**-12**	**-85**
Sub-Total For Other Land				**0**	**0**	**0**	**0**
TOTAL				**9,706**	**20,573**	**17,524**	**21,090**

Notes: [1] **Headings from the IPCC Guidelines Reporting Instructions p.1.14-1.16: 5A - Changes in Forest and Other Woody Biomass Stocks; 5B - Forest and Grassland Conversion; 5C - Abandonment of Managed Lands; 5D - Emissions and Removals from Soils, and 5E - Other.**

[2] **For the purpose of reporting, it is necessary to reverse the sign so that the resulting values is expressed as (-) for removal or uptake and (+) for emissions.**

[3] **FL- Forest Land, CL-Cropland, GL-Grassland, WL-Wetland, SL-Settlement Land, OL – Other Land.**

Table 27: Total LULUCF Non-CO_2 Emissions from Vegetation Fires (Gg)

Non-CO_2 Emission	Sector in IPCC Guidelines	1995	2000	2005	2010
CH4	5E	2.77	2.71	2.77	2.70
N2O	5E	0.03	0.03	0.03	0.03

Table 26 and Table 27 identify that Kenya's LULUCF sector has been a net emitter (net loss from carbon pools) between 1990 and 2010. The average CO_2 emissions over this time period were 17.2 mega tonnes (Mt) per year. This finding is consistent with the observed loss of forest cover in Kenya over the same time period where most of the living biomass is stored. It is estimated that overall, living biomass carbon stocks declined from 829 MT of Carbon in 1990 to 760 MT of Carbon in 2010. Soil carbon stocks were estimated to decline only slightly from 3,016 MT of carbon in 1990 to 3,015 Mt of carbon in 2010.

Indirect Greenhouse Gas Emissions

Indirect greenhouse gas emissions of NO_X and CO are the result of vegetation fires. Table 27 identifies these emissions over time.

Table 28: Total LULUCF Indirect GHG Emissions from Vegetation Fires (Gg)

Indirect GHG Emissions	Sector in IPCC Guidelines	1995	2000	2005	2010
NO_X	5E	0.18	0.18	0.18	0.17
CO	5E	256.9	251.1	256.3	250

Waste

Wastes through the processes of disposal, treatment, recycling and incineration produce greenhouse gas emissions. The most important gas produced in this source category is methane (CH_4). Two major sources of this type of CH_4 production are solid waste disposal to land and wastewater treatment. In each case, methanogenic bacteria break down organic matter in the waste to produce CH_4. The emission potential increases the better the disposal site control conditions are and the greater the depth of the solid waste. Wastewater emission potential increases for wastewater that is treated in anaerobic conditions and has a high degree of organic content, such as those from the residential and commercial sectors, food and beverage industries and from the pulp and paper industry.

Waste incineration, like other forms of combustion, generates CO_2 as well as smaller amounts of CH_4 and N_2O emissions, depending on the composition of the waste. The breakdown of human sewage can also lead to significant amounts of indirect N_2O emissions.

The calculation of methane emissions from Solid Waste Disposal Sites (SWDS) was completed using the Tier 1 First Order Decay (FOD) Model methodology from the *2006 IPCC Guidelines*. The FOD method produces a time-dependent emission profile that better reflects the true pattern of the degradation process over time, as opposed to the default method that assumes all potential CH_4 is released in the year the waste is disposed. The 2006 Waste Model spreadsheet developed by the IPCC was employed to estimate emissions between 1995 and 2010. Solid domestic or municipal waste received at solid waste disposal sites in Kenya is summarized in Table 28.

Table 29: Major SWDS operating in Kenya and Waste Amounts Received

Location of SWDS	Type of SWDS	Waste Received (t/yr.)	Population (million)	waste generation rate (kg/cap/yr.)	Fraction of Urban Waste Received	Fraction of Total Waste (%)
Nairobi Dandora [1]	Unmanaged Deep SWDS (>5m)	292,000	3.05	239	40%	26.4%
Mombasa, Mwakirunge [2]	Unmanaged Deep SWDS (>5m)	123,000	1.20	183	56%	
Kisumu [3]	Unmanaged shallow SWDS (<5m)	28,800	0.952	151	20%	4.0%
Nakuru [4]	Unmanaged shallow SWDS (<5m)	18,250	0.473	193	20%	
Rest of Urban Population	Not Sent to SWDS		7.18	183	0%	69.6%

Source: [1] **Report on Taskforce on Identification of Technological Options for Solid Waste Management in Nairobi County, January 2014.**
[2] **Detailed Design and Environmental Impact Assessment for Solid Waste Management Project in Mombasa Town. INGEROP Africa.**
[3] **Environmental Impact Assessment of the Proposed Landfill for Solid Waste Disposal in Kisumu. Geoplan Consultants.**
[4] **Mwanzia P., Kimani, S.N., Stevens, L. (2013). Integrated Solid Waste Management: Decentralised service delivery case study of Nakuru Municipality, Kenya. 36th WEDC Interational Conference, Nakuru, Kenya.**

The fraction of domestic sewage treated by different wastewater treatment systems is shown in Table 39. The methane conversion factor represents the percentage of total potential methane emissions that can be expected for each system and is based on IPCC defaults from the *2006 IPCC Guidelines*.

The activity data required to estimate incineration emissions is the annual amount of municipal waste, sewage sludge, clinical waste or hazardous waste that is incinerated.
Table 30, Table 31 and Table 32 present emissions of CO_2, CH_4 and N_2O for the waste sector.

Table 30: Wastewater Treatment Systems

Wastewater Treatment Systems	Fraction of Total Sewage (%) [1]	Methane Conversion Factor [2]
Flowing sewer	55%	0
Sea, lake discharge	10%	0.1
Anaerobic deep lagoon	30%	0.8
Septic system	5%	0.5
Average based on total	**100%**	**0.275**

Source: [1] **Expert Estimate informed by Table 6-7** ***Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*****: Reference Manual. Waste Volume**
[2] ***2006 IPCC Guidelines for National Greenhouse Gas Inventories*****. Volume 5: Waste. Table 6.3.**

Table 31: Total Waste CO_2 Emissions (Gg)

Source	CO_2 Emissions (Gg)				Change 1995-2010
	1995	2000	2005	2010	
A.2. Solid Waste Disposal on Land	-	-	-	-	0%
B.1 Industrial Wastewater	-	-	-	-	0%
B.2 Domestic and Commercial Wastewater	-	-	-	-	0%
C. Waste Incineration	5.88	6.57	7.16	8.30	+41%
TOTAL WASTE EMISSIONS	**5.88**	**6.57**	**7.16**	**8.30**	**+41%**

Table 32: Total Waste CH_4 Emissions (Gg)

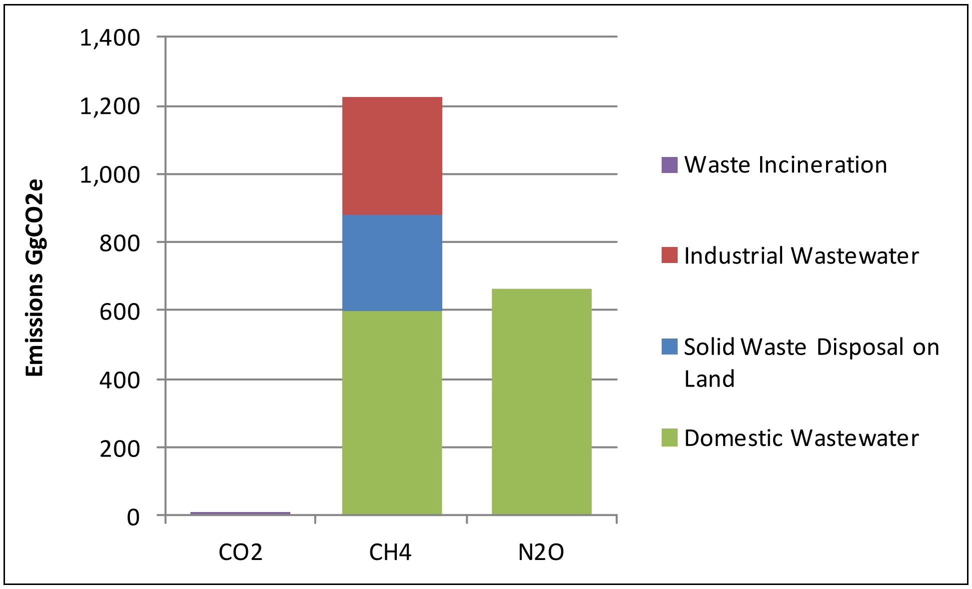
Source	CH_4 Emissions (Gg)				Change 1995-2010
	1995	2000	2005	2010	
A.2. Solid Waste Disposal on Land	2.77	5.32	8.8	13.21	+377%
B.1 Industrial Wastewater	29.4	11.68	13.82	16.55	-44%
B.2 Domestic and Commercial Wastewater	10.16	16.17	21.55	28.64	+182%
C. Waste Incineration	0.00	0.00	0.00	0.00	+41%
TOTAL WASTE EMISSIONS	**42.34**	**33.17**	**44.17**	**58.40**	**+38%**

Table 33: Total Waste N_2O Emissions (Gg)

Source	N_2O Emissions (Gg)				Change 1995-2010
	1995	2000	2005	2010	
A.2. Solid Waste Disposal on Land	-	-	-	-	0%
B.1 Industrial Wastewater	-	-	-	-	0%
B.2 Domestic and Commercial Wastewater	1.5	1.62	2.17	2.14	+43%
C. Waste Incineration	0.00	0.00	0.00	0.00	+41%
TOTAL WASTE EMISSIONS	**1.50**	**1.62**	**2.17**	**2.14**	**43%**

Domestic and industrial wastewater accounts for more than 75% of overall CH4 emissions. Figure 32 identifies the relative importance of CH_4 and N_2O emissions for the different waste sub-sectors in 2010. Indirect greenhouse gas emissions are not estimated for the waste sector.

Figure 32: Waste Sector Greenhouse Gas Emissions in 2010 expressed in CO_2e (Gg)



KEY SOURCE ANALYSIS

Key category analysis was performed for the 2010 inventory results. Excluding LULUCF emissions/removals, two emission sources accounted for more than half of greenhouse gas emissions on a carbon dioxide equivalent (CO_2e) basis. The most important emission sources were both related to agriculture, and primarily, to livestock. Enteric Fermentation accounted for 30% of emissions and N2O emissions from agricultural soils accounted for 25% of overall emissions. The major contributor to N2O emissions from agricultural soils is manure applied or left on agricultural lands. In total fifteen IPCC source categories listed in Table comprised 95% of greenhouse gas emissions. Table 43 lists these key IPCC source categories from highest to lowest.

Table 34: Key Source Analysis (Excluding LULUCF)

IPCC Source Category	Sector	Source Categories to be Assessed in Key Source Category Analysis [1]	Applicable Greenhouse Gas	Emission Estimate (current year, non-LULUCF) (Gg CO2eq)	Level Assessment excl. LULUCF (%)	Cumulative level excl. LULUCF (%)
Sum	**Sum**	**Sum**		**48,412.8**		
4.A	Agriculture	CH_4 Emissions from Enteric Fermentation in Domestic Livestock	CH_4	14,540.2	30.0%	30.0%
4.D	Agriculture	N_2O (Direct and Indirect) Emissions from Agricultural Soils	N_2O	11,890.4	24.6%	54.6%
1.A.3	Energy	CO_2 Mobile Combustion: Road Vehicles	CO_2	6,830.3	14.1%	68.7%
1.A.4	Energy	Other Sectors: Residential CH_4	CH4	1,968.0	4.1%	72.8%
2.A	Industrial Processes	CO_2 Emissions from Cement Production	CO_2	1,849.3	3.8%	76.6%
4.E	Agriculture	CH_4 Emissions from Savannah Burning	CH_4	1,666.6	3.4%	80.0%
1.A.2	Energy	CO_2 Emissions from Manufacturing Industries and Construction	CO_2	1,604.2	3.3%	83.3%
1.A.1	Energy	CO_2 Emissions from Stationary Combustion (Liquid-A)	CO_2	1,253.3	2.6%	85.9%
1.A.4	Energy	Other Sectors: Residential CO_2	CO_2	952.5	2.0%	87.9%
6.B	Waste	CH_4 Emissions from Wastewater Handling	CH_4	948.9	2.0%	89.9%
6.B	Waste	N_2O Emissions from Wastewater Handling	N_2O	663.6	1.4%	91.2%
4.B	Agriculture	CH_4 Emissions from Manure Management	CH_4	541.0	1.1%	92.3%
1.A.4	Energy	Other Sectors: Commercial CO_2	CO_2	495.9	1.0%	93.4%
1.A.3	Energy	CO_2 Mobile Combustion: Aircraft	CO_2	433.5	0.9%	94.3%
1.A.4	Energy	Other Sectors: Residential N2O	N2O	361.6	0.7%	95.0%

Including LULUCF emissions/removals, the most important emission source is from the LULUCF sector, CO_2 emissions from Forest Land remaining Forest Land. This source was estimated to account for 24% of overall emissions. Including enteric fermentation CH_4 emissions and N_2O emissions from soils, these three emissions sources accounted for 60% of all emissions. In total sixteen IPCC source categories listed in Table 44 comprised 95% of greenhouse gas emissions. The table lists these key IPCC source categories from highest to lowest.

Table 35: Key Source Analysis (Including LULUCF)

IPCC Source Category	Sector	Source Categories to be Assessed in Key Source Category Analysis [1]	Applicable Greenhouse Gas	Total absolute estimate incl. LULUCF (current year) (Gg CO2eq)	Level Assessment incl. LULUCF (%)	Cumulative level incl LULUCF (%)
Sum	**Sum**	**Sum**		**69.675.5**		
5.A	LULUCF	1. Forest Land Remaining Forest Land	CO_2	16821.0	24.1%	24.1%
4.A	Agriculture	CH_4 Emissions from Enteric Fermentation in Domestic Livestock	CH_4	14540.2	20.9%	45.0%
4.D	Agriculture	N_2O (Direct and Indirect) Emissions from Agricultural Soils	N_2O	11890.4	17.1%	62.1%
1.A.3	Energy	CO_2 Mobile Combustion: Road Vehicles	CO_2	6830.3	9.8%	71.9%
5.B	LULUCF	2. Land Converted to Cropland	CO_2	3560.0	5.1%	77.0%
1.A.4	Energy	Other Sectors: Residential CH_4	CH_4	1968.0	2.8%	79.8%
2.A	Industrial Processes	CO_2 Emissions from Cement Production	CO_2	1849.3	2.7%	82.5%
4.E	Agriculture	CH4 Emissions from Savannah Burning	CH_4	1666.6	2.4%	84.9%
1.A.2	Energy	CO_2 Emissions from Manufacturing Industries and Construction	CO_2	1604.2	2.3%	87.2%
1.A.1	Energy	CO_2 Emissions from Stationary Combustion (Liquid-A)	CO_2	1253.3	1.8%	89.0%
1.A.4	Energy	Other Sectors: Residential CO_2	CO_2	952.5	1.4%	90.3%
6.B	Waste	CH_4 Emissions from Wastewater Handling	CH_4	948.9	1.4%	91.7%
6.B	Waste	N_2O Emissions from Wastewater Handling	N_2O	663.6	1.0%	92.6%
5.B	LULUCF	1. Cropland Remaining Cropland	CO_2	615.0	0.9%	93.5%
4.B	Agriculture	CH_4 Emissions from Manure Management	CH_4	541.0	0.8%	94.3%
1.A.4	Energy	Other Sectors: Commercial CO_2	CO_2	495.9	0.7%	95.0%

Based on the key category analysis as well as the uncertainty analysis it is possible to prioritize efforts to improve the inventory and identify recommendations. These recommendations are provided in the following Uncertainty Analysis Chapter that follows.

UNCERTAINTY ANALYSIS

Estimates of emissions and removals of greenhouse gases presented in this inventory have uncertainty due to several causes. These uncertainties include the lack of precision of activity data to incomplete knowledge of the processes that cause emissions or removals of greenhouse gases. The *2000 Good Practice Guidance* recognizes that the uncertainty of estimates cannot be completely eliminated and that the main objective should be to produce accurate estimates, i.e., estimates that are neither underestimated nor overestimated, while at the same time, whenever possible seeking to improve estimate precision.

In accordance with the recommendations, an attempt was made in the inventory to ensure that estimates of greenhouse gas emissions and removals were not biased. Estimate precision varied depending on each sector's available data as well as resources that could be investigated for determining emission factors that suited circumstances in Kenya. Where emissions and removals were identified in the key category analysis as the most important overall, emphasis was given, where possible, to ensuring that the best activity data and emission factors available were used.

The overall Inventory uncertainty is the result of the uncertainty associated with all activity and emission factor data and other parameters used in the estimates. For most sectors, it was not possible to conduct a detailed uncertainty analysis, since that would demand a considerable effort in analyzing the accuracy and precision of basic information used. Nevertheless, a general evaluation of Inventory precision was conducted based on the judgment and knowledge of inventory specialists. The objective was to identify sources of emissions and removals where additional resources could be used in the future to reduce the level of overall uncertainty. The precision associated with activity data and emission factors, as well as emission or removal estimates, is expressed as a ± a given percentage based on a 95% confidence interval limit.

Table 45 details the results of the analysis of uncertainty for emission and removal estimates. More detailed descriptions of uncertainties are provided in the *sectoral level inventory reports*.

The highest uncertainty of emission estimates when considering both uncertainty with activity data and emissions factors is related to the estimates of the carbon stocks of forest (i.e., Forest Land Remaining Forest Land) in the LULUCF sector. The combined uncertainty as a percentage of total national emissions in 2010 is 17.5%. The next highest source is related to direct and indirect emissions of N_2O from agricultural soils. The combined uncertainty as a percentage of total national emissions in 2010 for this source is 8.4%.

Table 36: Tier 1 Uncertainty Calculations and Reporting

IPCC Source Category	Gas	Year emissions 2010	Activity data uncertainty	Emission factor uncertainty	Combined Uncertainty	Combined uncertainty as % of total national emissions in year 2010
		Gg CO_2 equivalent	%	%	%	%
	CO_2	11,755	10	5	11.2	1.83
	CH_4	4,137	60	50	78.1	4.49
1.A Fossil Fuel Combustion	N_2O	1,299	60	100	116.6	2.10
1.B Fugitive Emissions	CH_4	1	10	50	51.0	0.00
2.A.1 Cement Production	CO_2	1,849	2	35	35.1	0.90
2.A.2 Lime Production	CO_2	35	20	2	20.1	0.01
2.A.4 Soda Ash Production and Use	CO_2	243	20	20	28.3	0.10
2.F Consumption of Halocarbons	HFC	82	100	0	100.0	0.11
4.A Enteric Fermentation	CH_4	14,540	10	30	31.6	6.39

4.B Manure Management	CH4	541	10	20	22.4	0.17
	N_2O	225	10	50	51.0	0.16
4.C Rice Cultivation	CH_4	278	10	40	41.2	0.16
4.D Agricultural Soils	N_2O	11,890	10	50	51.0	8.42
4.E Prescribed Burning of Agricultural Residues	CH_4	1,667	40	20	44.7	1.04
	N_2O	304	40	20	44.7	0.19
4.F Field Burning of Agricultural Residues	CH_4	105	50	50	70.7	0.10
	N_2O	31	50	50	70.7	0.03
5.A.1 Forest Land Remaining Forest Land	CO_2	16,821	69	30	75.0	17.53
	CH_4	3	30	70	76.2	0.00
	N_2O	0	30	70	76.2	0.00
5.B.1 Cropland Remaining Cropland	CO_2	615	40	70	80.6	0.69
5.B.2 Land Converted to Cropland	CO_2	3,560	69	30	75.0	3.71
5.C.1 Grassland Remaining Grassland	CO_2	179	69	30	75.0	0.19
5.E.1 Settlements Remaining Settlements	CO_2	-85	69	30	75.0	-0.09
6.A Solid Waste Disposal on Land	CH_4	277	69	30	75.0	0.29
6.B.1 Industrial Wastewater	CH_4	348	69	30	75.0	0.36
6.B.2 Domestic and Commercial Wastewater	CH_4	601	69	30	75.0	0.63
	N_2O	664	69	30	75.0	0.69
6.C Waste Incineration	CO_2	7	69	30	75.0	0.01
	CH_4	0	69	30	75.0	0.00
	N_2O	0.2	69	30	75.0	0.00
	TOTAL	**71,974**				

The results in Table 44 suggest that efforts to reduce the overall uncertainty of Kenya's greenhouse gas inventory could be focused on only a few emission sources. A total of five sources contribute to a combined uncertainty above 1% as a percentage of total national emissions in 2010. The following recommendations are made to reduce uncertainties associated with these five sources which would greatly reduce the overall uncertainty of the inventory:

- **Carbon stocks for forest land remaining forest land.** The primary activity required is to improve the overall understanding of carbon stocks in forests. The representation of forest lands in the inventory should be improved. This work has already been advanced by the Kenya Forest Service and, and a report on the National Forest Inventory is being prepared. Included in report will be the new categories for land representation. In addition, careful monitoring through the examination of regular and consistent geo-spatial data should be conducted to improve estimates of forest land-use changes. It is essential that data be collected to link land-use changes from the available GIS data to above ground biomass stocks, biomass growth and biomass removals. As part of this effort detailed surveys should be undertaken to ascertain the amount of biomass (fuelwood, wood for charcoal, commercial harvesting) that is removed from forests and their geographic distribution. This would also reduce the uncertainty of CH_4 and N_2O emissions (see fourth recommendation).

- **N_2O emission from Agricultural Soils**. N_2O emissions are driven by the application of manure to soils, or simply by manure from pasture being left on grazing lands. The use of agricultural residues as a fertilizer enhancement also contributes to significant N_2O emissions. Improving the estimates of livestock populations and determining country specific rates of nitrogen excretion from livestock will greatly improve the overall estimates. Country-specific Tier 2 level nitrogen excretion rates for different livestock categories describe the annual average nitrogen excretion for each livestock species in the country in kg N/animal/yr. N excretion rates can be derived from N intake and N retention data. This typically requires the gross energy intake of the animal (MJ/animal/day), the percent crude protein in the diet, milk production for dairy cattle and weight gain per day. In addition, improving estimates of overall quantities of nitrogen fertilizers and agricultural residues applied as a fertilizer to fields would reduce overall uncertainty.

- **Enteric Fermentation**. Tier 1 emission factors are used in the analysis and the adoption of a Tier 2 methodology emission factors would significantly improve the quality of the estimates. The use of a Tier 2 methodology would require the development of country specific emission factors based on enhanced livestock characteristics. Data required to develop country specific emission factors includes average daily feed intake or alternatively weight, average weight gain per day, feeding conditions, milk production, fat content of milk, percentage of females that give birth, number of offspring and feed digestibility. It is recommended that this is pursued for dairy and non-dairy cattle livestock as this represents 67% of total enteric fermentation emissions. Improvements in estimates of overall livestock populations would also reduce uncertainty.

- **Fossil Fuel Combustion.** Uncertainty in fossil fuel combustion emissions is driven by the uncertainty in the consumption of fuelwood and charcoal in Kenya. A new national survey to characterize wood removal for energy consumption is imperative to improving the quality of the data. Surveys should be conducted for both consumers and producers of fuelwood and charcoal. A comparison of top-down end-use surveys with estimates of bottom-up harvesting and production could significantly reduce uncertainty. CH_4 emissions from the residential sector which is the fifth most important key category is dominated by emissions related to biomass combustion.

- **Carbon emissions from land converted to cropland.** New land-use data information gathered for Croplands should be examined to determine whether assumptions that approximately 5,000 ha per year of natural Forest Land as well as large areas of Woodlands and Bushlands were converted to croplands between 1990 and 2010. This data likely now exists with the Kenya Forest Service. In addition, it is important to improve estimates of how much carbon is released in relation to these conversions.

INVENTORY GAPS, NEEDS AND RECOMMENDATIONS

A number of significant gaps, needs and constraints were identified during the preparation of the Second National Communication (SNC) inventory for Kenya. Gaps include not only information on activity data, but also resources and capacity. There is a strong need for institutional capacity building and training of government staff to do the necessary data collection and analysis required to reduce inventory uncertainties and improve the quality of activity data and emission factors used to generate the inventory.

The sub-sections below summarize specific gaps, needs and recommendations associated with activity data collection, capacity building and development of an integrated and sustainable Greenhouse Gas Inventory System.

Activity Data Collection

Key data gaps that were identified in regards to activity data and are outlined in Table 46 below and are organized by IPCC Sector. Specific recommendations are also provided that could be followed to address the data gaps.

Table 37: Key Inventory Activity Data Gaps and Recommendations

IPCC Sector	Key Activity Data Gap Identified	Recommendation for Addressing Data Gap
Energy	National energy balances, including imports, exports, consumption and international bunker data for major economic sectors are not available (e.g., residential, commercial, transportation etc).	National energy balances should be routinely prepared by the Ministry of Energy and Petroleum and should include biomass fuels.
	Estimates of woodfuel and charcoal consumption have very high uncertainty and are not based on recent surveys.	A comprehensive nation-wide bottom-up survey of producers and a top-down survey of consumers should be conducted (by Kenya Forest Service) to reduce the level of uncertainty associated with production and demand for woodfuel and charcoal.
Industrial Processes	Lime production data is based on an international agency source (US Geological Survey)	Country-level data should be collected by the industry sub-sector (at Kenya Association of Manufactures or KEPSA) and available from the Kenya National Bureau of Statistics.
	Information on the amount of HFCs imported annually in bulk and in products is not complete and has a high degree of uncertainty. Bulk imports of HFCs are tracked by NEMA using customs excise data; however, the reliability of the data is low as there are problems with the assignment of appropriate HS Codes and information that clearly identifies the type of HFC or other ozone depleting substance that is being imported.	Additional training and support should be provided to customs agents so that there is a reliable tracking system for HFCs. The primary route of entry for HFCs is through products and surveys should be conducted to reliably estimate the number of HFC containing products imported and the charge and type of HFCs in associated air conditioning, refrigeration and aerosol products.
Solvent and Product Use	Information on solvents and paints imported is difficult to obtain and collate so that it can be used in inventory work. While customs tracks imports through HS Codes, the database is not easily accessible.	Data should be made available in electronic format and summarize annual quantities in consistent units of different solvents and paints associated with specific HS Codes.
	Information on bulk imports of nitrous oxide were not available for the inventory	Bulk imports of nitrous oxide gas should be tracked by customs and provided in electronic format indicating annual quantities imported.

IPCC Sector	Key Activity Data Gap Identified	Recommendation for Addressing Data Gap
Agriculture	Data on the fraction of different livestock that are managed under different animal waste management systems is lacking and default data was used.	The Ministry of Agriculture Livestock and Fisheries should undertake an assessment to accurately determine the fraction of different livestock that are managed under different animal waste management systems.
	Prescribed burning of Savannah was estimated from IPCC defaults, but it is suspected that burning practices have significantly changed over the years which may have reduced burning from historic levels.	The Ministry of Agriculture Livestock and Fisheries should undertake an assessment of the burning of savannah to determine if the estimated areas burned represent existing management conditions in Kenya.
	Prescribed burning of crop residues was estimated for four major crops (maize, rice, corn and sugarcane).	The Ministry of Agriculture Livestock and Fisheries should review the assumptions regarding prescribed burning of crop residues and if necessary conduct surveys to estimate the extent of the practice for different crops.
LULUCF	Changes in land-use were estimated using a forest orientated dataset of land-use classification from the Food and Agricultural Organization (FAO). The data was used because it was the best available at the time the inventory work was conducted.	The Kenya Forest Service (KFS) is working to develop a national land classification system aligned with IPCC Guidance and could become the future basis of estimating removals and emissions from the LULUCF sector. KFS is working on the National Forest Inventory, which will be able to inform the next GHG Inventory work. Continued research and effort is required to link the land-use changes indicated in this report to biomass stocks and changes in carbon pools.
	Estimates of wood removal from forests for woodfuel and charcoal are unreliable and not based on recent surveys.	Work on estimates of woodfuel removal and charcoal production identified for the energy sector would greatly enhance the robustness of the removal and emission estimates of the LULUCF sector. This work could be run by the Kenya Forest Service
Waste	Estimates of domestic and industrial solid waste sent to solid waste management sites have a high degree of uncertainty. The inventory work draws on the environmental assessments for four solid waste disposal sites within Kenya.	The National Environment management Authority should collect and provide data on the amount of waste deposited annually. This data should be estimated either through weigh scale records or records of the number of vehicle loads.

IPCC Sector	Key Activity Data Gap Identified	Recommendation for Addressing Data Gap
	The total degradable organic content of industrial wastewater was estimated based on the production (tonnes) of different products that typically generate high volumes of industrial wastewater. High level assumptions were made regarding the type of treatment facilities in place. The National Environment management Authority has additional data on more than a 1,000 wastewater treatment facilities that could be reviewed.	NEMA could undertake a review of existing data on industrial wastewater treatment sites to generate more reliable estimates of the total degradable organic content of industrial wastewater produced and the associated type of treatment.

Capacity Building

Capacity building is required at both the institutional and personnel level and multi-sectoral representation (i.e., Energy, Industrial Processes, Solvent and Product Use, Agriculture, LULUCF and Waste) is critical. Although some initial and basic training on greenhouse gas inventory work has been provided under the Ministry of Environment Water and natural Resources through the UNDP sponsored Low Emission Capacity Building Programme, it is recommended that training workshops be conducted as part of future greenhouse gas inventory work to provide both to government staff and local consultants sectoral level training. The workshops should focus on familiarizing a wide audience of stakeholders with inventory methodologies and tools, engaging them in the data collection process and providing them with hands-on experience with inventory data, methods and tools. The ultimate objective should be such that appointed government staff can complete all aspects of inventory work with limited outside consultancy.

Different national and county government departments and organizations integral to information gathering for the different sectors (e.g., Ministry of Agriculture Livestock and Fisheries, Kenya Forest Service, Ministry of Energy and Petroleum and the Kenya Revenue Authority) need to develop capacity to continue supporting GHG inventories. One suggested approach is to provide training for sector leads from each of the six major sink/source categories (Energy, Industrial Processes, Solvent and Product Use, Agriculture, Land-Use Change & Forestry, and Waste). It is recommended that at the beginning of the development of future inventories that responsibilities, roles, resources and training for sectoral teams be clearly identified. Sustainable Development and Environment Staff, who are ultimately responsible for the preparation of the inventory, should be exposed to all sector training so as to serve as local assistance to national experts.

The capacity building should be designed to establish ongoing data collection and analysis in all the relevant government ministries and departments, should include the necessary private sector participation at both association and industry sector levels.

Sustainable Greenhouse Gas Inventory Systems

Developing a sustainable GHG Inventory system should be a key objective for Kenya to address the challenge of more frequent and demanding reporting of inventories to the United Nations Framework Convention on Climate Change (UNFCCC). Frequent, accurate, consistent, complete and transparent reporting for Kenya is crucial for not only meeting international obligations but for the assessment of Nationally Appropriate Mitigation Actions (NAMAs) and for projecting global progress towards targets to stop dangerous climate change warming.

In the context of more frequent reporting of national GHG inventories by non-Annex I Parties, it is imperative that the preparation process shift from a project-based approach to a more internalized and institutionalized approach (UNFCCC, 2012). This shift would support the timely delivery of the required information and more efficient use of available resources by Parties. Experience in Kenya has demonstrated that because the development of greenhouse gas inventories has been conducted on an ad-hoc basis with the use of consultants there has been a “memory loss” between the preparation of the INC and the SNC and insufficient capacity developed within internal structures. Clear records of activity data used in the INC and methodologies followed were not always retained which makes it difficult to validate previous assumptions and update the inventory.

Insufficient evidence and documentation of quality control/quality assurance also brought into question the reliability of the existing 1994 Inventory. In addition lessons learned from the preparation of the INC were not passed on in an effective manner since methodological choices were not always explained.

Key components of a sustainable GHG have been identified by IPCC and UNFCCC guidelines and are indicated below:

- Institutional Arrangements;
- Methods and Data Documentation;
- QA/QC Procedures;
- Archiving;
- Key Category Analysis; and,
- Inventory improvement planning.

A brief description of each of these components follows; however, any system must be tailored to account for national circumstances and constraints. Further details of these components are available from the United States Environmental Protection Agency’s (US EPA’s) approach to building sustainable national GHG inventory management systems using pre-defined National System Templates.

Institutional Arrangements

Institutional Arrangements identify how different organizations can work together for collective action. These arrangements can either be formal or informal, and should include provisions that define roles and responsibilities of all the organizations that are involved in the inventory preparation process including key stakeholders.

Clearly defining institutional arrangements can help inventory teams assess and document the strengths and weaknesses of existing institutional arrangements for inventory development so as to ensure continuity and integrity of the inventory, promote institutionalization of the inventory process, and facilitate prioritization of future improvements. Memoranda of Understanding can be executed between the lead institution and lead sector institutions that clearly outlines the expected deliverables and responsibilities and ensures that they have a mandate for ongoing contributions to the preparations of the inventories. Through clearly defined institutional arrangements, it will be easy to assess the existing capacity gaps and how to address them.

A sustainable GHG inventory system is best served by a strong lead institution that has a sound and capable expert team to develop inventories without extensive support from external consultants.

Methods and Data Documentation

Documenting the choice of methodologies and the activity data and emission factors used to prepare estimates of greenhouse gas emissions and removals is critical to the transparency of the inventory. Identifying documentation procedures can assist inventory teams in reporting the origin of methodologies, activity datasets, and emission factors used to estimate emissions or removals. Future inventory teams can then refer to the documentation to determine what information was collected, how the data were obtained, and what methods were used, as well as to reproduce estimates.

In addition to this inventory report, individual sector level inventory reports have been prepared to clearly document all methods and data for easy future reference.

QA/QC Procedures

Quality assurance (QA) is a planned system of review procedures. It is performed by personnel not directly involved in the inventory compilation and development process. Quality control (QC) is a system of routine technical activities to assess and maintain the quality of the inventory as it is being compiled. It is performed by the personnel compiling the inventory. Identifying QA/QC procedures can help to establish a cost-effective QA/QC program that improves transparency, consistency, comparability, completeness, and confidence in national GHG inventories.

Archiving

Archives refer to a collection of records in a given location that have been created during the development of the inventory (references, methodological choice, expert comments, revisions, etc.). An archive system helps to make a national inventory transparent, allows estimates to be easily reproduced and facilitates development of subsequent inventories by future inventory team members.

A position of Archiving Officer within the lead institution should be considered to undertake this task.

Key Category Analysis

Key category analysis (KCA) has been conducted for this inventory and is presented in the previous section. The KCA identifies the sources and/or sinks that have the greatest contribution to national emissions, and thus should be the focus of improvement efforts. Resources should be allocated to prioritize the necessary data collection and development of country specific emission factors.

Inventory Improvement Plan

The concept of continual improvement is useful in developing inventories with the objective of increasing the transparency, consistency, comparability, completeness and accuracy of inventories over time. Inventory improvement planning is the process of developing specific priorities for future capacity-building projects based on the needs identified for each of the key components of sustainable GHG inventories (i.e., institutional arrangements, methods and data documentation, QA/QC procedures, archiving and Key Category Analysis. One of the key inputs into the inventory improvement process should be feedback obtained through reviews of previous GHG Inventory reports.

OTHER PLANS AND INTERVENTIONS

Partnership of the GoK with Australia Aid and Clinton Climate Initiative.

The System for Land-based Emissions

Estimation in Kenya (SLEEK) is a Government of Kenya program to develop a robust Measurement, Reporting and Verification

system to estimate land-based emissions in Kenya and provide this data to drive development in the country.

The System for Land-Based Emissions Estimation in Kenya (SLEEK) is a cutting-edge system that will track emissions in Kenya and find innovative ways to deliver this information to Kenyans.

SLEEK's primary aim is to allow Kenya to accurately estimate and track its carbon emissions in the land sector. This includes forestry, agriculture, and other land uses. To do this, it will bring together a wide range of data sources and scientific information – climate data, models of Kenya's plants and crops, information about the carbon content of our soils and maps of land use.

The system will also play a key role in providing information to help Kenya respond to a range of other development challenges. This includes guiding Kenya's reforestation effort, helping reduce emissions from agriculture, and helping Kenya benefit from carbon markets.

SLEEK will also help put better information in the hands of farmers and communities. SLEEK will provide data that can be used to develop apps that can help farmers in a wide range of ways, such as informing decisions about which crop to plant, how many cattle their land can support, and where trees are most likely to survive.

To realise this ambitious agenda, SLEEK is bringing together scientists and policy makers from across the government, strengthening their capacity to share knowledge and work across academic boundaries. The program is being delivered by the Ministry of Environment, Water and Natural Resources and is supported by the Government of Australia through the Clinton Foundation.

What's MRV?

Measurement, Reporting and Verification systems are used by countries to track their carbon emissions and report changes to the United National Convention on Climate Change (UNFCCC). They play an essential role in helping tackle climate change by providing essential information about a country's carbon emissions.

SLEEK is Kenya's Measurement, Reporting and Verification (MRV) system for the land-sector. It will combine weather data, biological growth models (capturing carbon emissions and sequestration from trees, crops and soils), and land cover maps to estimate the changes in Kenya's land-sector emissions over time. It will also develop scenarios and models to assess changes in carbon emissions in response to land use changes.

Why does Kenya want a MRV system?

Without an accurate assessment of Kenya's emissions it will be difficult to plan effective policies to reduce emissions as well as benefit from international programs to reduce emissions through stopping deforestation or implementing clean growth policies. SLEEK will position Kenya as a leader in emissions estimation and will provide a basis for other countries in the region and across the world to learn from Kenya.

SLEEK is being delivered by wide range of institutions and Ministries across the Government of Kenya.

These institutions are working collaboratively through element working groups, which are teams that have been specially convened to address each of the areas needed to build a Measurement, Reporting and Verification (MRV) system. These teams are being coordinated by the Ministry of Environment, Water and Natural Resources and Natural Resources.

- **Climate Parameters and Trends:** This team is compiling comprehensive climate data covering Kenya and scenarios showing how this could change.

  The Climate Parameters and Trends Element Working Group is responsible for building comprehensive climate maps that will allow SLEEK to estimate emissions at any location in Kenya. These maps will show temperature, rainfall, solar radiation, frost and evaporation. To complete this task, the team must extrapolate from Kenya's weather stations using new software that is being implemented in Kenya for the first time, which will allow Kenya to generate comprehensive maps.

  The Climate team will also develop scenarios and trends based on IPCC projections. This will improve Kenya's capacity to plan for the impacts of a changing climate.

  A key part of the group's work is to digitize over 1.8 million paper climate records that are currently stored in paper format. Once these records are digitised, Kenya's scientists will have access to a far more complete climate record that will allow them to run more accurate analysis and models. This will help Kenya's farmers, communities and land managers by providing them with more accurate weather data to help them make essential decisions

- **Crop Growth & Plant Parameters:** This team is building models that will track carbon as crops and plants grow.

  The Crop Growth and Plant Parameters Element Working Group is responsible for assessing the amount of carbon that is stored and emitted in Kenya's crops and plants as they grow. To do this, the team will undertake detailed assessment of the main crops in Kenya and will develop models that can track carbon emissions from crops during the growth process.

  Measuring the emissions from a particular crop is not easy – all leaves, stems and branches need to be measured, and carbon needs to be followed into the soils, deadwood and the atmosphere. This work requires the scientists involved in SLEEK to set-up a range of experimental sites, where they can track the growth of Kenya's most important plants in fine, scientific detail.

  The team is also responsible for identifying the management practices that are used in Kenya. This is because the level of carbon stored by a particular crop can differ significantly based on the management of that crop. For example, double cropping maize with a second crop will produce a significantly different response compared with planting maize alone.

- **Soil Carbon:** This team is assessing the level of carbon stored in Kenya's soils and using models to track this change over time.

  The Soil Carbon Element Working Group is responsible for assessing the level of carbon stored in Kenya's soils. Carbon is naturally stored in soils and is essential for any type of tree growth. As trees grow they draw on stores of carbon. Equally, when trees and plants die or drop leaves some of this carbon is reintroduced into the soil, while the rest emitted into the atmosphere.

  To assess the carbon in Kenya's soils, the Soil Carbon team will customize the RothC model for Kenya. RothC is an international model that is used around the world to track the flow of carbon dioxide and other gases within soils.

  To undertake this customization the Soil team will need to set up field trials across Kenya to understand the different soil types across the country. To do this, they will need to setup intensive field sites that can track changes in carbon over time. They will also need to understand how soil carbon changes with different land-uses.

Once the team has developed a robust understanding of different soil types and how they change over time, the team will need to develop maps that show the distribution of different soil types across Kenya

- **Forest Biomass and Growth:** This team is developing models to track how carbon is stored and released by trees as they grow.

  Forests are one of the most important carbon sinks in Kenya. The Forest team will be responsible for tracking the changes in Kenya's forest cover over time, and understanding how the changes in Kenya's forests effect emissions.

  This is done by measuring the amount of carbon stored in trees as they grow. To do this, scientists must measure the entire tree as it grows to understand how much carbon is stored in the parts of tree such as the branches, trunk and leaves. This scientific process must be undertaken for each of the key Kenyan species and models must be developed to be able to simulate the process.

  The team also must assess the carbon in the dead wood and litter that is shed by the main Kenyan species.

  Having understood the amount of carbon typically stored in Kenyan species, the team will be responsible for understanding the different ways that Kenyan forests are managed. This will allow the team to use the forest models to estimate carbon flows across Kenya's forests.

- **Land Use Change and Management:** This team is responsible for understanding the drivers of change in Kenya's land sector, which will help explain change in the future.

  This team will examine the key drivers of change in Kenya's land-sector. They will look at the factors that typically lead to changes from one use to another. For example, this team will look at the factors which lead to conversion of forests to agriculture, such as building new roads or the expansions of new forests communities.

  This understanding will allow the team to understand how policy decisions will affect Kenya's land-sector. This will provide policy-makers and communities with a far more detailed assessment of the implications of land-policy decisions.

- **Modelling:** The modelling team is working to combine the information and data collected through SLEEK to produce a unified, accurate report of Kenya's emissions form the land-sector.

  The Modelling team is responsible for combining all the data collected through SLEEK and using it to estimate Kenya's emissions.

  To do this, the team is working with experts to develop and apply cutting-edge tools that will be able to track changes in Kenya's emissions from year to year by combining the data-sets in a way that simulates natural processes using Kenyan specific data.

- **Land Cover Change:** This team is responsible for using remote sensing imagery to develop maps that will show the changes in land-cover over time.

  The Land Cover Change Element Working

Groups is responsible for using remote sensing and other satellite imagery to map Kenya's lands. These maps will provide as much information as possible on the land cover. For example, the maps will show whether the land is covered by forest, buildings or a particular crop.

Using historical satellite imagery, this team will then be able to compare maps over time, showing how the land cover has changed in Kenya. This information will be provided to the modelling team, who will be able to use the maps to estimate how Kenya's carbon emissions have changes as a result of changes in land cover.

- **Crop Selection App:** SLEEK will provide weather data & crop data to help farmers make better decisions about how to use their land.

- **Forest App:** This app can use SLEEK weather, land-use and forest data to help identify sites where reforestation is most likely to be successful.

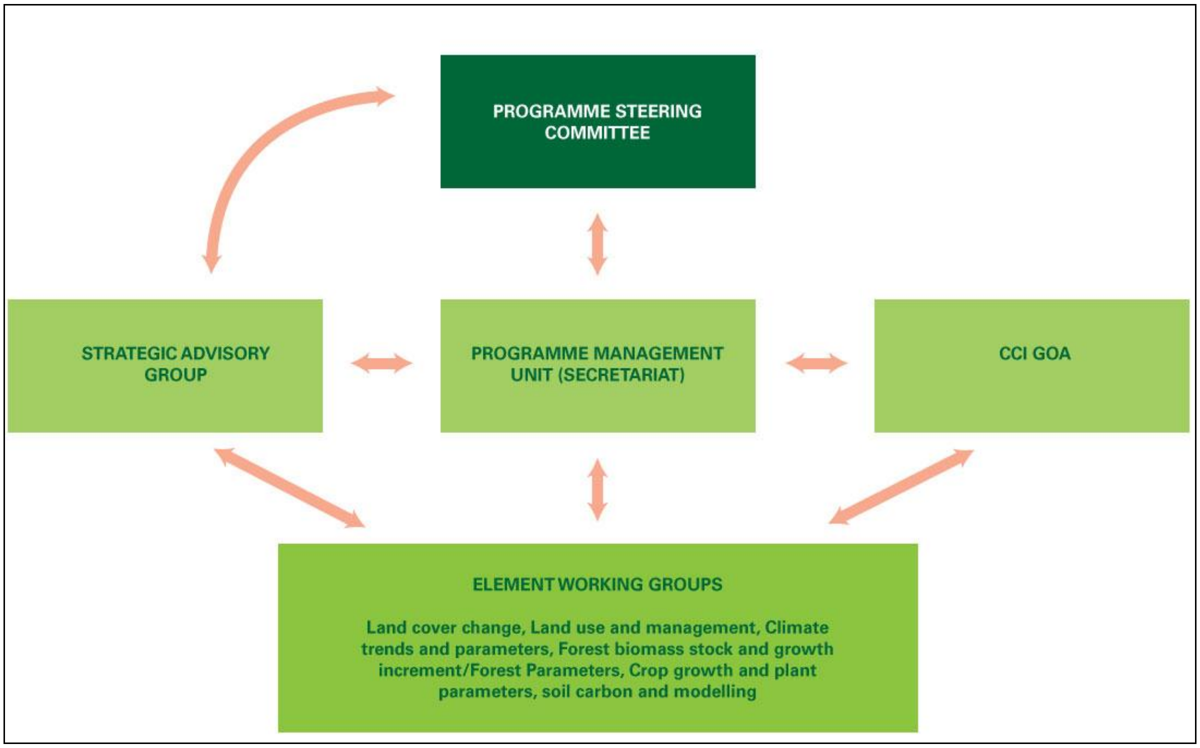
STATE OF THE ART GIS LAB SET UP AT DRSRS

The Department of Resource Survey and Remote Sensing (DRSRS) has been part of the SLEEK program leading the component of data provisioning in the area of Land cover and land cover change across the country. Clinton Foundation has invested in a state of the art GIS lab in the institution to build the country's capacity to map and track land cover change and provide the data during the program and for the long term. The lab has been equipped with 14 desktops and 5 laptops, a server and the latest versions of Geographic Information System (GIS) and Remote Sensing software that will be used to produce credible land cover maps for monitoring land use changes over time to improve decision making in land use management.

Representatives from Survey of Kenya, Kenya Forest Service, DRSRS and Regional Centre for Mapping of Resources for Development have already started working in the lab and started the land cover mapping work for the country. The lab will continue to produce these maps for sustainable flow of data into the SLEEK data platform beyond the program timelines. Over the past 3 weeks, the team has been carrying out data preparation and testing of various land cover mapping methods to identify the most suitable method that is applicable for Kenya.

This will set a benchmark of standards for sustainability.

Program Structure



Source: MoEWNR; http://www.sleek.environment.go.ke/program-structure/

The Program Steering Committee develops policy, coordinates inter-ministerial support, and approves all workplans and budgets. It has representatives from the heads of all the institutions delivering SLEEK.

The Strategic Advisory Group leads the continual improvement of SLEEK, identifies new opportunities for the GoK to benefit from SLEEK and encourage the exchange of ideas and experiences between participants

The Program Management Unit will support the running of SLEEK by providing administrative support, secretariat services and tracking progress.

Element Working Groups are comprised of technical and policy experts, and will deliver the workplans to develop SLEEK

PARTNERS

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CHAPTER 3

Assessment of Vulnerabilities and Adaptation Report

TABLE OF CONTENTS

INTRODUCTION

Although Kenya has little historical or current responsibility for global climate change, and emissions are small relative to global emissions, the country is highly vulnerable to its impacts. Adaptation to climate change is the main priority of the country.

Developing countries such as Kenya have low adaptive capacity to withstand the adverse impacts of climate change due to the high dependence of a majority of the population on climate-sensitive sectors, coupled with poor infrastructure facilities, weak institutional mechanisms, and lack of financial resources. Kenya is, therefore, seriously concerned with the possible impacts of climate change.

An assessment of the impacts of present and projected climate change on natural and socio-economic systems is therefore central to the whole issue of climate change for Kenya. Climate change impact assessment involves the following:

- Identification, analysis, and evaluation of the impacts of climate variability and changes on natural ecosystems, socio-economic systems, and human health.
- Assessment of the vulnerabilities of the affected communities and sectors, such as farmers, forest dwellers, and fishermen, and assessment of the potential adaptation responses.

The assessment of climate change impacts, and vulnerabilities and adaptation to climate change require a wide range of physical, biological, and socio-economic models, methods, tools, and data. The methods for assessing the vulnerability, impacts, and adaptation have significantly improved compared to Kenya's Initial National Communication (INC). This improvement has facilitated a much deeper analysis and understanding of the impacts due to climate change on the various sectors.

Recognising that the risks posed by climate change are legitimate but highly unpredictable, the Government of Kenya published in 2010 its NCCRS, which investigated climate vulnerability. The NCCAP)[116] process included a climate risk-based adaptation analysis through an extensive consultative process which was built on the findings of the NCCRS, with the aim to:

- Provide evidence of the key climate risks to Kenya
- Assess climate change impacts on the sectors
- Document climate adaptation activities that are underway, planned and recommended
- Develop a set of potential and priority adaptation actions to address projected climate impacts per sector that will feed into Kenya's National Adaptation Plan (NAP)
- Support the integration of climate change adaptation into relevant new and existing sector policies, development, budgetary and planning processes and strategies, and across different levels.

The adaptation analysis conducted during the NCCAP is summarised in the Adaptation Technical Analysis Report (ATAR) and detailed in a series of reports compiled in the Adaptation Annex to the NCCAP.

A comprehensive National Adaptation Plan (NAP) to accompany the NCCAP is at an advanced stage of development. Evidence and recommendations of the ATAR have been drawn on to set adaptation priorities and to frame an adaptation strategy that responds to Kenya's development needs and climate vulnerability by proposing initiatives to build adaptive capacity and resilience through social sectors. A framework is being developed for the governance of climate adaptation decision-making and implementation from local to national levels. The draft NAP addresses the integration of climate change adaptation into relevant new and existing policies, programmes and activities; and incorporating adaptation planning in the annual and medium-term planning processes and strategies, within all relevant sectors and at different levels of government.

This chapter on Assessment of Vulnerabilities and Adaptation to Climate Change in Kenya assesses past climate trends and briefly summarises the possible future climate scenarios in the country, the risks and vulnerabilities associated with the trends. Adaptation actions are then proposed. The chapter draws on existing assessments and research through desk research, supplemented with expert interviews. The chapter draws extensively from prior work including the NCCRS, NCCAP, ATAR and Draft NAP, and includes updated research.

BASELINE CLIMATIC, ENVIRONMENTAL AND SOCI-ECONOMIC SCENARIO

Kenya's baseline climatic, environmental and socio-economic scenarios have been described in detail in Chapter 1 of this Second National Communications report.

The country is situated between 5°N 5°S and longitudes 34°E and 42°E with varied landforms types which are divided into plains, escarpments, hills with low and high mountains and breaks. What would otherwise be a largely tropical climate is moderated by a diverse topography and the influence of the Indian Ocean and Lake Victoria. This means that Kenya experiences significant geographical climate variations. The Indian Ocean runs along the country's south-eastern border, bringing a comparatively wet climate to the narrow coastal zone. This gives way to large areas of low lying semi-arid land that stretch north and west, before rising sharply to the temperate highland plateau, one of Africa's most fertile regions. The plateau is bisected by the East Africa Rift Valley, which separates Lake Victoria in the west and the mountainous regions of the central and northern highlands that include the nation's highest peak of Mount Kenya (at 5,200 m).

Droughts and floods, often regionally concentrated, occur relatively frequently (on average every three to four years), and are linked to El Niño or La Niña episodes.[117] An important pattern of ocean-influenced climate variability comes from the Indian Ocean Dipole (IOD), which can accentuate the effects of El Niño episodes and lead to extreme weather in the region. More generally, climate variability of both rainfall and temperature significantly impacts Kenya's economy. For example, it has been estimated that flooding costs the country in the region of 5.5 per cent of GDP every seven years and drought costs approximately 8 per cent of GDP every five years. In total these climatic events cost the country around 2.4 per cent of GDP per year.[118]

CLIMATE CHANGE SCENARIOS

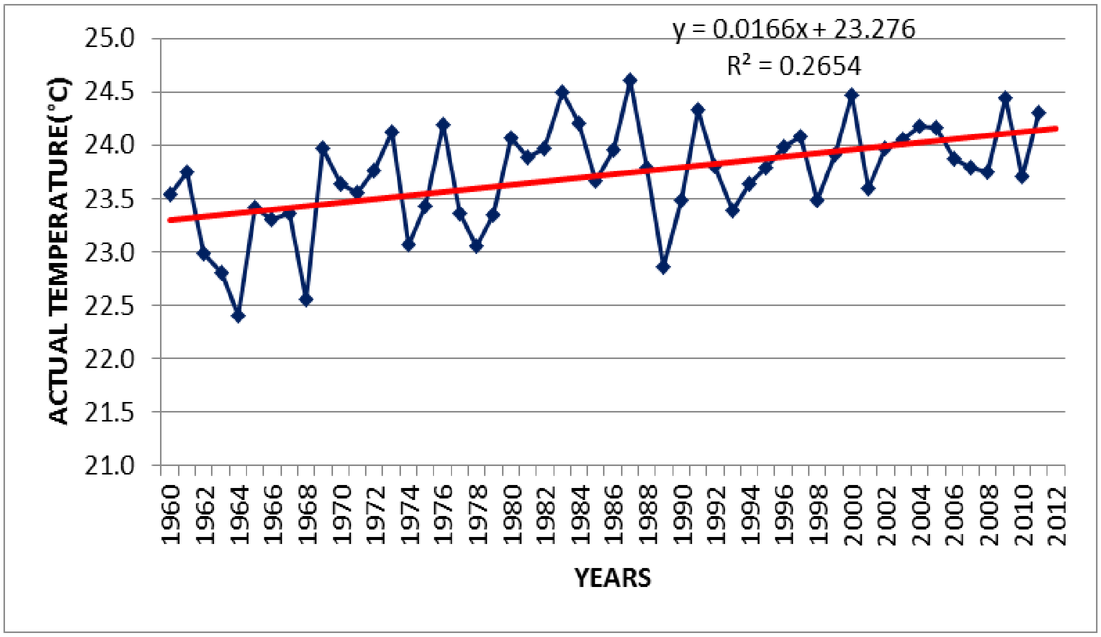
Present Climate Change (Trends and baseline)

Observed Temperature Trends

Temperatures in Kenya vary dramatically from region to region, with high altitude regions experiencing substantially cooler temperatures than the coastal and lowland zones. Nairobi sits in the central highlands at an elevation of 1,800m and has a mean annual temperature of 18°C, whereas Mombasa, in the coastal lowlands, experiences mean annual temperatures of 26°C.[119] Kenya's equatorial location means that there is little temporal variation in temperature, with the coolest months (June to August) typically being 2°C cooler than the warmest.

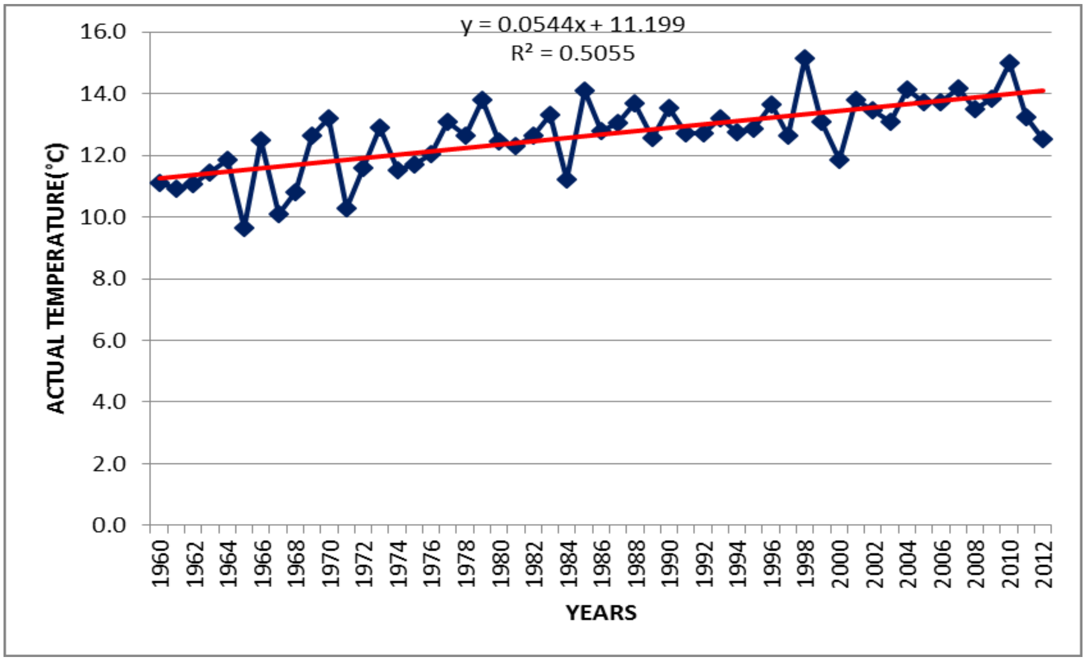
Observed climate data for Kenya shows a distinct warming trend since the 1960s.[120] From the early 1960s, Kenya has experienced generally increasing temperature trends over vast areas. Over the inland areas, the trends in both minimum (night/early morning) and maximum (daytime) temperatures depict a general warming (increasing) trend with time. However, the increase in the minimum temperatures is steeper than in maximum temperatures. The result of the steeper increase in Tmin and a less steep increase Tmax is a reduction in the diurnal temperature range (difference between the maximum and minimum temperatures) – Figures 33-38 depict these trends for some selected representative locations in the country.

Figure 33: Temperature Trends for Nairobi (Central Kenya). Annual Maximum temperature.



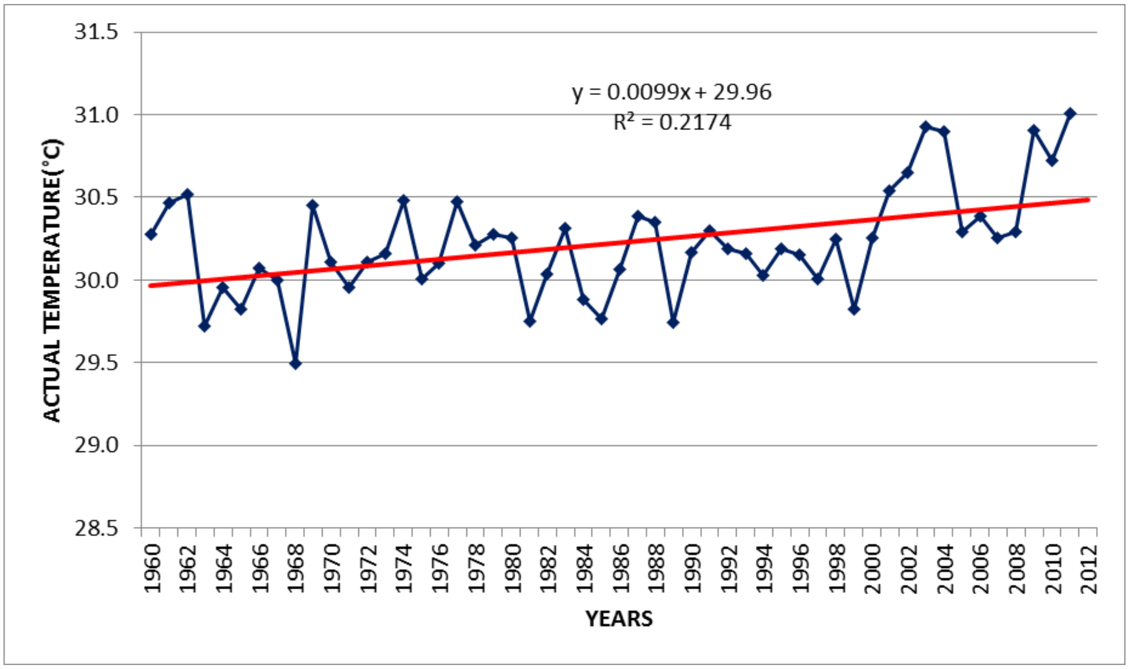
The maximum temperature depicts a steady increase over the years
Source: Data and figure from KMD, 2012

Figure 34: Temperature Trends for Nairobi (Central Kenya). Annual Minimum temperature.



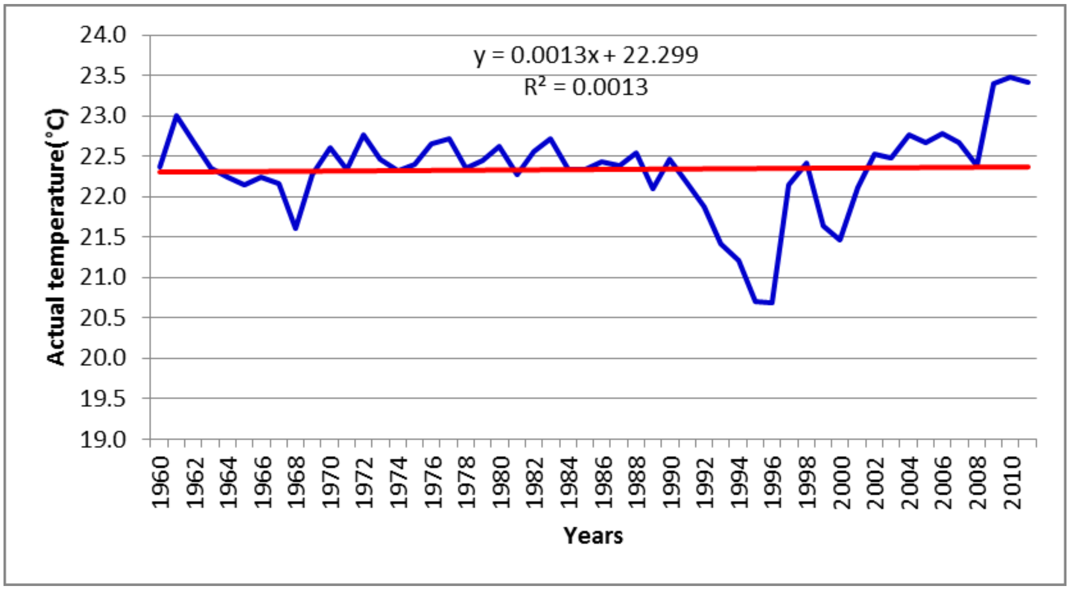
The minimum temperature depicts a steady increase over the years
Source: Data and figure from KMD, 2012

Figure 35: Temperature Trends for Mombasa (Coastal Kenya). Annual Maximum Temperature.



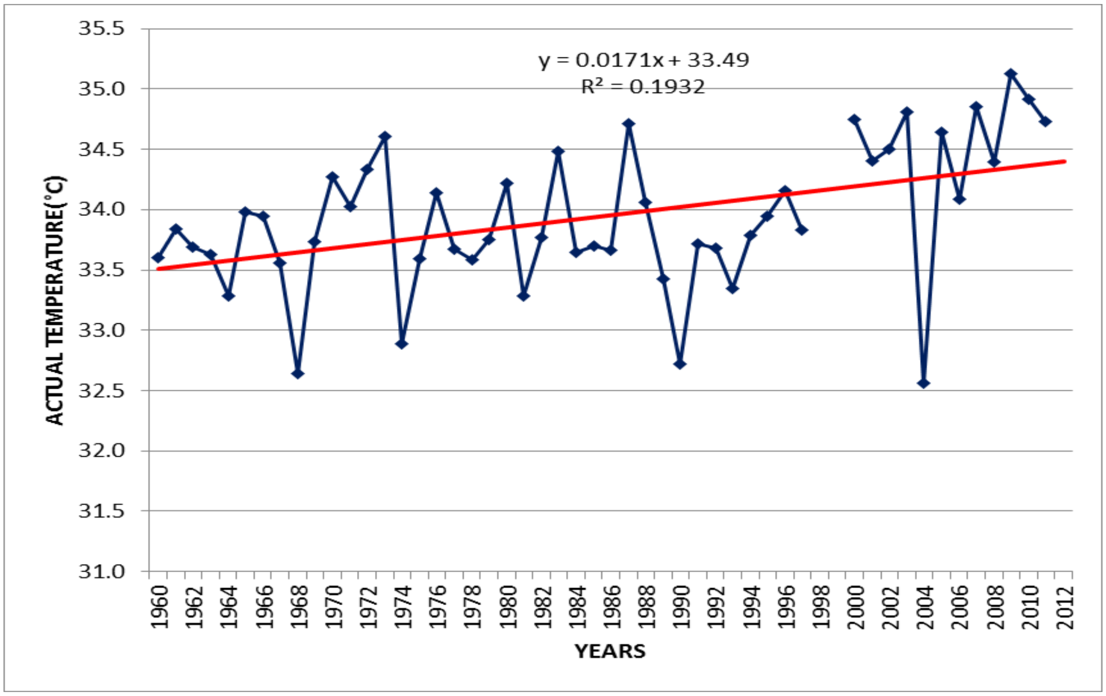
The maximum temperature depicts a steady increase over the years
Source: Data and figure from KMD, 2012

Figure 36: Temperature Trends for Mombasa (Coastal Kenya). Annual Minimum Temperature.



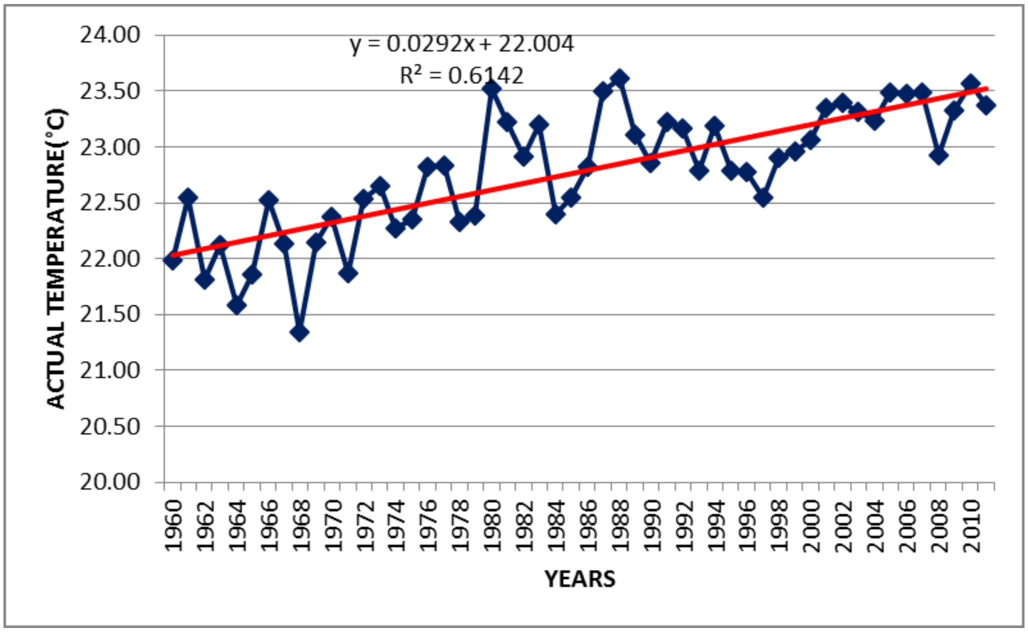
The minimum temperature depicts a steady increase over the years
Source: Data and figure from KMD, 2012

Figure 37: Temperature Trends for Wajir (North-eastern Kenya). Annual maximum Temperature.



The maximum temperature depicts a steady increase over the years
Source: Data and figure from KMD, 2012

Figure 38: Temperature Trends for Wajir (North-eastern Kenya). Annual minimum Temperature.



The minimum temperature depicts a steady increase over the years
Source: Data and figure from KMD, 2012)

Temperature trends in Kenya since 1960 have the following characteristics:[121]

- Mean annual temperature has increased by approximately 1°C at an average rate of 0.21°C per decade.
- The increase in temperature has been most rapid in the months from March to May (0.29°C per decade) and slowest in June to September (0.19°C per decade).
- The average number of hot days per year (defined as daily temperature that is in the top 10% of daytime temperatures for that region and season) has increased by 57 (a 15.6% increase) between 1960 and 2003. The rate of increase is highest in March to May with the average number of hot days increasing by 5.8 days per month.
- The average number of hot nights per year (defined as night-time temperature that is in the top 10% of night-time temperatures for that region and season) increased by 113 (a 31% increase) between 1960 and 2003. The rate of increase is highest from September to November with the average number of hot nights increasing by 12 days per month.
- The average number of cold days and nights (defined as temperatures in the lowest 10% for that region and season) has decreased by 4.4% and 11.4% respectively. The rate of decrease of cold days is highest in September to November (5.7%) and the rate of decrease of cold nights is highest from December to February (11.5%).

Observed Precipitation Trends

On an annual basis, rainfall in Kenya is governed primarily by the movement of the Inter-Tropical Convergence Zone (ITCZ), a belt of low pressure that forms near the equator and migrates south through Kenya in October to December and returns, moving northwards in March, April and May. The ITCZ brings wet weather to the region and so Kenya experiences two distinct wet periods:

- The 'long rains' (March to May)
- The 'short rains' (October to December).[122]

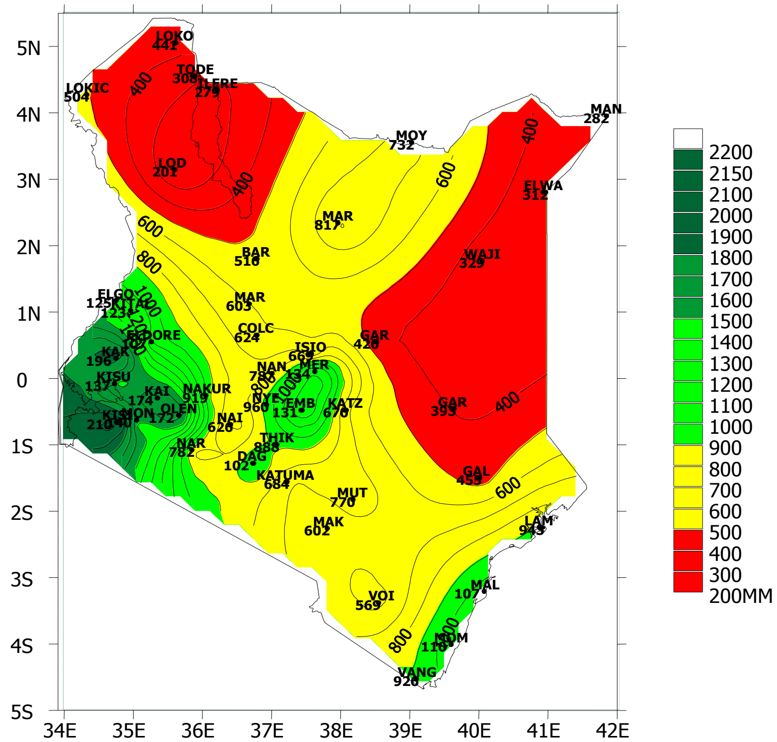
The 'long rains' bring more than 70% of Kenya's total rainfall with the 'short rains' contributing a further 20%.[123] The remaining 6 months of the year are typically dry, contributing just 10% of the country's total rainfall. There is also significant geographical variation, with the Arid and Semi-Arid Lands (ASALs) typically receiving less than 250mm compared with up to 2,000 mm in the high mountain regions (Figures 39 A and B).

As is evident from Figure 39 A, Kenya's rainfall also varies over longer time periods.[124] Annual variation in rainfall is influenced by the relationship between the ITCZ and the surface temperatures of the Indian Ocean. Warmer than average ocean surface temperatures – El Niño episodes – usually result in above average rainfall in the short rainfall season, whereas colder than average surface temperatures – La Niña episodes – bring drier than average weather.[125] As the 'short rains' are most affected by the presence of El Niño or La Niña conditions, they account for the majority of the inter-annual rainfall variability (74%).[126]

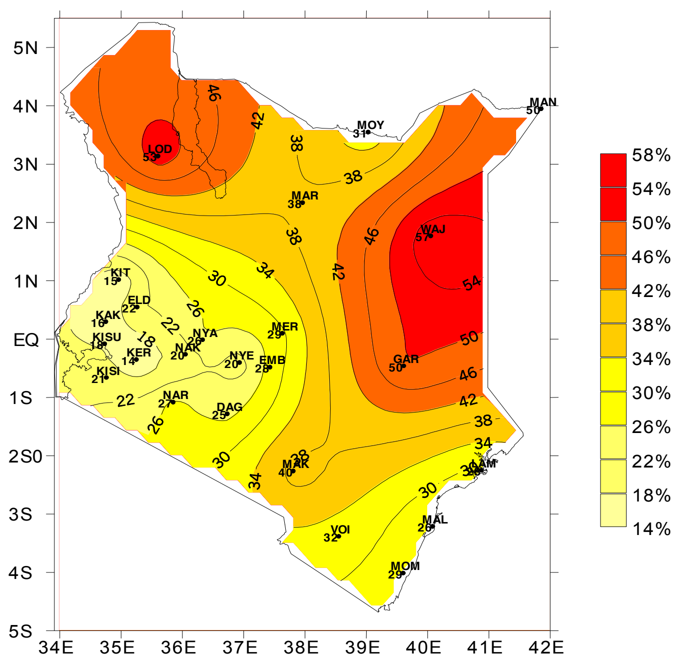
Although there is little evidence of an overall change in precipitation, there is a significant geographical diversity in observed rainfall trends. Observed climate trends show mixed trends with some areas having increasing and others decreasing rainfall all over the country on an annual basis. Whilst considerable uncertainty remains over the statistical significance of rainfall trends in Kenya, some studies have suggested that the rainfall during the 'short rains' can be isolated from the total rainfall.[127] This would explain the trend for northern wetting and southern drying.

Even though some studies suggest a generally mixed rainfall trends in the country, rainfall patterns are highly localised. Rainfall variations over Mombasa on Kenya's coast and Lodwar in the North West of the country demonstrate the localised nature of rainfall trends over the last 50 years. (Figures 40 [A, B, and C] and Figure 41 [A, B and C])

Figure 39: Distribution of mean annual rainfall and rainfall variation in Kenya. A: Distribution of mean annual rainfall. Wetter areas border Lake Victoria and central highlands of the Rift Valley. B: Red shades show areas with high variation coefficients



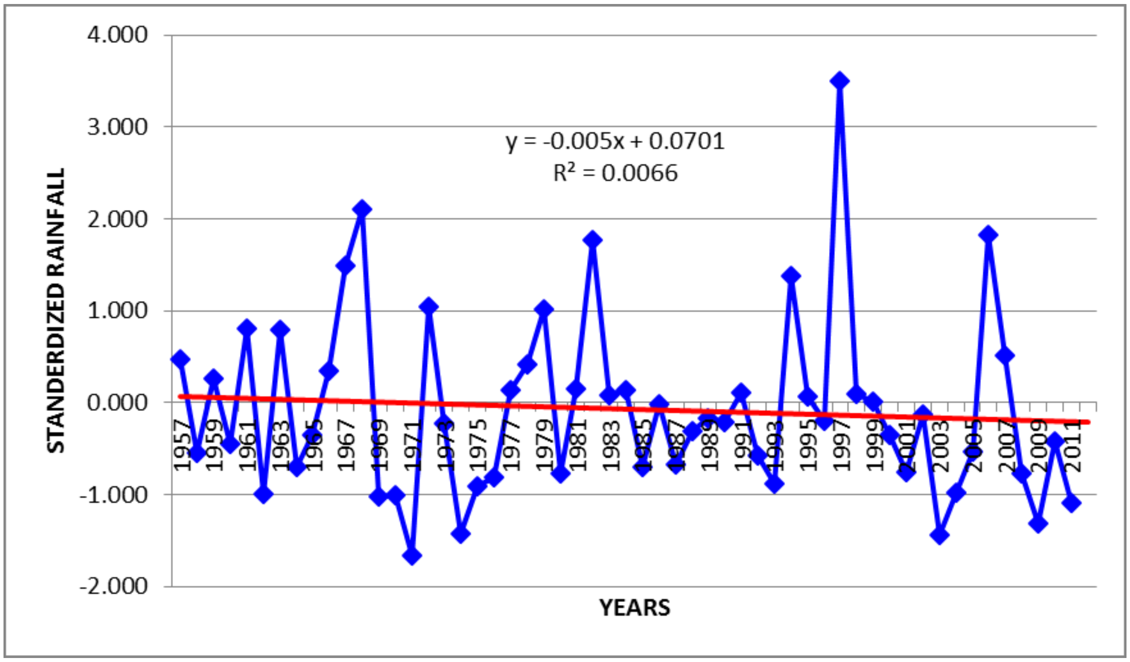
A: Mean annual rainfall distribution over Kenya (Source: Data and figure from KMD, 2012)



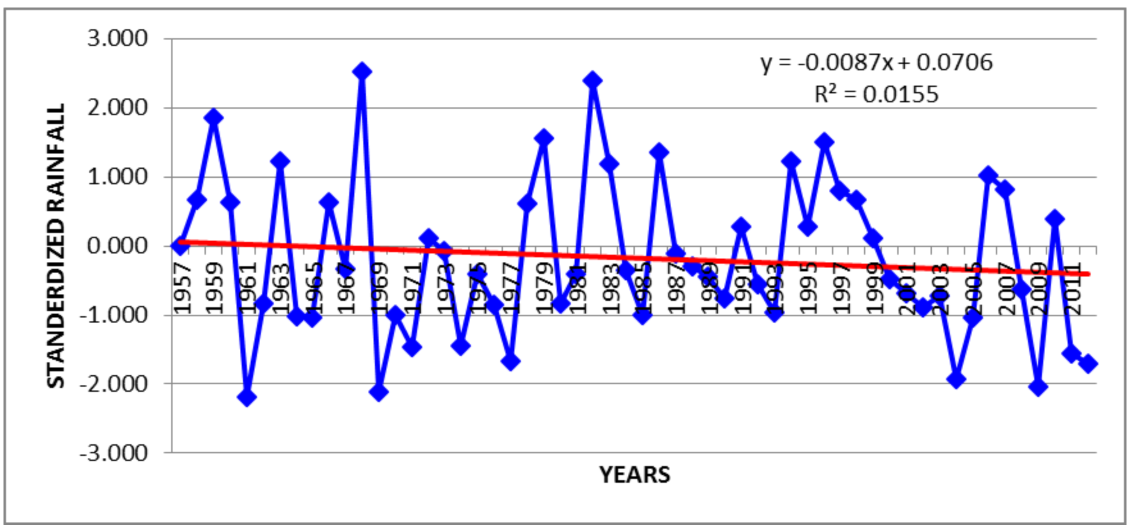
B: Annual Rainfall variability in Kenya (Source; Data and figure from KMD, 2012)

Source: Data and figure from KMD, 2012

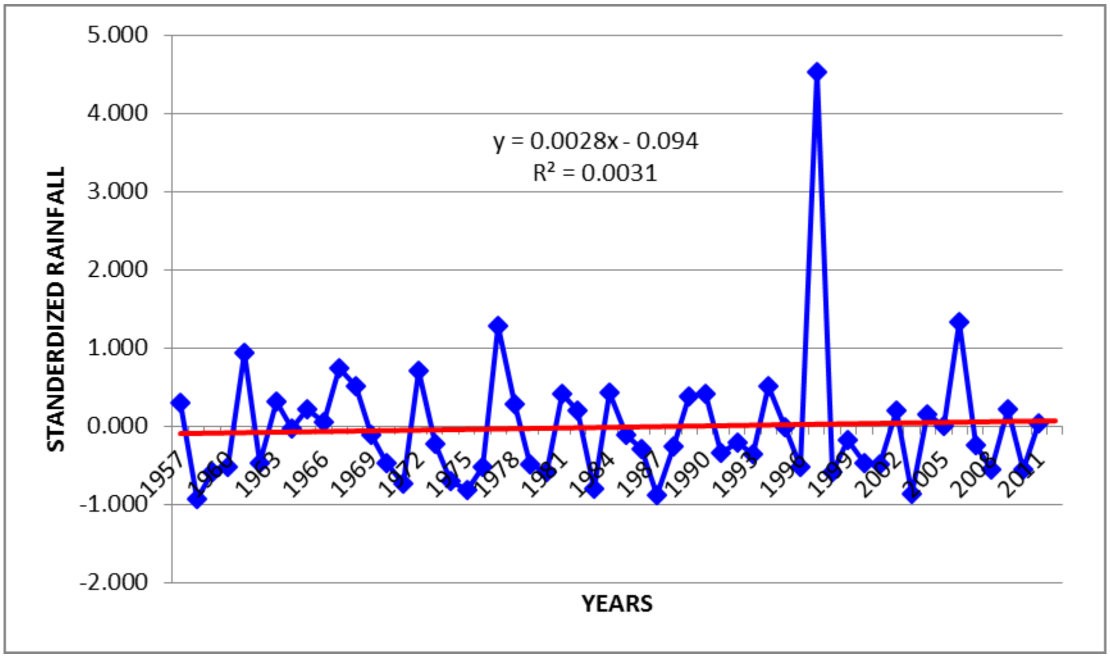
Figure 40: Trend in the seasonal and annual variation rainfall over Mombasa (Coastal Kenya)



A: Total Annual Rainfall Trend: The total Annual rainfall received depicts a steady decline over the years
Source: Data and figure from KMD, 2012

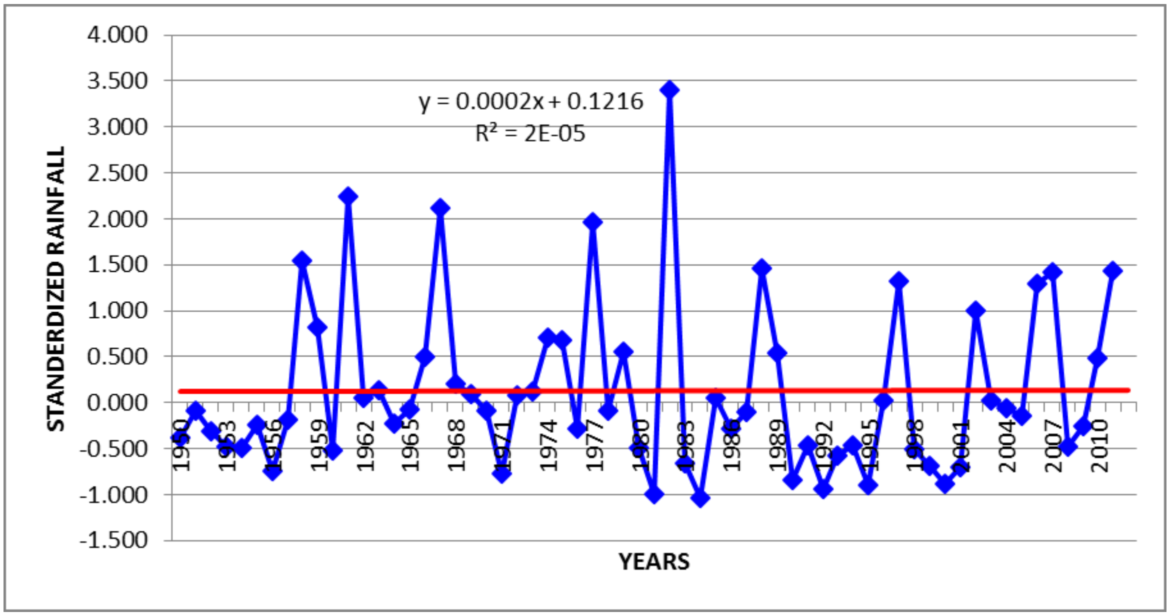


B: March-April-May (MAM) Rainfall Trend: The total rainfall received during the Long Rains (MAM) Season depicts a steady decline over the years
Source: Data and figure from KMD, 2012

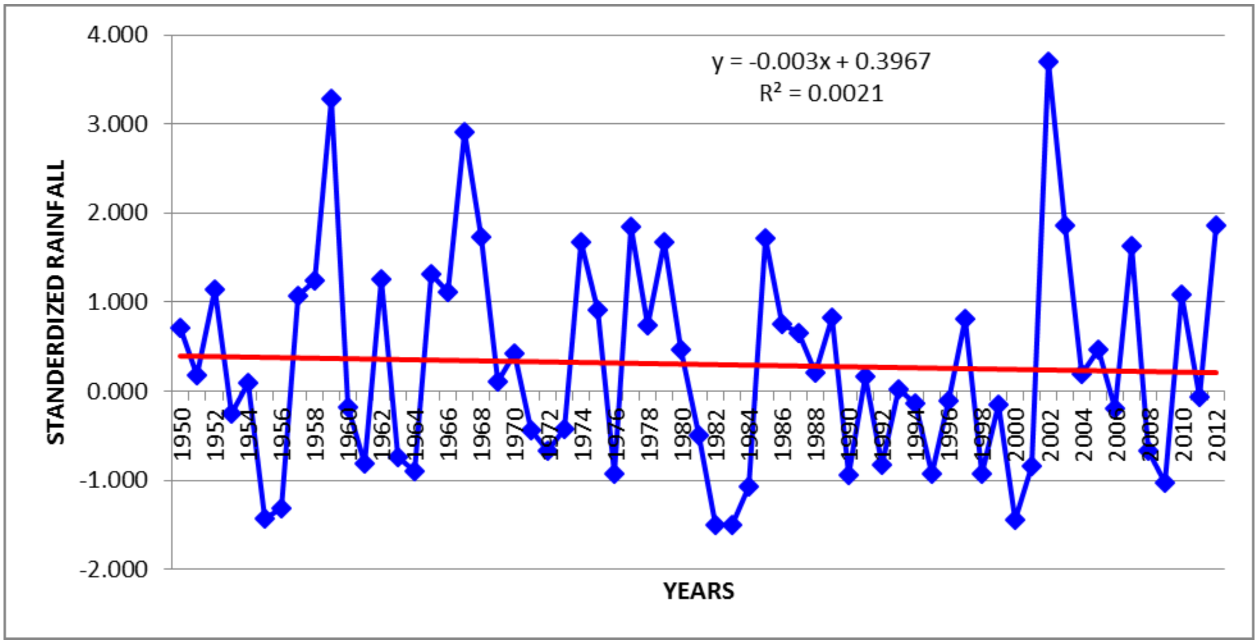


C: October-November-December (OND) Rainfall Trend: The total rainfall received during the Short Rains (OND) Season depicts a slight increase over the years
Source: Data and figure from KMD, 2012

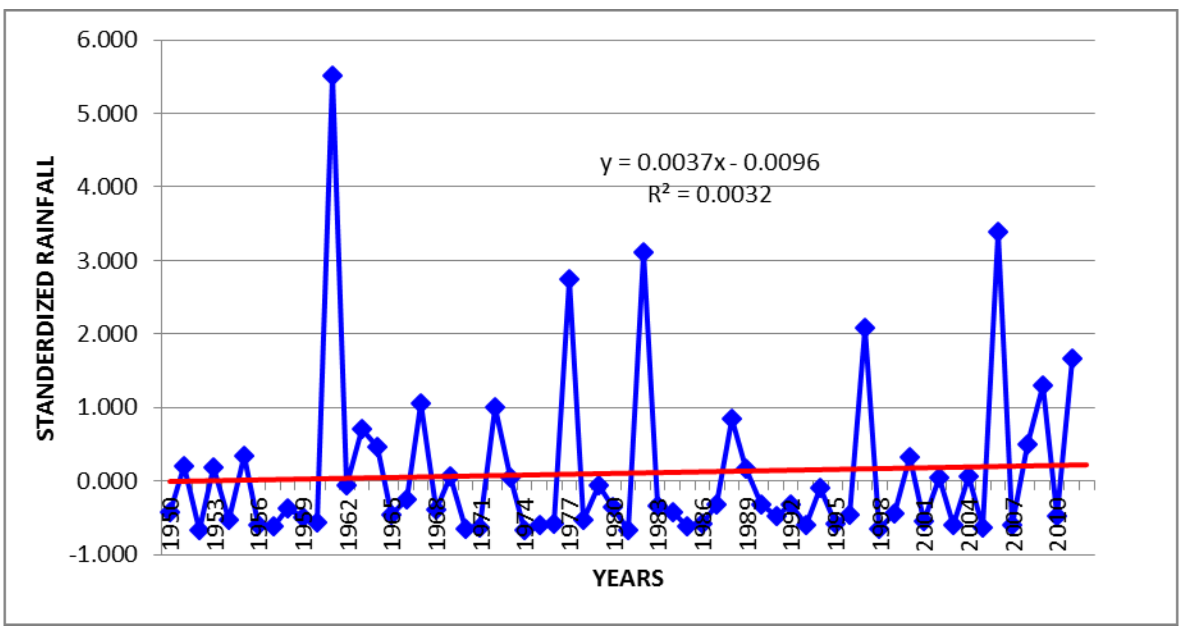
Figure 41: Trend in the seasonal and annual variation rainfall over Lodwar (NW Kenya)



A: Total Annual Rainfall Trend: The total Annual rainfall received depicts a slight increase over the years
Source: Data and figure from KMD, 2012



B: March-April-May (MAM) Rainfall Trend: The total rainfall received during the Long Rains (MAM) Season depicts a steady decline over the years
Source: Data and figure from KMD, 2012



C: October-November-December (OND) Rainfall Trend: The total rainfall received during the Long Rains (OND) Season depicts a steady increase over the years
Source: Data and figure from KMD, 2012

In summary, rainfall trends in Kenya since 1960 have the following characteristics:[128]

- Observations of rainfall for Kenya as a whole do not show statistically significant trends.
- Some evidence shows that northern areas of the country have become wetter, and southern areas drier, although this is subject to considerable uncertainty.
- Trends in extreme rainfall events based on daily rainfall data are mixed. They show a generally increasing trend in the proportion of heavy rainfall events (defined as daily rainfall total that is in the top 5% of rainfall events for that region and season).
- Trends for 1-day rainfall maxima and 5-day rainfall maxima also show inconsistent trends.
- Rainfall patterns in the country are highly localised.
- Periodic droughts occur in Kenya relatively frequently. Moderate drought events have been recorded on average every 3-4 years and major droughts affect the country every 10 on average. Prolonged droughts have become more common since 2000, increasing the amount of arid and semi-arid land area to 80% of the total surface area.[11]

Future Climate Change (Climate Change Scenarios)

For Kenya, Regional Climate Models (RCMs) that give greater spatial resolution for Kenya have also been developed.[129] [130]

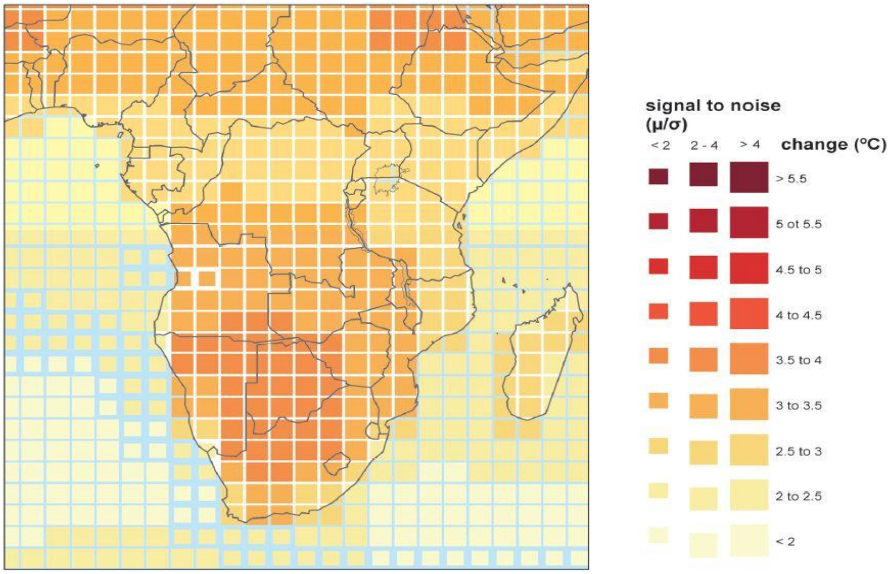
Future Temperature Trends

General Circulation Models (GCM)[131] data indicates that the following trends are considered likely for temperatures in Kenya.[132] Statistics quoted are for medium emissions scenario, relative to the baseline period 1961-1990, unless otherwise stated (see NCCAP and ATAR for more details):

- Mean annual temperature is projected to increase by between 0.8 and 1.5°C by the 2030s and 1.6°C to 2.7°C by the 2060s.
- An increase is projected in the frequency of hot days and hot nights. Projections indicate that hot days could occur on 19-45% of days by the 2060s and 26-69% of days by the 2090s. Hot nights are projected to increase more quickly, occurring on 45-75% of nights by mid-century and 64-93% of nights by the end of the century.
- Projections suggest a decrease in the number of days and nights that are considered 'cold' in the current climate. Cold days and nights are expected to become very rare. GCM projections suggest that there will be no cold days or nights by the 2090s.

Figure 42 provides a visualization of the trend that GCMs have suggested for increased temperatures for Kenya.[133] Here the size of the pixels indicates the degree of agreement over the magnitude of the increase. There is good model agreement of temperature increases of up to 3°C by 2100.

Figure 42: Temperature change for Africa by 2100 (from the 1960-1990 baseline) averaged over 21 CMIP3 models

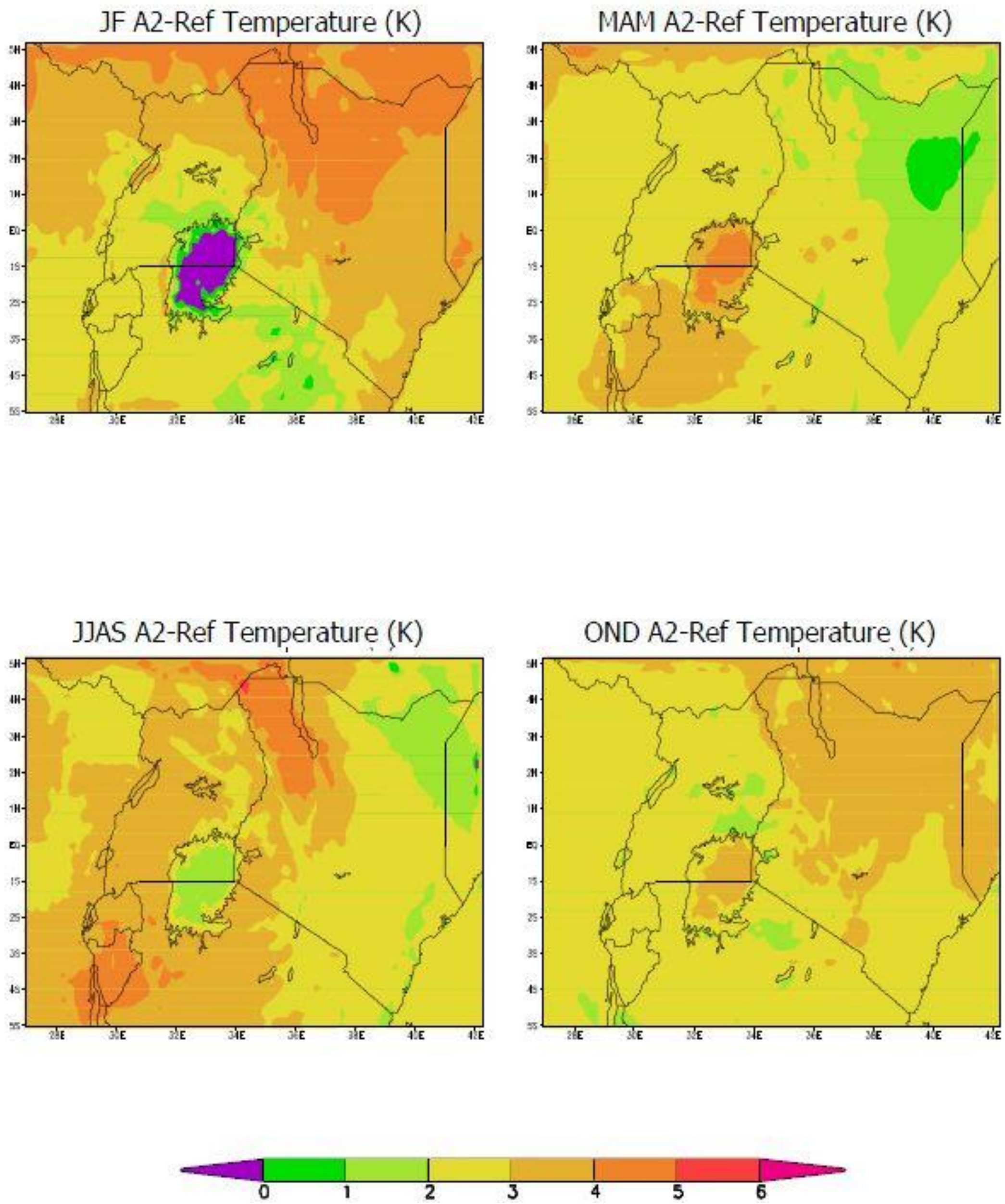


Source: Met Office. (2011). Climate: Observations, projections and impacts. Kenya. Exeter, UK: Met Office.

Using the RCMs, the following temperature trends in Kenya have been projected (See Figure 43):[134]

- The whole of the country could warm by between 1°C and 5°C (by 2071-2100).
- The dry seasons (March to May and October to December) will experience the greatest increase in temperature, particularly in the north of the country.
- The 'long rains' from March to May will exhibit the smallest increase, particularly in the northeast of the country, where negligible changes are projected in comparison to the baseline period.
- The northwest of the country will be warmer by around 1°C more than the rest of the country.
- North eastern regions, in particular around Wajir, will experience relatively less warming than the rest of the country, by approximately 1 -2°C.

Figure 43: RCM (RegCM3) temperature projection results for 2071-2100 (A2 emission scenario; 20km resolution).



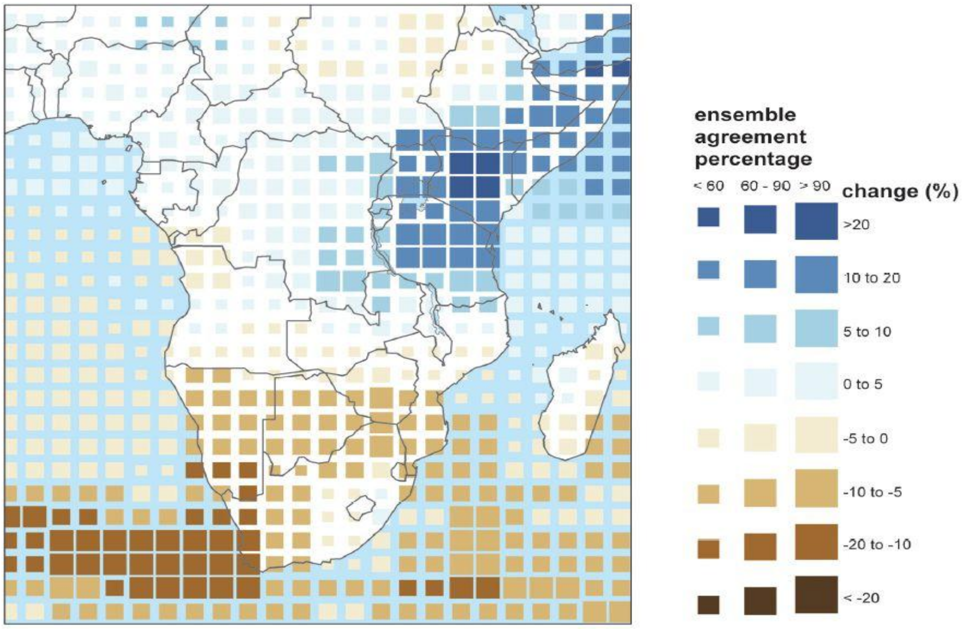
Source: GoK; National Adaptation Technical Analysis Report (ATAR)

Future Precipitation Trends

GCM data indicates that the following trends may be seen for rainfall in Kenya.[135] The following statistics are for an A1B (medium) emissions scenario unless otherwise stated (see the NCCAP and ATAR for more details).

- GCMs suggest that there may be increases in average annual rainfall in Kenya by the 2060s. However there is considerable model disagreement with a range of projections varying from a 5% decrease to a 17% increase by the 2030s and no change to a 26% increase by 2060s.
- The increase in total rainfall is projected to be largest from October to December (-6 mm to +29 mm per month by 2030s and 0 mm to 30 mm by the 2060s) and proportional changes largest in January and February (-14 % to +50 % by 2030s and -6 % to +60 % by the 2060s). Again, the broad span of projections indicates high levels of model disagreement.
- The GCMs suggest with greater confidence (on the basis of good model agreement) that the proportion of annual rainfall that occurs in heavy events will increase. The range of increase varies from 2 to 11% by the 2060s and 2 to 12% by the end of the century.
- There is also relatively good model agreement that 1 and 5-day rainfall annual maxima will increase. The range of predicted increase for 5-day events is between 2 to 19mm by the 2060s and 2mm to 24mm by the end of the century.
- Figure 44 provides a visualisation of the trend that GCMs have suggested for increased precipitation for Kenya. Here the size of the pixels indicates the degree of agreement over the magnitude of the increase. It shows that there is relatively strong model agreement that precipitation will increase over Kenya.

Figure 44: Percentage change in precipitation for Africa by 2100 (from 1960-1990 baseline) averaged over 21 CMIP3 models. The size of the pixels indicates the degree of agreement over the magnitude of the increase.

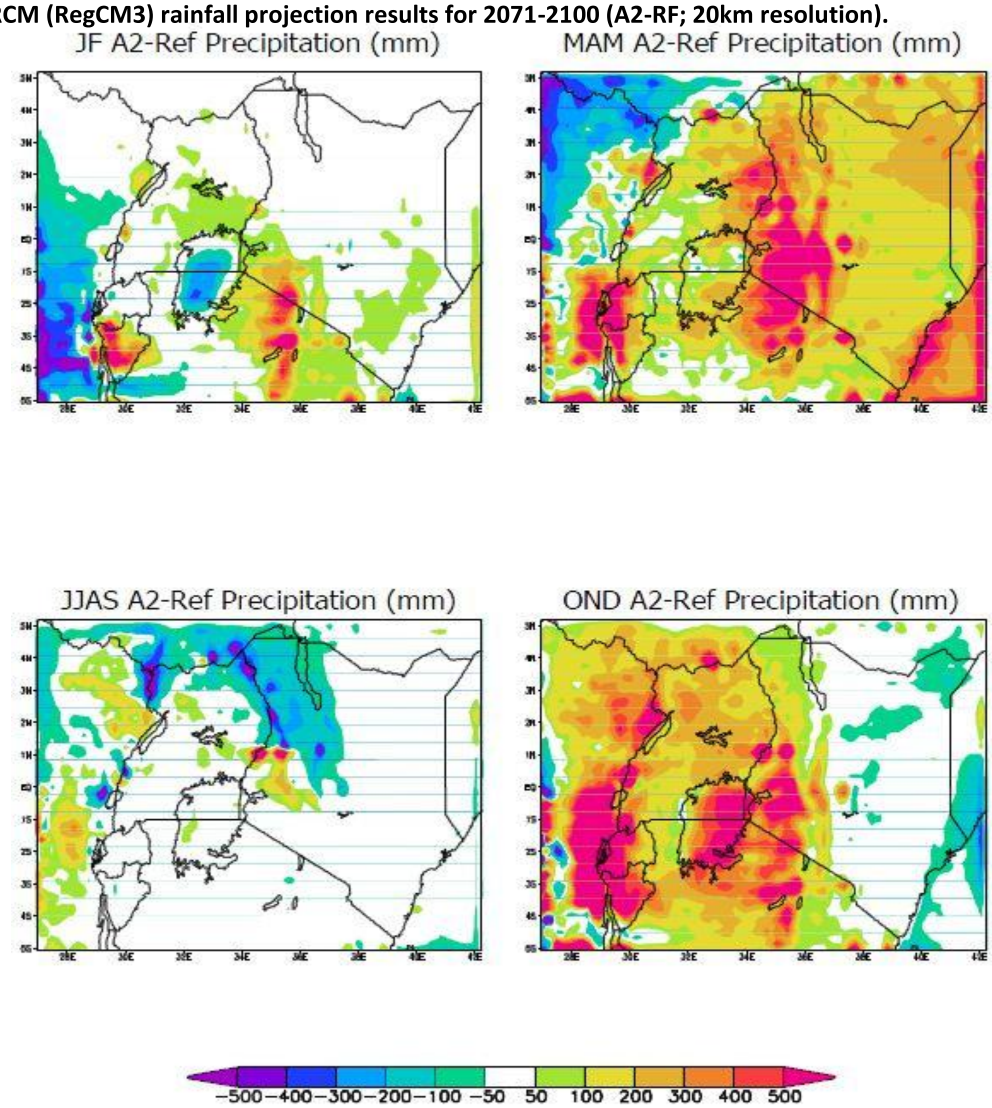


Source: Met Office. (2011). Climate: Observations, projections and impacts. Kenya. Exeter, UK: Met Office.

Through RCMs, the following precipitation trends are projected in Kenya by the 2090s:

- During the 'long rains', Kenya could experience a significant increase in rainfall with the largest increase occurring over the highland districts and the coastal region (Figure 45 top right).
- During the 'short rains' an increase in rainfall could predominantly affect the region to the west of the Rift Valley. The rest of the country could experience slightly decreased rainfall in isolated pockets (Figure 45 bottom right). This is in contrast to the GCM average results, which suggest wetter conditions during the 'short rains'.[136]
- The northeast of the country is projected by the RCM to become significantly drier on an annual basis. This is in contrast to the GCM projections that suggest that the north of the country may become wetter, but is in line with observed rainfall trends since 1960.[137]

Figure 45: RCM (RegCM3) rainfall projection results for 2071-2100 (A2-RF; 20km resolution).



Source: GOK: National Adaptation Technical Analysis Report (ATAR)

Summary of Future Climate Change in Kenya

Based on climate model output, Kenya may see a general trend towards warmer, wetter conditions in the coming decades. Table 47 provides a summary of the projected climatic changes for Kenya for the 2030s, 2050s and beyond. The information is based on GCM and RCM statistics relative to a 1961-1990 baseline and based on the mid-range A1B emissions scenario unless otherwise stated.

Table 38: Summary of GCM and RCM based climate change projections in Kenya (relative to a 1961-1990 baseline and based on the mid-range A1B emissions scenario unless otherwise stated).

Climate Variable	2030s	2050s and beyond
Temperature	No GCM simulations suggest temperatures in the future will be cooler than present. Mean annual temperatures are projected to increase by between 0.8 - 1.5°C across the country by the 2030s. Droughts are projected to become more extreme over the coming decades.	Mean annual temperature may increase by between 1.6 to 2.7°C by the 2060s. There is good GCM agreement that temperatures may increase by 3°C by 2100· Droughts are considered likely to occur with similar frequency to the present but with increased severity. This is linked to increases in temperature affecting evaporation rates rather than reduced precipitation. GCM projections indicate that hot days could occur on 19-45% of days by the 2060s. Under emissions scenarios A2 and A1B, GCM projections suggest that there will be no cold days or nights by the 2090s.
Precipitation	Rainfall seasonality is projected to remain the same. There is considerable GCM disagreement over the extent of mean annual rainfall change. Projections range from a 5% decrease to a 17% increase by the 2030s. Almost all the GCM simulations show wetter conditions in October to December. The RegCM3 regional model predicts that increased rainfall in northern Kenya could be restricted to areas west of the Rift Valley.	Rainfall seasonality is considered likely to remain the same. There is considerable disagreement between GCMs over the extent of mean annual rainfall change, ranging between no changes to a 26% increase by 2050s. The RegCM3 regional model indicates there may be greater rainfall in the west of the country (A2 emissions scenario, 2090s). Rainfall events in the short and long rainy seasons are considered likely to become more extreme (A2 emissions scenario, 2090s).

Source: NCCAP (2013-2017); GoK and ATAR

Knowledge Gaps and Next Steps

Relatively high quality climate records, and speciality precipitation data, are available for Kenya since the 1960s. The number of rainfall

monitoring stations in Kenya has decreased from 2,000 in 1977, 1,497 in 1990 and 700 in 2012. Today, Kenya has 62 temperature stations and 27 synoptic climate stations measuring a range of climate variables.[138]

Key knowledge gaps for climate information include[139]:

- Understanding rainfall seasonality and geographical variations by increasing the number of rainfall monitoring stations to improve regional modelling.
- The role of ocean patterns on the regional climate is not well understood. Improved understanding of the relationship between the ENSO (El-Niño Southern Oscillation) and IOD (Indian Ocean Dipole) and precipitation events would be advantageous.
- Further research on the influence of topography and of Lake Victoria on local climate patterns is needed.
- Some of the climate data that has been collected is yet to be digitised and information exchange is limited by poor communications in some parts of the country.

Uncertainty about future climatic conditions will persist, unless there is continued investment in seasonal forecasts and downscaled climate projections.[140] The common approach of representing uncertainty is to examine output from different climate models risks. However, this may result in a gross over-estimation of our current ability to predict sectoral responses to climate change, for example in agriculture.[141]

Although more exhaustive characterisation of uncertainty may be scientifically tractable, the prospect of reducing uncertainty depends on further progress being made in the underpinning climate science.[142, 143]

A number of specific actions have been identified and these can be found in Table 4 9 .

CLIMATE CHANGE IMPACTS AND VULNERABILITY

The increasing variability in climate and the projected incremental changes in air and sea temperatures, precipitation and sea level, together with changes in the frequency and severity of extreme events will have significant implications for social, economic and environmental systems. The cumulative impacts of climate change over the next two to three decades have the potential to reverse much of the progress made towards the attainment of Vision 2030. The costs of climate change could be equivalent to 2.6 per cent of Kenya's GDP each year by 2030.

Droughts and floods in particular have devastating consequences on the environment, society and the wider economy. The associated spillover to the macro-economy has been significant. The overall impact of the 2008-2011 drought in Kenya is estimated at KSh 968.6 billion (USD 12.1 billion), and was predicted to have caused a slowing down in the growth of the country's economy by an average of 2.8 per cent per year during that period. Similarly, the 1998-2000 drought is estimated to have resulted in a 16 per cent reduction in the GDP in each of the 1998-99 and 1999-2000 financial years.[144] Lost industrial production alone due to inadequate power supply during this period amounted to a loss of approximately KSh 110 billion (USD 1.4 billion).[145]

Floods have also caused equally devastating consequences in recent years, including loss of lives and livelihoods, personal property damage and damage to infrastructure, with ramifications for the economy. For example, the 1997-98 El Niño floods are estimated to have caused damage equivalent to at least 11 per cent of GDP, including KSh 62 billion (USD 777 million) in damage to transport infrastructure and KSh3.6 billion (USD 45 million) to water supply infrastructure.

While floods are generally associated with higher damages on public infrastructure assets, the burden of droughts falls more heavily on people, communities and the private sector. In particular, the livestock and agriculture sectors were the most affected by the 2008 and 2011 drought events, with respective drops in productivity of 72 per cent and 13 per cent.[146] Along with these direct impacts, climate-related events affect the overall performance of the economy in the long run. Other macro-economic trends which have been evident during droughts and which appear to be exacerbated by climate related effects include:

- Reduced foreign exchange earnings (Kenyan business and international competitiveness)
- Altered balance of payments (e.g. reduced exports, increased imports)
- Current account deficit (e.g. reduced government revenues or increased expenses)
- Price inflation (e.g. increased food or energy prices).

As detailed in the NCCAP (2013-2017), the impacts and risks identified below are based on desk-based review, utilising peer-review and grey literature, together with Kenya's First National Communication to the UNFCCC, stakeholder and county consultations, Technology Needs Assessment reports and other relevant national planning documents. By incorporating an assessment of their future likelihood and consequence (the two key elements of risk), the assessment prioritised and ranked impacts with reference to the themes of the Medium Term Plan. The strength of this methodology is that it puts climate effects at the centre of the analysis and derives priorities to address the most important risks – often assessed in terms of expected economic losses where there is adequate information.

Recent UNFCCC decisions have recommended national adaptation planning be based on assessments of development needs and climate vulnerability. This approach recognises that adaptation actions need to address socio-economic development deficits as well as climate effects. The strength of this approach is that a fuller integration with national development planning and implementation is possible than through the climate risks-based approaches. In the Draft National Adaptation Plan (NAP), the climate risk-based approach of the ATAR and development needs and climate vulnerability have been combined to draw the strengths from each. For this reason, this report has heavily borrowed from the work already done in the Draft NAP. Underpinning the Draft NAP is a Risk Assessment Report (TR1), which builds on the review of impacts undertaken for the National Climate Change Response Strategy (NCCRS)[147], and provides a more comprehensive and systematic assessment of how climate change may exacerbate existing vulnerabilities.

The climate change impacts and risks to Kenya's economy have been analysed in detail for each sector in the Adaptation Technical Analysis Reports (ATAR). Impacts for particular sectors have been analysed as follows:

Water Resources

Freshwater resources are already highly influenced by inter-and intra-annual rainfall variability, including the extremes of flooding and drought and climate change may further reduce the availability of this resource through altered rainfall patterns, higher evaporation, lower lake levels, accelerated loss of glaciers and rising sea level. Water availability is already a significant problem in cities. For example, Mombasa receives only half of the water required to meet its needs, which leads to rationing and use of private sources.[148] Increased temperatures and rainfall variability are likely to exacerbate the conditions already experienced and may in the future have a significant impact on water availability.

In coastal locations, sea level rise is likely to render more acute the current water supply and salinisation problem, as freshwater aquifers are contaminated with saline water.

Agriculture, livestock and fishing (food security)

Climate change has the potential to significantly affect agriculture-based livelihoods by challenging the sustainability of current arable, pastoral and fishing practices. Agriculture is extremely vulnerable to climate change, due to the natural connections and dependencies that exist between climatic conditions and plant development. There are a variety of climate drivers that are likely to directly and indirectly impact agricultural productivity, as outlined below:

- Higher temperatures are likely to directly reduce yields of desirable crops in the long-term. For example, parts of south west Kenya have been highlighted as potentially experiencing a flip in the number of reliable crop growing days from more than 90 to less than 90 by the 2050s.[149] This will clearly have implications for rural livelihoods and “cropping might become too risky to pursue as a major livelihood strategy”.
- Changes in precipitation patterns are likely to directly increase the likelihood of short-term crop failures and long-term production declines. Rain-fed agriculture is and will remain the dominant source of staple food production and the livelihood foundation of the majority of the rural poor in Kenya.[150] The high inter-annual unpredictability in precipitation is already having devastating consequences on rural livelihoods in Kenya, with droughts and floods a frequent occurrence in both the arid and semi-arid lands (ASALs) and the high potential areas.
- A number of indirect impacts, such as increased rates of runoff and soil erosion, and increased crop losses from wildlife migrations, insects, diseases and weeds, could significantly magnify production losses.

Due to the fact that the majority of farmers are small-scale and subsistence, depending on the 20% of Kenya’s land that is suitable for producing crops for their own needs, the ultimate end-point consequences resulting from a decline in agricultural production are detrimental impacts for food security and human health.

With respect to the longer-term implications of a changing climate on agricultural productivity, for Kenya there will be distinct “winners and losers”, as climate change inevitably favours some crops and regions over others. Equally, some regions, namely the mixed rain-fed temperate and tropical highlands, are projected to experience an increase in crop yield, whereas others, namely the ASALs, are projected to witness a significant decline in crop yields and livestock numbers, as water resources become increasingly scarce. These patterns are largely driven by regional variability in future precipitation and geographic exposure to extreme events, particularly drought frequency. For instance, for large parts of the ASALs and lowlands, where maize cropping is possible, maize yields are projected to decline by 20 per cent by the 2050s.[151] These losses are in the range of 200-700 kg/ha, although in some grid squares in the analysis, losses are larger than this.[152]

However, maize yields are projected to increase in some of the highland areas of the East African region, including the central and western highlands of Kenya, and the Great Lakes Region by the 2050s. These increases in yield equate to between 200-700 kg/ha.[153] In a

further study,[154] maize yield in the mixed rain-fed temperate / tropical highland were projected to increase by 33.3% by 2030s and 46.5% by the 2050s. The possible trends for maize are particularly encouraging, considering the nation's dependence on this crop and the high source of calories per capita per day this crop contributes (36%).[155]

For the livestock sector, implications of climate change on livestock-based rural livelihoods are predicted to be largely negative, with farmers expected to incur heavy losses in the future. Grazing and mixed rain-fed livestock systems are highly vulnerable to climate, due to their heavy dependence on natural resources. A changing climate is likely to have a number of direct and indirect impacts on livestock production, as outlined below:

- Higher temperatures and reduced water availability directly cause heat stress in livestock, which affects physiological processes, health and mortality. For example, heat stress for cattle causes a decrease in food intake and an increase in respiratory rate, which affects milk yields.[156] In a warmer climate, excessively high temperatures are predicted to damage livestock production (through losses of herds to drought, which frequently occurs currently in ASALs), as farmers are forced to reduce their stock levels or risk losing them altogether.[157]
- Livestock systems are directly impacted by natural disasters, specifically flooding. For example, during the El Niño flood of 1997/98, large numbers of livestock died from drowning in the floodwaters, with several regions experiencing losses of over 90%.[158]
- Climate change may indirectly cause increased disease pressure on livestock, through direct effects on pathogens, hosts, vectors and epidemiology, together with a number of indirect effects, including changes in ecosystems and the abundance and/or distribution of the competitors, predators and parasites of vectors.[159]
- Climate-induced changes in crop resources will have knock-on negative and positive consequences for livestock systems, through the allocation of feedstuffs, such as pasture, forage and grain. Changes in the quantity and quality of feed will encourage farmers to either decrease or increase their stocks.[160]

Pastoralism is the dominant form of livestock keeping in Kenya. Approximately 60% of the country's livestock is found in the ASALs, which constitute about 80% of the country's land mass and home of approximately 10% of the country's population[161]. Extreme weather and climate events already greatly impact the livelihoods of pastoralists in Kenya, as the ASALs are largely characterised by high evapotranspiration rates, low organic matter and poor infrastructure.[162] Greater drought frequency, in particular, may inhibit crop and animal system recovery, resulting in long-term degradation of grazing resources, continual reduction in herd size, and destabilisation of the social and economic standing of resource-poor livestock keepers.20[163]
An increased drought frequency to more than one drought every five years could cause significant, irreversible decreases in livestock numbers in ASALs.[164] Results indicate that a drought once every five years (i.e. representative of current conditions) keeps herd sizes stable in ASALs.[165] Increased probability of drought to once every three years has the potential to decrease herd sizes, due to increased mortality and poorer reproductive performance of the animals.[166] Recent drought-associated food insecurity has been highest among the pastoralists and small-scale mixed farmers found within these regions.[167]

For the fisheries sector, climate change-induced degradation of both freshwater and marine environments is likely to have significant implications for associated biodiversity and fisheries. Increasing water temperatures and decreasing water levels are likely to negatively impact fish stocks, with detrimental consequences for the rural communities such systems support. With respect to marine fishing activities, direct effects of climate change on marine capture fisheries include sea level rise, sea temperature change, lower ocean pH levels, and changes in rainfall that will affect estuarine fisheries, changes in ocean circulation, increased storm frequency and intensity. These direct effects will in turn alter fish habitats and change the distribution and composition of species, which will have a profound impact on marine ecosystems and fisheries.

In recent times, the fisheries sector has experienced the detrimental consequences of climate variability, specifically droughts. The 2008-2011 drought impacted Kenya's fisheries sector in a variety of complex and interrelated ways. Low inflows into the lakes and reservoirs as a result of prolonged drought condition coupled with the high evaporative effects have contributed to receding water levels (e.g. Lakes Turkana, Naivasha, and Baringo) and the drying up of ponds.[168] The receding water in the Lakes reduced the breeding grounds and also the fishing grounds, and some of the streams feeding the lakes dried altogether.[169]

In summary, these are the impacts of climate variability and climate change on Agriculture, Livestock and Fishing sector:

- Higher temperatures are likely to directly reduce yields of desirable crops in the long term. For example, parts of south west Kenya have been highlighted as potentially experiencing a significant reduction in the number of reliable crop growing days by the 2050s[170].
- Changes in precipitation patterns are likely to directly increase short-term crop failures and long-term production declines for rain-fed agriculture. The high inter-annual unpredictability in precipitation is already having negative consequences on rural livelihoods.
- A number of indirect impacts, such as increased rates of runoff and soil erosion, and increased crop losses from wildlife migrations, insects, diseases and weeds, could significantly magnify production losses.
- Declines in agricultural production will be detrimental for the food security and human health of small-scale subsistence farmers and their local communities.
- Approximately 60 per cent of the country's livestock is found in the ASALs, which constitute about 80 per cent of the country's land mass and which are home of 30 per cent of the country's population[171]. Pastoralism is the dominant form of livestock-keeping in the ASALs and given the recourse to mobility to manage climate variability, pastoralism is inherently adaptive. However, the increased frequency of extreme weather events, multiply the impact of factors that constrain pastoralists' livelihoods. Climate change introduces additional uncertainties into existing vulnerabilities, particularly in the ASALs.[172]

Droughts, being the prime recurrent disaster in Kenya have occurred in 1991/92, 1995/96, 1998/2000, 2004/2005, and 2008-11. The cycle of drought is becoming shorter, more frequent and more intense. Each of these events has caused severe crop losses, famine and population displacement in the country. The prolonged drought of 2008 - 2011 resulted in crop production losses of Ksh 69 billion for food crops and Ksh 52 billion for cash crops, with maize, tea and coffee losses being the highest.

The livestock sector experienced the worst impacts, losing approximately Ksh 699 billion, with Ksh 56 billion in damages due to costs from veterinary care, water, feeds and production decline and Ksh 643 billion in losses due to animal deaths.[173]

During the 2008-2011 drought, the fisheries sector experienced effects with estimated value of Ksh 4.2 billion, comprising Ksh 3.6 billion in losses and Ksh 0.5 billion in damages.

Impacts on coastal zones

Climate change impacts, including increases in sea surface temperature, sea level rise and coastal erosion, are likely to put additional pressure on coastal ecosystems[174], including islands, estuaries, beaches, coral reefs and marine biodiversity. Sea level rise in combination with extreme weather events is likely to intensify flooding as the majority of the coastland is low-lying. Coral reef ecosystems are particularly vulnerable to climate change impacts, with associated consequences for the livelihoods of millions of people depending on those ecosystems for food, income and shoreline protection. In the Western Indian Ocean region, corals are already experiencing substantial stress from increasing water temperatures and ocean acidity, with several significant coral bleaching and mortality events in recent decades (e.g. 1998). Climate change is very likely to lead to more of such events and lower the recovery rate of pre-bleaching coral cover, following increasing sea surface temperatures. Furthermore, marine biological invasions are increasingly recognised as a threat to biodiversity. Invasive alien species and Harmful Algal Blooms (HABs) are a current and significant threat to the health of coastal ecosystems that may be climate-change related. A number of medium to large-scale HABs impacted the northern coasts of East Africa between December 2001–February 2002) and led to extensive fish mortality in Kenya (e.g. surgeon fish, snapper, triggerfish).[175]

In coastal locations, ports and transport infrastructure is particularly exposed, together with tourism assets and settlements situated close to the coast.

Human health

Climate change is expected to put at risk human health by exacerbating the magnitude and occurrence of existing impacts, such as heat stress, air pollution, asthma, vector-borne diseases (such as malaria, dengue, schistosomiasis – also referred to as swimmer's itch or snail fever – and tick-borne diseases), water-borne and food-borne diseases (such as diarrhoeal diseases). According to the World Health Organisation, increasing temperatures and precipitation patterns arising from a changing climate in the past 30 years already claim over 150,000 lives annually,[176] among which 88% of the disease burden afflicts children under the age of 5. The current burden of climate-sensitive disease is high in Kenya and future climate change is expected to "exacerbate the occurrence and intensity of future disease outbreaks and may increase the spread of diseases in some areas".[177] For Kenya, the potential implications of a changing climate on health are as follows:

- Geographic exposure to malaria, which is one of the most physically and economically debilitating diseases in Kenya, is predicted to shift due to increasing temperatures and changing distribution of precipitation. Reports indicate that the Kenyan Highlands, which were initially free of malaria, will be exposed to the risk of malaria following increasing temperatures and precipitation.[178] [179] [180] In contrast, exposure will likely be reduced in lower altitudes.[181] A recent modelling study has projected that by 2055, as a result of the central average climate warming (2.3°C) across the projections, the population annually affected by malaria in rural areas over 1,000 metres (which comprises 63.5% of the population of Kenya) would increase by up to 74%. However, there is controversy over the spread of malaria to the Highlands because most of the studies fail to integrate non-climate factors, such as the decline in the control and treatment of the disease.[182]

- Increasing annual temperature is likely to be responsible for increasing prevalence of diarrheal disease, particularly among children under 5 years. Furthermore, extreme events, especially extreme rainfall, will further threaten the health of the increasing population without basic sanitary infrastructure and reliable waste collection infrastructures.
- Extreme events and El Niño floods are also likely to lead to increasing outbreaks of other diseases such as cholera and rift valley fever. For example, rift valley fever outbreaks in East Africa are closely associated with the heavy rainfall that occurs during the warm phase of the ENSO phenomenon.[183]
- In coastal areas, toxins from HABs can create significant health risks for humans and wide-ranging impacts on marine ecosystems. The most potent HABs produce neurotoxins that may be responsible for human illness or death via consumption of contaminated seafood, particularly bivalve molluscs (e.g. oysters, mussels), commonly referred to as shellfish poisoning. During recent years there has been an apparent increase in the occurrence of HABs in many marine and coastal regions[184] and a number of cases are reported in Kenya. This may be due to increased stratification of the upper water column, changes in ocean circulation altering phytoplankton assemblages and increased freshwater run-off from land with consequent nutrient enrichment (eutrophication).

Forestry and wildlife

Anticipated impacts of climate change on biodiversity include shift of ecosystem boundaries, change in natural habitats and sharp increases in extinction rates for some species.

During the 2008-2011 drought, drought and indirect impacts from wildfires included environmental losses as a result of damages to plant and animal species, habitats, reduced forest productivity, lower water levels, increased livestock and wildlife mortality rates.

Kenya's natural resources, in particular its rich flora and fauna, are among the country's most valuable natural assets. The natural environment is exceptionally diverse and as a consequence climate-related risks will vary depending on the setting.

Drought, in particular, already threatens Kenya's rich biodiversity and species loss has been observed, while in other places, the number of indigenous and important species has dwindled significantly.[185] Drought also causes poorer habitat suitability in terms of food, water, cover and useable space, leading to wildlife migration, mortality through starvation, predation, reduced production and recruitment (survival of young ones) and broader environmental degradation. In addition to these extreme events, the slow creeping change in temperature and precipitation patterns over the longer-term are likely to negatively impact vegetation and wetlands, with associated consequences for birds and animals higher up the food chain.

The distribution of forests in Kenya is largely determined by precipitation, which means climate change has the potential to cause significant forest dieback and biodiversity loss. This would have associate detrimental consequence for rural livelihoods that are dependent on forest goods and services. Forest fires are an additional hazard that is influenced by climatic conditions. Since about 1990, Kenya has lost an average of >5,700 hectares of forested land per year due to forest fires.[186] The projected rise in temperatures and long periods of drought are predicted to lead to more frequent and more intense fires. Forest fires have in the recent past affected Kenya's major forests, including the Mount Kenya forest fire in February/March 2012.

Urban and housing

Climate change is likely to make rural livelihood strategies and living conditions increasingly challenging and as a result is likely to exaggerate the rural-to-urban migration trend Kenya is currently experiencing. Specific risks and challenges for communities, especially those living in urban environments and particularly the most vulnerable, include river and flash flooding, with flood related fatalities constituting 60 per cent of disaster victims in Kenya. Extreme events and particularly El Niño rains are likely to undermine the health of Kenya's inhabitants directly through increasing numbers of injuries and deaths and indirectly through water quality issues and food insecurity. Drought and associated water scarcity, in particular, have the potential to exacerbate existing inequalities. Women in Kenya have been observed to be disproportionately affected by drought because pre-existing gender discrimination exposes them to higher rates of poverty and insecurity and because of the extra socio-economic burden they have meeting the needs of households, children, the vulnerable and the elderly.

Arid and semi-arid lands

The influx of civil strife and drought-driven refugees to northern Kenya creates challenges for the ASAL economy and natural resource base. According to UNHCR, Kenya hosted 650,000 refugees located in three camps in 2012. KFS reported that 11.3 million tonnes of fuelwood were cut by the refugees from an area of 80-km radius over three years. The recovery of these resources will take a long time in the pastoral areas.

Over the past few decades, transformations in the ASALs have impacted on the livelihoods of the pastoralists. Migration of rural communities from the congested high-potential areas and the dry arid areas to cities has contributed to overpopulated slums and settlements that lack basic services. The dwellers of the slums in turn continue to migrate to the semi-arid areas and pursue non-pastoral activities such as cropping in grazing lands not well suited for agriculture.

The 2008-2011 drought in Kenya had profound impacts on many communities, destroying livelihoods and increasing vulnerability. In pastoralist areas where men are traditionally responsible for livestock, reduced herd sizes forced men to migrate to urban centres for wage employment. This had implications for women and children due to the additional burden of sustaining household food, water and human security. School attendance rates decreased, child labour increased and conflicts over resources were observed to intensify.

Tourism

With its close connections to the environment and climate itself, tourism is considered to be a highly climate-sensitive industry.[187] A wide range of climate-induced environmental changes will have profound effects on tourism at the local and regional destination level.

Changes in water availability, biodiversity loss and reduced landscape aesthetics, increased natural hazards, coastal erosion and inundation and the increasing incidence of vector-borne diseases will all impact the tourism industry to varying degrees. However limited research has been undertaken on the impacts of climate change on tourism in Kenya.

Manufacturing, Transport and Trade

Climate change has the potential to impact manufacturing, retail and trade sectors across a range of economic scales, from individual businesses operating in manufacturing, wholesale and retail through to the national economy and international trade. Impacts to critical supporting infrastructure, such as energy, water, communications and transport, have the potential to reverberate into the private sector, with consequences for business continuity, revenue, workforce and associated supply chains.

Climate induced changes in productivity in the tea, coffee and vegetables subsectors have implications for exports and imports. For example, recent crop failure in maize resulted in the importation of 2.6 million bags between 2008 and 2009, worth Ksh 6.7 billion.[188]

Reduced output of hydropower that resulted from 2008-2011 drought reduced revenue for the electricity utility, Kenya Power Company by Ksh 2.6 billion. Likewise, the Kenyan electricity producer KenGen also reported a downward trend in their revenue in late 2010, totalling Ksh 1.25 billion.[189] Reduced hydropower production was accompanied by an increased share of thermal power generation at a higher cost of generation. The losses due to higher production costs are estimated to be about Ksh 29.8 billion contributing to total cumulative losses of approximately Ksh 32.4 billion.

Climate change is a potential "external shock" to the financial services sector for example through exposure to indirect risks to investment portfolios, and retail customers defaulting on loans, and to insurance through increased risks leading to high claim ratios and lower uptake of insurance cover.

Infrastructure (for energy and transport)

A range of climate drivers have the potential to compromise infrastructure design, function and performance across a range of settings. In coastal locations, ports and transport infrastructure is particularly exposed, together with tourism assets and settlements situated close to the coast. Riverine flooding and landslides have the potential to cause significant damage to physical infrastructure such as roads, bridges, water pipelines and power lines, resulting in widespread disruption, a requirement for additional capital expenditure and wider environmental damage. Droughts cause underperformance of hydroelectric power infrastructure, with power generation in periods of drought reduced by almost 40 per cent of normal years.[190]

PRIORITY ADAPTATION OPTIONS

The development of the draft National Adaptation Plan (NAP) included the identification of criteria, which were used to select priority actions under each Medium Term Plan theme. The criteria were weighted to ensure actions addressing existing vulnerabilities scored highly. Projected changes were addressed through the selection of no and low regrets measures, incorporation of knowledge of future climate change into decisions on long-lived fixed assets and policies, and identifying where a long lead-in decision timeline is required before an action can take effect. Adaptation priorities identified and elaborated in the NAP are listed below in Table

48. These priorities are based on risk and vulnerability assessments across the MTP II sectors, and build on NCCAP priority actions in a

wide range of sectors. For details, reference is made to the NCCAP and the ATAR.

Table 39: Adaptation priorities identified and elaborated in the NAP

• MTP SECTOR	• PRIORITY ADAPTATION ACTIONS
• Energy	• Increase the resilience of current and future energy systems*
• Science, Technology and innovations	• Support innovation and development of appropriate technologies that promote climate resilient development*
Public sector reforms	Integrate climate change adaptation into the public sector reforms
• Human Resource Development, Labour and Employment	• Enhance adaptive capacity and resilience of the informal private sector
• Infrastructure	• Climate proofing of infrastructure (energy, roads, buildings, ICT)*
• Land Reforms	• Mainstream climate change adaptation in land reforms*
Education and training	Enhance awareness, education and training in climate change adaptation across public and private sectors
Health	Strengthen integration of climate change adaptation into the health sector*
Environment	Enhance climate information services
	Enhance the resilience of ecosystems to climate variability and change*
Water and irrigation	Mainstream of climate change adaptation in the water sector by implementing the National Water Master Plan (2014)*
Population, urbanisation and housing	Enhance the adaptive capacity of the population, urbanisation and housing sector*
Gender, Vulnerable Groups and Youth	Strengthen the adaptive capacity of vulnerable groups (lactating women, children under 5, elderly, sick, physically challenged) through social safety nets and insurance schemes
Tourism	Enhance the resilience of the tourism value chain
Agriculture, livestock development and fisheries	Enhance the resilience of the agriculture, livestock and fisheries value chains by promoting climate smart agriculture and livestock development*
Private Sector/ Trade; Manufacturing; Business Process Outsourcing, Financial services	Create enabling environment for the resilience of private sector investment, demonstrate an operational business case*
Oil and mineral resources	Integrate climate change adaptation into the extractive sector, including climate proofing of infrastructure*
Devolution	Mainstream climate change adaptation into county integrated development plans

*** Denotes adaptation actions that have mitigation co-benefits.**

ADAPTATION GOVERNANCE

The following organisations constitute part of the governance framework for adaptation in Kenya:

- The Climate Change Secretariat, MENRRDA leads the work on adaptation, including the development of the NAP and implementation of the NCCAP.
- NEMA is the National Designated Authority for the CDM and the National Implementing Entity managing activities under the Adaptation Fund.
- The Vision 2030 Secretariat, Ministry of

Planning and Devolution, is undertaking work to assess adaptation and mitigation in flagship projects.

- The Ministry of Planning and Devolution is developing climate change indicators in its Handbook to measure progress under the MTP2.
- County government are developing climate change indicators to track progress under their County Integrated Development Plans.
- The National Drought Management Authority undertakes activities on drought management and emergency preparedness that improve adaptive capacity.

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CHAPTER 4

Measures to Mitigate Climate Change

TABLE OF CONTENTS

INTRODUCTION

Articles 4.1 and 12.1, of the United Nations Framework Convention on Climate Change commits Parties to develop national and, where appropriate, regional programmes and measures that will result in the mitigation of human-induced climate change. Such measures may either reduce the increase in greenhouse gas emissions (abatement) or increase terrestrial storage of carbon (sequestration). All the measures have to be in compliance with the applicable national and international agreements, policies and legislation.

Although developing countries are not required to take on emission reduction commitments, Kenya views undertaking climate change mitigation and assessment as a means to sustainable development. For the country, undertaking mitigation evaluation analysis also facilitates the implementation of mitigation projects, strengthening of institutional and human capacity-building and the prioritisation and evaluation of social, economic and environmental programmes.

This chapter presents Kenya's mitigation evaluation analysis, describing the low-carbon assessment undertaken in the six mitigation sectors: energy, transport, industry, agriculture, forestry and waste management. The assessment presented in this report is based on the Mitigation chapter of the NCCAP, but with updated data and information. Detailed analysis of the development scenarios were carried out during the NCCAP process in 2012. Therefore, this report does not attempt to conduct assessment of the country's low carbon development pathway with new development scenarios. It however updates the detailed assessment carried out during the NCCAP process by applying the latest available data and information, some of which were not available at the time of developing the NCCAP.

As per the NCCAP, the assessment – which includes a bottom-up assessment of mitigation opportunities and a top-down economy-wide economic, energy and emissions model – provides the evidence base for prioritising low-carbon development opportunities and, ultimately, developing investment proposals to attract international climate finance through nationally appropriate mitigation actions (NAMAs) and reducing emissions from deforestation and forest degradation plus the role of conservation, sustainable management of forests and enhancement of forest carbon stocks (REDD+).

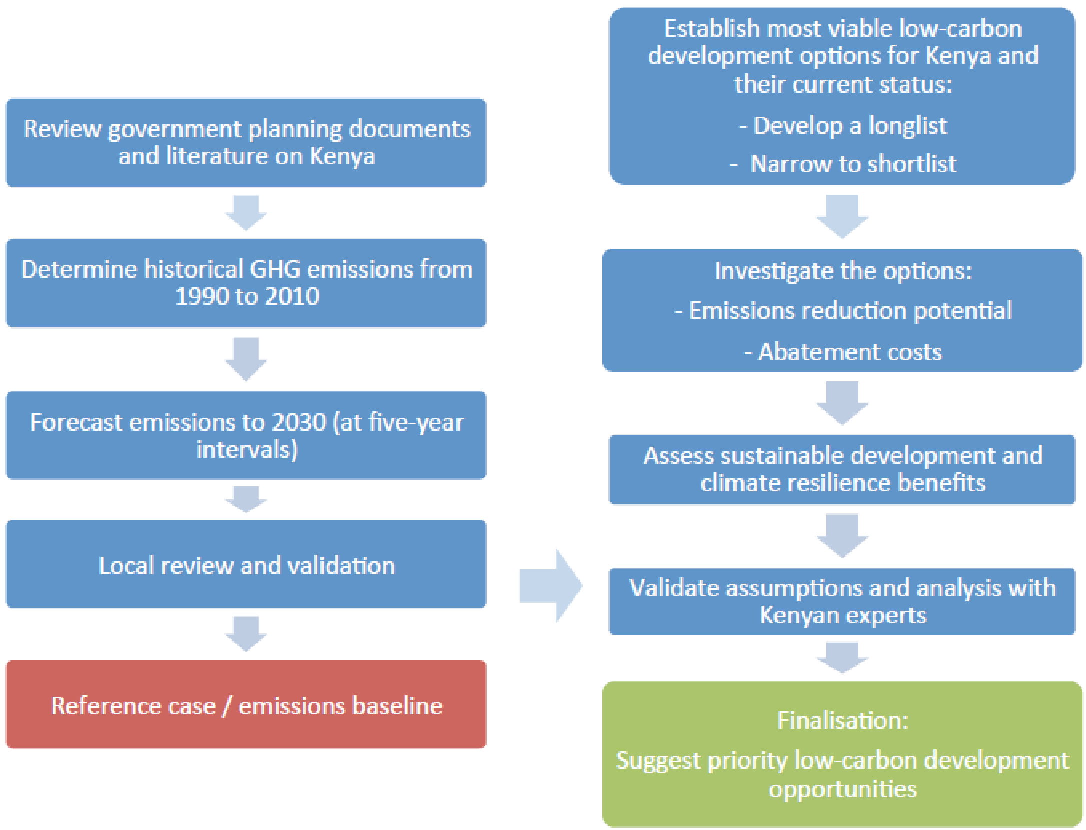
METHODOLOGY FOR THE MITIGATION ASSESSMENT

Within the framework of Kenya's national circumstances and the country's sustainable development objectives, Kenya has used available and appropriate methods in order to formulate and prioritise programmes containing measures to mitigate climate change. The measures applied include social, economic and environmental factors.

The mitigation assessments conducted by Kenya entail the generation of information on the national analysis of the potential costs and impacts of the various technologies and practices to mitigate climate change, which are relevant for sustainable development and useful for policy making with regard to formulation and prioritisation of mitigation programmes.

Under Subcomponent 4 of the NCCAP, a detailed technical analysis was undertaken to identify the main elements of a low-carbon development pathway, recognising that the pathway needs to emphasise sustainable development and climate resilience co-benefits. This view was supported by stakeholders and experts through an extensive consultation and validation process. The NCCAP's low carbon analysis carried out under the NCCAP process, and updated in this Second National Communications, demonstrate that mitigation actions can contribute to low-carbon pathways in the six sectors set out in the UNFCCC: energy, transport, industry, agriculture, forestry and waste. However, some of the sector baseline emissions are different as the Second National Communications has applied the latest available data. The emission reduction options and their potential however remain the same as those determined in the NCCAP. The general methodology used to develop the low-carbon scenario assessment for the NCAPP is outlined in Figure 46. A detailed description of the methodology is provided in Chapter 6 of the NCCAP.

Figure 46: General methodology used to develop the low-carbon scenario assessment for the NCAPP



The mitigation assessment presented in this section deviates from the NCCAP work identified in Figure 45 in only a few small ways. A new emissions reference case or business as usual scenario is developed using the historical GHG emissions developed and presented in Chapter 2 as well as from new available historical data from 2011, 2012 and 2013. As a result emissions projected for each sector to 2030 vary from the NCCAP work. In some cases this changes expected energy demand or economic activity which affects the emission reduction potential of the mitigation options investigated under the NCCAP. Out of the 31 mitigation actions considered under the NCCAP approximately 11 mitigation actions in the electricity generation and energy demand sectors required significant updates due to baseline changes.

The NCCAP provides full details of a range of adaptation and mitigation actions in the context of a low carbon climate resilient development pathway. The actions have not been affected by the updated data and the potentials are exactly as specified in the NCCAP. The big wins identified will make a significant impact on sustainable socio-economic development, adaptation and mitigation in Kenya. They include:

- Geothermal power generation
- Restoration of forests on degraded lands and reforestation of degraded forests
- Climate smart agriculture and agroforestry
- Improved cookstoves
- Mass rapid transit system in Nairobi, including bus rapid transit with light rail transit corridors

All these 'big win' opportunities combine climate resilience and mitigation benefits and capture over two-thirds of the mitigation potential identified in the NCCAP low carbon assessment. More specific mitigation actions proposed for each national planning sector are presented in this report.

EMISSION BASELINE PROJECTION

An assessment of mitigation options to be undertaken as Nationally Appropriate Mitigation

Actions (NAMAs) or other appropriate mitigation programmes requires that there is a projection of expected baseline or business as usual emissions into the future that accounts for existing government policies from which to consider the impact of individual NAMAs. It is important that this projection reflects only existing policies, regulations and financial commitments and does not account for potential new policies or account for financing that is speculative in nature. For this reason, targets and goals expressed by the GoK in Vision 2030 and elsewhere, have not been considered as constituting the baseline, **unless** appropriate policies have been put in place and funds committed to reach them.

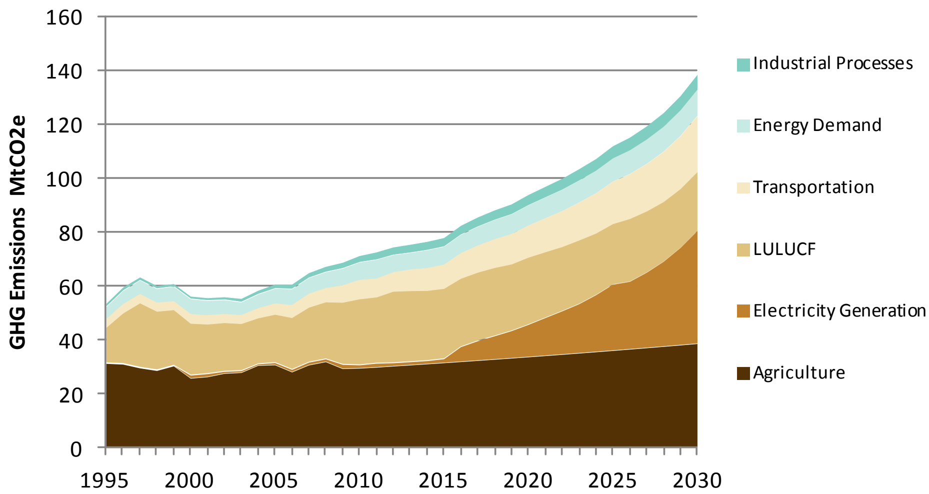
This section describes the methods used to project baseline emissions for Kenya out to 2030 for the entire Kenyan economy and by sector and then presents the results. The method applied is in line with the assessment done in the NCCAP. However, the data and information used for this chapter of Kenya's Second National Communications has been updated to reflect new information and data that has been generated since the NCCAP was prepared in 2012. The information is organised by the following seven sectors used for analysis in the low-carbon scenario analysis of the NCCAP:

- Energy demand
- Electricity generation
- Transportation
- Industrial processes
- Agriculture

- Forestry
- Waste.

Final projections of the baseline emissions for each sector out to 2030 are illustrated in Figure 47.

Figure 47: Emission Baseline Projection for Kenya (MtCO2e)



Sector	Baseline Emissions (MtCO2e)							
	1995	2000	2005	2010	2015	2020	2025	2030
Agriculture	30	23	26	30	32	34	36	39
Electricity Generation	0	1	1	1	1	12	24	40
LULUCF	12	21	18	21	26	25	23	20
Transportation	4	4	4	7	9	12	16	17
Energy Demand	4	5	5	6	7	8	9	10
Industrial Processes	1	1	1	2	3	4	5	6
Waste	1	1	2	2	2	3	3	4
TOTAL	**52**	**55**	**57**	**70**	**80**	**96**	**115**	**138**

In the reference case, emissions increase up until 2030 in all sectors except LULUCF:

- Electricity emissions grow the most, increasing from 5 million tonnes of carbon dioxide equivalent (MtCO2e) in 2010 to 40 MtCO2e in 2030. Much of this increase is attributed to new coal and natural gas coming online to meet increasing energy demand.

- Forestry sector emissions are likely to decline after 2020 due to the reduced clearing of forests and increases in the number and size of trees, a result of tree planting programmes and a reduced projection in wood harvesting.
- Agriculture and forestry sectors are the largest emitters, accounting for approximately 75 per cent of emissions in 2010 and 45 per cent in 2030, mainly due to emissions from livestock and deforestation.
- Emissions in other sectors grow significantly, with transport emissions increasing by about three times between 2010 and 2030, and emissions from the waste sector and energy demand doubling in the same time period.

Energy Demand

The Energy demand sector includes all fuel combustion emission sources that are not related to the electricity generation sector and the transport sector. This includes fossil and biomass fuels consumed by residential, commercial, industrial, agriculture, forestry and fishing sectors. Future growth in petroleum product consumption in the Energy Demand Sector was estimated based on the overall historic growth of all fossil fuels between 2000 and 2009. This total growth was estimated to be 3.4% per year. The growth rate in coal consumption was based on the demand for energy to meet future cement production, estimated to increase by 5% annually. Future biomass consumption data were available from a UNEP study and these were used to estimate the biomass growth rates.[191] Table 49 summarises the assumptions that are used to develop the projections of the inventory emissions between 2011 and 2030. Table 50 indicates projected fuel consumption by sub-sector between 2010 and 2030 in five-year increments.

Table 40: Projection assumptions for other energy demand

Fuel	Metric	Assumption	Notes
Kerosene, LPG, Fuel Oil, Jet kerosene, aviation gasoline	Tonnes per year	+3.4% per year	Historical data for 2011 to 2013 also used. 3.4% growth rate based on historical average growth between 2000 and 2010.
Coal	TOE per year	+4.0% per year	Historical data for 2011 to 2013 also used. 4.8% growth rate based on Forecast growth rate of Manufacturing GDP in Vision 2030.
Refinery Usage	Tonnes per year	Reduced to zero in 2015	Reflects non-operational status of the refinery
Fuelwood	Tonnes per year of dry matter (dm)	+0.84% per year	Based on data from two studies: Ministry of Environment, Water and Natural Resources (2013). *Analysis of Demand and Supply of Wood Products in Kenya*. Study carried out by Wanleys Consultancy Services. Nairobi, Kenya and United Nations Environment Programme (2006). *Kenya: Integrated assessment of the Energy Policy With focus on the transport and household energy sectors*. In conjunction with Ministry of Ministry for Planning and National Development.
Charcoal Consumption	Tonnes per year	+1.3% per year	

Agricultural Residues	Tonnes per year (dm)	+2.8% per year	Based on data from Environment Programme (2006). *Kenya: Integrated assessment of the Energy Policy With focus on the transport and household energy sectors*. In conjunction with Ministry of Ministry for Planning and National Development.

Table 41: Forecast residential, commercial and industrial energy fuel consumption (TJ)

Fuel Type	2010	2015	2020	2025	2030
Residential					
LPG	1,855	2,098	2,480	2,931	3,464
Illuminating Kerosene	11,737	11,758	13,898	16,427	19,416
Fuelwood	193,524	201,820	210,471	219,494	228,902
Charcoal	53,664	57,167	60,900	64,876	69,112
Agricultural Residues	82,630	94,984	109,186	125,511	144,277
Commercial					
LPG	1,855	2,098	2,480	2,931	3,464
Illuminating Kerosene	2,404	2,408	2,847	3,365	3,977
Fuelwood	22,778	23,754	24,772	25,834	26,942
Charcoal	2,824	3,009	3,205	3,415	3,637
Fuel Oil	2,734	2,286	2,701	3,193	3,774
Industrial					
LPG	444	503	594	702	830
Fuelwood	11,389	11,877	12,386	12,917	13,471
Fuel Oil	11,729	9,805	11,589	13,698	16,191
Heavy diesel oil	352	281	332	393	464
Bituminous Coal	6,917	9,597	12,103	15,264	19,250
Energy Industries (Charcoal Production and Refinery)					
Fuelwood	207,000	220,515	234,913	250,250	266,590
Refinery Usage	4,543	0	0	0	0
TOTAL (All sectors)					
Bituminous Coal	6,917	9,597	12,103	15,264	19,250
LPG	4,154	4,699	5,554	6,565	7,759
Gasoline	26,844	38,001	50,193	66,303	87,596
Aviation Gasoline	112	105	125	147	174
Jet Kerosene	6,015	6,571	7,766	9,179	10,850
Illuminating kerosene	14,141	14,167	16,745	19,791	23,393
Light diesel oil	65,745	77,674	103,035	136,720	181,476
Heavy diesel oil	1,005	804	950	1,123	1,327
Refinery Usage	4,543	0	0	0	0

Additives	3,308	4,613	6,116	8,108	10,752
Fuelwood	434,691	457,966	482,543	508,495	535,905
Charcoal	56,488	60,176	64,105	68,291	72,749
Agricultural Residues	82,630	94,984	109,186	125,511	144,277

In order to be able to analyse demand side mitigation options, it is critical that fuel consumption and related emissions be allocated to end-uses. Historical information on the total consumption of different energy consumers (urban households, rural households, commercial and industry) is available from the data on petroleum fuels sales and a number of reports. However, there is little comprehensive information available on the end-use demand where these fuels are ultimately consumed, such as for cooking, lighting and heating water. A large number of reports provide details on usage patterns of households and ownership of appliances but this data only indirectly indicates actual energy consumption. Other data, especially for biomass consumption, was often found to be contradictory and therefore not reliable.

End-use allocation is based on estimates from experts and from the literature. There is no comprehensive source of information in Kenya on the historical end-use consumption patterns of different consumers of biomass and fossil fuels. A large number of documents were reviewed that provided some evidence of end-use consumption patterns or ownership of appliances specific to certain fuels but this data was seldom aggregated to the national level or only indirectly indicated actual energy consumption.

For example, there was detailed data on the distribution of cooking devices used by urban and rural households, but this data only indirectly indicated fuel consumption. Additional data or assumptions were required in order to estimate how much fuel and what type of fuel was consumed. Expert opinion or detailed end-use fuel consumption patterns from other countries were in some cases used to identify the share of fuel used by different end-uses. As a result, there is a fair degree of uncertainty associated with the end-use allocation and a number of the estimates are not Kenyan specific. However, the uncertainty in end-use allocation does not affect overall estimates of emissions, but it does impact the uncertainty associated with estimates of the potential for mitigation where specific end-uses are targeted.

Table 51 summarises the allocation of different fuels to both consumers and specific end-uses. The cement industrial sector is separated from the energy consumption of all other industry.

Table 42: Estimate of end-use consumption by fuel and consumer (%)

Fuel	Consumer	Total Fuel Share by Consumer	End-Use Consumption by Fuel and Consumer (%)			
			Cooking	Hot Water	Industrial Process	Lighting
Kerosene	Urban	58%	0%	0%	0%	58%
	Rural	25%	0%	0%	0%	25%
	Commercial	11%	0%	0%	0%	11%
	Other Industrial	6%	0%	0%	6%	0%
Fuel Oil	Commercial	46%	0%	37%	0%	9%
	Cement	22%	0%	0%	22%	0%
	Industrial	32.2%	0%	0%	54%	0%
Heavy Diesel Oil	Commercial	70.7%	0%	57%	0%	14%
	Industrial	29.3%	0%	0%	29%	0%
Lubricants	Industrial	100%	0%	0%	100%	0%
LPG	Urban	44.7%	45%	0%	0%	0%
	Rural	0%	0%	0%	0%	0%
	Commercial	44.7%	45%	0%	0%	0%
	Industrial	10.7%	0%	0%	11%	0%
Coal	Cement	100%	0%	0%	100%	0%
Agricultural Residues	Urban	20%	17%	1%	0%	2%
	Rural	60%	51%	3%	0%	6%
	Commercial	10%	8%	2%	0%	0%
	Industrial	10%	0%	0%	10%	0%
Fuelwood	Urban	5%	4%	0%	0%	1%
	Rural	80%	68%	4%	0%	8%
	Commercial	10%	8%	2%	0%	0%
	Industrial	5%	0%	0%	5%	0%
Charcoal	Urban	75%	75%	0%	0%	0%
	Rural	20%	20%	0%	0%	0%
	Commercial	5%	5%	0%	0%	0%
	Industrial	0%	0%	0%	0%	0%

Electricity Generation

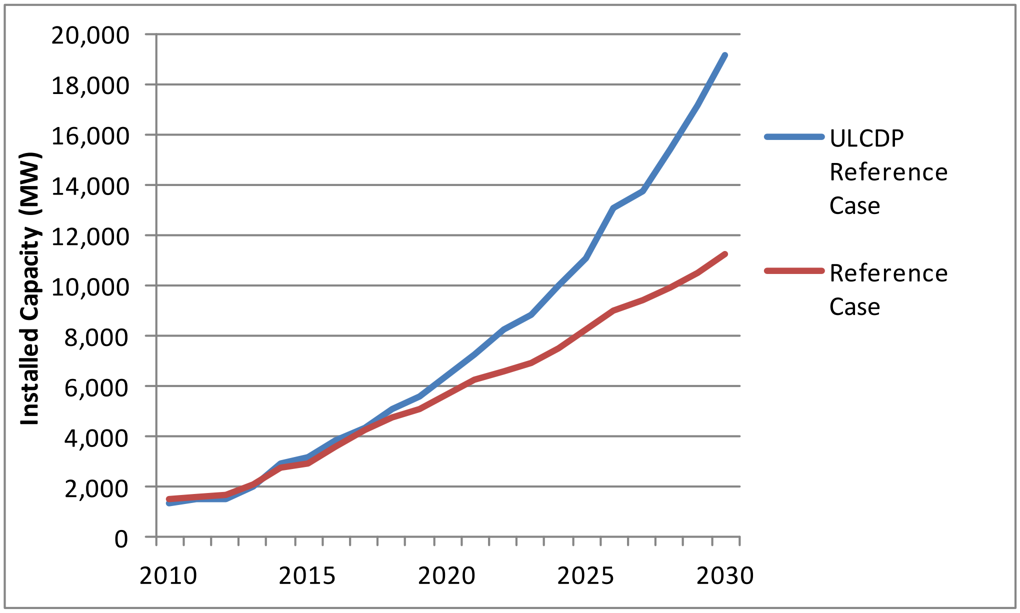
Developing a baseline projection for Kenya's electricity sector is challenging because there is considerable uncertainty regarding how the sector may grow to meet a large suppressed demand for electricity. Specific plans are in place but they assume very high growth rates. The *Updated Least Cost Power Development Plan (ULCPDP)* presumes a 14% per annum growth rate in electricity supply between 2010 and 2030 in their reference case.[192] This compares to historical growth in electricity supply of about 7% between 2000 and 2010. The cost to achieve this dramatic growth is estimated at U.S$ 41.4 billion (excluding committed projects) while generation technologies that are expected to make up the vast majority of new supply still face considerable barriers to implementation.[193] Technologies such as nuclear, coal and wind have either not been proven in Kenya or have limited current penetration. Geothermal, which is expected to comprise the largest portion of generation, has high initial costs, long lead times and risk of resource exploration that must be overcome.

The baselines outlined in the NCAPP and in this section are in line with each other but they are not identical to the reference case in the Updated Least Cost Power Development Plan.[194] This is because the objective of the baseline emissions forecast is to consider a scenario based on existing policies and regulations and assume no growth in international aid and related international investments. Specifically, any additional international support and investment for electricity generation projects that may be tied to low-carbon development are not included in the emissions reference case, unless the international support and related investments have already been committed. Including such international support would mean that the substantial renewable generation investment in geothermal, wind and small hydro in the aspiration of Vision 2030 reference case could not be part of a NAMA, for example. Consequently, including this potential investment in the baseline would mean that billions of dollars in investment opportunity through the development of NAMAs and other mitigation projects could not be considered in the mitigation scenario.

Figure 48

Figure 48 compares the total installed capacity between 2010 and 2030 presented in the reference case adopted in this low-carbon analysis to the reference case in the Updated Least Cost Power Development Plan.[195]

Figure 48: Comparison of installed capacity between 2010 and 2030



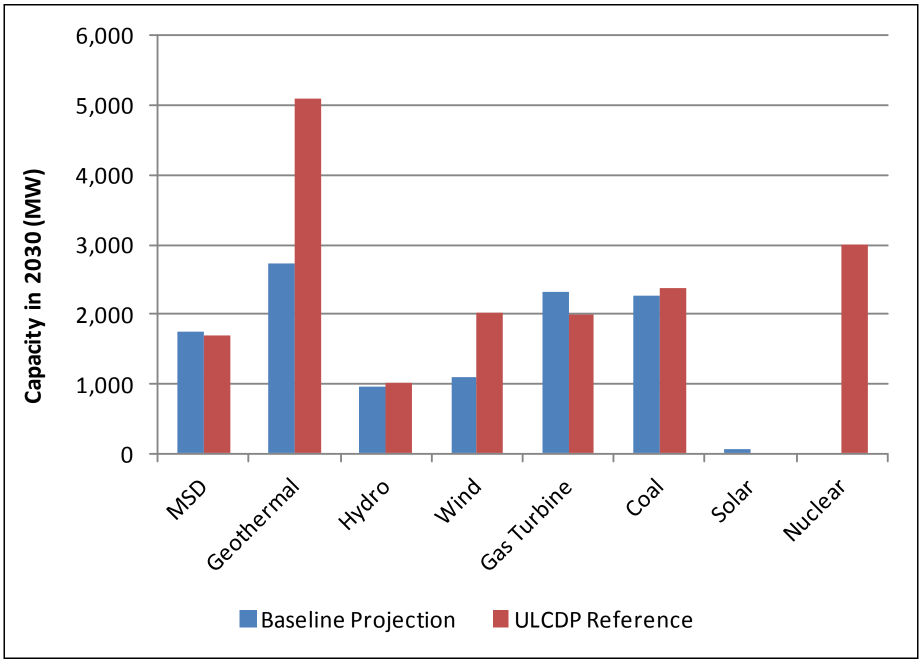
Revised projections of short-term generating capacity installations were provided by the then Ministry of Energy (now Ministry of Energy and Petroleum).[196] Table 52 outlines the new generation capacity that is included in the baseline for the years between 2012 and 2017.

Table 43: Information provided from the Ministry of Energy and Petroleum on new capacity additions

New Additions to Capacity Between 2012 and 2017		
New power plants and generating capacity that will come online in the next five years	2012	HYDRO 21MW – Sang Geothermal 2.3 MW – Eburru Geothermal 75 MW – Olkaria
	2013	Wind 60MW - Aeolus MSD 81MW - Triumph MSD 84MW - Gulf MSD 87MW - Melec MSD 80MW – Muhoroni Wind 6.8 MW - Ngong
	2014	Geothermal 140 MW – Olk4 Wind 300 MW - Turkana Geothermal 36 MW - Olk3 Wind 50 MW - Osiwo Hydro 32 MW- Kindaruma Geothermal 140 MW - Olk 1 – 4&5
	2015	Geothermal 280MW Hydro 6 MW – small hydro
	2016	IMPORT 400MW Coal 600MW - Mombasa
	2017	Geothermal 140MW Geothermal 45MW

For years beyond 2017, the baseline projection deviates from the *Updated Least Cost Power Development Plan* 2011 reference case in order to reflect a baseline that is based on existing policies and regulations and assumes no growth in international aid and related international investments, specifically assuming no additional international support that would be tied to NAMAs or similar mitigation activities. Since there is no gas generation in the medium term, the analysis adopts the trend identified in the ULCDP. Imports also assumed follow the same trend as the ULCDP. All other technologies including coal, medium-speed diesel (MSD), wind, hydro and geothermal are based on the same rate of growth generation capacity that is installed in the medium term plan (2012 to 2017). In the baseline it is assumed that no nuclear energy will be added before 2030. Figure 49 compares the installed capacity of different technologies in 2030 in the reference case adopted in the low-carbon analysis to the reference case that is presented in the *Updated Least Cost Power Development Plan*.[197]

Figure 49: Comparison of installed capacity in 2030 (MW)



Total generation capacity under the GHG emissions reference case is 11,191 MW in 2030 versus from 17,220 MW under the Updated Least Cost Power Development Plan. This represents an annual average growth rate in capacity of 11% versus 14% in the Updated Least Cost Power Development Plan. The growth rate assumed in the low-carbon scenario reference case is still considerably larger than historic growth in the economy and the sector. Table 53 identifies the total installed capacities of various generation technologies.

Table 44: Baseline generation capacity by technology type (MW)

Generation Type	2010	2015	2020	2025	2030
MSD	425	877	1,085	1,415	1,745
Geothermal	189	556	1,312	1,872	2,734
Hydro	730	790	845	904	963
Wind	7	207	631	805	1,095
Gas Turbine	74	14	694	1,414	2,314
Coal	0	0	1,080	1,680	2,280
Solar	0	0	60	60	60
Nuclear	0	0	0	0	0
TOTAL	**1,425**	**2,444**	**5,707**	**8,150**	**11,191**

Future electricity generation by technology type was estimated by multiplying the installed capacity (MW) of each technology by an average capacity factor for that technology (hours per year). These utilisation rates, shown in Table 44, are based on those presented in the *Updated Least Cost Power Development Plan* and where applicable, are an average of peaking and baseline load.

Table 45: Utilization rate for different plant generation types

Generation Type	Utilization (average % of time operating
Geothermal	90%
Cogeneration	40%
MSD	28%
Hydro	60%
Wind	30%
Gas Turbine	46%
Coal	64%
Solar	16%

Table 45 presents the total baseline generation forecasted by technology type that is determined by multiplying the installed capacities in Table 45 by utilization rates in Table 46.

Table 46: BAU generation by plant type (TWh)

	2010	2015	2020	2025	2030
MSD	2,056	2,152	2,662	3,471	4,281
Geothermal	1,442	4,384	10,344	14,759	21,555
Hydro	3,224	4,152	4,439	4,749	5,059
Wind	17	544	1,659	2,117	2,879
Gas Turbine	145	24	2,813	5,733	9,383
Coal	0	0	6,055	9,419	12,783
Solar	0	0	112	252	392
Nuclear	0	0	0	0	0
TOTAL	**6,884**	**11,255**	**28,084**	**40,500**	**56,332**

In addition to this generation supply there is also an expectation that Kenya will import some power to meet their needs. Expected imports are based on the ULCDP reference case and are summarised in Table 47.

Table 47: BAU electricity imports (GWh)

	2010	2015	2020	2025	2030
Imports	38	200	1,000	1,200	2,000

Total consumption is equal to total domestic generation plus imports minus losses from transmission as well as distribution and commercial losses. These losses are based on the *Updated Least Cost Power Development Plan* (ULCPDP) and reported in Table 57. Note that the analysis does not look at or assume reserves. Basically the capacity factor used accounts for any reserves that are required. For example, MSD has a capacity factor of only 28%, which indicates that it is primarily used for peak loading.

Table 48: Total consumption (GWh)

	2010	2015	2020	2025	2030
Supply	6,833	11,197	27,990	40,350	56,120
Transmission and Distribution losses	1,110	1,623	4,058	5,850	8,138
Losses (%)	16.25%	14.50%	14.50%	14.50%	14.50%
Total Consumption	**5,754**	**9,744**	**24,786**	**34,524**	**49,697**

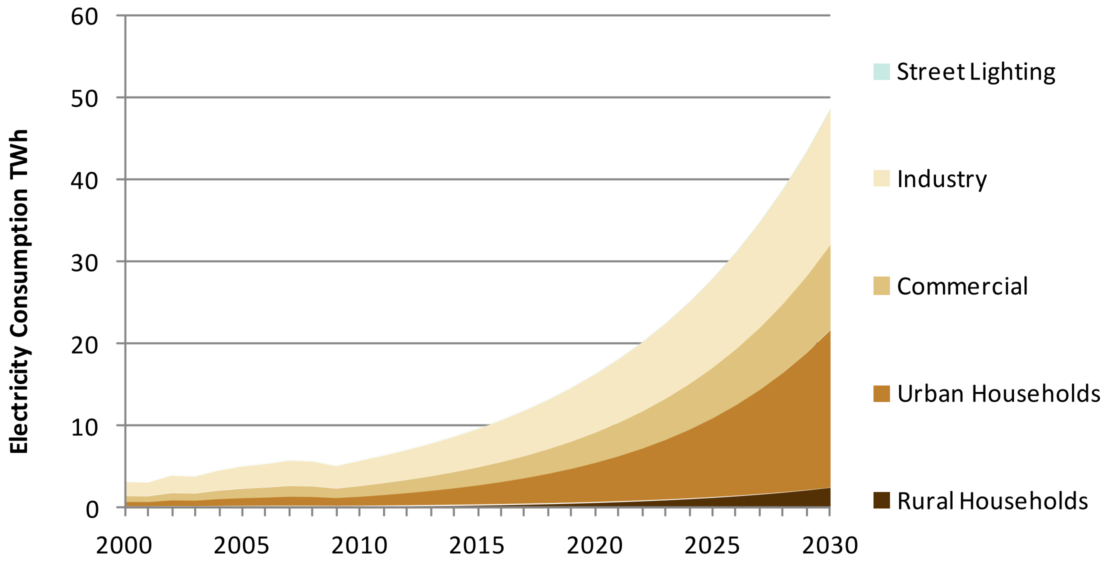
Total consumption of electricity was allocated todifferent sub-sectors based on data from the ULCPDP and then to end-uses based on available data (See Table 48). Projection assumptions for electricity end-uses are summarised in Table 95.

These projection assumptions are aligned with the ULCPDP and balance with the baseline projection nof supply (total consumption in Table 48). Electricity consumption projections are presented in Figure 50 by the major consumers (households, commercial, industry and street lighting).

Table 49: Projection assumptions for electricity end-uses (Stock, Demand and Efficiency)

Stock	Metric	Assumption	Notes
Rural			
	Units	+15.7% per year	Based on customer growth of 12.3% and urban stock growth of 3% annually.
Urban	Units	+15.7% per year	Based on customer growth of 12.3% and urban stock growth of 3% annually
Commercial	Units	+11.8% per year	Based on customer growth of 8.5% and urban stock growth of 3% annually
Industry	Units	+9.5% per year	Based on customer growth of 6.4% and urban stock growth of 3% annually
Demand	**Metric**	**Assumption**	**Notes**
Rural	Hours/yr.	+0.5% per year	Service demand growth is estimated to increase 0.5% per year for the projection period.
Urban			
Commercial			
Industry			
End-Use Efficiency	**Metric**	**Assumption**	**Notes**
Air Conditioning	Watts	-1% per year	Based on research of historic trends in end-use efficiency and assessment of technological potential.
Cooking	Watts	-0.75% per year	
Hot Water Heating	Watts	-0.75% per year	
Plugload	Watts	-1% per year	
Lighting	Watts	-2% per year	
Refrigeration	Watts	-0.82% per year	
Industrial Process	Watts	-1% per year	

Figure 50: Electricity consumption projections by major consumer



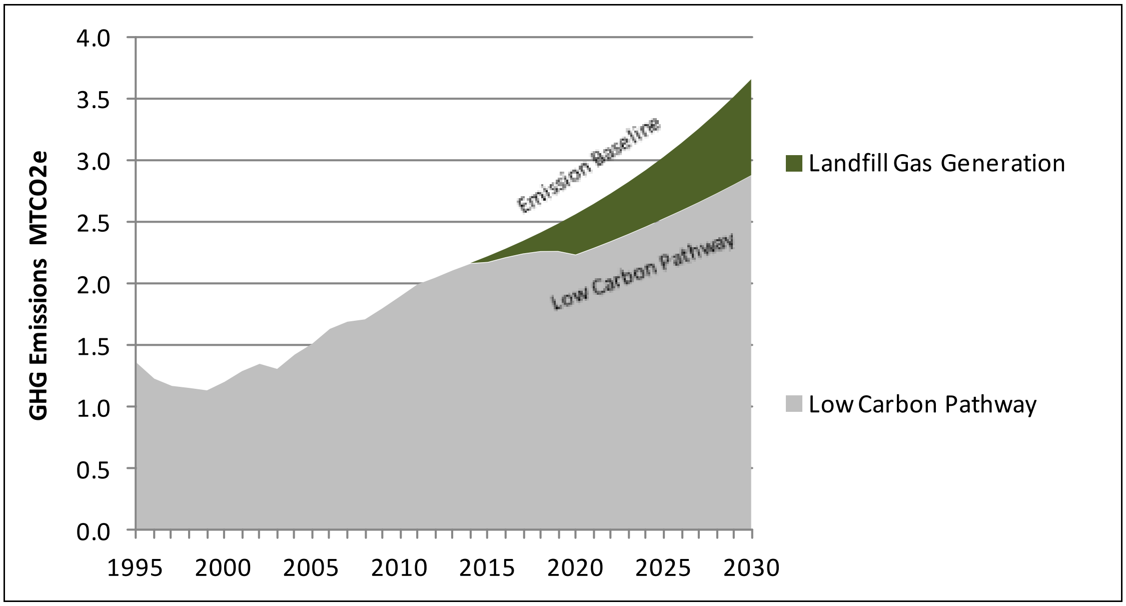
Transportation

The future growth in petroleum product consumption for road transportation (gasoline, light diesel oil and additives) was determined based on estimates of the growth rate in the overall vehicle stock, the growth rate in the use of vehicles (demand for service) and the change in average fuel efficiency over time. There were no known projections of this growth in Kenya and the analysis employed knowledge of historic growth to inform these assumptions. With is an

abatement potential of 0.8 $MtCO_2e$ in 2030, it is the main low carbon development oppoturnity (see figure 64). Methane capture can go hand in hand with proper management of solid waste, thereby improving groundwater quality, local air quality and safety by avoiding dangerous methane gas build –ups, as well as hygienic conditions. Improved management will result in small increases in employment and the methane capture can be combined with baseload electricity production and thus improving energy security.

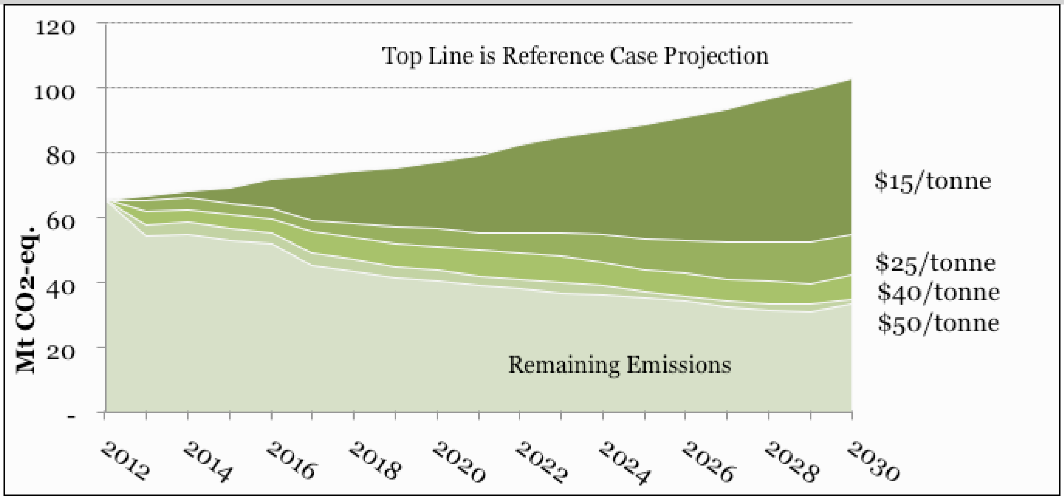
ith *an abatement potential of 0.8 $MtCO_2e$ in 2030, is the main low carbon development opportunity (see Figure 64). Methane capture can go hand in hand with proper management of solid waste, thereby improving groundwater quality, local air quality, and safety by avoiding dangerous methane gas build-ups, as well as hygienic conditions. Improved management will result in small increases in employment and the methane capture can be combined with baseload electricity production, improving energy security.*

Figure 64: Low carbon development wedges for the waste sector



	Emission Reductions ($MtCO_2e$)			
	2015	**2020**	**2025**	**2030**
Landfill Gas Generation	0.05	0.33	0.50	0.78

Figure 65: Economy-wide abatement potential for all sectors (US$/tonne CO_2e)



Source: GoK NCCAP Mitigation Analysis 2012

Projected investment *costs for mitigation actions*

According to the NCCAP, implementing the six priority low carbon actions would require investments of KSh1,371– 1,773 billion (USD16.12 – 20.84 billion) until 2030 (equivalent to a Net Present Value of KSh600 – 770 billion at a real discount rate of 10 per cent) or 391 – 495 billion over the period 2013 to 2017. The summarised investment costs for implementing the six low carbon options to 2030 are shown on Table 66. The details of these costs are provided in the NCCAP.

The methodology used for calculating these primary costs is detailed in the Low Carbon – Mitigation Annexes of the NCCAP. It is estimated that KSh839 – 1,110 billion of these investment costs would have to be borne by the public sector, with the remaining costs covered by private sector and household investments. Kenya sees clear potential to make effective use of bilateral and multilateral funding, as well as international climate finance mechanisms – such as the Green Climate Fund and emerging NAMAs and REDD+ mechanisms– in moving forward with the implementation of these actions.

Table 57: Projected investment costs *for priority mitigation actions*

Number	Action	Estimated Cost KSh to 2030
MITI-1	Restoration of Forests on Degraded Lands	186-290 billion
MITI-2	Geothermal	877-1115 billion
MITI-3	Reforestation of Degraded Forests	48-61 billion
MITI-4	Improved Cookstoves and LPG Cookstoves.	20 billion
MITI-5	Agroforestry	70-117 billion
MITI-6	Bus Rapid Transit and Light Rail Corridors	170 billion
MITI-7	Development of GHG inventory and improvement of emissions data	42 million
MITI-8	Measuring, reporting on & monitoring forestry emissions &sinks	624 million
MITI-9	Mainstreaming of low-carbon development options into planning	21 million
	Total Cost	1371-1773 billion KSh
Total KSh for next five years (USD4596–5815 million equivalent)		391 – 495 billion
Total USD Equivalent to 2030		16-22 billion

Source: GoK NCCAP Mitigation Analysis 2012

SUMMARY OF MITIGATION ACTIONS

Based on the comprehensive bottom-up assessment in the NCCAP and the update conducted during the preparation of the Second National Communication, six proposed priority areas for low carbon development and proposals for their implementation are described in Table 67 below. These six priority areas cover about three-quarters of total abatement potentials found in this study. Their full deployment would almost halve GHG emissions by 2030 compared to the reference case scenario (cross-sectoral interactions not taken into account). Investment costs would vary, but significant reductions can be obtained at marginal costs of less than US$15 per tonne of carbon. Some of these options also deliver fuel savings, which may result in overall social cost savings relative to high emitting options.

Significant investments will be required and a series of barriers will need to be addressed before the low-carbon opportunities can be realised. Implementing the six priority low carbon actions would require investments of KSh 1,371 – 1,773 billion (USD 16.12 – 20.84 billion) until 2030 (equivalent to a Net Present Value of KSh600 – 770 billion at a real discount rate of 10 per cent). Out of these investment costs, it is estimated that KSh839 – 1,110 billion would have to be borne by the public sector, with the remaining costs covered by private sector and household investments. A large challenge is financing the higher upfront costs of low carbon investments. Kenya sees clear potential to make effective use of bilateral and multilateral funding, as well as international climate finance mechanisms – such as the Green Climate Fund and the international support likely to be mobilised to support the emerging NAMA and REDD+ mechanisms– in moving forward on the Action Plan, in addition to systematic domestic support.

Low carbon option	Government planning sector	Lead Agency	Investment costs for implementation to 2030 (KSh and USD, 2011)	Estimated split between public, private sector and household investments	NPV of investment at a 10% real discount rate (KSh and USD, 2011)	Abatement potential and sustainable development impacts
Restoration of forests on degraded lands including in rangeland	Environment, Water and Sanitation (Forestry)	Kenya Forest Service	KSh 186 – 290 billion, (USD 2.2 – 3.4 billion)	100% public	KSh 69 – 108 billion (USD 0.81 – 1.3 billion)	- Abatement potential to 2030 of 32.6 $MtCO_2e$ - Contributes to constitution's goal of 10% tree cover - Biodiversity benefits - Sustainable forest products contribute to improved livelihoods - *Conservation may remove access to forests for communities*
Geothermal	Infrastructure	Ministry of Energy, working with GDC	KSh 877 – 1,115 billion (USD 10.3 – 13.1 billion)	About 45% public / 55% private sector investment assuming current electricity market structure	KSh 399 – 507 billion (USD $4.7 – 6.0 billion)	- Abatement potential to 2030 of 14.1 $MtCO_2e$ - Energy security, economic growth - *May require relocation of communities/ villages*
Reforestation of degraded forests	Environment, Water and Sanitation (Forestry)	Kenya Forest Service	KSh 48 – 61 billion (USD0.56 – 0.71 billion)	100% public	KSh 18 – 22 billion (USD 0.21 –0.26 billion)	- Abatement potential to 2030 of 6.1 $MtCO_2e$ - Sustained water availability (generation of hydropower) - Contributes to constitution's goal of 10% tree cover - Biodiversity benefits - Sustainable forest products contribute to improved livelihoods

Low carbon option	Government planning sector	Lead Agency	Investment costs for implementation to 2030 (KSh and USD, 2011)	Estimated split between public, private sector and household investments	NPV of investment at a 10% real discount rate (KSh and USD, 2011)	Abatement potential and sustainable development impacts
Improved cookstoves and LPG cookstoves	Population, Urbanisation and Housing	Ministry of Energy	KSh 20 billion (USD 0.24 billion) Improved cookstoves: KSh 9 billion (USD 0.11 billion) LPG stoves: KSh 11 billion (USD 0.13 billion)	Improved cookstoves: about 75% consumer costs and 25% public support costs LPG stoves: about 85% consumer cost and 15% public support	KSh 10 billion (USD 0.12 billion) Improved cook-stoves: KSh 4.5 billion (USD 0.053 billion) LPG stoves: KSh 5.3 billion (USD 0.062 billion	- Abatement potential to 2030 of 5.6 + 1.7 $MtCO_2e$ - Health benefits from reduced indoor air pollution - Lower fuelwood demand and defor-estation - Potential cost savings to households
Agroforestry	Agriculture	Ministry of Agriculture	KSh 70 – 117 billion (USD0.82 – 1.37 billion)	100% public	KSh 26 – 43 billion (USD0.31 – 0.51 billion)	- Abatement potential to 2030 of 4.1 $MtCO_2e$ - Increased soil fertility and crop yields, improving livelihoods of farmers and food security - Improved climate resilience - Contributes to goal of 10% tree over on farms
Bus rapid transit (BRT) with light rail transit (LRT) corridors	Infrastructure	Ministry of Transport	KSh 170 billion (USD 2 billion) BRT: KSh 21 billion (USD0.25 billion) LRT: KSh 149 billion (USD1.75 billion	About 75-85% public investment cost for infrastructure and 15-25% private costs for vehicle stock	KSh 79 billion (USD 0.93 billion) BRT: KSh 10 billion (USD0.116 billion) LRT: KSh 69 billion (USD0.81 billion)	- Abatement potential to 2030 of 2.8 $MtCO_2e$ - Reduced traffic congestion - Improved local air quality - Improved road safety

Table 60: Summary of Mitigation Actions

Number	Action	Estimated Cost KSh to 2030
MITI-1	**Restoration of Forests on Degraded Lands -Undertake** a programme of work to restore forests on 960,000 hectares up to 2030 including: inter alia dryland forest restoration activities; awareness raising, consultation and demonstration; capacity building; development, testing and application of compensation and benefits-sharing mechanisms; measuring, monitoring and	**186-290billion**
MITI-2	**Geothermal -** Develop an additional 2,275 MW of geothermal capacity by 2030 through a support programme aimed at encouraging private sector investment. The programme could include: additional grants for the early phases of geothermal development, access to loans for latter stage development, risk mitigation instruments, capacity building programmes, and harmonization and improvement of the regulatory framework.	**877-1115 billion**
MITI-3	**Reforestation of Degraded Forests -** Undertake a programme of work to replant forests on 240,000 hectares of land that were previously forests; including, inter alia: tree planting activities; awareness raising, consultation and demonstration; policy development; capacity building; measuring, monitoring and reporting; and research.	**48-61 billion**
MITI-4	**Improved Cookstoves and LPG Cookstoves -** Undertake a programme to support the use of improved cookstoves and of LPG cookstoves, including increasing awareness of improved cooking practices, undertaking pilot initiatives which promote the use of LPG, increasing awareness of stove quality, increasing access to soft loans, building capacity of stove producers, and improving access to testing facilities.	**20 billion**
MITI-5	**Agroforestry -** Convert 281,000 hectares of existing arable cropland and grazing land that have medium or high agricultural potential to agroforestry by 2030 through a programme of work that includes: research to identify appropriate agroforestry practices; technological development; extension services and training of extension workers; capacity building and education for farmers; pilot projects; research to determine potential in	**70-117 billion**

MITI-6	**Bus Rapid Transit and Light Rail Corridors -** Implement an extensive Mass Transit System for greater Nairobi, based predominantly on Bus Rapid Transit corridors complemented by a few Light Rail Transit corridors.	**170 billion**
MITI-7	**Development of GHG inventory and improvement of emissions data** Develop Kenya's GHG inventory, building on the information developed in the SC4 reference case of GHG emissions; develop Kenya specific emissions factors, especially in the agricultural sector; improve overall data; and build capacity to develop, use and monitor data and impacts.	**42 million**
MITI-8	**Measuring, reporting on and monitoring forestry emissions and sinks -** Develop a national forest inventory, forest reference scenario, and a monitoring and reporting system that allows for transparent accounting of emissions and removals in the forestry and land-use sectors.	**624 million**
MITI-9	**Mainstreaming of low-carbon development options into planning processes-** Undertake low-carbon assessments of current and new flagship projects; mainstream low-carbon screening and planning in the county planning process and sectoral development plans. Build capacity on the use of the tools to update the low-carbon scenario assessment.	**21 million**
Total KSh to 2030		KSh1,371 – 1,773 billion
Total KSh for next five years (4596 – 5815 USD equivalent)		KSh 391 – 495 billion

Source: GoK NCCAP Mitigation Analysis 2012

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NEMA (2005). Identification and Quantification of Dioxins and Furan Releases in Kenya. Kenya National Inventory of POPs under the Stockholm Convention.

UNEP (2006). Kenya: Integrated assessment of the Energy Policy With focus on the transport *and household energy sectors.* United Nations Environmental Programme. In conjunction with Ministry of Ministry for Planning and National DevelopmentTable 59 below identifies the specific assumptions used to estimate future growth in on-road vehicle fuel demand.

Table 50: Assumptions regarding future growth in on-road vehicle fuel demand

Metric	Assumption	Notes
Growth in passenger and freight vehicle stock	+6.5% per year	Historic growth of vehicle stock between 2000 and 2010 was 7.2%. This level of growth is substantially above average growth in GDP over the same period. While strong growth will likely continue due to high demand projected average growth between 2010 and 2030 is estimated to be somewhat lower than this historical growth rate. Growth in 2010 was approximately 6%.
Growth in Service Demand (vehicle km travelled)	+1% per year	Increased travel per vehicle is likely as this is a trend that has been observed in most countries where road networks are being expanded as is the case in Kenya; however, this growth rate is expected to be very small due to the limited capacity of current roadways to handle both new vehicle stock and additional traffic.
Change in fuel efficiency of passenger vehicles	+1.8% per year	Historic improvements between 2000 and 2010 in average fleet wide fuel efficiency are low. This may be explained by the fact that average car size, and proportion of trucks and SUV vehicles increased over the last decade. We assume that fuel efficiency will improve at an increased rate going forward. New fuel efficiency is based on a fleet turnover rate of 4% (average lifetime of vehicle 25 years) and an average improvement in fuel economy of new vehicles compared to on-road vehicles determined from fuel economy data for Japanese vehicles. The average improvements in fuel economy for new vehicles is 33% for passenger vehicles,

Change in fuel efficiency of freight vehicles	+1.2% per year	Historic improvements between 2000 and 2010 in average fleet wide fuel efficiency are low. This may be explained by the fact that average car size, and proportion of trucks and SUV vehicles increased over the last decade. We assume that fuel efficiency will improve at an increased rate going forward. New fuel efficiency is based on a fleet turnover rate of 4% (average lifetime of vehicle 25 years) and an average improvement in fuel economy of new vehicles compared to on-road vehicles determined from fuel economy data for Japanese vehicles. The average improvements in fuel economy is 25% for freight vehicles.

Rail, marine and domestic aviation sub-sectors were assumed to have an average demand growth of 4.4%. This growth rate is in line with current projections for the economy and business as usual estimates in the growth rate of transport petroleum demand in a UNEP study.[198] An average improvement in fuel efficiency of 1% was assumed. This efficiency improvement is consistent with an increase in rail fuel efficiency of 1.1% per year in the United States between 1990 and 2006.[199]

In order to look at low-carbon options that differentiate between personal passenger, bus and freight vehicles it is necessary to divide the total consumption of on-road transportation fuels indicated in Table 98 into these end-uses. This is challenging because there is limited information on the fuel usage by end-use in Kenya. The basis for the on-road allocation by end-use was vehicle registration data between 2000 and 2006[200] and detailed vehicle registration data on new vehicles available for 2005 and 2008.[201] Table 60 below indicates the distribution by on-road vehicle type. Passenger vehicles include all personal passenger vehicles including motorcycles.

Table 51: Distribution of vehicle types in Kenya based on historic data

Type	Historic Fleet (2006)
Passenger Vehicles	85.8%
Buses	5.3%
Freight Vehicles	8.9%
TOTAL	**100%**

New vehicle registration data between 2005 and 2008[202] indicates that approximately 22% of the newly registered vehicles in this period were diesel and 78% were gasoline. There are several reasons why this historic share is likely not indicative of the average share in the on-road fleet of vehicles.

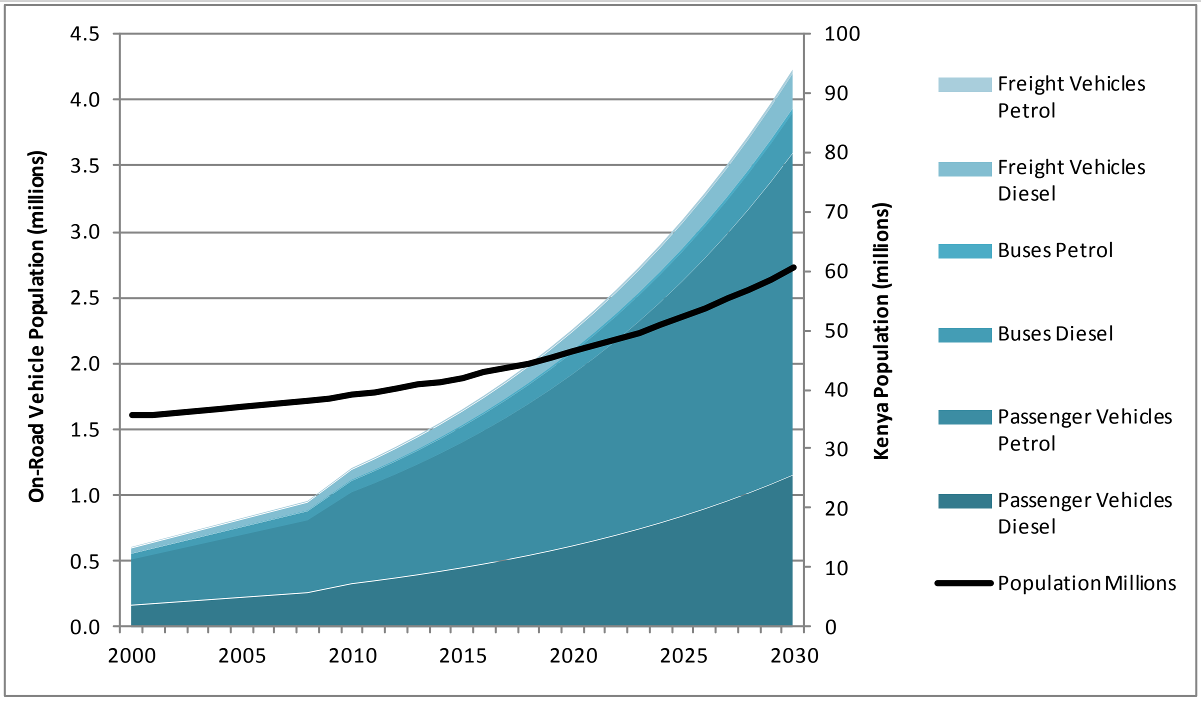
Table 52: Share of vehicles by fuel type for passenger, buses and freight vehicles

Vehicle Type	Fuel	% Share	Vehicles in 2010
Personal Passenger Vehicles	Diesel	32%	329,475
	Petrol	68%	700,135
	ALL	**100%**	**1,029,610**
Buses	Diesel	90.0%	57,169
	Petrol	10.0%	6,352
	ALL	**100.0%**	**63,521**
Freight Vehicles	Diesel	90.0%	96,182
	Petrol	10.0%	10,687
	ALL	**100.0%**	**106,869**
TOTAL	Diesel	40%	482,826
TOTAL	Petrol	60%	717,174
TOTAL	**TOTAL**	**100%**	**1,200,000**

First, is the rising share of gasoline vehicles in recent years and second, is that vehicle lifetime for diesel vehicles is on average longer. Based on these factors, the share of passenger diesel vehicles was adjusted to 32% of the total, and the share of diesel buses and freight vehicles was adjusted to 90%. Table 61 indicates the vehicle type and fuel shares used in the model.

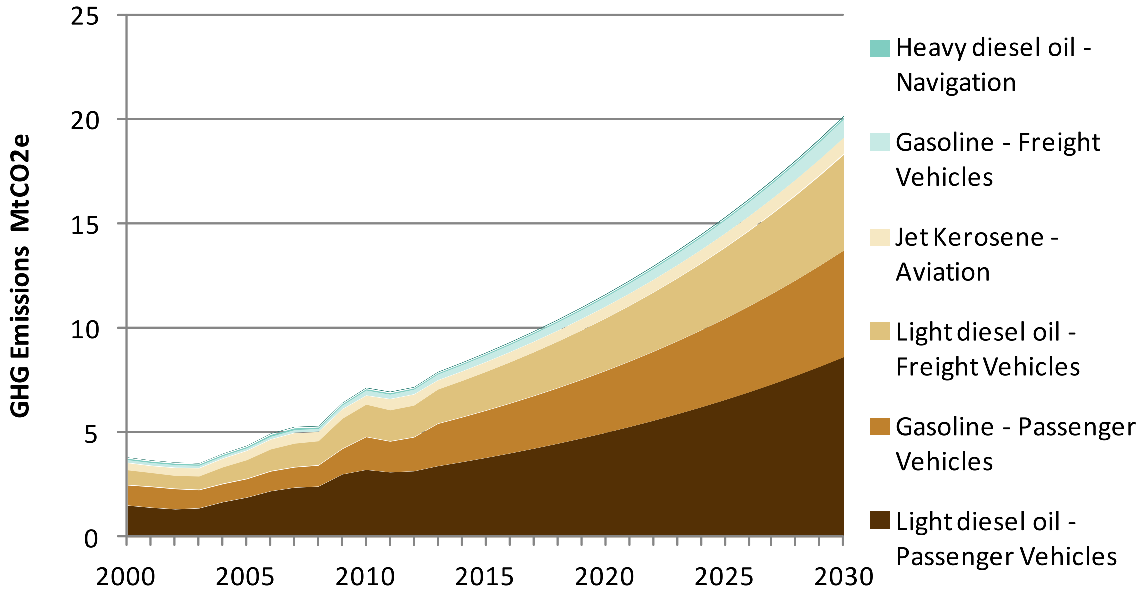
Total projections of on-road vehicle population by fuel and vehicle type are shown in Figure 51 relative to the total Kenyan population (black line). This figure illustrates that the number of vehicles is expected to increase significantly faster than for overall population. In 2010 vehicle ownership was approximately 30.7 vehicles per thousand population. This level of ownership more than doubles in 2030 to 69.9 vehicles per thousand population.

Figure 51: On-road vehicle population growth in Kenya (millions)



Baseline projections of transportation emissions broken down by fuel type and major end-use is indicated in Figure 52.

Figure 52: Baseline greenhouse gas emission projections for the transportation sector



Industrial Processes

In Kenya the main industrial processes emission sources are releases from processes that chemically or physically transform materials (for example, cement, lime and soda ash are notable examples where there are processes that release a significant amount of CO_2). Different GHGs – including CO_2, CH_4, N_2O, hydrofluorocarbons and perfluorocarbons– can be produced during these processes.

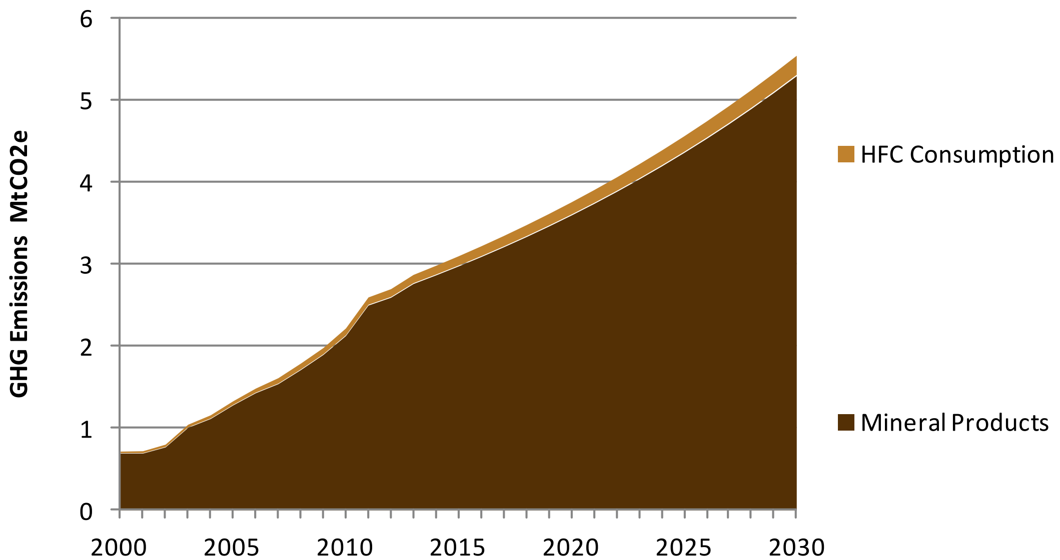
Table 62 identifies projection assumptions used to develop baseline emission projections in the Industrial Processes Sector.

Table 53: Baseline projection assumptions for emission sources in industrial processes sector

Sector	Product	Future Growth Rate (2010 to 2030)	Notes
Mineral Products	Cement (tonne clinker)	+4.75% per year	Historical data for 2011 to 2013 also used. 4.8% growth rate based on Forecast growth rate of Manufacturing GDP in Vision 2030.
	Lime (tonne quicklime)		
	Soda Ash (tonne trona)		
	Pulp and Paper (tonne production)		
HFC Consumption	HFCs (tonnes)	+5.3% per year declining to +4% per year	Based on vehicle stock growth rate (representing refrigerant products), but considering that alternatives to HFCs will develop a market share of 40% by 2030).

Figure 53 presents the baseline emission projections for two emission source categories in the Industrial Processes Sector.

Figure 53: Baseline emission projections in the industrial processes sector



Industrial Process	Industrial Process Baseline GHG Emissions (MtCO2e)						
	2000	2005	2010	2015	2020	2025	2030
Mineral Products	0.7	1.3	2.1	3.0	3.6	4.4	5.3
HFC Consumption	0.0	0.0	0.1	0.1	0.1	0.2	0.2
TOTAL	**0.7**	**1.3**	**2.2**	**3.1**	**3.7**	**4.6**	**5.5**

Agriculture

The agricultural sector is currently the largest source of GHG emissions of all sectors. More than one-third of total national emissions are from this sector alone. Despite its important contribution to overall emissions, data required to calculate GHG emissions is lacking and there is significant uncertainty associated with the emission estimates when compared to energy demand, electricity generation and transportation sectors.

The management of soils on agricultural lands, such as cultivation and tillage, are assessed in the agricultural sector as long as they do not involve conversion to a land use other than agriculture. The agricultural sector does not include energy emissions from fuel combustion, which are included within other sectors such as transportation and the household, commercial and industrial energy sectors. It also does not include the conversion of non-agricultural land-uses to agriculture and the management of plantations which are considered in the forestry sector.

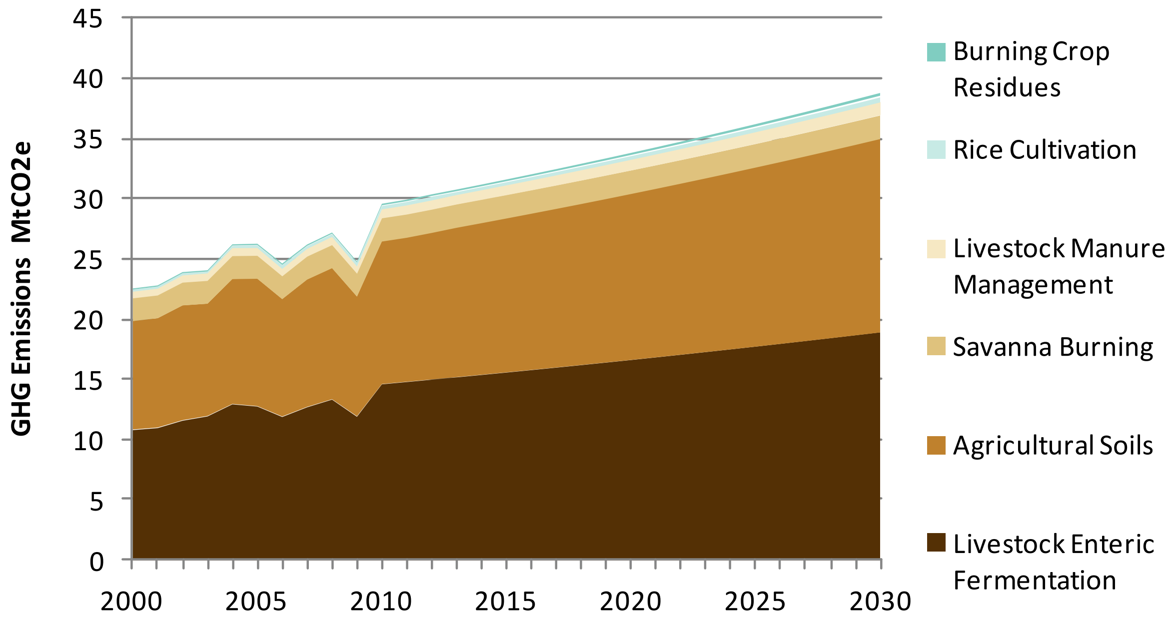
Projections are based on assumptions regarding the change in activity related to different agricultural emission sources. Table 63 summarises the assumptions that are used to develop the projections of the inventory data between 2011 and 2030.

Table 54: Projection assumptions for agricultural emission sources

Emission Source	Metric	Assumption	Notes
Enteric Fermentation, Manure Management and Related Agricultural Soils Emissions	Livestock Population (Poultry, Swine)	+3% per year	Forecast growth rate of Agricultural GDP in Vision 2030.
	Livestock Population (Cattle, Sheep, Goat, Camels, Donkeys)	+1.3% per year	Future growth rates of livestock between 2010 and 2030 are likely to be below average historic growth rates of livestock as there is mounting evidence that current populations of livestock on rangelands in Kenya may be near or above their carrying capacity.[203]
Rice Cultivation	Production of Rice	+3% per year	Historical data for 2011 to 2013 also used. 3% growth rate based on Forecast growth rate of Agricultural GDP in Vision 2030.
Agricultural Residues	Production of Rice, Wheat, Maize, Sugarcane	+3% per year	Historical data for 2011 to 2013 also used. 3% growth rate based on Forecast growth rate of Agricultural GDP in Vision 2030.
Agricultural Soils	Application of Nitrogen fertilizer	+3% per year	Historical data for 2011 to 2013 also used. 3% growth rate based on Forecast growth rate of Agricultural GDP in Vision 2030.
Savannah Burning	Hectares of land burned	0% per year	No change in current practices forecasted.

Figure 54 indicates the baseline emission projection for agricultural emission sources based on the assumptions outlined in Table 64.

Figure 54: Agricultural Baseline Emission Projection for Kenya ($MtCO_2e$)



Agriculture Source	Agriculture Baseline GHG Emissions (MtCO2e)						
	2000	2005	2010	2015	2020	2025	2030
Livestock Enteric Fermentation	10.8	12.7	14.5	15.5	16.5	17.7	18.8
Agricultural Soils	9.0	10.6	11.9	12.8	13.9	15.0	16.2
Savanna Burning	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Livestock Manure Management	0.6	0.7	0.8	0.8	0.9	1.0	1.1
Rice Cultivation	0.2	0.2	0.3	0.3	0.3	0.4	0.4
Burning Crop Residues	0.1	0.1	0.1	0.1	0.2	0.2	0.2
TOTAL	**22.6**	**26.3**	**29.6**	**31.4**	**33.6**	**35.9**	**38.5**

LULUCF

The LULUCF Sector includes estimates of emissions and removals of greenhouse gases associated with increases or decreases of carbon in living biomass as land-use changes occur over time, for example, in the conversion of a forest area to cropland, or when establishing new forest lands through reforestation or afforestation.

Emissions and removals in the LULUCF Sector were estimated using a State and Transition Simulation model called ST-Sim. The model is a stochastic, empirical simulation model that can be used to estimate how carbon flows between various carbon pools over time. The carbon pools represented in the model are consistent with IPCC Guidelines and include above-ground biomass, below-ground biomass, soil organic matter and the atmosphere. Carbon flows are triggered either by transitions between land-uses, or by disturbances and changes in management. There are also natural processes such as biomass growth and decay that occur on a continuous basis. The probability of transitioning a parcel of land from one state (a particular land-use classification) to another is defined in the model based on available data on land-use change, management activities and disturbances.

Projections of land-use changes and biomass removals (e.g., wood, charcoal, timber) that impact emissions and removals from LULUCF between 2011 and 2030 are based on a number of different assumptions which are summarised in Table 64.

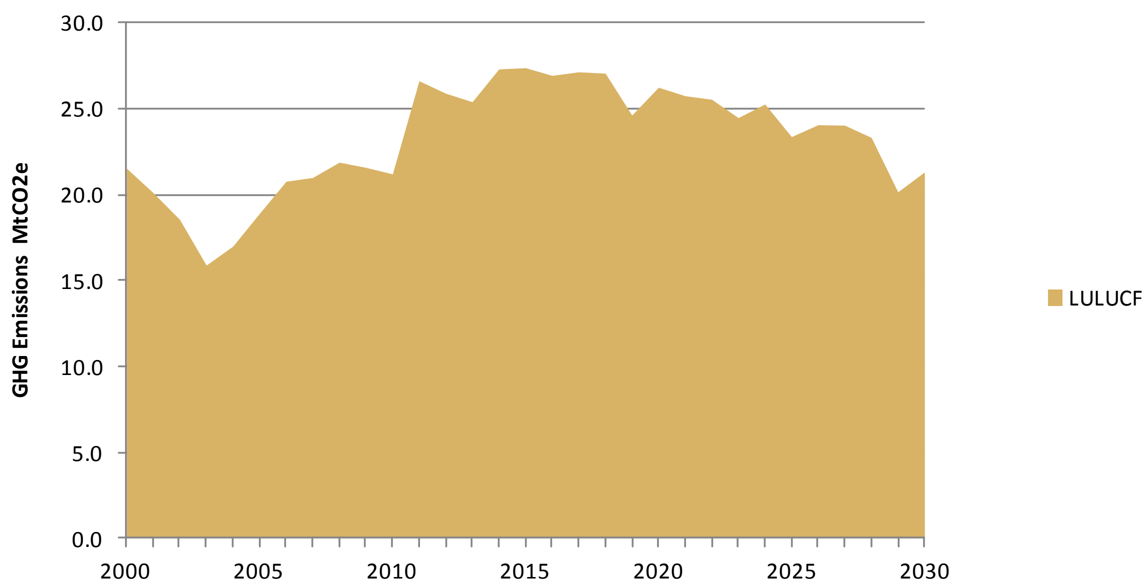
Table 55: Projection assumptions for Land Use, Land-Use Change and Forestry

Emission / Removal Category	Metric	Assumption	Notes
Conversion of Forest Land to Farm lands	Ha converted per year between 1990 and 2010	Reduced by 50% between 2010 and 2030	Increased protection and forest management under the Forest Conservation And Management Bill, 2014 is expected to reduce the rate of deforestation. A 50% reduction is projected from existing measures in place.
Conversion of Settlement to Farm lands	Ha converted per year between 1990 and 2010	Reduction to zero	No settlement land is expected to be converted to farmlands between 2010 and 2030.
Conversion of Plantation to Farmlands	Ha converted per year between 1990 and 2010	Loss of 300 hectatres per year (1990 to 2010) to Increase of ~3,000 ha per year	Trend in historical data between 2010 and 2013 indicates an increase in the size of plantations of approximately 3,000 ha per year.
Woodfuel Removal	Tonnes of wood (dm)	+0.84% increase per year	Woodfuel supply is constrained in some markets and future demand is based on an *Analysis of Demand and Supply of Wood Products in Kenya*. (Ministry of Environment and Natural Resources, 2013).

Charcoal Production	Tonnes of charcoal	+1.3% increase per year	Charcoal supply is constrained in some markets and future demand is based on an *Analysis of Demand and Supply of Wood Products in Kenya*. (Ministry of Environment and Natural Resources, 2013).
Commercial harvest	Tonnes of wood (dm)	1.9% increase per year	Projections of commercial harvest (Poles and posts, paper and paper board and industrial wood) are based on an *Analysis of Demand and Supply of Wood Products in Kenya*. (Ministry of Environment and Natural Resources, 2013) and *Kenya Forestry Assessment Report* (Mbugua, D., 2006)
Forest Fire	Area of Forest Land burned (ha)	unchanged	Historical forest fire activity is highly variable, but the average was 9,000 ha per year between 1980 and 2011. While impacts of climate change may affect the frequency of forest fires there is no available information to indicate a new trend between 2010 and 2030.

In Figure 55 the net baseline emissions from LULUCF emission and removals is presented. Net emissions are total emissions minus total removals and therefore the figure indicates that it is expected that the LULUCF sector in Kenya remains a net emitter over the entire 2000 to 2030 time period.

Figure 55: LULUCF Net Baseline Emission Projection (MtCO2e)



LULUCF Sub-Sector	LULUCF Baseline GHG Net Emissions (MtCO2e)						
	2000	2005	2010	2015	2020	2025	2030

Forest Land	14.1	14.1	19.7	19.7	20.2	17.8	18.9
Cropland	4.6	3.4	4.6	6.0	4.5	4.4	2.9
Grassland	0.3	0.3	0.2	0.3	0.3	0.3	0.3
Wetlands	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Settlements	0.1	0.0	-0.1	0.0	0.0	0.1	0.0
TOTAL	**19.1**	**17.8**	**24.4**	**26.0**	**24.9**	**22.6**	**22.1**

Waste

Wastes through the processes of disposal, treatment, recycling and incineration produce greenhouse gas emissions. Two major sources of this type of CH_4 production are solid waste disposal to land and wastewater treatment. Waste incineration, like other forms of combustion, generates CO_2 as well as smaller amounts of CH_4 and N_2O emissions, depending on the composition of the waste. The breakdown of human sewage can also lead to significant amounts of indirect N_2O emissions.

Historic solid waste data disposal was estimated from Environmental Impact Assessments for four solid waste disposal sites in Kenya (Dandora, Mombasa, Kisumu and Nakuru). Table 65 identifies the assumptions regarding municipal solid waste volumes that were employed in a First Order Decay Spreadsheet Model. The forecast assumes that waste per capita after 2015 and the percent of waste going to SWDS remains the same.

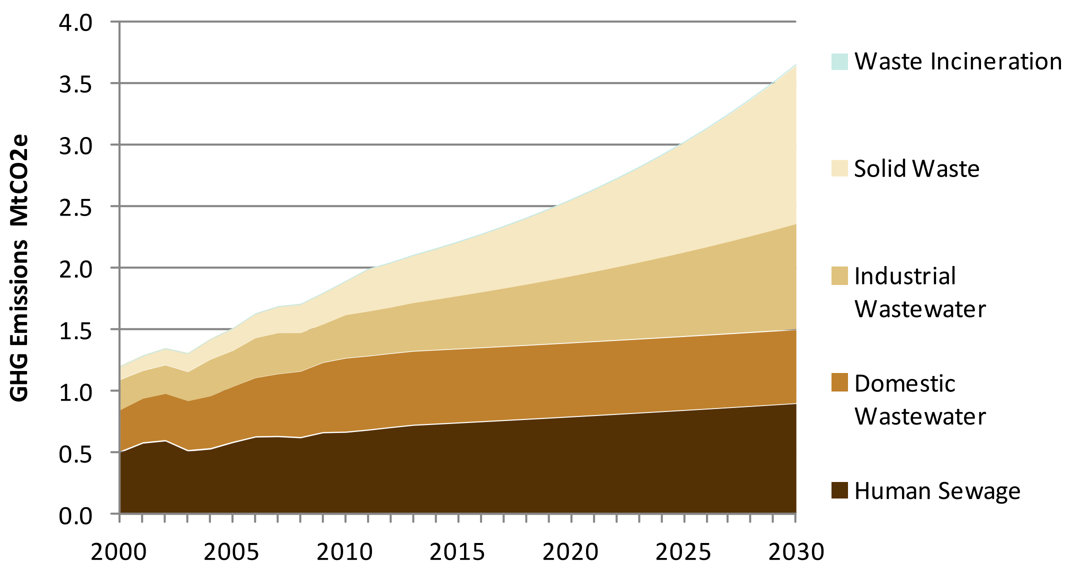
Table 56: Urban solid waste generation summary (2010 to 2030)

Year	Population	Waste per capita	Total MSW	% to SWDS
	millions	kg/cap/yr.	Gg	%
2010	12.9	275	3537	60%
2011	13.6	272	3686	60%
2012	14.3	268	3843	60%
2013	15.1	265	4010	60%
2014	16.0	262	4186	60%
2015	16.9	259	4372	60%
2016	17.8	259	4617	60%
2017	18.8	259	4875	60%
2018	19.9	259	5147	60%
2019	20.0	259	5434	60%
2020	22.1	259	5738	60%
2021	23.4	259	1959	60%
2022	24.7	259	6397	60%
2023	26.1	259	6754	60%

Year	Population	Waste per capita	Total MSW	% to SWDS
	millions	kg/cap/yr.	Gg	%
2024	27.5	259	7132	60%
2025	29.0	259	7530	60%
2026	30.7	259	7951	60%
2027	32.4	259	8395	60%
2028	34.2	259	8864	60%
2029	36.1	259	9359	60%
2030	38.1	259	9882	60%

Future growth in the amount of wastewater and sludge produced assumes that the fraction of wastewater going to different types of wastewater treatment remains the same and that the amount of degradable organic content is based solely on population growth as identified in Vision 2030 projections. Figure 56 indicates the baseline emission projections for the major emission source categories related to the Waste Sector.

Figure 56: Baseline emission projections for the waste sector

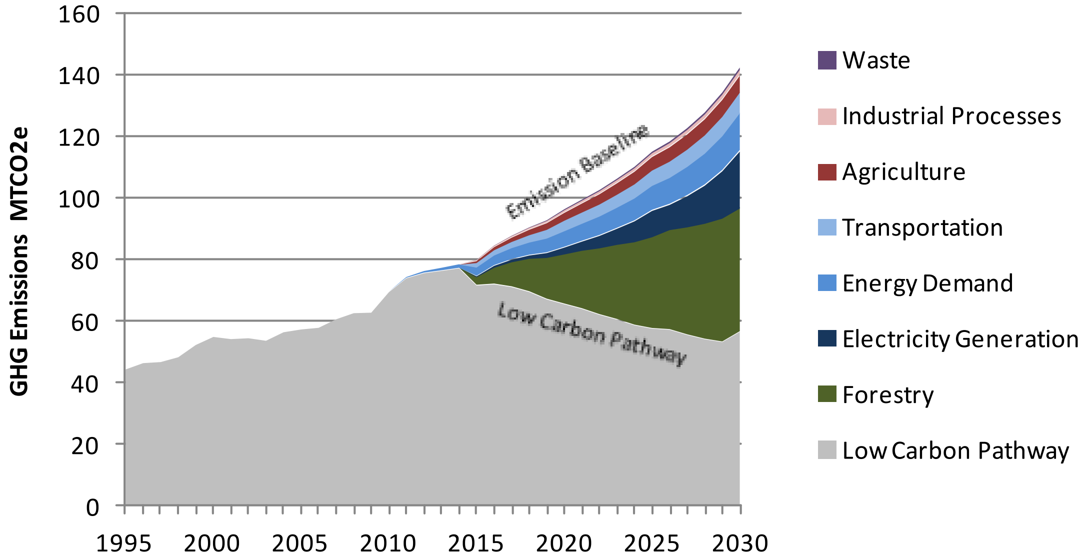


Waste Source	Waste Baseline GHG Emissions (MtCO2e)						
	2000	2005	2010	2015	2020	2025	2030
Human Sewage	0.5	0.6	0.7	0.7	0.8	0.8	0.9
Domestic Wastewater	0.3	0.5	0.6	0.6	0.6	0.6	0.6
Industrial Wastewater	0.2	0.3	0.3	0.4	0.5	0.7	0.9
Solid Waste	0.1	0.2	0.3	0.4	0.6	0.9	1.3
Waste Incineration	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	**1.2**	**1.5**	**1.9**	**2.2**	**2.6**	**3.0**	**3.7**

MITIGATION SCENARIO

Figure 57 indicates the composite mitigation abatement potential of low-carbon development opportunities in seven sectors. The biggest GHG emission reduction potential is in the forestry sector followed by electricity generation.

Figure 57: Composite abatement potential for all sectors for Kenya (technical potential) in $MtCO_2e$



Sector	Emission Reductions (MtCO2e)			
	2015	2020	2025	2030
Forestry	2.71	16.24	29.76	40.20
Electricity Generation	0.28	2.24	8.61	18.63
Energy Demand	2.74	5.16	7.92	12.17
Transportation	1.54	3.52	5.13	6.92
Agriculture	0.63	2.57	4.41	5.53
Industrial Processes	0.26	0.69	1.03	1.56
Waste	0.05	0.33	0.50	0.78

Kenya's low-carbon development opportunities

a) Energy

The analysis of low-carbon development options in the energy sector considered two categories:

- Electricity supply
- Energy demand, including options such as energy efficiency and fuel switching.

In terms of electricity supply, the installed capacity in Kenya in 2010 was 1,425 megawatts. Generation was dominated by hydroelectricity, medium-speed diesel and geothermal power which respectively accounted for 51, 30 and 13 per cent of electricity sent to the national grid. Rapidly increasing demand for electricity and fluctuating hydroelectric output have led to an increase in diesel-based generation in recent years. In addition, there has been a strong focus on expanding geothermal power, which is considered a key enabler for Kenya's economic growth. Although geothermal is the most promising renewable energy source, Kenya also has excellent bioenergy, solar, wind and hydro resources for the supply of electricity.

The analysis of six low carbon development options for electricity supply (Figure 58) shows that geothermal power has by far the largest abatement potential (14 $MtCO_2e$ per year) in 2030, with other technologies varying between 0.5 and 1.4 $MtCO_2e$. Increasing the share of renewable electricity can have benefits in terms of energy security (through decreased energy imports) and reduced costs of generation. In particular, geothermal power can provide low-cost base load generation, facilitating economic activity and development. It would also reduce the current reliance on hydropower thereby improving climate resilience.

As part of the NCCAP implementation, the Kenya has already developed a NAMA for the acceleration of geothermal development in Kenya. This NAMA has been posted in the NAMA registry.

Energy Demand

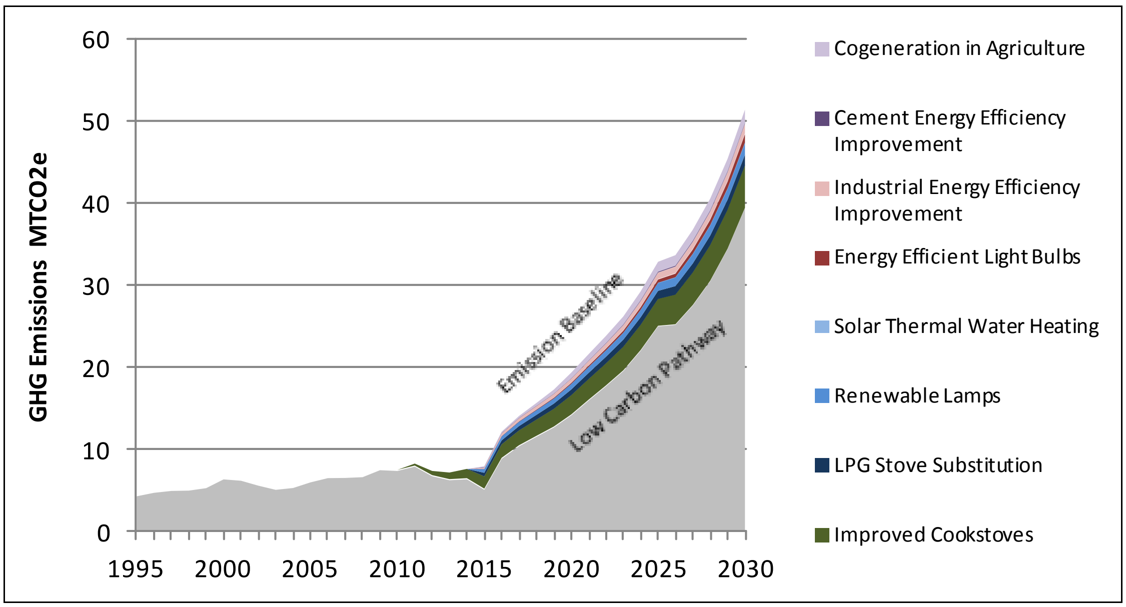
Energy demand includes the final use of electricity and other sources of energy, such as biomass combustion. At present, roughly 25 per cent of the population is connected to the electricity grid. About 60 per cent of electricity is consumed by the commercial and industrial sectors, while approximately 25 per cent is used by households. Direct fuel combustion of biomass from wood sources, such as fuelwood and charcoal, is the dominant fuel source in Kenya, accounting for almost 70 per cent of primary, non-electricity, non-transport energy demand. This has placed the forests under pressure and has led to widespread scarcity of biomass. Direct fuel use in the industrial and commercial sectors is relatively low. Moreover, the energy sector may be an important transition point. The exploitation of indigenous coal resources is beginning and domestic oil resources were discovered in early 2012.

Electricity demand, particularly household demand, is expected to rise sharply with continued economic development and a growing share of the population gaining access to electricity. Even when using a conservative approach to estimate future energy demand, energy-related GHG emissions are expected to increase from 8 $MtCO_2e$ in 2010 to 50 $MtCO_2e$ in 2030.

Eight low carbon development options were analysed in the energy demand sector (Figure 58). Improved cookstoves that reduce the volume of biomass required for cooking have the largest potential for GHG emission reductions, 5.6 Mt CO_2e a year in 2030. Replacing kerosene lamps with renewable lighting technologies, using liquefied petroleum gas (LPG) instead of fuelwood for cooking, and cogeneration of heat and power in agriculture were also found to have significant abatement potentials of over 1.5 $MtCO_2e$ a year in 2030. The opportunities for promoting energy efficiency are captured under energy efficiency across industry, energy efficient electrical appliances and energy efficient light bulbs.

Sustainable development benefits associated with the use of improved fuelwood or charcoal-based and LPG-based cookstoves include significant health benefits as a result of reduced indoor air pollution. Health benefits are also expected with the replacement of kerosene lamps with distributed renewable energy (such as solar) lanterns. These technologies can also bring cost savings to consumers, depending on the price of alternatives. Improved cookstoves and the use of LPG for cooking contribute to increased climate resilience as they lower fuelwood demand and reduce pressure on forests.

Figure 58: Low carbon development wedge for energy demand

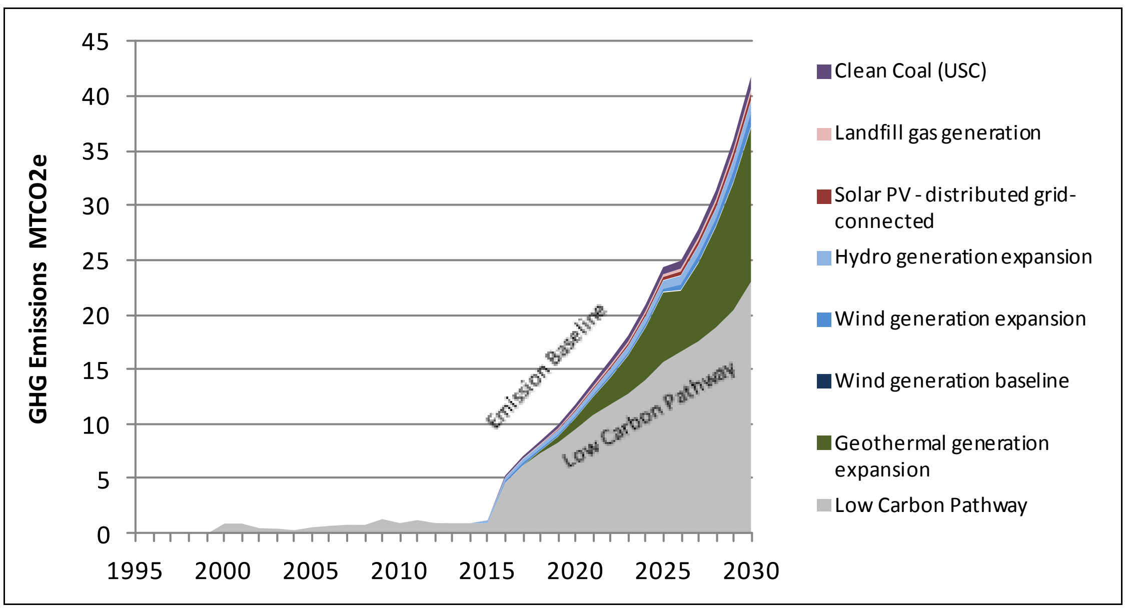


	Emission Reductions ($MtCO_2e$)

	2015	2020	2025	2030
Improved Cookstoves	1.49	2.35	3.30	5.22
LPG Stove Substitution	0.45	0.71	0.99	1.30
Renewable Lamps	0.46	0.70	1.02	1.51
Solar Thermal Water Heating	0.00	0.02	0.06	0.14
Energy Efficient Light Bulbs	0.01	0.12	0.39	1.00
Industrial Energy Efficiency Improvement	0.16	0.48	0.77	1.15
Cement Energy Efficiency Improvement	0.05	0.07	0.17	0.21
Cogeneration in Agriculture	0.13	0.72	1.23	1.64

Electricity Generation

Figure 59: Low carbon development wedge for electricity supply



	Emission Reductions ($MtCO_2e$)

	2015	2020	2025	2030
Geothermal generation expansion	0.00	1.01	6.37	14.07
Wind generation baseline	0.00	0.00	0.00	0.00
Wind generation expansion	0.00	0.20	0.33	1.36
Hydro generation expansion	0.25	0.42	0.76	1.10
Solar PV - distributed grid-connected	0.00	0.11	0.29	0.65
Landfill gas generation	0.02	0.14	0.21	0.34
Clean Coal (USC)	0.00	0.36	0.65	1.11

Note: The methodological approach for the electricity sector analysis deviates from a traditional analysis of climate mitigation options. Usually, mitigation options are assumed to replace a business as usual alternative or reference mix (Figure 59). However, for this analysis, the ambitious electricity expansion plans needed to satisfy Vision 2030 were assumed to be supply constrained in the absence of external support. International climate finance for low-carbon development opportunities provides the funding for additional capacity expansion that would not be installed in the reference case.

Transportation

Kenya's transport sector is dominated by road transport. The total vehicle population (excluding motorcycles) is estimated to have doubled from 600,000 vehicles in 2000 to 1,200,000 vehicles in 2010. Public transport is relatively under-developed and is dominated by minibuses (matatus). The vast majority of freight transport, including transit freight headed to other countries, is served by trucks. At the same time, increasing urbanisation and the growth of major cities have put pressure on urban transport systems and infrastructure. In Nairobi and other major cities, severe traffic congestion, especially during the extended peak hours, contributes to local air pollution and leads to significant economic losses in time and fuel. That said, the majority of individual trips in cities are still by foot because public transport services are comparatively expensive and private cars are out of the financial reach of the majority of Kenyans.

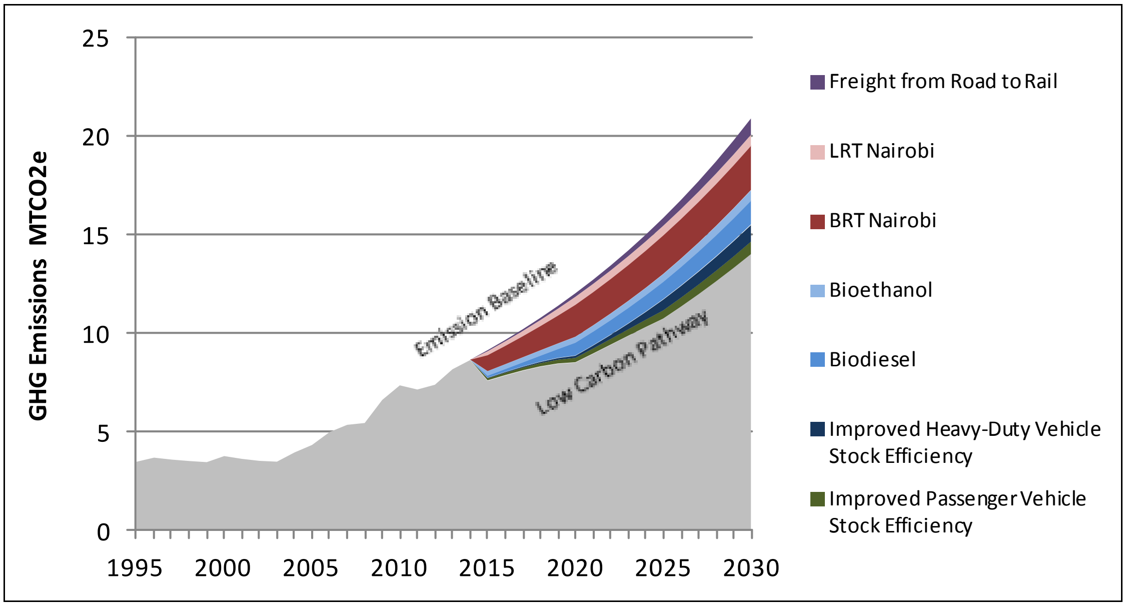
With the sector experiencing strong growth, GHG emissions from transport are projected to grow significantly from 7 MtCO2e in 2010 to almost 20 MtCO_2e in 2030 (Figure 60). Improved traffic conditions and access to modern transport services are required, along with increased efficiency through improved technologies, alternative (including non-motorised) modes of transport and fuel substitution.

Seven low carbon development options were analysed for the transport sector (Figure 5.4). The option with the largest mitigation potential is the development of an extensive mass transit system for greater Nairobi in the form of bus rapid transit (BRT) corridors, complemented by light rail transit (LRT) in very high thorough fare corridors. This public transport system has an abatement potential of approximately 2.8 $MtCO_2e$ a year in total. The second largest mitigation potential is the introduction of biodiesel, with a 10 per cent blend requirement having a potential of approximately 1.2 $MtCO_2e$ a year in 2030. The abatement potentials for the other low-carbon development options vary between 0.5 and 0.8 $MtCO_2e$ a year in 2030.

According to the Nairobi County Government, the BRT system implementation programme has been started in early 2015. A BRT system NAMA is also underway as part of the implementation of the NCCAP. In addition, Kenya has already commissioned the construction of a standard gauge railway from the Port of Mombasa all the way to the City of Kisumu. This will facilitate high speed train transport and is expected to shift a significant passenger and freight transport from road to rail.

Introducing large-scale bus rapid transit (potentially complemented with some light rail transit) has significant associated benefits in terms of reduced traffic congestion, improved local air quality and improved road safety. These options are in line with the priorities of the Government of Kenya, which has started to secure funding for these actions. A shift of freight transport from road to rail through modernising and extending the existing rail network would facilitate regional trade, as well as improve traffic safety and road infrastructure lifetimes. While the use of biofuels would lower GHG emissions and the need for fossil fuel imports, large-scale production of biofuels could compete for land with food production if poorly planned; any move towards commercial growing of biofuel crops should be pursued in a well-regulated manner.

Figure 60: Low carbon development wedge for transportation



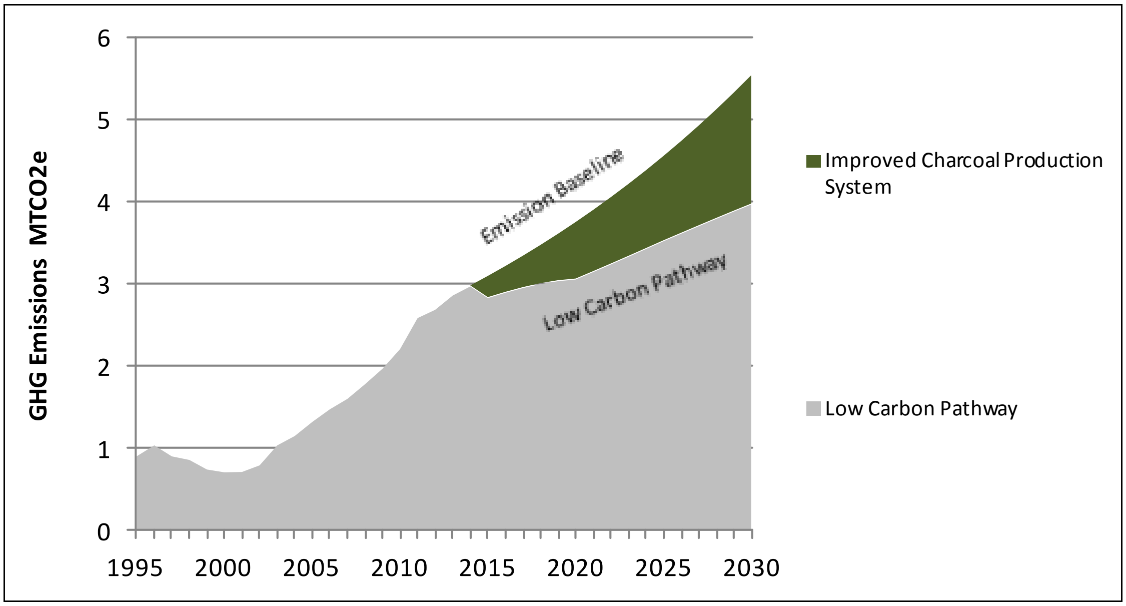
	Emission Reductions ($MtCO_2e$)			
	2015	2020	2025	2030
Improved Passenger Vehicle Stock Efficiency	0.10	0.22	0.42	0.64
Improved Heavy-Duty Vehicle Stock Efficiency	0.03	0.11	0.55	0.84
Biodiesel	0.10	0.65	0.88	1.21
Bioethanol	0.23	0.30	0.40	0.55
BRT Nairobi	0.82	1.64	1.98	2.28
LRT Nairobi	0.21	0.41	0.50	0.57
Freight from Road to Rail	0.05	0.18	0.40	0.83

Industrial Processes

The industrial sector is relatively small in Kenya, both in terms of its share of GDP and contribution to total GHG emissions (in terms of process emissions). 95 per cent of industrial process emissions in Kenya are created by two industries: cement manufacturing (1.9 $MtCO_2e$ in 2010) and charcoal manufacturing (0.8 $MtCO_2e$ in 2010). The figures for charcoal production assume that the feedstock used is completely carbon neutral. If 35 per cent unsustainable biomass usage is assumed, emissions from charcoal production increase to 4.3 $MtCO_2e$.

In the reference scenario, emissions from charcoal production are projected to remain relatively stable, while emissions from cement production increase to 4.4 $MtCO_2e$ in 2030. Process emissions from cement manufacturing can be reduced by replacing clinker in the cement mix with alternative materials. Although some Kenyan cement companies are already implementing this approach to varying degrees, this was not considered in this low carbon analysis. The most significant low carbon development opportunity is the introduction of more efficient kilns for charcoal production, with an abatement potential of 1.6 $MtCO_2e$ per year in 2030 (see Figure 61). Sustainable development benefits include reduced fuelwood demand leading to lower levels of deforestation.

Figure 61: Low carbon development wedge for industrial processes



	Emission Reductions ($MtCO_2e$)			
	2015	2020	2025	2030
Improved Charcoal Production System	0.26	0.69	1.03	1.56

Agriculture

Agriculture is the largest source of GHG emissions; it was responsible for more than one-third of Kenya's total emissions in 2010. Agricultural emissions are likely to increase from 30 $MtCO_2e$ in 2010 to 35 $MtCO_2e$ in 2030 (Figure 61), largely driven by livestock methane emissions and land use change , which account for 90 per cent of agriculture emissions and about 30 per cent of overall national emissions. The sector also plays an important role in sequestering carbon in soil and trees on farms.

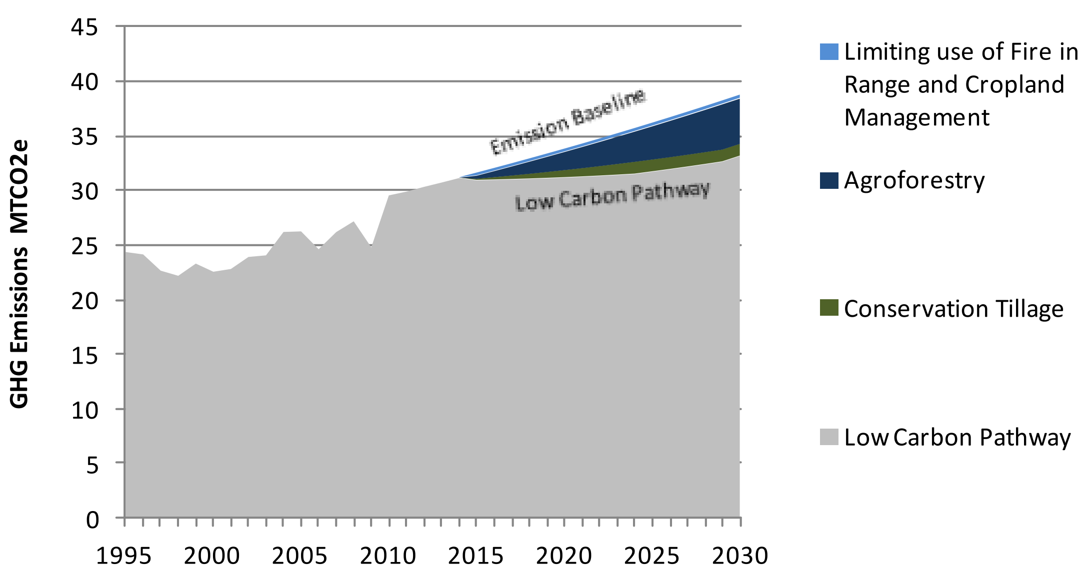
Agricultural low carbon development options have the potential to abate in the order of 6 MtCO2e per year in 2030 (Figure 62). The most significant reduction can be achieved through agroforestry, which has an abatement potential of 4 $MtCO_2e$

per year in 2030. Other low carbon development options include conservation tillage and limiting the use of fire in range and cropland management, with abatement potentials of over 1.1 and 1.2 $MtCO_2e$ per year in 2030, respectively. These three options are elements of a climate-smart agriculture approach, and a framework to encourage investment in climate-smart agriculture will be an important action.

Low carbon development actions in the agricultural sector have important sustainable development benefits, including improved retention of water and nutrients in the soil, and reduced soil erosion. These actions increase soil fertility and crop yields, improving food security and the livelihoods of farmers. Such efforts are important in arid and semi-arid lands where climate conditions are expected to become more extreme. Efforts to increase agroforestry will help meet Kenya's goal of increasing tree cover on farmland to 10 per cent as a means to preserving and maintaining the environment and combating climate change.

Important actions related to the livestock sector include manure management through biogas promotion, and rangeland pasture rehabilitation, management and conservation. In addition, actions to help farmers and pastoralists adapt to climate change, discussed in Adaptation chapter of this Second National Communication , should be undertaken in a manner that is as low-carbon as possible, complemented by awareness raising and education.

Figure 62: Low carbon development wedge for agriculture



	Emission Reductions ($MtCO_2e$)			
	2015	2020	2025	2030
Conservation Tillage	0.11	0.65	1.09	1.09
Agroforestry	0.28	1.66	3.05	4.16
Limiting use of Fire in Range and Cropland Management	0.24	0.26	0.27	0.29

LULUCF

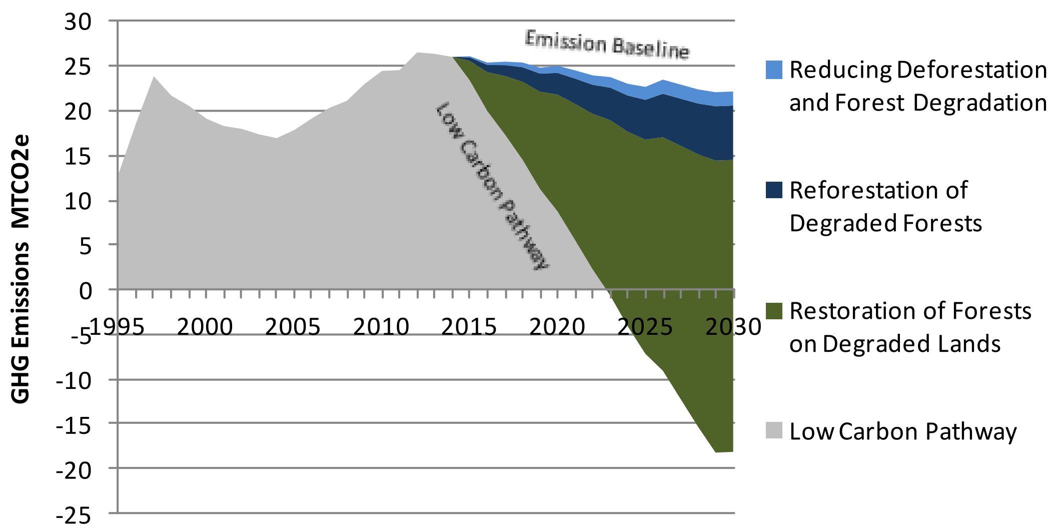
Forestry and other land use related emissions accounted for 23 $MtCO_2e$ in 2010, or about 32 per cent of national emissions. Emissions primarily originate from deforestation, where forests are cleared for fuelwood and charcoal production or to create agricultural land. The Government of Kenya is working to increase tree cover to 10 per cent of total land area – a goal stated in the 2010 constitution.

Emissions are expected to increase to 26 $MtCO_2e$ in 2015 and then decline to 22 $MtCO_2e$ by 2030, (See Figure 63). Reduced deforestation and increases in the carbon stock of trees contribute to the decline in emissions. On-going GoK REDD+ activities are taken into account in the reference case. Low carbon development actions in the forestry sector have the potential to abate an additional 40 $MtCO_2e$ per year in 2030 compared to the baseline (Figure 63).

The most significant abatement potential can be achieved through restoration of forests on degraded lands. Abatement potential of 32.6 $MtCO_2e$ per year by 2030 is likely through conservation and sustainable forest management interventions. Restoration of degraded forests has an abatement potential of 6.1 $MtCO_2e$ per year by 2030, and reducing deforestation and forest degradation potentially can abate 1.6 $MtCO_2e$ per year by 2030.

Kenya's forest resources provide important environmental and ecosystem services, and contribute to economic development, rural livelihoods, water availability and climate resilience (adaptation benefits). Maintenance of and increased forest cover in water catchments is critical for sustaining water availability and the generation of hydropower.

Figure 63: Low carbon development wedge for the LULUCF



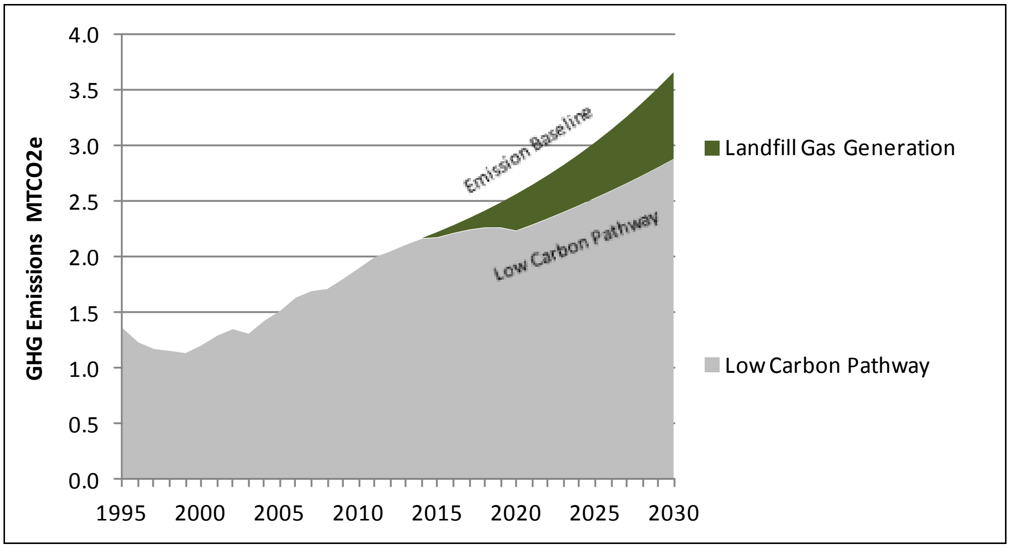
	Emission Reductions ($MtCO_2e$)			
	2015	2020	2025	2030
Restoration of Forests on Degraded Lands	2.17	13.03	23.88	32.56
Reforestation of Degraded Forests	0.40	2.42	4.44	6.06
Reducing Deforestation and Forest Degradation	0.13	0.79	1.44	1.57

Waste

Landfills and sewage treatment plants generate GHG emissions through the production of methane. Waste management and access to sewerage systems have improved, yet comprehensive coverage is still lacking. The share of the waste sector in total GHG emissions is low and is expected to remain modest. Waste-related GHG emissions are expected to increase from 1.8 MtCO2e per year in 2010 to 3.7 MtCO2e in 2030.

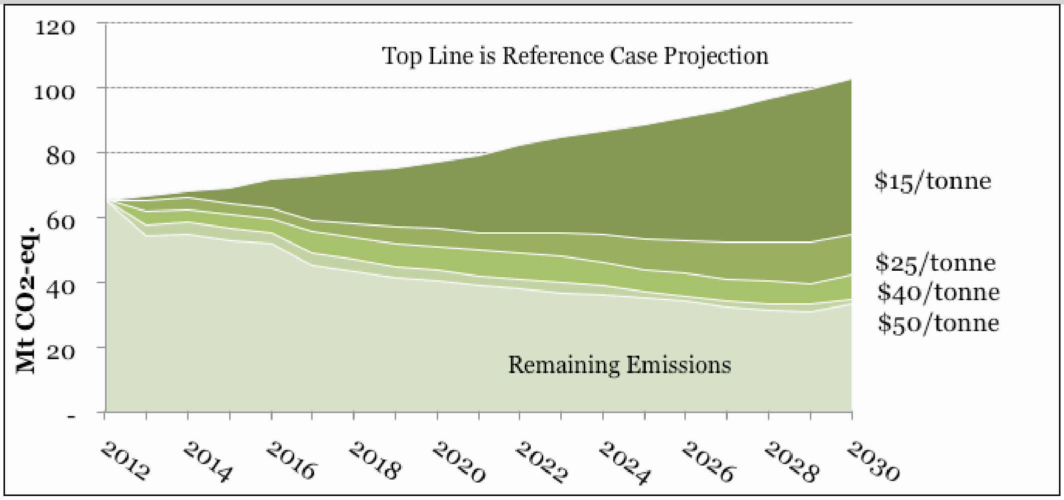
Landfill gas methane capture,[204] with an abatement potential of 0.8 MtCO2e in 2030, is the main low carbon development opportunity (see Figure 64). Methane capture can go hand in hand with proper management of solid waste, thereby improving groundwater quality, local air quality, and safety by avoiding dangerous methane gas build-ups, as well as hygienic conditions. Improved management will result in small increases in employment and the methane capture can be combined with baseload electricity production, improving energy security.

Figure 64: Low carbon development wedges for the waste sector



	Emission Reductions ($MtCO_2e$)			
	2015	**2020**	**2025**	**2030**
Landfill Gas Generation	0.05	0.33	0.50	0.78

Figure 65: Economy-wide abatement potential for all sectors (US$/tonne CO2e)



Source: GoK NCCAP Mitigation Analysis 2012

Projected investment costs for mitigation actions

According to the NCCAP, implementing the six priority low carbon actions would require investments of KSh1,371– 1,773 billion (USD16.12 – 20.84 billion) until 2030 (equivalent to a Net Present Value of KSh600 – 770 billion at a real discount rate of 10 per cent) or 391 – 495 billion over the period 2013 to 2017. The summarised investment costs for implementing the six low carbon options to 2030 are shown on Table 66. The details of these costs are provided in the NCCAP.

The methodology used for calculating these primary costs is detailed in the Low Carbon – Mitigation Annexes of the NCCAP. It is estimated that KSh839 – 1,110 billion of these investment costs would have to be borne by the public sector, with the remaining costs covered by private sector and household investments. Kenya sees clear potential to make effective use of bilateral and multilateral funding, as well as international climate finance mechanisms – such as the Green Climate Fund and emerging NAMAs and REDD+ mechanisms– in moving forward with the implementation of these actions.

Table 57: Projected investment costs for priority mitigation actions

Number	Action	Estimated Cost KSh to 2030
MITI-1	Restoration of Forests on Degraded Lands	186-290 billion
MITI-2	Geothermal	877-1115 billion
MITI-3	Reforestation of Degraded Forests	48-61 billion
MITI-4	Improved Cookstoves and LPG Cookstoves.	20 billion
MITI-5	Agroforestry	70-117 billion
MITI-6	Bus Rapid Transit and Light Rail Corridors	170 billion
MITI-7	Development of GHG inventory and improvement of emissions data	42 million
MITI-8	Measuring, reporting on & monitoring forestry emissions &sinks	624 million
MITI-9	Mainstreaming of low-carbon development options into planning	21 million
	Total Cost	1371-1773 billion KSh
Total KSh for next five years (USD4596–5815 million equivalent)		391 – 495 billion
Total USD Equivalent to 2030		16-22 billion

Source: GoK NCCAP Mitigation Analysis 2012

SUMMARY OF MITIGATION ACTIONS

Based on the comprehensive bottom-up assessment in the NCCAP and the update conducted during the preparation of the Second National Communication, six proposed priority areas for low carbon development and proposals for their implementation are described in Table 67 below. These six priority areas cover about three-quarters of total abatement potentials found in this study. Their full deployment would almost halve GHG emissions by 2030 compared to the reference case scenario (cross-sectoral interactions not taken into account). Investment costs would vary, but significant reductions can be obtained at marginal costs of less than US$15 per tonne of carbon. Some of these options also deliver fuel savings, which may result in overall social cost savings relative to high emitting options.

Significant investments will be required and a series of barriers will need to be addressed before the low-carbon opportunities can be realised. Implementing the six priority low carbon actions would require investments of KSh 1,371 – 1,773 billion (USD 16.12 – 20.84 billion) until 2030 (equivalent to a Net Present Value of KSh600 – 770 billion at a real discount rate of 10 per cent). Out of these investment costs, it is estimated that KSh839 – 1,110 billion would have to be borne by the public sector, with the remaining costs covered by private sector and household investments. A large challenge is financing the higher upfront costs of low carbon investments. Kenya sees clear potential to make effective use of bilateral and multilateral funding, as well as international climate finance mechanisms – such as the Green Climate Fund and the international support likely to be mobilised to support the emerging NAMA and REDD+ mechanisms– in moving forward on the Action Plan, in addition to systematic domestic support.

Table 58: Suggested priority low-carbon development opportunities up to 2030

Low carbon option	Government planning sector	Lead Agency	Investment costs for implementation to 2030 (KSh and USD, 2011)	Estimated split between public, private sector and household investments	NPV of investment at a 10% real discount rate (KSh and USD, 2011)	Abatement potential and sustainable development impacts
Restoration of forests on degraded lands including in rangeland	Environment, Water and Sanitation (Forestry)	Kenya Forest Service	KSh 186 – 290 billion, (USD 2.2 – 3.4 billion)	100% public	KSh 69 – 108 billion (USD 0.81 – 1.3 billion)	- Abatement potential to 2030 of 32.6 $MtCO_2e$ - Contributes to constitution's goal of 10% tree cover - Biodiversity benefits - Sustainable forest products contribute to improved livelihoods - *Conservation may remove access to forests for communities*
Geothermal	Infrastructure	Ministry of Energy, working with GDC	KSh 877 – 1,115 billion (USD 10.3 – 13.1 billion)	About 45% public / 55% private sector investment assuming current electricity market structure	KSh 399 – 507 billion (USD $4.7 – 6.0 billion)	- Abatement potential to 2030 of 14.1 $MtCO_2e$ - Energy security, economic growth - *May require relocation of communities/ villages*
Reforestation of degraded forests	Environment, Water and Sanitation (Forestry)	Kenya Forest Service	KSh 48 – 61 billion (USD0.56 – 0.71 billion)	100% public	KSh 18 – 22 billion (USD 0.21 –0.26 billion)	- Abatement potential to 2030 of 6.1 $MtCO_2e$ - Sustained water availability (generation of hydropower) - Contributes to constitution's goal of 10% tree cover - Biodiversity benefits - Sustainable forest products contribute to improved livelihoods

Source: GoK NCCAP Mitigation Analysis 2012

Table 59: Suggested priority low-carbon development opportunities up to 2030 (*continued*)

Low carbon option	Government planning sector	Lead Agency	Investment costs for implementation to 2030 (KSh and USD, 2011)	Estimated split between public, private sector and household investments	NPV of investment at a 10% real discount rate (KSh and USD, 2011)	Abatement potential and sustainable development impacts
Improved cookstoves and LPG cookstoves	Population, Urbanisation and Housing	Ministry of Energy	KSh 20 billion (USD 0.24 billion) Improved cookstoves: KSh 9 billion (USD 0.11 billion) LPG stoves: KSh 11 billion (USD 0.13 billion)	Improved cookstoves: about 75% consumer costs and 25% public support costs LPG stoves: about 85% consumer cost and 15% public support	KSh 10 billion (USD 0.12 billion) Improved cook-stoves: KSh 4.5 billion (USD 0.053 billion) LPG stoves: KSh 5.3 billion (USD 0.062 billion	- Abatement potential to 2030 of 5.6 + 1.7 $MtCO_2e$ - Health benefits from reduced indoor air pollution - Lower fuelwood demand and defor-estation - Potential cost savings to households
Agroforestry	Agriculture	Ministry of Agriculture	KSh 70 – 117 billion (USD0.82 – 1.37 billion)	100% public	KSh 26 – 43 billion (USD0.31 – 0.51 billion)	- Abatement potential to 2030 of 4.1 $MtCO_2e$ - Increased soil fertility and crop yields, improving livelihoods of farmers and food security - Improved climate resilience - Contributes to goal of 10% tree over on farms
Bus rapid transit (BRT) with light rail transit (LRT) corridors	Infrastructure	Ministry of Transport	KSh 170 billion (USD 2 billion) BRT: KSh 21 billion (USD0.25 billion) LRT: KSh 149 billion (USD1.75 billion	About 75-85% public investment cost for infrastructure and 15-25% private costs for vehicle stock	KSh 79 billion (USD 0.93 billion) BRT: KSh 10 billion (USD0.116 billion) LRT: KSh 69 billion (USD0.81 billion)	- Abatement potential to 2030 of 2.8 $MtCO_2e$ - Reduced traffic congestion - Improved local air quality - Improved road safety

Source: GoK NCCAP Mitigation Analysis 2012

Table 60: Summary of Mitigation Actions

Number	Action	Estimated Cost KSh to 2030
MITI-1	**Restoration of Forests on Degraded Lands -**Undertake a programme of work to restore forests on 960,000 hectares up to 2030 including: *inter alia* dryland forest restoration activities; awareness raising, consultation and demonstration; capacity building; development, testing and application of compensation and benefits-sharing mechanisms; measuring, monitoring and	**186-290billion**
MITI-2	**Geothermal -** Develop an additional 2,275 MW of geothermal capacity by 2030 through a support programme aimed at encouraging private sector investment. The programme could include: additional grants for the early phases of geothermal development, access to loans for latter stage development, risk mitigation instruments, capacity building programmes, and harmonization and improvement of the regulatory framework.	**877-1115 billion**
MITI-3	**Reforestation of Degraded Forests -** Undertake a programme of work to replant forests on 240,000 hectares of land that were previously forests; including, *inter alia*: tree planting activities; awareness raising, consultation and demonstration; policy development; capacity building; measuring, monitoring and reporting; and research.	**48-61 billion**
MITI-4	**Improved Cookstoves and LPG Cookstoves -** Undertake a programme to support the use of improved cookstoves and of LPG cookstoves, including increasing awareness of improved cooking practices, undertaking pilot initiatives which promote the use of LPG, increasing awareness of stove quality, increasing access to soft loans, building capacity of stove producers, and improving access to testing facilities.	**20 billion**
MITI-5	**Agroforestry -** Convert 281,000 hectares of existing arable cropland and grazing land that have medium or high agricultural potential to agroforestry by 2030 through a programme of work that includes: research to identify appropriate agroforestry practices; technological development; extension services and training of extension workers; capacity building and education for farmers; pilot projects; research to determine potential in	**70-117 billion**

MITI-6	**Bus Rapid Transit and Light Rail Corridors -** Implement an extensive Mass Transit System for greater Nairobi, based predominantly on Bus Rapid Transit corridors complemented by a few Light Rail Transit corridors.	**170 billion**
MITI-7	**Development of GHG inventory and improvement of emissions data** Develop Kenya's GHG inventory, building on the information developed in the SC4 reference case of GHG emissions; develop Kenya specific emissions factors, especially in the agricultural sector; improve overall data; and build capacity to develop, use and monitor data and impacts	**42 million**
MITI-8	**Measuring, reporting on and monitoring forestry emissions and sinks -** Develop a national forest inventory, forest reference scenario, and a monitoring and reporting system that allows for transparent accounting of emissions and removals in the forestry and land-use sectors.	**624 million**
MITI-9	**Mainstreaming of low-carbon development options into planning processes**- Undertake low-carbon assessments of current and new flagship projects; mainstream low-carbon screening and planning in the county planning process and sectoral development plans. Build capacity on the use of the tools to update the low-carbon scenario assessment	**21 million**
Total KSh to 2030		KSh1,371 – 1,773 billion
Total KSh for next five years (4596 – 5815 USD equivalent)		KSh 391 – 495 billion

Source: GoK NCCAP Mitigation Analysis 2012

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CHAPTER 5

Other Information Considered Relevant For Implementation Of The Convention

TABLE OF CONTENTS

INTRODUCTION

This report provides information of other information considered relevant to the achievement of the objectives of the Convention. The report is structured as follows:

Section 2 covers the steps taken to integrate climate change into relevant social, economic and environmental policies and the relevant national, social, economic and environmental policies and activities geared towards the implementation of the Convention.

Section 3 briefly describes the activities related to technology transfer, including the country's technology needs assessments. It covers the priority needs on transfer of know-how and access to ESTs, including measures relating to enhancing the enabling environment for their development. Also illustrated are the country's current and planned technology transfer mechanisms, development and enhancement of the country's endogenous capacities and know-how, especially as relates to the grid connected energy.

Section 4 provides a description of the country's climate change observation and research systems, including research to adapt to and mitigate climate change and the country's participation in, and contribution to, activities and programmes, as appropriate to its national, regional and global research networks.

Section 5 provides information on climate change education, training and public awareness in the country. This includes plans of the country in strengthening the mainstreaming of climate change in education, training and public awareness.

Section 6 provides a brief description of the country status on capacity-building activities at the national, regional and sub-regional levels. This includes plans of the country in strengthening the coordination, dissemination and sustainability of capacity-building activities in the country. The section includes information on Kenya's efforts to promote information sharing.

Section 7 describes the country's constraints and gaps, and related financial, technical and capacity needs. As associated with the implementation of activities, measures and programmes envisaged under the Convention, and with the preparation and improvement of national communications on a continuous basis.

STEPS TAKEN TO INTEGRATE CLIMATE CHANGE INTO RELEVANT POLICIES

Kenya is highly vulnerable to climate change and therefore faces challenges in economic development. Kenya Vision 2030 – the long-term development blueprint for the country – aims to transform Kenya into "a newly industrialising, middle-income country providing a high quality of life to all its citizens in a clean and secure environment." As Kenya strives to achieve middle income status, national development is challenged by the environmental consequences of economic growth and the presence of climate change. In recognition of the serious threats posed by climate change and in adhering towards the implementation of the Convention the Government as discussed below has taken and continues to take bold measures to secure the country's development against the risks and impacts of climate change.

KEY POLICIES CONTAINING MEASURES TO MAINSTREAM CLIMATE CHANGE

In recognition of the serious threats posed by climate change and the need to implement the Convention, the Government has taken and continues to take measures to secure the country's development against the risks and impacts of climate change. The main strategies and policies, as well as other relevant sectoral policies are described below.

Kenya's National Climate Change Response Strategy (NCCRS)

In 2010, the Government launched a National Climate Change Response Strategy (NCCRS). The Strategy was the country's first national policy document to fully recognize the reality of climate change. It provided evidence of climate impacts on different economic sectors and proposed adaptation and mitigation strategies. It presented a series of observed climatic trends in Kenya, including a general warming over land locations. The Strategy not only improved understanding of the global climate change regime and the impacts of climate change in the country but also been guiding policy decisions since its launch.

Kenya's National Climate Change Action Plan (NCCAP)

A comprehensive NCCAP was launched in 2013. It takes adaptation and mitigation efforts to the next stage of implementation and guides action to respond to climate change challenges. The NCCAP encourages people centred development, ensuring that climate change actions support achievement of Kenya's development goals and Vision 2030.

The NCCAP was developed, through an extensive consultative process, and has received support from a wide range of stakeholders including development partners.

Eight subcomponents form the core of the NCCAP and represent long-term and integrated strategies for achieving key climate change goals. The eight subcomponents are;

Subcomponent 1: Long-term National Low Carbon Climate Resilient Development Pathway facilitates mainstreaming of climate change aspects in the country's long term development planning and budgeting. The Ministry responsible for planning has used this as a platform to integrate climate change into the Vision 2030 Medium Term Plan (2013-2017).

Subcomponent 2: Enabling Policy and Regulatory Framework forms the basis for policy and legislative framework to promote coherence, coordination and cooperative governance of climate change issues in Kenya.

Subcomponent 3: Adaptation Analysis and Prioritisation identified and prioritised immediate, medium and long-term adaptation actions. The proposed actions have informed the 2013-2017 Medium Term Plan and the country's National Adaptation Plan.

Subcomponent 4: Mitigation identified potential low-carbon development opportunities in the six mitigation sectors set out in Article 4.1 of the UNFCCC: energy; transport; industry; agriculture; forestry; and waste management. This has provided the basis for identifying potential internationally and domestically supported NAMAs and REDD+ activities that would promote sustainable development.

Subcomponent 5: The Technology draws attention to the barriers affecting the uptake of technologies related to adaptation and mitigation.

Subcomponent 6: National Performance and Benefit Measurement provides a framework for measuring, monitoring, evaluating, verifying and reporting results of mitigation actions, adaptation actions and the synergies between them.

Subcomponent 7: Knowledge Management

and Capacity Development provides a knowledge management system to address the sharing of climate change-related knowledge and proposed capacity building measures to address the institutional and technical capacity needs of the various actors.

Subcomponent 8: Finance developed an innovative financial mechanism that includes a climate fund, investment strategy and carbon trading platform to position the country to access finances from various sources.

TECHNOLOGY TRANSFER

Kenya's National Climate Change Strategy, its Action Plan and the second Medium Term Plan (MTP) 2013-2017 articulate a low carbon and climate resilient development. This require access to, diffusion and transfer of environmentally sound technologies (ESTs). Kenya like most developing countries does not have adequate technological capacity to meet these needs and effectively mitigate and adapt to climate change. While the Government has continuously committed to facilitate the identification of relevant ESTs and knowledge in most sectors of its economy, the adoption, diffusion and application has remained low mainly due to financial constraints, limited capacity and awareness amongst users.

For a developing and industrialising country like Kenya to tackle the issues of poverty and achieve the Millennium Development Goals (MDGs), economic activities and growth have to continue. The country has already developed its development blue print, Vision 2030, through which the country is to realise its development objectives looking into the future up to 2030. According to the emissions analysis in the NCCAP, the development envisaged in Vision 2030 is likely to result in continued, and even increased emissions of greenhouse gases in the Business-As-Usual (BAU) development pathway scenario. However, a low carbon climate resilient development pathway as recommended in the NCCAP is a promising option for Kenya.

Previously, and with varying degrees, Kenya has applied modern technologies to better cope with climate variability. In future, the country plans to apply new technologies to pave way for low carbon climate resilient development.

Despite the aforementioned Kenya's technology needs assessment reveal ESTs adoption, diffusion and application has remained low, mainly due to financial constraints, limited capacity and awareness amongst users.

Status of Kenya's Technology Needs Assessment

Kenya, being a developing country, does not have adequate technological capacity to effectively mitigate Climate Change. Kenya therefore needs to transfer, develop and adapt appropriate technologies for Climate Change mitigation and adaptation. In order to do this, Kenya, as a country, has had to identify the technology needed to address Climate Change in line with the country's Vision 2030 and other national development priorities. It is for the above reason, and in conformance with Article 4, paragraph 5 of the Convention, with decision 4/CP7 that Kenya has carried out two fully participatory Technology Needs Assessments (TNAs) that involved many stakeholders, including the Government, Private Sector, Civil Society and International Organisations. The TNA's were undertaken in 2005 and 2013, with the objective of identifying, evaluating and prioritising technological needs for the purpose of achieving sustainable development, increasing resilience to climate change and avoiding dangerous anthropogenic climate change. The TNA's have been carried out with reference to the guidelines laid out in UNDP (2003) and Gross et al. (2004).

The 2005 TNA was the country's initial formal step towards the assessment of EST's needs in the country. The TNA also marked Kenya's first step towards factoring the development and diffusion of EST's in the country's investment strategy. The sectors covered were those identified in the country's initial national communication (INC). The study addressed both the need for technologies to mitigate climate change and to facilitate adaptation but with a greater emphasis on mitigation than adaptation due to inadequate resources. It reported a number of opportunities for both greenhouse gas (GHG) mitigation and adaptation without much in terms of prioritisation and next steps.

The technologies identified in 2005 for the agriculture and water sectors included drought tolerant sorghum, drip irrigation, conservation tillage, bio-technology, tissue culture banana, early warning systems, hay production and soil and water conservation. Technologies for the development of renewable energy resources, such as geothermal, solar and wind power were also identified. The technologies developed in the energy sector have not only been crucial for mitigation but also supports adaptation, from improving the accessibility of energy for rural households and businesses, to enhancing the energy security of the country through diversification away from hydropower.

On adaptation technologies, the 2005 TNA identified a number of opportunities for reducing the vulnerability of smallholder farmers and broadly recommended that to be successful, adaptation planning should not be undertaken as a separate exercise from other planning processes in Kenya. "Mainstreaming" climate change planning into other planning processes is the key to successful adaptation and limiting the negative effects of climate change. This would facilitate the incorporation of the anticipated effects of climate change into poverty reduction strategies and rural development strategies. Many of the recommendations were not specific to climate change and made good sense from a sustainable development point of view. Those that could be accomplished at low cost, but have high impacts were identified as representing the highest priorities for short-term action.

The 2005 TNA further recommended that successful rural development and successful adaptation to climate change need to be implemented through an integrated ecosystems approach to agriculture and natural resource management. In the process, it was thought that environmental services projects such as the Clean Development Mechanism (CDM) offered opportunities to gain experience with these integrated types of projects. However, by 2013, it was evident that such projects had not been implemented for the last 8 years as had been anticipated.

The TNA further outlined a number of opportunities to reduce the vulnerability of smallholder farmers through better use of forestry opportunities.

The later TNA of 2013 was the output of a fully country-led process and the views and information contained therein was the product of the National TNA team, led by NEMA. The report filled the gaps of the initial process and led to the country's prioritisation of its EST needs in mitigation and adaptation, development of the technology action plans (TAPs), project ideas which and also recommended enabling frameworks to address identified barriers to the diffusion of the prioritised technologies. The TAPs and the project ideas prepared will facilitate the identification of technology transfer projects and their links to financing sources. These will form the basis for a portfolio of projects and programmes to facilitate the transfer of, and access to, climate technologies and know-how in the country.

Specifically, the 2013 TNA report applied a multi-stakeholder process and a linear additive Multiple Criteria Analysis Framework to further prioritise technology needs for climate change mitigation within the energy and waste management sectors. The complete results of the TNAs process can be found http://unfccc.int/ttclear/templates/render_cms_page?TNR_cre.

In addition, in 2013, Kenya nominated the Director, Kenya Industrial Research and Development Institute (KIRDI) as the National Designated Entity (NDE) for the Climate Technology Centre and Network (CTCN). Kenya's NDE will serve as the national entity for the development and transfer of technologies and a focal point for interacting with the CTCN regarding requests from the country about its technology needs. The institutional structures to efficiently operationalise the NDE functions are currently being put in place.

Priority Sectors and Technology Options

As already reported above, the TNA process was participatory and involved a number of stakeholders including civil societies, international organisations and private sector. Energy (including Transport-subsector) and Waste Management were the prioritised sectors for mitigation and Agriculture and Water for adaptation.

Why the Priority Technologies

The portfolio of technologies chosen were those with better socio-economic and/or sustainable development benefits for the country. The technology prioritisation process generated an initial list of specific technologies. The criteria for prioritisation was based on the following:

- Technology and innovation
- Barriers in implementation
- Potential for fundable projects.

The initial list was taken through a multi-criteria analysis (MCA), with weightings for identification of final options as shown in Annex 1 ANNEX 1: TABLES AND FIGURES
Table 61. The weightings were determined by a broader stakeholder community, and the scores summed to give a ranked priority list of prioritised technologies discussed below.

Mitigation

Energy

The TNA process revealed that decentralised renewable energy systems have an important role to play in the country's 80 per cent population with limited electric energy access. The Solar Home Systems (SHS) and Solar Dryers technologies were prioritised to meet most of this need.

SHS technology

SHS technology is ranked highly due to its potential to provide electricity in the rural areas where about 95 per cent of the population is not connected to the grid.[205] The SHS market in Kenya started to develop in earnest in 1982 purely along commercial lines.[206] Despite its long establishment in the country, its diffusion has been slow. This is mainly attributed to high initial installation costs, lack of awareness of the potential social and economic benefits and a lack of adherence to system standards by suppliers resulting in low quality products in the market.[207,208] The lack of quality standards, for example, has led to reduced performance and lower lifetime making it not a preferred choice with end users. Therefore, there is interest to increase diffusion and to promote cooperation agreements with internationally recognised centres of excellence to enable exchange of information (particularly standardisation, lessons learned, measurements and support) and promoting project execution in the country.[209] The TNA process identified a large potential (about 7,000,000 households) for its diffusion in the country.[210] It also recognised an additional potential to provide electricity to the already grid connected households in both the urban and rural areas as a measure to ensure continuous power supply in view of frequent power outages.[211] The country's target for SHS technology is to reach three million households by 2020 and including rural based institutions such as schools, hospitals, dispensaries, prisons and Government offices.

Solar dryers

Solar dryers were ranked highly due to their contribution to the agriculture sector. Agriculture is the main economic activity and source of livelihoods in Kenya. Farmers produce cereals, vegetables and other foods that require drying to prevent spoilage and facilitate storage. Direct solar drying by laying products out in the sun is traditionally used. The traditional open sun drying, has inherent limitations such as:

- High crop losses due to inadequate drying
- Fungal attacks
- Insects, birds and rodents encroachment
- Unexpected down pour of rain and other weathering effects.

In such conditions, solar-energy crop dryers appear increasingly to be attractive. While the small scale farmers could still rely on the direct drying, the method is seen as not effective for large and medium scale farmers. The unreliability has made these farmers rely on either technologies that use fuel wood or diesel as is the case with the National Cereals and Produce Board (NCPB) of Kenya whose bulk of dryers use diesel or wood fuel. Over 45 stations of NCPB use diesel while 65 of the tea factories use wood fuel. The prioritised solar dryers have potential to replace the use of diesel and wood fuel mitigating climate change and enhancing conservation of forests within the country. The German Development Institution (GIZ) has played a key role in introducing the technology in the country. The Kenya Industrial Research and Development Institute is equally working with institutions and women's groups in developing improved dryers for their fruits, vegetables, cereals and legumes on a commercial basis.[212] However the diffusion has been slow mainly due to lack of awareness.[213]

The interest is to increase diffusion of solar dryers with the following targets in mind:

- 50,000 small scale family units
- 1,000 commercial farmers and companies
- 100 cooperative societies and associations
- 65 vegetable processers and tea factories

If the target are realised, the diffusion will more than double the number of commercial farmers and family units using the technology.[214]
Notwithstanding the prioritised decentralised renewable technologies noted above, the country’s current and planned energy sources of hydropower, geothermal, wind, natural gas, coal and biomass also warrants technology know how. These include:

Hydropower

Kenya’s total installed large hydropower capacity is 743 megawatts, majority of which is the less disbursed large hydropower (>15 megawatts plants). Small hydro (>15 megawatts plants) potential is estimated at 3,000 megawatts, of which less than 30 megawatts have been exploited and only 15 megawatts supply the grid.[215] Although a mature technology in the country, large hydropower is very sensitive to climate variability. On the other hand, the small hydropower, which is disbursed over a larger geographical area, reduce the susceptibility of the country to major fluctuations in power supply in the event of depressed rain in specific regions of the country. Its environmental impacts are minimal through the use of run-of-the-river schemes in which no dam or reservoir storage is involved hence minimal interference with natural habitats and farmlands, and no relocation of people. The small hydropower development is therefore seen as serving a critical part of the solution towards sustainable electricity supply, bridging the demand supply gap and meeting the electricity needs of the country. However, the country lacks appropriate technologies, adequate capacity for installation and repairs and infrastructure facilities to manufacture turbines or parts that might be critical in maintenance of the plants.[216] [217] In the past, specifically development of small hydropower has been hindered by:

- High installation costs averaging US$ 2,500 per kilowatt
- Inadequate hydrological data
- Effects of climate change
- A limited local capacity to manufacture small hydro power components

Expansion of small hydropower generation in Kenya can result in great socio- economic and environmental benefits and is an area where Kenya can import knowledge, products and services.

Natural gas & coal

As of early 2015, all coal and gas utilised in the country was imported. However, there have been new discoveries of oil and coal. These include the already identified commercially viable coal reserves in Mui Basin Kitui County – with further exploration work ongoing in other parts of the country. With the discovery, the Government has plans to build a coal fired power plant in its coastal region which may expose it to sea level rise. For the natural gas there is still no sufficient volumes of this discovered. Any of these fuels adoption will need climate change issues factored and the most modern technologies (such as Pulverization (critical, super critical and ultra-super critical for coal) and Combined Cycle Gas Turbines for Gas) and including clean coal technology and carbon capture and storage. Technology transfer will be required from both developed and developing countries.

Wind

Kenya has vast unexploited wind energy resource that, in combination with appropriate Government policies, can result in financially feasible and highly successful wind-farm projects for investors[218] and fulfil power requirements for the whole country.[219] According to the Ministry of Energy and Petroleum, Kenya has a proven wind energy potential of as high as 346 W/m2 and speeds of over 6m/s in many parts.[220]

High capital cost and lack of sufficient wind regime data have been some of the barriers affecting the exploitation of wind energy resources. Moreover, potential areas for wind energy generation are far away from the grid and load-centres, requiring high capital investment for the transmission lines.

Currently (2012), wind provides about 7.1 MW of electricity. [221] Different initiatives are planned to achieve this, such as substituting thermal generation of energy with wind power plants and combining wind with thermal plants (wind-diesel hybrid). These are seen as routes to cut down on the large amounts of foreign exchange required for the diesel thermal power plants. To aid the wind energy plans the Ministry of Energy and Petroleum has developed a Wind Atlas and installed more than 60 Wind Masts and Data Loggers in various counties across the country to collect site specific data with a view to open up electricity generation from wind. The wind energy is one of the fastest growing sources and its technological advances are rapidly reaching the global market. For example Horizontal-Axis Wind Turbine (HAWT) has been popular Vertical-Axis Wind Turbine (VAWT) are gaining popularity. VAWT is not as efficient as HAWT, however they fit urban areas well due to their compact designs. Kenya in its aspiration to explore it as a resource, could seek to consider these advances and to adapt technologies and materials to make them more appropriate for the country. Technology transfer will be required from developed countries.

The technology advancement to harness power from wind energy would also help in cost reductions in generation for Kenya. Also, wind energy poses a unique opportunity for Kenya to directly leapfrog the path taken by industrialised countries, to renewable sources of energy directly

The Government has estimated that 500 megawatts and 2 gigawatts of wind capacity will be installed in Kenya by 2016 and 2030, respectively. It is encouraging independent investment in the wind sector and has introduced a competitive feed-in tariff in order to attract investments in the wind sector.

Geothermal

Kenya was the first African country to build geothermal energy sources, thus a leading producer of geothermal energy in Africa. The current (2012) production of about 573 megawatts is still fairly small, compared to the country's full potential of 7,000 megawatts.[222] There are 14 geothermal fields identified along the Rift Valley, with only one (Olkaria) developed to date. Geothermal has been identified in the NCCAP and the National Least Cost Power Development Plan as one of Kenya's most effective technologies to meet growing electricity demand and keep the sector on a high-growth low-carbon development pathway. Plans are there to increase geothermal production capacity by another 1,000 megawatts by 2017 and 5,000 megawatts by 2030.[223]

Geothermal has numerous advantages over other sources of electricity that make it suitable as a source for base load electricity generation for the country:

- It is not affected by drought and climatic variability
- It has the highest availability (capacity factor) at over 95%
- It is green energy with no adverse effects on the environment
- It is indigenous and readily available in Kenya, unlike most thermal energy that relies on imported fuel.

Realising the need to reduce the long gestation periods in the development of geothermal power, the Government has set up the Geothermal Development Company (GDC) to undertake integrated development of geothermal power through initial exploration, drilling, resource assessments and the promotion of direct utilisation of geothermal resources. GDC is 100 per cent owned and funded by the Government. By undertaking the initial project activities, GDC will absorb the attendant risks associated with geothermal development and therefore open up opportunities for both public and private participation. GDC is working on its first geothermal plant of 200 MW in Menengai via support from Scaling Up Renewable Energy Program in Low Income Countries (SREP) programme. The proposed Menengai geothermal field development will be the first field to be developed outside Olkaria. SREP will help GDC, design and test out an investment and project structure with the help of development partners that could be replicated for developing the other fields.

Currently, the main bottlenecks to geothermal expansion are capital limitations of the two main (government-owned) geothermal developers, KenGen and GDC, and a long lead-time for bringing capacity on-line. Only by making it attractive for private investors to co-invest in earlier development stages will the sector expand fast enough to meet its ambitions.

To this end, Kenya has developed a NAMA with an overarching goal of accelerating geothermal resource development in Kenya by catalysing private sector investments.

According to the NAMA proposal, Kenya needs approximately US$ 20 billion of investments to reach its geothermal targets. There is an acute awareness that a significant portion will need to come from private sources. Three categories of barriers prevent significant private participation:

- Financial barrier due to a high risk-low return profile.

- Inadequate commercial and technical capacity to deal with IPPs, access to wider capital funds, permits and approvals, and private sector developers who have different (often more rigorous) needs concerning contractual documents.
- Capacity constraint in future involving local human resources with geothermal related knowledge and skills, good data sets and information on resources. Reaching Kenya's ambitious goals for geothermal power generation will require a significant scaling up of human resource capacities and know-how. This will include both knowledge development through university and college curricula, as well as skills development, through on-site training in geothermal fields.

The overall NAMA seeks to address these barriers through a set of technical and financial support instruments as shown in Annex 1

Table *62*. The NAMA has been posted to the UNFCCC NAMA registry and is requesting for external support besides to complement the Government efforts

The capacity development supported by SREP is important to make GDC a credible actor in developing other geothermal fields. In terms of technology transfer, Kenya is geared to becoming an exporter geothermal knowledge, products and services in the region.

Biomass and biofuels

The Government has identified the existence of power generation using forestry and agro-industry residues such as the use of bagasse for co-generation. The total potential for co-generation using sugarcane bagasse is significant. So far only Mumias Sugar Company (Independent Power Producer) generates 35 megawatts out of which 26 megawatts is dispatched to the grid. The generation potential within the other 10 sugar factories is estimated to be up to 300 megawatts have not been exploited. The sugar industry also has the potential to produce ethanol from molasses, a waste product from sugar production. Ethanol was introduced in Kenya as a fuel blend for gasoline in 1983. However, due to management and pricing problems, its use was discontinued in 1993. The Government has in its plan to reintroduce power alcohol as a motor fuel in its long-term policy to enhance security of supply and redress the trade imbalance arising from petroleum imports.

Currently the total installed capacity for ethanol production is 22 million litres per year which can be blended with petroleum. The blending technology already exists but for most of the sugar plants, the existing co-generations technologies require upgrading.

Waste

Methane capture from biogas digesters in rural households is the technology prioritised for the waste sector. It is the most preferred because it has many benefits. It provides clean energy for rural household for cooking and lighting. It boosts crop production at lower costs and reduces indoor air pollution. It also reduces deforestation and hence enhances carbon sinks. Although the technology is currently promoted by the Government and Non-Governmental Organisations, resulting in a number of biogas digesters in the country, its penetration remains very low mainly due to limited trained installations technicians. It is estimated that up to 2,000 units have been installed in total, though it is impossible to estimate what percentage remain in working condition due to the dispersed and sometimes uncontrolled and informal nature of installations.[224] The preliminary targets for the technology are farmers who undertake mixed farming, institutions and commercial enterprises. The diffusion target is to have 120,000 households, institutions and commercial enterprises having access to bio-digesters by the year 2030.[225]

Adaptation

Water

Surface runoff water harvesting and roof rain water harvesting are the prioritised technologies. Increasing resilience, to limited per capita freshwater availability, is a need in the country. Currently most precipitation that falls on human settlements is lost to the atmosphere through evapotranspiration, and or runs into rivers away from settlements before use. This is particularly relevant in the ASALs, where limited rainfall received is usually very intense and often seasonal.[226] The technologies are considered to have the potential to contribute greatly to the volume of freshwater available for human use in the country. A report by UNEP[227] showed that rainwater harvesting in the country has the potential to supply the water needs of between six and 10 million people. It shows rainfall contribution is more than adequate to meet the needs of the current population several times over, if rainwater harvesting is fully implemented. As such collection and storage of rainwater through surface or roof catchment can provide a convenient and reliable water supply during seasonal dry periods and droughts. Both technologies have been adopted in some parts of the country but adoption and diffusion in many parts are facing several barriers particularly the high installation cost. For example for the surface runoff water harvesting, there are presently only 26 large dams in the country and 3,000 small dams and water pans with a total storage capacity of about 124 million m^3, which is far below the required threshold of 4.5 billion m^3 of storage.[228] The targets for the transfer and adoption of the two selected technologies are to construct 10,000 community surface run-off rainwater harvesting systems, each with a capacity of about 30,000 m^3 in the ASALs and to assist 500,000 households in the ASALs to install roof rainwater harvesting systems, each with a capacity of 10 m^3, both by 2017. [229]

Agriculture

Drought Tolerant Sorghum Variety and Drip Irrigation technologies are prioritised. The rainfall pattern is unreliable in most parts of the country and droughts have become more frequent and severe. Therefore there is need for development and introduction of high yielding, drought tolerant, early maturing crop varieties, such as the drought tolerant sorghum, in order to enhance food security in the country. Drought tolerant sorghum varieties such Serena and Seredo, are produced as a result of plant breeding to enhance their resistance or tolerance to stresses that result from climate variability. Both grow in areas with as little as 250 mm of rainfall per annum. The breeds have been developed and adopted by some farmers in the country. Extension agents and NGOs are also promoting drought tolerant sorghum for food security and beer brewing. However, studies on the extent of adoption by farmers in the country are still on-going. [230] The preliminary target for the transfer and diffusion of drought tolerant sorghum varieties is to introduce the technology to one million farmers by the year 2017. [231]

Drip irrigation on the on the other hand was ranked highly as it is considered to provide 90 per cent water-use efficiency in contrast to surface irrigation and sprinkler systems, which provide 60 per cent and 75 per cent efficiency, respectively.[232] It enables farmers to adapt to climate change in crop production under erratic rainfall pattern[233]. Available statistics show a very low adoption level of drip irrigation in the country. According to the Government, almost all National Irrigation Board schemes are surface irrigated.[234] The small number of drip irrigation usage is attributed to the high capital investment cost and to some extent the low technical know-how of the farmers regarding the use of the technology.[235] The TNA process target for the drip irrigation technology is introduction of 500,000 and 1,000 drip irrigation systems to individual farmers and institutions, respectively by the year 2017.

Identified Barriers to Technology Needs and Enabling Environments

All of the ranked technologies have had early adoption in Kenya. The key challenge for Kenya is for their successful diffusion. A list of potential barriers and proposed enabling framework to their diffusion is shown in Annex 1 Table 63. In Kenya, three barriers stand out:

- High cost of purchase, installation and maintenance;
- Weak policies and lack of standards; and
- Limited information and awareness.

In as much as cost is fundamental and seems as the major barrier to development of all the prioritised technologies in the country, it is recognised that it is only part of the picture. Their development has as much to do with local private sector interest in the technology, availability of quality equipment and market awareness. Therefore for most of these technologies, an informed private sector infrastructure with a whole network of players including importers, distributors, assemblers, technicians and marketing agents is required, none of whom will invest if they don't understand the technology and the potential demand. This makes information and awareness campaigns a key measure. Therefore outreach programmes and including through successful demonstration projects are considered necessary to raise awareness of the benefits.

Current Mechanisms for Technology Transfer in Kenya

The principal mechanisms of technology transfer in Kenya, have mainly been administered by the GEF and the CDM. Others such as Japan sectoral crediting mechanism and NAMAs are starting to take centre stage. One NAMA for accelerated geothermal electricity development submitted to the UNFCCC registry is seeking financial and capacity development support.[236]

Technology Transfer Associated with CDM Projects

Under the Kyoto protocol, the CDM projects is perceived to have made some limited contributions to technology transfer. [237]
An assessment of the project design documents (PDDs) of Kenya's registered CDM projects[238] (Annex 1) shows that of the 20 registered CDM projects in Kenya, 16 projects claimed some technology transfer benefits. However, it has not been possible to establish the extent to which the CDM contributed to their implementation and how many of the projects have actually been implemented and therefore, realised technology transfer benefits.

Despite any explicit technology transfer mandate, several CDM projects have been found to contribute to technology transfer by financing emission reduction projects using technologies not available in Kenya. There is wide disparity across various project types and the analysis revealed that only in the renewable energy (geothermal, cogeneration, wind, hydro, solar and biogas), water purification and energy efficiency (efficient transformers, lighting and cookstoves) sectors there was some degree of technology transfer. Still comparative assessment reveals that the component of technology transfer is inadequate and comparatively small. Waste-to-energy, and industrial energy sectors show no significant technology transfer unlike the other sectors where there is some technology transfer involved for projects.

Regardless of the aforesaid, with the inception of GEF and CDM, technology transfer has become a vital and recognised activity in Kenya

and has led to capacity building within the country, but the pace and progress are somewhat slow and need immediate and consistent ramp-up.

On the policy front there is no evidence to show that CDM has been capable of encouraging policy changes to foster technology innovation in the country. Project level CDM being an instrument that concentrate on single projects, it can be said it has been useful for Kenya in the very early stage of demonstration of the technology, but the real technology transfer processes requires much more effort. A number of studies[239] have expectation that scaled-up mechanisms such as CDM Programme of Activities (PoAs) and NAMAs may be able to mobilise cumulative technological learning on a much larger scale than project-by-project CDM. Kenya's 14 registered PoAs[240] (Annex 1
Table *65*) have the objective of scaling up the deployment of technologies to targeted end-users across Kenya. PoA model eliminates cost barriers and bring in the private sector players. A trend already observed especially with the improved cooking stoves. Equally, NAMAs are expected to support an enhanced scale of activity from a wider set of participants. Kenya has developed and submitted one NAMA for accelerated geothermal electricity development in Kenya. Both are areas which Kenya seeks to maximise on.

Apart from the efforts undertaken through the mechanisms enabled by the UNFCCC and other multi and bilateral organisations, several steps are also being taken at the national level. The NCCAP is the first nation-wide overarching framework that maps the roadway to low carbon and climate-resilient future, with significant focus on technology being a major driver. The other document is the Technology Needs Assessment and Technology Action Plans for Climate Change Mitigation; March 2013.

Applying modern technologies to better cope with climate variability is not new to Kenya. Technology developments have helped Kenya cope with climate variability in the past, and new technologies will help Kenya move toward a low carbon climate resilient development pathway. Examples of such technologies include geothermal electricity generation, wind power generation, energy-efficient light bulbs such as compact fluorescent lights, solar (photovoltaic, thermal), improved cook stoves, drought tolerant crop varieties (such as drought-tolerant sorghum developed by the Kenya Agricultural Research Institute), conservation agriculture, drip irrigation technology for arid and semi-arid regions, and water harvesting and purification technologies, among others.

Kenya has recently established the first Climate Innovation Centre in the world (a World Bank initiative) at the Strathmore Business School. Dedicated to supporting climate change technologies and research and development entrepreneurship, its main focus will be on innovative technologies in the area of energy, agriculture and water supply that will contribute to green development and growth. The centre will play an important role in developing green technologies in Kenya and will target solutions that are relevant across the East Africa region. To improve climate knowledge and information management and capacity, Kenya is in the process of establishing the Climate Change Resource Centre at Kenya Meteorological Services (KMS). In addition, the country has set up, and is in the process of equipping, the National Climate Diagnostic Laboratory at KMS.

Indigenisation of technology is a must for ensuring, low carbon technology penetration, owing to the high costs of the technology. As climate change and its mitigation are seen as a collective responsibility of all countries in the world, diffusion of technology and capacity building should be the major focus as well, both at multilateral and national levels.

The development of domestic technological capability is crucial because an endogenous technological change may lead to substantial reduction in carbon prices as well as GDP cost, and it is in this context that significant action on the technology transfer component should be addressed through various agreed mechanisms. Apart from this, capacity building in terms of institutional infrastructure, development of skilled professionals, and better incentive structures for adoption of low carbon technologies will create a more favourable technology transfer environment, which can be achieved through structured and dedicated R&D expense allocations.

Re-emphasising the importance of technology transfer to Kenya so as to meet climate change related challenges, it is imperative to ramp up the mechanisms of technology transfer in terms of value as well as the portfolio significantly. This would not only help in mitigating significant carbon from the atmosphere but also help Kenya in meeting its development goals.

Technology Transfer under the GEF Mechanism

The GEF as an operating entity of the financial mechanism of the UNFCCC has become the largest public sector funding source to support the transfer of ESTs to developing countries. The climate change focal area strategy programming has evolved over the years through the different replenishment cycles. The GEF climate change investments have promoted technology transfer at all stages of the technology development cycle, from demonstration of innovative emerging low-carbon technologies to diffusion of commercially proven ESTs and practices. Kenya has had GEF funded projects right from the pilot stages in 1991 to the current cycle GEF 5 as shown in Annex 1 Table 66.

The cycle one of GEF 1994-1998, had programmatic long-term approaches and short-term projects promoting mitigation through the use of commercialised or nearly commercialised technologies that were not yet widely disseminated. [241] GEF-2 (1998–2002) to GEF-3 (2002–2007) addressed technology transfer through energy efficiency and renewable energy technologies that were mature (such as wind, solar and geothermal), available in international markets, and profitable, yet faced human, institutional, technological, policy, or financial barriers to dissemination in developing countries such as Kenya. [242] GEF-4 (2007–2010) focused heavily on climate change issues. The current GEF-5 (2010–2014) endeavours to make a transformative impact in helping GEF-recipient countries such as Kenya move to a low-carbon development path through market transformation and investment in environmentally sound climate-friendly technologies. It continues to support the technology transfer framework through six key objectives:

- Promote the demonstration, deployment, and transfer of innovative low-carbon technologies;
- Promote market transformation for energy efficiency in the industrial and building sectors;
- Promote investment in renewable energy technologies;
- Promote energy-efficient low-carbon

transport and urban systems

- Promote conservation and enhancement of carbon stocks through sustainable management of LULUCF; and
- Support enabling activities and capacity building.

Kenya is at the stage that requires market pull to achieve widespread adoption and diffusion of its prioritised technologies hence these objectives fit with the aim detailed in the TAPs and project idea notes.

A key recent GEF activity in Kenya was the National Portfolio Formulation Exercise organised by NEMA and held in March 2011 to identify the country's priority areas and recommend bankable project proposals for endorsement by the Operational Focal Point[243] for submission to the GEF secretariat/council. The participants included members of the National Steering Committee made up of key stakeholders including Government ministries and departments, GEF Implementing Agencies (UNEP, World Bank, UNDP, UNIDO, and FAO), Academia and Civil Society Organisations. The objective of the meeting was to provide an opportunity for the stakeholders to review all project proposals seeking funding from GEF to ensure that they address national priorities and generate local, national and global environmental benefits.

The GEF portfolio in Kenya, under the replenishment cycles, is broadly spanned over five focal areas, including climate change (mitigation and adaptation), biodiversity, land degradation, international waters, and persistent organic pollutants (POPs).[244] The study of projects supported by the climate change focal area of the GEF reveals that many projects do contribute towards technology transfer, although the overall contribution from the portfolio is quite limited. It is, however, noted that the share of projects supported by the GEF has a major component in which there is no technology transfer. This trend is more or less consistent across all GEF replenishment cycles. However, in the latest cycles, there is some improvement in the overall share of projects involving technology transfer, but this is substantially low. The same trend is visible in value terms as well. The total funds contributing only to the technology transfer activities (the total project outlay from GEF to technology transfer projects) have shown an increasing trend, but the actual amount contributing to technology transfer activities is much smaller. Direct assessment of the exact and direct contribution of the GEF mechanisms to technology transfer activities in Kenya's portfolio was not possible because the necessary detailed information was not available for all the projects. But this would constitute important information to be revealed on the technology transfer aspect.

As far as the GEF portfolio is concerned, a number of projects under implementation indicate that technology transfer and capacity building is taking place across the nation, in various sectors. A fair amount of low-carbon technologies and know-how is being transferred and purchased, most involving cross-boundary acquisitions, but it is not adequate.

RESEARCH AND SYSTEMATIC OBSERVATION

Various systematic observation and research activities related to national, regional and the global climate change are carried out in Kenya. The country continues to be active in both fields, both independently and with international partners. Various institutions including international organisations, universities and autonomous institutions of excellence, promote, undertake and coordinate climate and climate-related research activities and programmes in the country. Kenya Meteorological Department (KMD), a department currently under the Ministry of Environment, Natural Resources and Regional Development Authorities (MENRRDA), was started in 1929, is mandated by the Government to promote and undertake climate and climate change-related research and systematic observations in the country. Its mandate is broad and includes:

- Managing surface and upper air meteorological observations and the publication of the climatological data;
- Provision of meteorological and climatological services to the country's key sectors of agriculture, forestry, water resources management, civil aviation and public utilities;
- Provision of meteorological services to shipping in the west of Indian Ocean and to military aviation for the safety of national defence;
- Maintenance of an efficient telecommunications system for rapid collection and dissemination of meteorological information required for national and international use in accordance with the World Meteorological Organization (WMO) and the International Civil Aviation Organization (ICAO) procedures;
- Co-ordination of research in meteorology and climatology including co-operation with other authorities in all aspects of applied meteorological research; and
- Capacity building programmes in all fields of meteorology and other related scientific subjects which are relevant to development within the country and other countries that participate in its training activities.

Collaborating very closely with KMD are two other institutions:

- Africa's IGAD Climate Prediction and Applications Centre (ICPAC), which was formerly known as the Drought Monitoring Centre, Nairobi (DMCN), and a specialised institution of IGAD with its headquarters in Nairobi. It undertakes climate monitoring and seasonal predictions of climate stress and serves eleven member countries[245] in the Greater Horn of Africa region. It is a "Regional Centre of Excellence" providing climate early warning information and supporting specific sector applications to enable the region cope with various risks associated with extreme climate variability and change for poverty alleviation, environment management and sustainable development.
- The Institute for Meteorological Training and Research (IMTR), which is responsible of training personnel in meteorology, hydrology and related geo-sciences in the country and other Anglophone countries in Africa. The institute is upgraded to the status of the WMO Regional Training Centre (WMO-RTC). IMTR RTC is also regarded as a "Centre of Excellence" with two components, one located on the grounds of the KMD offering diploma courses and at the University of Nairobi, Department of Meteorology located at Chiromo Campus offering degree courses. The two work very closely together, especially in the coordination of international training programmes for the WMO members.

Kenya's Systematic Observation, Monitoring and Research

The need for information and tools to enable Kenya to cope with the impacts of climate change is real and urgent. The Fifth Assessment Report (AR5) by the Intergovernmental Panel on Climate Change (IPCC) highlighted that Kenya is one of the 20 countries and regions most at risk. To ensure that the country is sufficiently resilient and prepared the Government recognises that the country requires the development and delivery of operational meteorological and climatological information prepared, interpreted and delivered to meet its society's needs. Kenya has the infrastructure and framework to enable this, such as its network discussed below and including institutionally through the KMD's new sub-branch of Climate Change and Pollution (CCP) monitoring services. However more is required. The CCP is specifically created to undertake research, monitoring, detection and assessment for climate change within the country. The sub-branch constitute three divisions which include:

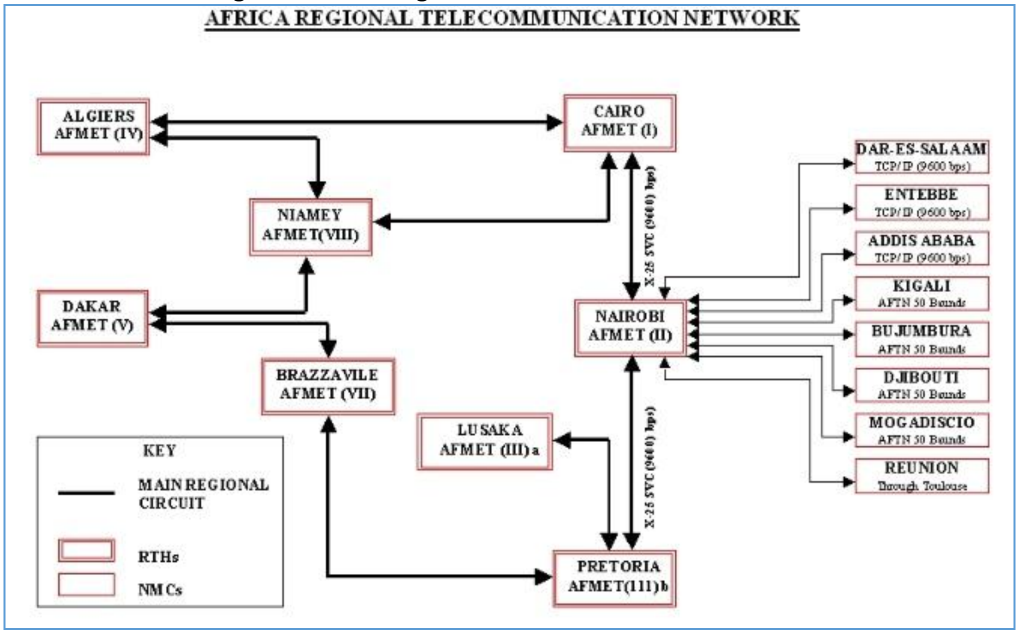
- Climate Change;
- Atmospheric pollution monitoring; and
- Urban pollution monitoring.

The climate change division carry out extensive scientific research in the country consistent with the regional and global issues of climate change. The atmospheric pollution monitoring division undertakes long-term measurements of atmospheric chemical composition and background pollution. It provides vital information on GHGs and aerosols in equatorial Africa, and the effect of biomass burning on the regional build- up of tropospheric ozone. The latter is undertaken at Mt. Kenya Global Atmosphere Watch (GAW) Station part of the WMO Atmospheric Research and Environment Programme. While the urban pollution monitoring division undertakes environmental monitoring for continuous measurement of Carbon Monoxide (CO), surface Ozone (O_3) and meteorological parameters. This enables continuous monitoring of ambient vehicular emissions and provide early warning system on climate-related health impacts in the country.

Systematic Observation

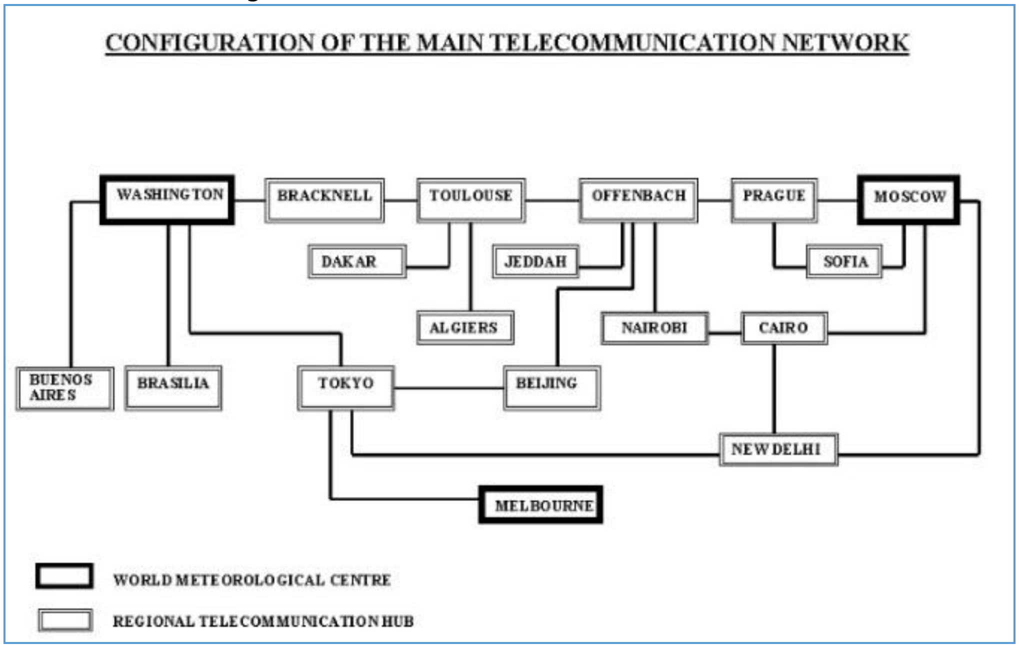
The country hosts a number of observational stations and an extensive communication network to support the systematic observation monitoring and research. The communication centre at KMD is a Regional Telecommunications Hub (RTH) that collects observational data originating from its own and associated National Meteorological Centres (NMCs) relaying such data directly to the global Main Telecommunication Network (MTN) as shown in Figure 65 & Figure 66, respectively.

Figure 66 Africa regional telecommunication network



Source: KMD website

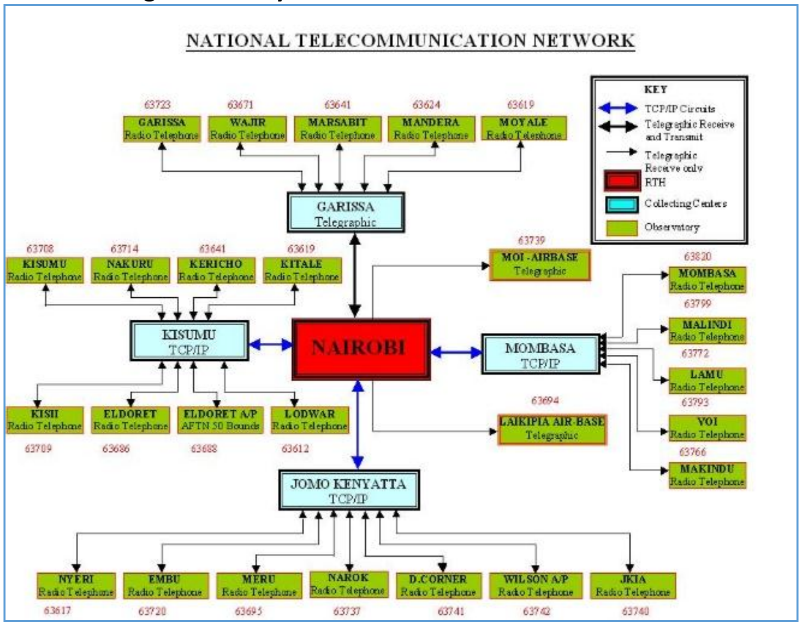
Figure 67 Global main telecommunication network



Source: KMD website

The national level communication configuration infrastructure include round the clock data collection stations from geographically dispersed observing locations as shown in Figure 67 forming the national observational network and feeding into real-time data analysis, modelling and forecasting activities.

Figure 68 Kenya national communication network



Source: KMD website

The country's national observational network consists of:

- Approximately 38 manned surface climate observatory stations (called Synoptic Stations) that provide information on rainfall, temperatures, wind speed and direction, air pressure, soil temperature, solar radiation, sunshine duration, relative humidity, evaporation and cloud cover; [246]
- 72 Automatic Weather Stations (AWSs);[247]
- About 500 active rainfall stations most of which are operated by volunteer observers. 2,500 stations were started sometime back but they are now dormant stations. [248]
- Three satellite receiving stations, two for Metro-Sat. Second Generation (MSG) and one for National Oceanic and Atmospheric Administration (NOAA). The NOAA is currently not functional. [249]
- 4 marine tidal gauges with automatic meteorological sensors at Shimoni, Kilifi and Lamu by Kenya Meteorological Services and at Malindi by Kenya Ports Authority. These gauges are used to monitor ocean tides and waves as well as tsunamis. The data collected is also used to study sea level rise associated with global warming. The data is crucial in providing information to support decision making in adaptation planning for coastal zone management.[250]
- 3 upper air stations located at Dagoretti Corner, Garissa and Lodwar. Of these, only one at Dagoretti is currently operational and is making one ascent instead of two ascents per day due to inadequate resources for purchasing consumables. This is a major drawback because both morning and afternoon ascents are required for effective weather and climate forecasts.[251]
- Aviation Weather Observing Systems at Jomo Kenyatta International, Wilson, Mombasa, Kisumu, and Eldoret airports. These systems are able to detect and monitor hazards associated with extreme weather events.[252]
- 1 ozone Global Atmosphere Watch (GAW) station on Mt. Kenya with two stations in Nairobi;[253]
- 19 hydro-meteorological automatic weather stations (12 owned by Kenya Meteorological Services and 7 by the Office of the President) which have been installed in the water catchments[254]
- Four lightning and thunderstorm detection systems at Nairobi, Mombasa, Kisumu and Eldoret. These are used to provide severe weather warnings especially for aviation safety;[255]
- About fourteen agro-meteorological stations manned by KMD and 5 (at Ruiru, Kisii, Koru, Marienain Meru, Kitale and Mwela in Bungoma) manned by coffee research foundation.[256]
- Three river gauges one is vandalised[257]
- Two buoys one in Lake Victoria and other Rusinga Island.[258]

The observations made are relayed to the National Meteorological Centre immediately by use of telephones, fax, radio telephone and teleprinters from four Data Collection Centres of Garissa, Kisumu, Mombasa and Jomo Kenyatta

Figure 68) in the country. The NMC then uses the information to provide products such as but not limited to:

- Daily, five-day, monthly and seasonal weather forecasts.
- Agro-meteorological bulletins that are issued every 10 days to provide information on

assessment of crop performance and expected climate conditions that may affect the crops.

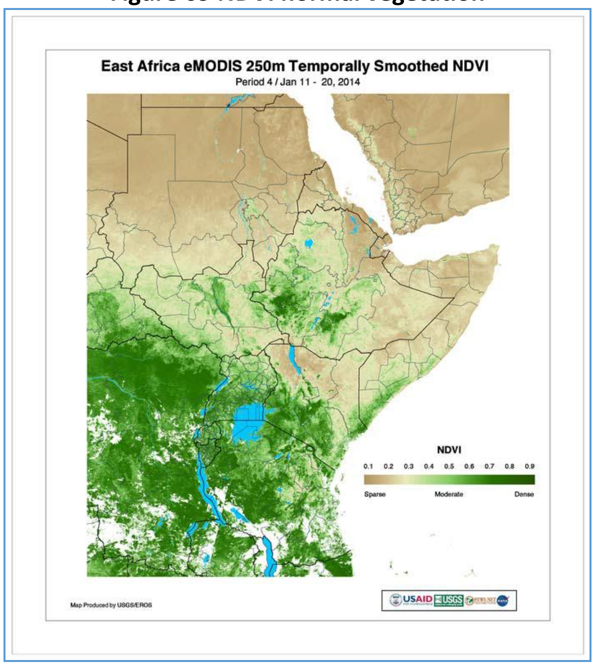
- Seasonal climate forecasts that contain information on expected performance of rainfall in the various parts of the country. The forecasts also contain warnings on expected climate related hazards including areas likely to be at risk and advisories on cautionary measures that should be taken. These seasonal forecasts are issued in good time for early warning for communities and institutions for preparedness and contingency adaptation planning.[259]
- Information on marine conditions include general state of the ocean such as wave heights, wind speeds, visibility, and ocean currents. This information is provided to the communities in the proximity of the oceans, ships and fishermen.[260]
- Hydrological information include state of the river flows of major rivers especially the potential for flooding of rivers such as River Nzoia. This information is provided to communities who live in close proximity of the rivers for early warning and preparedness.[261]

The weather and climate information is provided to the user communities in a number of ways including the following:

- Print and electronic mass media where the information is made available to the media and in case of special bulletins which must be issued in full, KMD buys space in the media.
- Information provided to the local communities through provincial directors of meteorology.
- Radio Internet (RANET) which is an innovative community based radio program established with the aim of providing climate information to the local communities as widely as possible. The climate information is disseminated through the internet and broadcast by the radio to the local community groups.
- Through internet-Weather and climate information can also be accessed through the KMD internet site: www.meteo.go.ke or through telephone Number: 0203876957.

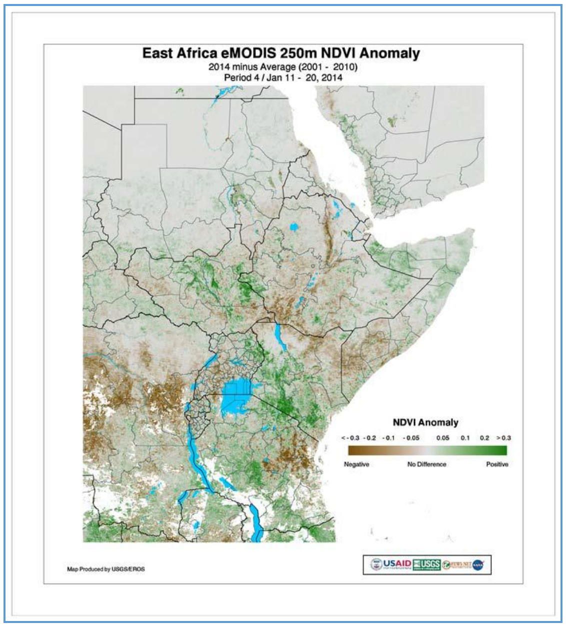
Despite Kenya's observational network installed at strategic areas so that the observations represent the general climate of a large area,[262] the quantity and quality are considered not enough to cover the whole country and the larger region effectively.[263] Kenya, like many other developing countries, operates on a lean budget to meet its meteorological needs.[264] This has led to the inadequate observation and monitoring sites, with sub-optimal size of sites that are used. A typical example are the rainfall stations that have been declining due to economic constraints. The economic constraints have not only hampered maintenance of the relevant equipment but also the personnel to man the stations.[265] According to the KMD, there were over 2,000 rainfall stations in Kenya in the year 1977. However the number of rainfall stations drastically dropped to 1,653 by the year 1988, 1,497 by 1990. At present there are only 500 rainfall stations in the country. The number of meteorological stations, which run on voluntary basis, (schools; administration centres, national reserves, forest stations and individual farms) have also been declining.[266] In addition, most of the climates monitoring stations are concentrated in humid and semi-humid areas which have high rain fed agricultural potential. Climate monitoring networks in the ASALs are seriously limiting yet it is in these areas where the need to understand the high climate variability in the country is most required. The data currently obtained tend to be one-dimensional, or monitored at limited spatial scales, preventing the formulation of a complete picture. Equally a lot of data found is raw and data gaps exist resulting in inconsistencies and omissions, making them unsuitable for use in planning. The NOAA satellite is not operating. This is another typical example and an unfortunate position for the country as satellite observed or generated data goes a long way in assisting Kenya meet its climatic and weather related goals and needs.[267] A crucial satellite product Normalised Difference Vegetation Index (NDVI is of major input in environmental and weather monitoring on vegetation in the country. It is used by both environmentalists as well as meteorologists to monitor drought. In Kenya as in most African countries, most livelihoods are highly dependent on agriculture. This makes it very necessary to keep track of the behaviour of vegetation which is to a large extent the indicator of foliage performance. The monitoring is achieved through monitoring of NDVI and its anomalies (Figure 68 & Figure 69 respectively) over a reasonable period and season.

Figure 69 NDVI normal vegetation



Source: Gitonga 2014

Figure 70 NDVI vegetation anomalies



Source: Gitonga 2014

In coupling vegetation monitoring with weather forecasts, meteorologists would be well equipped to advice the decision makers in the country accordingly.[268] With the limited satellite in operation, the needed information for contingency, such as adaptation planning, is therefore substantially hindered.

Research

Research is important for the country not only in understanding the causes, manifestations and impacts of climate change, but also in responding to it. The Kenya Meteorological Society (KMS), in conjunction with KMD, Department of Meteorology, University of Nairobi (UON) and other stakeholders have been organising national and international workshops on meteorological research, applications and services. In addition to dealing with pressing global issues, KMS also facilitates sustained interaction of meteorologists and users of meteorological products and services. This is through facilitating communication of important findings, which contribute towards the advancement of meteorological knowledge among Kenyans and beyond. KMS organises local and international meteorological workshops, conferences and symposia, introduces public education and sensitises the public on the important aspects of meteorology such as drought, desertification and climate change. The ultimate goal of such ventures is to enable meteorologists to better tailor their products to the needs of the users and the country.

One of the other ways that KMS achieves its goal is by publication of the quarterly Journal of the Kenya Meteorological Society, which was launched in September 2007. The journal aims at enhancing the dissemination of research findings by scientists within Kenya and beyond. KMS also publishes a quarterly newsletter called 'The KMS Bulletin'. This is distributed to various institutions and individuals. The objective of the Newsletter is the promotion of public education and awareness on weather and climate.

Status of National and Regional Programmes

WMO Integrated Global Observing System (WIGOS) Demonstration Project Kenya

The project aims at integrating all the national observation systems in Kenya. These include land, sea, and upper air observations and other national observing networks that provide time critical data and products. Its objectives include:

- Modernise the national observational network by increasing the number of automatic weather stations, installation of two upper-air stations, increasing the number of hydro-meteorological stations, establishing a seismic network in the country and installation of two urban climatology pollution monitoring stations.
- Significantly improve the availability of national and regional observational data and products.
- Improve the regional instruments calibration centre.
- Standardise instruments and methods of observation in Kenya.
- Provide end-product quality assurance.

In support of the project, KMD is in the process of procuring an Integrated Meteorological Information System (IMIS). The IMIS will be able to pre-process, decode, process, manage, perform quality control and integrate conventional surface and upper-air observations. The project evaluation indicates slow progress due to lack of sufficient resources with main constraints being:

- Inadequate funding from the national budget.
- Difficulties in explaining WIGOs benefits to partner institutions leading to mistrust and lack of cooperation.

Radio and Internet (RANET) Communication-Kenya

RANET-Kenya project was established in 2001 and is based at the KMD as part of a global RANET project. It seeks to transmit vital weather and climate information to rural communities using radio and internet. To achieve this, KMD is working with many partners such as government departments, NGOs and Community Based Organisations (CBOs) operating in the local communities, addressing challenges that affect them such as a food security and poverty reduction. RANET has two components namely, Community FM radio stations and Satellite download centres/ information centres. Kenya has four community FM radio stations and more than 22 RANET information centres. In these centres, it is possible for the local communities to receive, information on weather, climate, health and other developmental information in web format without the necessity of the services of Internet Service Provider (ISPs). This is made possible through the use of worldspace digital receivers connected to computers through a worldspace pc adaptor. In addition to reaching the rural communities on weather and climate, RANET-Kenya takes the initiative to develop malaria prediction models for application in specific high risk zones of Kenya.

Integrating Indigenous Knowledge in Climate Risk Management – Nganyi Rainmakers

This is an ICPAC led project linking scientific and indigenous knowledge. The team worked with local community rainmakers (Nganyi in Western Kenya) to develop harmonised consensus forecasts. In the process, it was hoped that traditional knowledge will be better understood and valued, scientific knowledge will be increased, and communities at risk from climate change will have more reliable information in local languages to help them protect their health and livelihoods. To start the process, ICPAC produced a seasonal forecast downscaled for local use by the KMD, then climate scientists and Nganyi forecasters met to develop a consensus forecast for the region. With the help of local government officials and development agencies, the harmonised forecast was then converted into advisories in local languages concerning community health and agriculture for that season. Building trust between scientists and rainmakers was the delicate part of the process. Building on lessons learned in the project, ICPAC and other research partners aim to see harmonised forecasts used on a wider scale in the country and beyond.

Kenya's Turn-Key Tsunami Early Warning System (EWS)

This is a project to measure water levels at three points along Kenya's coast for early warning of tsunamis and data collection crucial to monitor, predict meteorological and climatic events. It is envisaged that the establishment of EWS decreases the impact of tsunamis and other related maritime disasters (e.g. tropical cyclone, oil spills, marine accidents, store surges and strong ocean waves, etc.) within the country. It uses modern technologies in ocean monitoring as new developments in ocean climate modelling require that the data be accurate and the system be durable to maximise the system's ability for early detection of tsunamis and weather and climate modelling activities.

African Satellite Meteorology Education and Training (ASMET)

The ASMET began in 1997 with the aim of reducing the impact of weather related disasters in Africa. This has been achieved by providing weather forecasters lessons that teach them how to improve their forecasts by making better use of satellite data. The initial lessons were developed by a team of meteorology instructors from the WMO's Regional Training Centres, IMTR in Nairobi, Kenya and EAMAC in Niger. The first phase of the project was funded by several organisations, notably European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) and GIZ (Germany). Since then, EUMETSAT has been the sole funder ASMET. Through the project, various training activities have been undertaken at the two WMO regional training centres. The training at IMTR Nairobi and EAMAC focuses on Anglophone and Francophone African countries, respectively. During the initial phase, four instructors from EAMAC and IMTR attended a nine-month fellowship program on the instructional design and lesson production process producing its first lesson: Integrating Satellite Imagery of the ITCZ into Analyses. Since then, the team has produced a number of lessons, which was used for other meteorologists within the country and region. More information can be found on the ASMET website, http://www.meted.ucar.edu/communities/asmet/.

Education, Training and Public Awareness

The climate is a complex system and raising public awareness of the basic science, its uncertainties and the risks are vital in order to engage the public in a debate about the actions needed to combat climate change and reduce its future risks. Therefore Kenya recognises education, training, and public awareness on climate change as essential component of its action on climate change.

Education

The Government has, since independence in 1963, developed a number of education policies for provision of quality, targeted and complete education. Various commissions have been appointed by successive governments to address emerging issues that have needed to be integrated into the education system. However none of these commissions formed has explicitly addressed climate change issues within the education system.[269] As such climate change is not formally acknowledged in Kenya's education curricular at primary, secondary and tertiary levels.[270] The National Climate Change Response Strategy (NCCRS) also acknowledged this, noting that "A major concern in Kenya is the lack of adequate climate change information, knowledge to researchers, planners, policy makers and the general public on climate change impacts, adaptation and mitigation measures." Among the measures it recommends is to carry out curricular review to integrate climate change into the Kenya education system.

During the NCCAP development in 2012, the country undertook a content analysis and interviews to establish the extent to which climate change had been integrated into Kenya's education system. Content analysis involved examination of the relevant education policy documents since independence. Also analysed were the curricular of primary, secondary and tertiary levels of education at the time. In the case of universities in-depth interviews were held with heads of departments of relevant sections where climate change courses were taught. The results of the content analysis and interviews revealed that:

- 0.36 per cent of the primary school curriculum addresses directly or indirectly issues related to climate change.
- 0.53 per cent of the secondary school curriculum addresses directly or indirectly issues related to climate change.
- 1.11 per cent of the primary teacher training curriculum addresses directly or indirectly issues related to climate change.
- 0.66 per cent of the secondary teacher education curriculum addresses directly or indirectly issues related to climate change.
- 0.45 per cent of the Tertiary and vocational education and training (TIVET) curriculum addresses directly or indirectly issues related to climate change. Similarly analysis of other tertiary institutions revealed that only 0.46 per cent, of their curricula address directly or indirectly issues related to climate change.
- 27.3 per cent of the university curriculum addresses directly or indirectly issues related to climate change. It was recognised that University programmes have the highest proportion of courses that present possible entry points for climate change content, compared to other lower levels of the Kenyan education system.

The following strategies were then proposed to integrate climate change in the country's education system:

Primary level education: It was recommended that the formulators of the primary school curriculum make a conscious effort to introduce basic principles of climate change and its impact into the primary school subject matter by integrating it into all subjects to the extent possible. The possible entry points courses proposed were nature study and agriculture.

Secondary schools: courses were proposed to be introduced incrementally at secondary school level. The students at secondary school need to be equipped with skills to support a future low carbon and climate resilient economy. Integrating climate change in secondary education was proposed to happen through the introduction of content that makes learners aware of the need to develop climate adaptation and mitigation capacities for their country.

Post-secondary vocational institutions: the country experiences lack of middle level technicians. This is seen as an opportunity to train secondary leavers with skills to support the widespread adoption of adaptation and mitigation practices needed to support the NCCAP. For example, whereas it is desirable for the country to promote diffusion and adoption of solar heat systems, supportive networks for installation and maintenance of solar power systems are not well established nationally. This is a strong leverage to support integrating of climate change into the curricular.

Universities: Whereas it was found that climate change as a subject is now being taught at some Kenyan universities, it was considered there is a need for these institutions to develop policies to ensure that all students trained there are familiar with climate change and its impacts. As climate change is a cross sectoral issue, civil engineers need to learn how to design and develop structures that can withstand climate shocks, doctors need to be aware of the effects of climate change on human health, architects should have the skills and training to design houses that need minimal energy to run and maintain and teachers ought to be equipped with knowledge about climate change in order for them to be suited to teach a curriculum that integrates climate change across all subjects taught at schools in Kenya. Therefore, it was proposed that the subject be infused into the various professions taught at universities in the country.

Training and Public Awareness

Level of Awareness and Understanding of Climate Change Issues

The level of awareness of climate change issues and impact is low countrywide.[271] The lack of clear, simple and relevant climate change information is one of the major hurdles affecting the country's response to climate change. Equally a number of studies including one by the British Broadcasting Corporation (BBC) in 2009 confirmed that most Kenyans feel they lack basic information to enable them cope with climate change.[272] Other challenges identified include:

- Unavailability of information in some locations within the counties.
- Information not documented formally.
- Unreliability of available information.
- High illiteracy levels within communities, hence limiting access.
- Low involvement by the mass media.
- Lack of in-depth scientific data.
- The absence of a central location or platform for climate change information.

Kenya's Public Awareness and Communication Strategy has been developed to address these gaps. It is developed to provide a framework for creating, collecting, organising, packaging, and disseminating climate change information to diverse publics in Kenya. The Government considers that the effective sharing of climate change information in the country will result in a clear and consistent set of messages aimed at enhancing public awareness of the pertinent issues of climate change and resulting in a better response in adaptation and mitigation. The strategy provides a framework for the Government to reach all segments of the Kenyan population with simplified and timely information on climate change. It will empower Kenyan citizens to enjoy their right to a healthy environment and to play a role in sustaining the environment for the benefit of current and future generations.

CAPACITY BUILDING

Under the framework 'capacity development' in the context of climate change is viewed as *"the actions needed to enhance the ability of individuals, organisations and systems to make and implement climate change decisions and perform functions in an effective, efficient and sustainable manner"*.[273]

Capacity-building in the country is seen as a cross-cutting issue which transcends all of the activities relating to the implementation of the country's obligations within the Convention. Historically Kenya has undertaken capacity-building efforts through dialogue between and among developed and developing countries, bilateral and multilateral institutions. Key has been those activities through the GEF. A summary representation is shown in Annex 1. Regardless of the progress made, lack of institutional support, and knowledge management seems to be the key obstacles to the sustained implementation from these capacity-building initiatives within the country.

In recognition of this, in 2012, Kenya developed a National Framework for Climate Knowledge Management and Capacity Development within its NCCAP. The framework focuses on climate change, it builds on and work in tandem with the country's initial work of the same under the National Capacity Self-Assessment (NCSA) programme by GEF.

The capacity development framework is fundamental to enable the full, effective and sustained implementation of the Convention. It is designed to enable individuals and organisations operating within the country's wider national system of implementation of the NCCAP, to achieve quality and timely results and deliver better performance. This will lead to the attainment of the country's commitments and its obligations to the Convention.

Constraints and Gaps, and Related Financial, Technical and Capacity Needs

The information in this section are drawn largely from knowledge gaps identified during the SNC development process.
Like most developing countries, Kenya faces several challenges in understanding, mitigating, and adapting to predicted climate change. These challenges arise from gaps in knowledge and understanding, and our ability to address them is constrained by a lack of capacity and research infrastructure, and an inability to communicate effectively and to facilitate the implementation of solutions and action. In particular, there is a need to develop human capacity, generate new and relevant knowledge, facilitate the establishment of research infrastructure, and bridge the divide between research results and socio-economic outcomes.

In the context of more frequent reporting of national GHG inventories by non-Annex I Parties, it is imperative that the preparation process shift from a project-based approach to a more internalised and institutionalised approach (UNFCCC, 2012). This shift would support the timely delivery of the required information and more efficient use of available resources by Parties. Experience in Kenya has demonstrated that because the development of greenhouse gas inventories has been conducted on an ad-hoc basis with the use of consultants, there has been a "memory loss" between the preparation of the INC and the SNC and insufficient capacity developed within internal structures. Clear records of activity data used in the INC and methodologies followed were not always retained which makes it difficult to validate previous assumptions and update the inventory.

Insufficient evidence and documentation of quality control/quality assurance also brought into question the reliability of the existing 1994 Inventory. In addition lessons learned from the preparation of the INC were not passed on in an effective manner since methodological choices were not always explained.

National Communication Process Constraints and Needs

The National Environment Management Authority (NEMA), a directorate under the MEWNR has had the mandate for the preparation of the country's First National Communication (FNC) and the Second National Communication (SNC).

The process of preparing SNC commenced in January 2014. The SNC process development has taken about 15 months. The SNC process has been led by external consultants contracted by NEMA for its preparation.

The consulting team engaged with NEMA and collected the necessary data and information through personal consultations. The outputs from the consultants have been reviewed and validated through multi-sectoral stakeholder workshops. While this has been efficient in providing for participation to a broader audience, the process has been neither effective not efficient in data and information gathering.

The SNC work has been developed mainly through secondary data from the work done under the NCCRS, NCCAP, the draft National Adaptation Plan (NAP) and Kenya's Vision 2030.

The SNC however provides a break from the past, applying the web-based UNFCCC software for the GHG Inventory section, clear technical reports for each of the UNFCCC GHG Inventory chapters. There are still significant gaps in both the quantity and quality of the data, the methods and systems of its collection and archiving, together with the quality assurance measures that are needed. Specific needs have been discussed in detail in the *Kenya National Greenhouse Gas Inventory Report.*

A most critical need is the setting up of an institutional arrangements, with supporting systems, which treat the national communication reporting process as an ongoing activity, and not just a project.

In order to meet the reporting requirements, both in quality and frequency, the Government needs to provide a robust and continuous institutional aspect for the preparation of NCs.

This will ensure that the required continuity is maintained and capacities created strengthened. One of the underlying principles here is to build on and take into account the country's planned climate change governance structures wherever possible. The continuous institutionalisation will ensure the whole process of preparing NCs is maintained and sustained. The current reactive nature of re-establishing the NC process is not sustainable and costly. Alternatively the team can consider design of governance structure to dovetail the interests, responsibilities and capacities of planned climate change governance structures. Once the institutional aspect is agreed to, there is a need for Kenya to immediately commence the Third National Communication process.

For successful implementation, access to funding remains a key need. Given the magnitude of the tasks, complexities of technological solutions, and diversity of adaptation and mitigation studies and assessments, prompt identification and release of funds, will undoubtedly contribute to an enhanced and sustained capacity.

Capacity building is required at both the institutional and personnel level and multi-sectoral representation (i.e., Energy, Industrial Processes, Solvent and Product Use, Agriculture, LULUCF and Waste) is critical. Although some initial and basic training on greenhouse gas inventory work has been provided under the Ministry of Environment Water and natural Resources through the UNDP sponsored Low Emission Capacity Building Programme, it is recommended that training workshops be conducted as part of future greenhouse gas inventory work to provide both to government staff and local consultants sectoral level training. The workshops should focus on familiarising a wide audience of stakeholders with inventory methodologies and tools, engaging them in the data collection process and providing them with hands-on experience with inventory data, methods and tools. The ultimate objective should be such that appointed government staff can complete all aspects of inventory work with limited outside consultancy.

The capacity building should be designed to establish ongoing data collection and analysis in all the relevant government ministries and departments, should include the necessary private sector participation at both association and industry sector levels.

National Communication Sector Specific Constraints and Needs

GHG inventories

A number of significant gaps, needs and constraints were identified during the preparation of the Second National Communication (SNC) inventory for Kenya. Gaps include not only information on activity data, but also resources and capacity. There is a strong need for institutional capacity building and training of government staff to do the necessary data collection and analysis required to reduce inventory uncertainties and improve the quality of activity data and emission factors used to generate the inventory.

Specific gaps, needs and recommendations associated with activity data collection, capacity building and development of an integrated and sustainable Greenhouse Gas Inventory System have been discussed in detail in the *Kenya National Greenhouse Gas Inventory Report 2010.* They are in the following areas:

The sub-sections below summarise specific gaps, needs and recommendations, which have been discussed in detail in the *Kenya National Greenhouse Gas Inventory Report*:

- Activity data collection gaps
- Capacity building
- Sustainable greenhouse gas inventory systems

The following key components of a sustainable GHG Inventory System, as identified by IPCC and UNFCCC guidelines, have been discussed in detail in the report:

- Institutional arrangements
- Methods and data documentation
- QA/QC procedures
- Archiving
- Key category analysis
- Inventory improvement planning

A major point to note is that the system must be tailored to account for national circumstances and constraints of Kenya. Further details of these components are available from the United States Environmental Protection Agency's (US EPA's) approach to building sustainable national GHG inventory management systems using pre-defined *National System Templates*.

Arrangements for continuous improvement, which have to be put in place, have been described in the *Kenya National Greenhouse Gas Inventory Report*:

Mitigation

In general, there are gaps in both the quality and quantity of data use for mitigation assessment.

In order to be able to analyse demand side mitigation options, it is critical that fuel consumption and related emissions be allocated to end-uses. Historical information on the total consumption of different energy consumers (urban households, rural households, commercial and industry) is available from the data on petroleum fuels sales and a number of reports. However, there is little comprehensive information available on the end-use demand where these fuels are ultimately consumed, such as for cooking, lighting and heating water. A large number of reports provide details on usage patterns of households and ownership of appliances but this data only indirectly indicates actual energy consumption. Other data, especially for biomass consumption, was often found to be contradictory and therefore not reliable.

End-use allocation is based on estimates from experts and from the literature. There is no comprehensive source of information in Kenya on the historical end-use consumption patterns of different consumers of biomass and fossil fuels. A large number of documents were reviewed that provided some evidence of end-use consumption patterns or ownership of appliances specific to certain fuels but this data was seldom aggregated to the national level or only indirectly indicated actual energy consumption.

For example, there was detailed data on the distribution of cooking devices used by urban and rural households, but this data only indirectly indicated fuel consumption. Additional data or assumptions were required in order to estimate how much fuel and what type of fuel was consumed. Expert opinion or detailed end-use fuel consumption patterns from other countries were in some cases used to identify the share of fuel used by different end-uses. As a result, there is a fair degree of uncertainty associated with the end-use allocation and a number of the estimates are not Kenyan specific. However, the uncertainty in end-use allocation does not affect overall estimates of emissions, but it does impact the uncertainty associated with estimates of the potential for mitigation where specific end-uses are targeted.

Developing a baseline projection for Kenya's electricity sector is challenging because there is considerable uncertainty regarding how the sector may grow to meet a large suppressed demand for electricity. Specific plans are in place but they assume very high growth rates. The Updated Least Cost Power Development Plan (ULCPDP) presumes a 14% per annum growth rate in electricity supply between 2010 and 2030 in their reference case. This compares to historical growth in electricity supply of about 7% between 2000 and 2010. The cost to achieve this dramatic growth is estimated at U.S$ 41.4 billion (excluding committed projects) while generation technologies that are expected to make up the vast majority of new supply still face considerable barriers to implementation. Technologies such as nuclear, coal and wind have either not been proven in Kenya or have limited current penetration. Geothermal, which is expected to comprise the largest portion of generation, has high initial costs, long lead times and risk of resource exploration that must be overcome.

The future growth in petroleum product consumption for road transportation (gasoline, light diesel oil and additives) was determined based on estimates of the growth rate in the overall vehicle stock, the growth rate in the use of vehicles (demand for service) and the change in average fuel efficiency over time. There were no known projections of this growth in Kenya and the analysis employed knowledge of historic growth to inform these assumptions.

In order to look at low-carbon options that differentiate between personal passenger, bus and freight vehicles it is necessary to divide the total consumption of on-road transportation fuels into these end-uses. This is challenging because there is limited information on the fuel usage by end-use in Kenya. The basis for the on-road allocation by end-use was vehicle registration data between 2000 and 2006 and detailed vehicle registration data on new vehicles available for 2005 and 2008.

The agricultural sector is currently the largest source of GHG emissions of all sectors. Despite its important contribution to overall emissions, data required to calculate GHG emissions is lacking and there is significant uncertainty associated with the emission estimates when compared to energy demand, electricity generation and transportation sectors.

Adaptation

Two knowledge gaps have been identified which have a direct impact on climate change impacts and vulnerability:

- Understand a changing climate
- Adapting to a changing climate

Understanding a Changing Climate

There is need for deeper understanding of how the climate and related ecosystems are changing, with special emphasis on the local level, the speed of the change and where it is happening. Understanding of the complex

interactions within Kenya's ecosystem and how certain changes will affect other aspects is necessary. This understanding, at the local level, is required to improve predictive capability and to plan appropriate adaptive responses.

As already explained under the section on *Research and Systematic Observations*, Kenya is active in monitoring and sharing earth observation data. What is not exactly clear at the local level is interpretation of the data to identify critical thresholds and how it should be communicated, for action, to the various stakeholders.

There is also uncertainty about the regional effects of large-scale global climate change.
Although many researchers tend to work within a single domain (land, air and sea), it remains a fact that ecosystems are interconnected. However, understanding how the ecosystems are linked, and how changes in one system will affect others, has been in adequate at the local level. There is need to understand what are the priority forms of change on the land, sea and air that will directly or indirectly affect the other ecosystems.

Current predictions of climate change rely on a number of models that simulate possible future changes in the real world. However, global models focus on broad-scale changes to the Earth's climate, and their predictions are often too coarse to be useful at a regional or local level. It is also true that, by adding understanding generated at a local level, it is possible to improve global models, their predictions, and therefore their usefulness. There are gaps in arrangements for understanding and incorporating local input in climate predictions.

There is need to continue to develop climate models that are specific for Kenya and the region in order to represent the country's and region's climate.

Adapting to a Changing Climate

It is currently understood that climate change is inevitable and that its impacts include increases in the magnitude and frequency of both floods and droughts, changes to fire regimes that will place people and property at higher levels of risk, rises in sea level and accompanying increases in the magnitude and frequency of storm damage along the coast, as well as changes to the dynamics of diseases affecting humans and livestock. However, at local level there is lack of understanding of the uncertainty and risk, which areas are most at risk from rapidly-changing conditions, what can be done to avoid, or minimise, adverse effects of change, and how can Kenya's biodiversity be protected from adverse change.

Another gap is lack of understanding on how the urban planners of our cities can build urban resilience.

It is difficult to predict the exact effects of climate change on food security and research is needed to enable better understating of the issue. For water planners, planning has been based more on historical data than on future predictions. This has a direct bearing on future water security. There is a local knowledge gap on how this should be changed.

There is inadequate information on the potential cost of planned adaptation responses to climate change. An estimate of the average annual cost of climate-related events (storms, floods, droughts, and fires) in Kenya cannot be made with any level of accuracy, due to a lack of reliable and comprehensive data.

Kenya, like other African countries, does not have enough adequately trained climate change professionals and support is needed in this regard. Future funding to develop enough climate change professionals is therefore needed.

Technology Transfer

Kenya like most developing countries does not have adequate technological capacity to meet its needs and effectively mitigate and adapt to climate change. While the Government has continuously committed to facilitate the identification of relevant environmentally sound technologies and knowledge in most sectors of its economy, the adoption, diffusion and application has remained low mainly due to:

- Financial constraints
- Limited capacity and awareness
- Lack of quality and standards

Finance constraints pertain to lack of access to capital and inappropriate subsidies (such as lack of appropriate fiscal policies and support mechanism of taxes, duty and pricing). These are further exacerbated by lack of clear plans and targets on technologies. Appropriate enabling framework through a wide array of policies, from certainty on target technologies to various financial incentives such as reducing import tariffs are necessary. Leverage of private sector finance is also necessary.

There is also a widespread lack of local technically trained staff to install, operate and maintain technologies including awareness and access to information on benefits of prioritised technologies. Comprehensive information and awareness campaigns will be necessary to raise awareness of the benefits of these technologies and even through successful demonstration projects. This must be coupled with training of skilled manpower (technicians, engineers and installers) for comprehensive support of the prioritised technologies to market deployment. The training will require not only the technical aspects, but also involve sales and marketing expertise.

Limited technical standards and quality control has led to technology higher failure rates which damages the reputation of equipment

manufacturers and suppliers and their technology. Development of certification systems for the technology equipment will make end users more confident about a technology through guaranteed-result schemes. The norms, standards, and testing procedures will ensure that relevant technologies sold and installed in the country are built to meet the highest international standards. Knowledge transfer systems and knowledge transfer networks is also a necessity for diffusion and success.

Research and Systematic Observation

While the Government remains the principal source of funding in research and systematic observation, its investment in this area has remained low - less than one per cent of the Gross Domestic Product. [274] The low budgetary allocation means there is a problem of:

- Lack of necessary equipment and infrastructure
- Weak information management in most programmes, and non-existent in some
- Inadequate staff and technical capacity for climate observation and climate change research

The lack of requisite equipment for data collection, research and modelling has meant that key institution such as the Kenya Metrological Department does not functioning optimally. The information management (processing of climatological data) is in coarse resolution and mostly processed manually with information in the hardcopy format. This process leads to highly likelihood of inaccurate data. This has hampered ability for the country to continuously collect and generate accurate data leading to gaps, inconsistencies and omissions. Accuracy of the information is very important not only for the country but also of its role regionally and globally. In addition staff technical capacity is inadequate and in some cases lacking. [275] They are therefore not able generate the required data and information for use in policy making and planning. This is further compounded by the low intake of research students in climate change related fields in the Kenyan universities. [276] Where there has been an attempt to train staff such on climate change modelling. The training has faced challenges in the areas of budgetary allocations to purchase climate change specific infrastructure, facilities and equipment particularly super computers for modelling.

In all of the above, access to more funding both domestically and externally is therefore necessary to training staff, upgrading equipment, plants and instruments required for improved information, products and services. Specific areas of needs[277] include:

- Infrastructure including suites of in situ sampling, observation and monitoring systems, and remote sensing imagery and imaging devices.
- Finance increase from Government and external sources.
- Robust and accessible information management systems.
- Skilled manpower and equipment. The need for suitably-qualified personnel to collect data, operate the relevant instrumentations, process and analyse data, and communicate results.
- Capacity building in modelling. To enhance the density of climatic data recording and strengthen existing ones
- State-of-the-art data processing and analysis hardware and software, relevant laboratory space and equipment

Education, training and awareness

Education, training and awareness have continued to lack since the first National Communication. Which has meant that climate change issues have continue to receive minimal consideration in the formal education.

While Kenya has now developed strategy and plans on education, training and awareness. The key challenge is its implementation. Effective management and implementation of these will need availability of adequate human, financial and infrastructural resources. The implementing organisations will also need to attract, develop, retain and effectively utilise human resources with specific knowledge, skills, attitudes and motivations required to address priority actions identified in the plans.

Capacity Building

Kenya has undertaken numerous capacity-building efforts. There are a number of civil society, academic and research institutions, private sector and individual researchers generating very useful climate change research work. Together they generate and consume climate change information and knowledge. However, lack of knowledge sharing seems to be a constraint. This prevents the sustained implementation and diffusion from the capacity-building initiatives within the country.

Institutional arrangement to formally mainstream of all the actors will bring immense benefit to the climate change agenda in Kenya.

If effected it will create a comprehensive collaboration arrangement that will allow the climate change information and knowledge to flow across the government, private sector, civil society, academic institutions and individual researchers. In addition appropriate knowledge management and information arrangement for flow among the national and county

governments, civil society, private sector, research institutions, individual researchers and academic institutions is required. The arrangement will address the generation or capture, organising, refining and dissemination of easily understandable and implementable knowledge products for the intended beneficiaries within an enabling environment.

ANNEX 1: TABLES AND FIGURES

Table 61 TNA process prioritised sector and technologies

Response	Sector	Technology options	Score
	Energy (including Transport-subsector)	Solar Home Systems (SHS)	0.86
		Solar Dryers	0.80
		Non-Motorized Transport (NMT)	0.66
		Mini-hydros	0.49
		Electric Trains	0.34
		Mass transport	0.24
		Co-generation	0.01
	Waste	Biogas	0.91
		Waste paper recycling	0.61
		Waste composting	0.50
		Plastic waste recycling	0.48
		Methane capture from landfills	0.44
		Waste re-use	0.27
Adaptation	Agriculture	drought resistant sorghum, and	0.97
		drip irrigation	0.83
		hay preservation	0.83
		Biotechnology - Tissue Culture Banana	0.55
		Early Warning System for Crop Production	0.32
		Conservation Tillage	0.14
	Water	roof rain water harvesting, and	0.92
		surface runoff water harvesting	0.90
		solar powered desalination	0.62
		Drilling of boreholes	0.36
		Construction of sand dams	0.32
		Treatment of waste water for irrigation	0.0

Source: 2013 TNA process mitigation and adaptation report

Table 62 Overall Geothermal NAMA – barriers, NAMA solutions, and key features (GoK, 2014)

NAMA to address gap through…	Risk mitigation instruments	Premium payment mechanism	Technical Assistance Facility	National Geothermal Capacity Building Program
Key features	Three sub-components are proposed for the early stage risks. Provision of contingent grants, complemented by a drilling risk insurance and a long term risk (LTR) guarantee.	A premium payment mechanism would entail disbursement of a pre-defined additional income per MWh to increase financial attractiveness on specific fields for a limited period.	A technical assistance facility (TAF) will provide advisors, training, secondments and workshops addressing IPP integration, mobilizing finance and expediting environmental and social approvals.	The NAMA will support a national geothermal capacity building program that undertakes training, research, mapping, planning and database development.

Table 63 Kenya's technology needs - identified barriers and their enabling framework

Technology options	Barriers	Proposed enabling framework
Solar Home Systems (SHS)	High cost in technology investment and installation	Setting up of local assembling industries for parts and components and enhancing R&D for technologies. Establishment of focused training programme for solar PV and SHS technicians.
	Lack of subsidies on technology and its components	Removal of VAT technology and its components. Currently VAT exemptions applies to complete SHS package as opposed to single component.
	High interest rates on loans	Lending of funds to viable renewable energy projects on concessional rates especially under the GoK proposed Green Energy Fund Facility.
	Local capacity knowledge: inadequate information and awareness	Conduct adequate information and awareness campaigns through print and electronic media.
	Lack of research and development	Initiation of research and development activities in technology through public and private sector partnership.
	Weak regulatory framework	Strengthening of regulatory framework.
Solar Dryers	High up front cost	Setting up of local assembling industries for solar dryer parts and components and enhancing R& D for technology.
	High interest rates	Lending of funds to viable renewable energy projects on concessional rates especially under the Government proposed Green Energy Fund Facility.
	Local capacity knowledge: inadequate information and awareness	Conduct adequate information and awareness campaigns through print and electronic media
	Inadequate skilled personnel	Establish critical mass of locally trained personnel
	Inadequate policy, legal and regulatory framework	Formulate enabling policy, legal and regulatory framework for technology
Biogas	High cost of capital	Reduction of import duty; Provision of soft low interest loans; provision of loan guarantees.
	Limited human skills	Technology suppliers to provide training and technical manuals for construction, operations and maintenance of the systems; Customise training programmes in the existing training institutions
	Lack of information and awareness on technologies	Potential investors in collaboration with government to undertake public awareness campaigns on the use of the products via print and electronic media
	Lack of policy and regulatory framework on	Government to formulate waste management and recycling policy, legislation and regulations

	waste management and recycling	
Drought resistant sorghum	Lack of available capital, credit and loans and high prices of seeds	Establishment of appropriate financial mechanisms and institutions to provide capital
	Market failures in relation to seed production, distribution and delivery systems	Establishment of functional markets: with adequate stockists; established certainty on the demand for seeds; simulation on seed demand; improved infrastructure.
	Inappropriate communication and extension approaches	Development of institutional and organisational capacity
	Inadequate awareness/training for farmers	Conduct adequate information and awareness campaigns on benefits especially in ASALs
Drip irrigation	High Cost of initial installation and maintenance	Reduce interest rates and increase credit facilities leading to adequate credit. Furthermore if tax rebates and incentives (tax waiver) are provided, the cost of importing kits will be reduced. Training of more technicians at subsidised rates leading to more specialised manpower and in turn better service delivery and low cost
	Limited human skills	Development of human skill involving capacity building for both farmers and technicians
	Lack of information and awareness on technology	Enhancement of information and awareness will promote use of drip irrigation and reduce social and cultural barriers and enhance community participation.
Roof rain water harvesting, and	High initial cost of installation	Establishment of appropriate financial mechanisms to facilitate provision of affordable loans.
	Poor policy guidance	Operationalised policy guidance to provide certainty and awareness to stimulate adoption
	Lack of knowledge by potential users of technology and its benefits.	Related institutions to create awareness on variability of weather and diffusion of roof rainwater harvesting should be created
	Lack of Government incentives/subsides	Government introducing of tax rebate and waivers.
	Inadequate and unsuitable roofs for rainwater harvesting	Promote appropriate housing design; Quality control of roofing materials.
Surface runoff water harvesting (community level)	High initial cost in technology investment (construction and labour)	VAT waiver for construction materials; introduction of low interest credits; provision appropriate smart subsidies.
	Inappropriate land tenure of small land holdings by	Introduction of appropriate land policy to discourage subdivision of land into small uneconomic units and

	individuals, leading to lack of land for establishment at community level	protect community land from land grabbers. Prioritised community land for technology use.

Source: 2013 TNA process mitigation and adaptation report

Table 64 Kenya CDM registered projects

Project name	Year of registration	Project specifically states no TT	No mention or indication of TT in the PDD	Mention or indication of TT of equipment and/ knowledge	Comments
35 MW Bagasse Based Cogeneration Project	Sep 2008			✓	There is an indication that: - Technology is new in the local sugar industry and therefore initially there would be inadequate trained manpower to operate it and Mumias Sugar Company will have to spend some time and resources to train personnel with right skills to operate the technology. - Implementation of the project will offer local people skills in high pressure cogeneration technology and will act as a clean technology demonstration for the other local sugar companies.
Olkaria III Phase 2 Geothermal Expansion Project in Kenya	Mar 2010			✓	There is a specific mention of TT that: - Technology specific training, - Attendance of international geothermal conferences to broadens the experience of the staff. - Olkaria provides different training opportunities to its staff. These courses and development opportunities contribute to the skills development within the country.
Olkaria II Geothermal Expansion Project	Dec 2010		✓		

Lake Turkana 310 MW Wind Power Project	Feb 2011			✓	There is a specific mention of TT that: - TT will take place in part through the training of more than 50 local engineers by Vestas to provide support to the operations and maintenance of the project over its lifetime. Vestas will be responsible for maintenance efforts over an initial 10-year period, including monitoring and reporting of system performance
Aberdare Range/ Mt. Kenya Small Scale Reforestation Initiative Kamae-Kipipiri Small Scale A/R Project	Jun 2011			✓	There is a specific mention of TT that: - The TT to the communities will be through Green Belt Movement training in the field on the technologies to be employed.
Aberdare Range / Mt. Kenya Small Scale Reforestation Initiative Kirimara-Kithithina Small Scale A/R Project	Oct 2011			✓	There is a specific mention of TT that: - The TT to the communities will be through Green Belt Movement training in the field on the technologies to be employed.
Redevelopment of Tana Hydro Power Station Project	Oct 2011		✓		
Aberdare Range/ Mt. Kenya Small Scale Reforestation Initiative Kibaranyeki Small Scale A/R Project	Mar 2012			✓	There is a specific mention of TT that: - The TT to the communities will be through Green Belt Movement training in the field on the technologies to be employed.

Nairobi River Basin Biogas Project	Jun 2012			✓	There is an indication that: The technology is "Deenbandhu model 2000", a model developed by the Indian NGO, Action for Food Production (AFPRO) there is a lack of skilled and/or properly trained labour to construct the specific Deenbandhu technology. The design combines durable quality with a lifetime of over fifteen years and cheap construction costs by using locally procured materials. Design of the model may develop over time as such Project participants decided to second trainers from AFPRO to Kenya to train masons in construction of biogas units.
60 MW Kinangop Wind Park Project	Jul 2012			✓	There is a specific mention of TT that: The project will enhance the TT to the country and the neighbouring countries through the application and promotion of wind turbines, accelerating the accumulation of experiences and absorption of this kind of technology and advancement of domestic wind power technology.
Karan Biofuel CDM project – Bio-residues briquettes supply for industrial steam production in Kenya	Sep 2012			✓	There is an indication that: - the project will promote and stimulate awareness about renewable biomass waste benefits, - - enhance diffusion of environmentally cleaner technologies
Optimisation of Kiambere Hydro Power Project	Oct 2012		✓		
Corner Baridi Wind Farm				✓	There is a specific mention of TT that:

	Dec 2012				- Transfer of environmentally safe and sound technology will take place through the introduction of state of the art wind turbine technology. - Transfer of know-how will take place through the training of local engineers and other technical staff by the operations and maintenance contractor with the support of the turbine manufacturer.
Kipeto Wind Energy Project	Dec 2012			✓	There is a specific mention of TT that: - Transfer of environmentally safe and sound technology will take place through the introduction of state of the art wind turbine technology. - Transfer of know-how will take place through the training of local engineers and other technical staff by the operations and maintenance contractor with the support of the turbine manufacturer.
Olkaria IV Geothermal Project	Dec 2012			✓	There is a specific mention of TT that: - Technology transfer - will enhance the transfer of geothermal technology to the country and the neighbouring countries through the application and promotion of geothermal, accelerating the accumulation of experiences and absorption of this kind of technology
Olkaria I Units 4&5 Geothermal Project	Dec 2012			✓	There is a specific mention of TT that: - Technology transfer - will enhance the transfer of geothermal technology to the country and the neighbouring countries through the

					application and promotion of geothermal, accelerating the accumulation of experiences and absorption of this kind of technology.
Energy efficiency improvement project through modification of heat exchanger network at Kenya Petroleum Refineries Ltd	Apr 2013			✓	There is an indication that: - the project is skills transfer that will take place between ESSAR Heavy End Engineering (the engineering, procurement and construction (EPC) contractors) and KPRL's technical and engineering staff. This will allow the local industry to maintain, improve and share essential industry related skills.
Restoration of Degraded Lands through Reforestation in MAU Forest Complex, Kenya	Feb 2014	✓			There is a specific mention that there is no technology transfer to the Host country.
Restoration of Degraded Lands through Reforestation in Aberdare Forest Complex & National Park area, Kenya	Feb 2014	✓			There is a specific mention that there is no technology transfer to the Host country.

Table 65 POA CDM registered projects

Project name	Year of registration	Project specifically states no TT	No mention or indication of TT in the PDD	Mention or indication of TT of equipment and/ knowledge	Comments
Efficient Cook Stove Programme: Kenya	Mar 2012		✓		
KTDA Small Hydro Programme of Activities	Sep 2012			✓	There is a specific mention of TT that: - The PoA would support transfer of TT and know-how from other regions and countries.
Barefoot Power Lighting Programme	July 2012			✓	There is a specific mention of TT that: - GEEREF aims to accelerate the transfer, development, use and enforcement of environmentally sound technologies for the world's poorer regions, helping to bring secure, clean and affordable energy to local people.
Kenya Improved woodstoves project	Aug 2012			✓	There is a specific mention of TT that: - With the PoA’s open access concept, allowing in principle both local manufacturers and importers of stoves to become part of the PoA, a wide variety of technology and design transfers may occur at the CPA level.
Green Light for Africa	Dec 2012		✓		
Project to replace fossil fuel based lighting with Solar LED lamps in East Africa	Dec 2012		✓		There is a specific mention of no transfer of technology: The CME will not be transferring any skills of manufacturing or developing any manufacturing factories within the PoA boundary and therefore there shall be no technology transfer for the CPAs

					implemented by the CME. Individual CPA operators who do incorporate technology transfer elements into the design of their CPAs will state so explicitly in the CPA DD.
African Clean Energy Switch – Biogas (ACES-Biogas)	Dec 2012			✓	There is a specific mention of TT that: - It is anticipated most of TT will be South-South (i.e. between non-Annex I countries). This is because there is limited usage of small-scale biogas systems in Annex I countries. TT from Annex I countries may come from larger institutional biogas systems. - Most of the TT will be in the form of know-how as due to the nature, e.g. constructed from bricks or size it is not possible to import systems. Biogas appliances however will likely be imported until local capacity is developed.
Improved Cooking Stoves Programme of Activities in Africa	Dec 2012		✓		
SimGas Biogas Programme of Activities	Dec 2012		✓		
East Africa Renewable Energy Programme (EA-REP)	Dec 2012			✓	There is a specific mention of TT that: Detailed information about the exact technology and measure applied by the individual Small-Scale Programme of Activities (SSC-CPAs) will be provided in the relevant section of the specific SSC-CPA-DD. The section will also include a description of technology and how know how is being applied by the specific SSC-CPA inter alia technology transfer to the Host Party(ies) for application in the SSC-

					CPA.
Nuru Lighting Programme	Oct 2012		✓		
Top Third Ventures Stove Programme	Dec 2012			✓	There is a specific mention of TT that: - The CME will ensure training and capacity building is conducted to transfer technology know-how to the end-user. The CME will work with each CPA Implementer to transfer this knowledge. Where possible, the efficient cooking technologies will be manufactured domestically thereby transferring further know-how to the domestic industry of the host party.
TATS Solar Lantern Programme of Activities	Dec 2012			✓	There is a specific mention of TT that: - The PoA will facilitate the transfer of industry-leading solar lantern technologies into Kenya. This transfer largely occurs "South-South" (between developing countries), as the products to be used in the PoA are manufactured in other developing countries (i.e. China, India, etc). - Further transfer of knowledge to Kenya is also made possible through the education and awareness-raising aspects of the PoA. End-users will receive information at the point of sale regarding the benefits of solar lanterns, as well as how to use the technology effectively.
International water purification programme	Nov 2012			✓	There is a specific mention of TT that: - The PoA stimulates the technology transfer of both equipment and knowledge from developed countries of Annex 1 to the host countries hosting the CPAs. The PoA fosters indeed the process covering the flows of know-how, experience and equipment and the capacity of

					developing countries to understand, utilize and replicate the technology to adapt it to local conditions and integrate it with indigenous technologies if possible. Each CPA will mention where the technology is coming from and how it is transferred to the Host Country.

Table 66 Kenya GEF climate change registered projects

	Category	GE cycle*	Project type	GEF grant	Co-financing	Status
Global	Monitoring of Greenhouse Gases Including Ozone	GE Pilot Phase (91-94)	FP	4,800,000	1,200,000	Project Completion
Regional	Building Capacity in Sub-Saharan Africa to Respond to the UN Framework Convention on Climate Change	GE Pilot Phase (91-94)	EA	2,000,000	0	Under Implementation
Global	Photovoltaic Market Transformation Initiative (IFC)	GE1	FP	30,000,000	90,000,000	Project Completion
Global	Solar and Wind Energy Resource Assessment	GE2	FP	6,512,000	2,508,000	Project Completion
National	Removal of Barriers to Energy Conservation and Energy Efficiency in Small and Medium Scale Enterprises Climate Change	GE2	FP	3,153,000	5,090,000	Project Closure
National	Enabling Activities for the Preparation of Initial National Communications Related to the UNFCCC Climate Change	GE2	EA	172,800	75,000	Project Closure
Regional	Building Sustainable Commercial Dissemination Networks for Household PV Systems in Eastern Africa	GE3	MSP	693,600	539,630	Project Closure
Regional	Integrating Vulnerability and Adaptation to Climate Change into Sustainable Development Policy	GE3	MSP	1,000,000	1,265,000	Project Completion

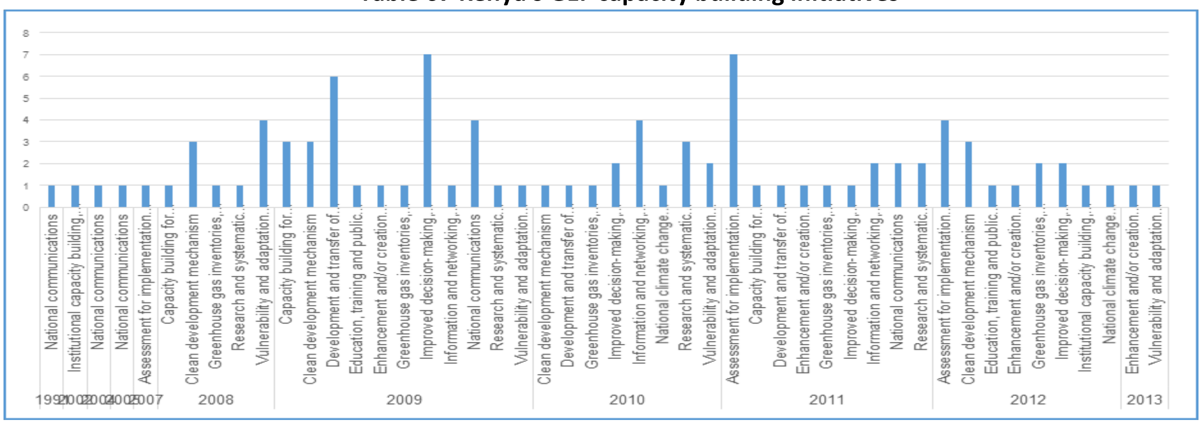
	Planning and Implementation in Southern and Eastern Africa					
Regional	African Rift Geothermal Development Facility (ARGeo)	GE3	FP	17,750,000	55,550,000	Under Implementation
National	Joint Geophysical Imaging (JGI) Methodology for Geothermal Reservoir Assessment Climate Change	GE3	MSP	979,059	1,754,260	Project Completion
National	Expedited Financing of Climate Change Enabling Activities Part II: Expedited Financing for (interim) Measures for Capacity Building in Priority Areas Climate Change	GE3	EA	100,000	0	Project Closure
National	Market Transformation for Efficient Biomass Stoves for Institutions and Small and Medium-Scale Enterprises Climate Change	GE3	MSP	975,000	5,646,470	Project Completion
Regional	Cogen for Africa Climate Change	GE3&4	FP	5,248,160	61,586,400	Under Implementation
Regional	Greening the Tea Industry in East Africa	GE3&4	FP	2,854,000	25,614,000	Project Completion
Regional	Lighting the "Bottom of the Pyramid"	GE3&4	FP	5,400,000	6,750,000	Project Completion
National	Development and Implementation of a Standards and Labelling Programme in Kenya with Replication in East Africa Climate Change	GE3&4	FP	2,000,000	8,760,900	Under Implementation
National	Adaptation to Climate Change in Arid Lands (KACCAL) Climate Change	GE3&4	FP	6,500,000	44,844,700	Under Implementation
Global	Piloting Climate Change Adaptation to Protect Human Health	GE4	FP	4,500,000	16,300,000	Under Implementation
Regional	Promoting Sustainable Transport Solutions for East Africa	GE4&5	FP	2,850,000	2,825,000	Under Implementation
Regional	LGGE Promoting Energy	GE4&5	FP	2,853,000	6,400,000	Under

	Efficiency in Buildings in Eastern Africa					Implementation
Global	SolarChill Development, Testing and Technology Transfer Outreach	GE5	FP	2,583,000	5,662,900	CEO Endorsed
Regional	RLACC - Rural Livelihoods' Adaptation to Climate Change in the Horn of Africa (PROGRAM)	GE5	FP	7,655,560	64,000,000	Council Approved
National	Sustainable Conversion of Waste into Clean Energy for GHG Emission Reduction Climate Change	GE5	MSP	2,000,000	9,572,000	PIF Approved

***Replenishment period of the GEF**

Source: GEF project cycle webpage

Table 67 Kenya's GEF capacity building initiatives



Source: UNFCCC capacity development portal

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[236] Found here http://www4.unfccc.int/sites/nama/_layouts/un/fccc/nama/NamaSeekingSupportForImplementation.aspx?ID=51&viewOnly=1 [last accessed 06 September 2014]
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[238] As of 26 July 2014
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[241] Transfer of Environmentally sound technologies: Case Studies from the GEF Climate Change portfolio, 2012 [revised]
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[243] NEMA houses the GEF OFP for the Kenya, with the mandate to endorse the projects that had been identified and reviewed by the NSC for funding from GEF
[244] During the current GEF-5 replenishment period (July 2010 – June 2014), Kenya received an indicative allocation to formulate and execute projects for US$8,950,000 in biodiversity, US$5,000,000 in climate change, and US$4,260,000 in land degradation
[245] Namely Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan, South Sudan and Uganda, Burundi, Rwanda and Tanzania
[246] Personal Communications with Peter Omeny
[247] Ibid
[248] Ibid
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[261] Technical Report 8: Availability and Accessibility to Climate Data for Kenya
[262] Technical Report 8: Availability and Accessibility to Climate Data for Kenya
[263] Gitonga 2014
[264] Ibid
[265] Kenya draft National Adaptation Plan
[266] Ibid
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[269] Knowledge Management and Capacity Development: Chapter 5.0: Integrating Climate Change in Education System
[270] Knowledge Management and Capacity Development: Chapter 5.0: Integrating Climate Change in Education System
[271] National Climate Change RS, National Climate Change Action Plan
[272] BBC, 2009 noted in the Knowledge Management and Capacity Development: Chapter 4.0: Public Awareness and Communication Strategy
[273] Knowledge Management and Capacity Development: Chapter 3.0: Climate

Knowledge Management and Capacity Development
[274] Mukabana n.d.p
[275] Ibid
[276] Ibid
[277] 1st SNC workshop attendees

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