Republic of Kenya

Ministry of Environment and Forestry

The National Long Term Low Emission Development Strategy

2022 - 2050

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FOREWORD *DRAFT*

Climate Change is a potential barrier to attaining planned development goals as Kenyan economy relies heavily on natural resources that are susceptible to drought, floods, and sea level rise. Climate change impacts have had severe consequences on the Kenyan economy, contributing to a decline of almost 5% of the country's GDP, demonstrating our vulnerability to climate change. Despite the undesirable consequences, proper planning of climate change mitigation and adaptation actions, offers us an opportunity to increase our resilience and adaptive capacity towards Climate Change.

The Government of Kenya developed the Climate Change Act (2016), a framework that guides climate action at the national and sub-national level, providing a platform for engagement and collaboration with the private sector and developing partners. Through this framework, several Climate Change Action Plans including the NCCAP (I&II), the NAP and the updated NDC were developed outlining mitigation and adaptation actions to be mainstreamed in sectoral, county development plans and by the non-state actors. In 2020, Kenya submitted its updated NDC to the United Nations Framework Convention on Climate Change (UNFCCC), in line with the Paris Agreement and pledged to increase its ambitions by reducing 32% of the GHG emissions relative to the business-as-usual scenario by 2030. The Paris Agreement requires parties to raise their ambitions, steering them towards achieving carbon neutrality by mid-century. In response, Kenya has developed this long-term low emission development strategy to meet this commitment, targeting sectors with high emission reduction potentials and those that are highly vulnerable to the impacts of climate change. The strategy builds on the commitments of previous Climate Change policies and plans, thereby ensuring a congruence of Climate Change efforts culminating towards carbon neutrality by 2050.

The long-term low emission development strategy assesses the country's emission reduction potential, estimates the level of investment and adaptation cost associated with the Representative Concentration Pathways (2.6 and 8.5) global projections. Following this assessment, the strategy outlines key targets and actions to be implemented delivering on the strategy's objectives. I firmly believe that this strategy will contribute towards the achievements of our development goals and will guide subsequent Climate Change ambitions. Therefore, I request all the relevant stakeholders to partake in the implementation of this strategy for the well-being of the country.

Cabinet Secretary
Ministry of Environment and Forestry

PREFACE *DRAFT*

Kenya is progressively becoming more vulnerable to the rising global temperatures, frequent intense droughts and floods caused by climate change. These impacts threaten the realization of Vision 2030 that seeks to transform Kenya into a newly industrializing middle-income country with high quality life to its citizens. Furthermore, Climate Change threatens the realization of the Big 4 Agenda on providing food security, affordable housing, manufacturing, and universal Health coverage to all its citizens. As a signatory to the United Nations Framework convention on Climate Change (UNFCCC), its Kyoto Protocol and the Paris Agreement, Kenya recognizes its obligation under Article 4, paragraph 19 of the Paris Agreement. Through these, the Government of Kenya has developed climate change legislation, strategies, policies, and plans that define Kenya's goals, objectives, and commitments towards tackling climate change. Thereby, enhancing the climate resilience and adaptive capacity of the people of Kenya. In 2016, the Climate Change act was developed, a fundamental framework that continues to guide the nation's response to Climate Change. These response measures are anchored in Kenya's Constitution, which recognizes its citizens' sovereign right to a clean and healthy environment in line with the Paris Agreement's obligations and objectives. In consultation with several stakeholders, including the national and county governments, the Ministry of Environment and Forestry has developed this long-term Greenhouse Gas emission development strategy considering its national circumstances.

The strategy sets out the overarching vision, objectives, and priority interventions that will successfully abate emissions in the country through a fair and cost-effective course, ensuring a transition towards a desirable, climate resilient and carbon-neutral economy by 2050. Moreover, the strategy also illustrates sectors' interdependence and vulnerability to climate risks, estimates Climate Change related losses at the sectoral level and the investment required to implement prioritized mitigation and adaptation interventions.

Kenya's long-term low emission development strategy aligns with existing national climate action plans and the country's development plans, and it will guide subsequent climate action plans. The objectives and measures outlined in this strategy will be achieved through the collective contributions and support of the national and county governments, civil society, the private sector, faith-based organizations, other non-state actors, and individual citizens. Implementing this strategy will benefit both present and future generations through the creation of high-quality jobs, community public health, and spurring investments that modernize the Kenyan economy while reducing costs and risks from climate change. The Ministry of Environment and Forestry anticipates challenges in achieving this strategy. Therefore, urges all relevant stakeholders to take up the responsibility of ensuring its successful implementation, to shield our present and future generations from the negative impacts of climate change.

Principal Secretary
Ministry of Environment and Forestry

ACKNOWLEDGEMENT *DRAFT*

The Kenya Long term low emission strategy is a product of concerted efforts by working groups comprising both state and non-state actors. The Ministry of Environment and Forestry provided policy direction, while sectoral experts provided technical support. I acknowledge their efforts in providing the country with a road map towards carbon neutrality by mid-century.

I also acknowledge the work of experts from the Government ministries, departments and agencies, counties, academia, private sector, and civil society partners for reviewing and validating this strategy. Special appreciation goes to the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ), United States Agency for International Development (USAID), the United Nations Development Programme (UNDP), and other development partners for facilitating and supporting the development of this strategy through several stakeholder engagements processes among others. Finally, I appreciate the Climate Change Directorate at the Ministry of Environment and Forestry for coordinating the process and ensuring that the quality of this strategy is of high standard. I encourage all stakeholders to participate in the implementation of this strategy, to steer our nation towards a better future for generations to come.

Director
Climate Change Directorate

TABLE OF CONTENTS

List of Tables

List of Figures

List of Figures

List of boxes

Acronyms

AfDB	African Development Bank
ASAL	Arid And Semiarid Lands
ATAR	Adaptation Technical Analysis Report
BAU	Business-As-Usual
BC	Benefits To Cost Ratio
BRT	Bus Rapid Transit
CBD	Central Business District
CCCFs	County Climate Change Funds
CCD	Climate Change Directorate
CCS	Carbon Capture and Storage
CCU	Climate Change Unit
CFL	Chlorofluorocarbon
CIDPs	County Integrated Development Plans
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CPA	Charcoal Producers Group
CPAs	Charcoal Producer Associations
CPGs	Charcoal Producer Groups
CSA	Climate-Smart Agriculture
EEZ	Exclusive Economic Zone
EJ	Exajoule
EMCA	Environmental Management and Conservation Act
EPRA	Energy And Petroleum Regulatory Authority
FAO	Food And Agriculture Organization
FAOSTAT	Food And Agriculture Organization Corporate Statistical Database
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System Mapping Tool
Gj	Giga Joules
GLOSS	Global Sea Level Observing System
GWP	Global Warming Potential
HFC	Hydrofluorocarbons
HIV	Human Immunodeficiency Virus
ICT	Information Communication Technology
IEA	International Energy Agency
IFPRI	International Food Policy Research Institute
IGAD	Inter-Governmental Authority on Development
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade
INTP	Integrated National Transport Policy
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IRS	Indoor Residual Spray
ITNS	Insecticide Treated Nets
IUU	Illegal Unregulated and Unreported
KENGEN	Kenya Electricity Generating Company
KFS	Kenya Forest Service
KMFRI	Kenya Marine & Fisheries Research Institute
KPC	Kenya Pipeline Company
LCPDP	Least Cost Power Development Plan
LEAP	Low Emissions Analysis Platform
LEDs	Light Emitting Diode
LPG	Liquefied Petroleum Gas
LTS	Long-Term Strategy

Acronyms

LULUCF	Land Use, Land-Use Change and Forestry
MAM	March April May
MDAs	Ministries Departments and Agencies
MoEP	Ministry Of Energy and Petroleum
MRTS	Mass Rapid Transit System
MRV	Measurement, Reporting and Verification
MSME	Micro, Small and Medium Enterprises
MTAR	Mitigation Technical Analysis Report
MTP	Medium Term Plans
MW	Mega Watts
NAMA	Nationally Appropriate Mitigation Action
NAP	National Adaptation Plan
NCCAP	National Climate Change Action Plan
NCCC	National Climate Change Council
NCS	National Cooling Strategy
NDC	National Determined Contribution
NDEF	National Drought Emergency Fund
NFRL	National Forest Reference Level
NGO	Non-Governmental Organizations
NIR	National Inventory Report
NSA	Non-State Actors
NSP	NAMA Support Project
NTSA	National Transport and Safety Authority
OND	October November December
OPC	Ordinary Portland Cement
PELIS	Plantation Establishment and Livelihood Improvement Scheme
PJ	Peta Joules
PLC	Portland Limestone Cement
PPC	Portland Pozzolana Cement
PPP	Public Private Partnership
PV	Photovoltaics
REA	Rural Electrification Authority
REALL	Real Equity for All
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RVF	Rift Valley Fever
SALM	Sustainable Agricultural Land Management Techniques
SCPNF	Sustainable Consumption and Production Networking Facility
SEZ	Special Economic Zone
SGR	Standard Gauge Railway
TMP	Transport Master Plan
UNDP	United Nations Development Programmed
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations Office for Disaster Risk Reduction
USAID	United States Agency for International Development
WASH	Water Sanitation and Hygiene Initiatives
WHO	World Health Organization
WRUA	Water Resources Users Associations

Executive Summary

Kenya has ambitious economic growth and emissions reduction targets. The flagship policy document, Vision 2030, aims to achieve middle-income status by 2030. However, with a clear strategy for decoupling economic growth from greenhouse-gas emissions, this growth could lead to around a three -fold increase in emissions between 2015 and 2050, to around 300 $MtCO_2e$/year. This long-term strategy (LTS) sets out Kenya's strategy to realise a fair and a cost-effective course for ensuring transition towards a competitive, resilient and carbon-neutral economy by 2050.

Kenya's updated NDC sets out its commitments with respect to climate change mitigation and adaptation to 2030. The LTS considers a longer time frame extending well beyond the horizon of the NDC, to 2050. It sets out a vision, objectives, and priority interventions for delivering economic growth whilst transitioning towards a carbon neutral economy. The LTS and NDC are intended to be largely consistent between 2020 and 2030, although the LTS reflects the latest data and policy decisions.

Whereas the NDC sets out commitments (both unconditional and conditional), the LTS outlines a strategy. The LTS, therefore, reflects the optimum approach to achieving the long-term vision based on information available in 2020. The LTS considers additional strategies for achieving the long-term vision and objectives, as well as the medium-term commitments and targets set out in the NDC. It highlights the priority interventions, actions and investments which will be needed to go beyond the NDC 2030 timeframe.

Despite its negligible share of global emissions, Kenya is committed to decarbonising key economic sectors in pursuit of net-zero. Kenya will target becoming a net zero economy by 2050. This builds upon her previous commitments to achieve a 32% reduction in emissions against BAU by 2030, as set out in the December 2020 updated NDC. Working towards net-zero will involve decarbonising the electricity system, shifts energy consumption from traditional carbon-based fuels towards conservation, hydrogen fuel and electricity, and through the widespread adoption of low carbon mass transportation for passengers and freight.

Achieving net-zero will also depend on significant carbon sequestration between now and 2050, driven primarily by the forestry sector. Although contemporary estimates of forest cover vary and depend critically on how forests are defined, continuous deforestation is increasing the sector's carbon footprint. If Kenya can reverse this trend and achieve forest cover of over 15% by 2050, Kenya can approach net zero.

Whilst this LTS sets out a pathway to bring Kenya close to net zero, based on known policy options, interventions and technologies at the time of writing, there remains a small gap to close. There is no excuse to delay action, and this LTS sets out the most viable path towards net zero based on what is currently known, building upon the commitments in Kenya's NDC. The priority for future updates to this LTS will be to identify new opportunities which can bridge the gap and ensure net zero 2050 is achieved.

Kenya must also prepare itself for additional socioeconomic losses associated with climate hazards, such as rising sea levels, rising temperatures, precipitation, and drought. These threats will intensify in the future, particularly if major economies fail to reduce their emissions. Adaptive measures in the agriculture sector must not come at the expenses of productivity improvements or food security, which will be essential for long-term growth.

Actualising this strategy will require significant technical assistance from the international community and improved access to finance. In addition, meeting the net-zero goal is critically dependent on the development of new technologies, and the transfer of that knowledge to Kenya. A collaborative approach with the international will therefore be essential to meeting this document's ambitious aims.

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01 INTRODUCTION

Kenya is already experiencing the adverse effects of climate change. According to the 2020 NDC update, socio-economic losses associated with climate change over the past year amount to between 3% and 5% of GDP. It is particularly impacted due to its reliance on climate sensitive natural resources for its economic development. Despite its relatively negligible Greenhouse Gas (GHG) emissions, estimated at about 0.1% of global figures in 2018, Kenya has put up ambitious policies and measures in pursuit of a low carbon climate-resilient development pathway to achieve the development goals set forth in its Vision 2030 strategy. The ambitions of Kenya to mitigate its own GHG emissions, whilst adapting to the inevitable changes in the global climate, up to 2030 are contained in the updated NDC, submitted to the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat on 24 December 2020. This long-term strategy (LTS) considers a longer time horizon, until 2050, and aims to act as a guide for the future NDC updates and other climate change policies.[1]

[1]Kenya Updated Nationally Determined Contribution, 2020. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Kenya%20First/Kenya%27s%20First%20%20NDC%20(updated%20version).pdf. Last accessed 2021-11-12

1.1 Purpose of this document

The Paris Agreement, adopted in 2015, sets three overall objectives, namely:

a. Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;

b. Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low Greenhouse Gas emissions development, in a manner that does not threaten food production; and

c. Making finance flows consistent with a pathway towards low Greenhouse Gas emissions and climate-resilient development.

The Paris Agreement further stipulates that, to attain these objectives, it will be necessary to achieve carbon neutrality in the second half of this century, establishing that all Parties to the Agreement should prepare and communicate in a successive and progressively more ambitious manner their Nationally Determined Contributions (NDC) to the global effort to reduce Greenhouse Gas (GHG) emissions. In this context, all Parties were invited to formulate and communicate their long-term development strategies with low GHG emissions (LTS). The objective of carbon neutrality means equating the level of GHG emissions with the carbon sink level by the year 2050 (net emissions equal to zero). This will require substantial emissions reductions and substantial increases in national carbon sinks, which should be implemented between 2020 and 2050. This document sets out Kenya's strategy to realise a fair and a cost-effective course for ensuring transition towards a competitive, resilient and carbon-neutral economy by 2050.

1.2 Relationship to the Nationally Determined Contribution

Kenya submitted its first NDC on 28th December 2016. The 2016 NDC committed Kenya to reducing GHG emissions relative to the BAU scenario by 30%, subject to sufficient international assistance. In the 2020 update, the Government of Kenya increased the target from 30% reduction to 32%, against the BAU scenario, by 2030. The total cost of mitigation and adaptation actions was estimated at $62 billion. 13% of these costs will be met through domestic resource mobilisation, with 87% requiring international support.

Kenya's updated NDC sets out its commitments with respect to climate change mitigation and adaptation to 2030. This LTS considers a longer time frame extending well beyond the horizon of the NDC, to 2050. It sets out a vision, objectives, and priority interventions for delivering economic growth whilst transitioning towards a carbon neutral economy. The LTS and NDC are intended to be largely consistent between 2020 and 2030, although the LTS reflects the latest data and policy decisions.

Whereas the NDC sets out commitments (both unconditional and conditional), the LTS outlines a strategy. The LTS, therefore, reflects the optimum approach to achieving the long-term vision based on information available in 2020. The LTS considers additional strategies for achieving the long-term vision and objectives, as well as the medium-term commitments and targets set out in the NDC. It highlights the priority interventions, actions and investments which will be needed to go beyond the NDC 2030 timeframe.

1.3 Net zero

Kenya has committed to moving towards net zero emissions by 2050. Whilst this LTS sets out a pathway to bring Kenya close to net zero, based on known policy options interventions and technologies at the time of writing, there remains a small gap to close. Recent decades have seen a rapid decline in the costs of emission mitigating technologies, such as solar-PV and wind electricity generation and battery technologies. Over the next 30 years, further innovation, research and development will bring the costs of emerging technologies and clean energy down further, whilst advancements can be expected in new technologies which cannot be predicted today. There is no excuse to delay action, and this LTS sets out the most viable path towards net zero based on what is currently known, building upon the commitments in Kenya's NDC. The priority for future updates to this LTS will be to identify new opportunities which can bridge the gap and ensure net zero 2050 is achieved. This requires international collaboration and investment in research, development and innovation to make emerging technologies economically viable.

1.4 Approach

It's Kenya's Intended NDC which became Kenya's 1st NDC after Kenya ratified the Paris Agreement. The updated NDC itself is built on the foundation of the following:

- Kenya's initial NDC
- The National Adaptation Plan (NAP) 2015-2030, which in turn is aligned to:
  - Constitution of Kenya
  - Climate Change Act (2016)
  - Vision 2030
  - Medium Term Plans – 5-year implementation plans for Vision 2030
  - The National Climate Change Response Strategy (2010)
  - National Climate Change Action Plan (NCCAP) 2013-2017
  - NCCAP 2018-2022 and its Annexes:
    - Adaptation Technical Analysis Report (ATAR 2018-2022)
    - Mitigation Technical Analysis Report (MTAR 2018-2022)
    - Third National Inventory Report (NIR 3)

The following figure shows the sequence of the major documents that serve as building blocks for the LTS.

Figure 1.1 Kenya's climate-related policy commitments

The level of ambition across mitigation and adaptation, key targets, and the supporting policies, investments and actions required to deliver on this ambition, were determined through an iterative, consultative, and cooperative process involving representatives from key sectors. The process was led by the Ministry of Environment. Decisions were made based on evidence available at the time.

Modelling work included the development of two scenarios (Business-As-Usual, and LTS), which are further described in section 1.6.3. These capture the range of ambition levels for reducing national emissions, while the adaptation modelling in section 3.3 reflects a range of potential losses and adaptation costs associated with the global temperature pathways RCP 2.6 and RCP 8.5.[2]

Table 6.1 Summary of modelling approaches

Modelling strand	Modelling Suite	Sectoral coverage*
Mitigation models	LEAP and Vivid Economics Land Use and Forestry Model	Power, industry, transport, waste, agriculture, and forestry
Adaptation models	Overall sectoral damage modelling, based on AfDB high level estimates and selected secondary sources Bespoke cost-benefit analysis of adaptation interventions, based on the IPCC framework	Agriculture, water, fisheries, forestry, tourism, health, human settlements, manufacturing and trade, energy, transport, vulnerable populations
Macroeconomic models	Macroeconomic projections from the Government of Kenya, supplemented with projections	Economy-wide

For greater detail on the modelling, see sections 6.1- 6.3 of the Technical Appendix, which describe the modelling suites used to deliver the quantitative analysis, as well as their sectoral coverage. Stakeholder consultation was vital for identifying adaptation and mitigation interventions, collecting information and data which supported modelling exercises, validating scenario assumptions, co-developing implementation plans and ensuring capacity building at the national level for effective implementation and monitoring. The stakeholder inputs and modelling outputs were synthesised to inform the priority interventions proposed in the LTS.

[2]Representative Concentration Pathways (RCPs) represent different emissions, concentration and radiative forcing projections leading to a large range of global warming levels. RCP 2.6 is a stringent pathway that is likely to keep global temperature rise below 2 °C by 2100 relative to the pre-industrial levels. In RCP 8.5 emissions continue to rise throughout the 21st century, resulting in global temperature rise above 4 °C by 2100 relative to the pre-industrial levels.

1.5 Climate Change Governance in Kenya

The Republic of Kenya is a unitary State with a multi-party-political system. In 2010, the Government of Kenya (Kenya) enacted a new constitution which created a devolved two-tier government consisting of a national government and county governments. The National Government has the overall responsibility for ensuring that programmes are put in place to deliver its obligations under the UNFCCC.

The Constitution of Kenya and the Vision 2030, together with the Climate Change Act (2016), provide a supportive framework for implementing climate change responses in the country. The Constitution of Kenya (2010) provides ground for the formulation of climate change legislations , policies & strategies, policies, and strategies by guaranteeing the right to a clean and healthy environment under the Bill of Rights. In addition, Vision 2030, the long-term national development blueprint encapsulates flagship programmes and projects with aspects of climate change adaptation and mitigation.

The Climate Change Act (2016) guides climate change action in Kenya and provides a framework for mainstreaming climate change across sectors. The Act establishes governance structures for climate change management in the country and defines the roles of both national and county governments in mainstreaming and implementing climate change actions in the country. The Act obligates the Cabinet Secretary responsible for climate change affairs to formulate an economy-wide five-year National Climate Change Action Plan (NCCAP) that provides mechanisms for mainstreaming climate change into all sectors and the County Integrated Development Plans (CIDPs). In accordance with the Act, the NCCAP represents the national mechanism through which climate change is to be addressed in Kenya, including implementation of the country's NDC.

The NCCAP 2018-2022 was an update of the NCCAP (2013-2017), which was Kenya's first NCCAP. The NCCAP, which covers Kenya's climate actions over the 5-year period from 2018 to 2022, guides Kenya on its priority climate change adaptation and mitigation actions. The actions define the country's low carbon climate resilient development pathway toward the achievement of Kenya's NDC targets. As an Annex to the NCCAP (2018-2022), a Mitigation Technical Analysis Report (MTAR 2018-2022) and an Adaptation Technical Analysis Report (ATAR 2018-2022) were provided to elaborate on the Mitigation and Adaptation actions, respectively.

The Act establishes the National Climate Change Council (NCCC), which is chaired the President of the Republic of Kenya. The Cabinet Secretary responsible for climate change affairs is the Secretary to the Council and formulates and periodically reviews climate change policy, strategy, and the NCCAP, and submits to the Council for approval. The NCCC is mandated by the Act to provide policy oversight and the coordination of climate change actions at the national, county, and sectoral levels and to approve the NCCAP.[3] The Act also established the Climate Change Directorate (CCD) which is the lead agency in coordinating government climate change plans and actions related measurement, monitoring, and reporting. The CCD is the Secretariat for the NCCC and coordinates the technical implementation of climate change functions. This includes providing analytical support and technical assistance on climate change and coordinating the implementation of and reporting on the NCCAPs.

The Act also allows for the regulation of non-state actors (NSA) in the reporting and management of emissions. Non-state actors include private sector, economic and social partners, and civil society, and cover a wide range of actors such as non-governmental organisations (NGOs), trade unions, academic and research institutions, foundations, media organisations, and others.[4] NSA can support in designing frameworks for monitoring and evaluation and strategies for targets. The Climate Change Act stipulates that private entities may be subject to climate change obligations. Such obligations include preparing reports on the status of its performance of climate change duties. Private entities are therefore responsible for proactively defining intended climate actions and monitoring performance within these actions. At the sub-national level, county governments designate a County Executive Committee member to coordinate climate change in each county through an established Climate Change Unit (CCU). Similarly, at sectoral level, state departments establish CCUs to integrate NCCAP actions into their strategies and implementation plans.[5]

[3]Government of Kenya, 2016. Climate Change Act.

[4]A. Bachore, 2020. 'The Role of Non-State Actors in Promoting Good Governance: The Case of Kenya', Global Scientific Journals 8, no 8, 570-4. NCCAP, 2018-2022.

[5]Kenya National Bureau of Statistics, 2019. Population and Housing Finance. Available at https://www.knbs.or.ke/?page_id=3142#. Last accessed 2021-11-12.

1.6 National Circumstances

The Republic of Kenya is a commercial, transportation, and communications hub for East Africa, with ambitious development plans. Over the period 2015-2019, Kenya experienced an average economic growth of 5.7%, and continued its success into 2020 when it received the rank of largest economy in the Eastern Africa region from the International Monetary Fund. The population of Kenya was 47.6 million in 2019, as per the census of 2019, and is expected to reach 60.4 million by 2030.[6] Its economic performance is bolstered by a stable macroeconomic environment, positive investor confidence, and a resilient services sector.[7] The Kenya Vision 2030 aims to transform Kenya into a newly industrializing, middle-income country providing a high quality of life to all its citizens by 2030 in a clean and secure environment.[8] Kenya aims to facilitate a low carbon development pathway for the nation, achieving both core economic and environmental objectives.

1.6.1 Kenya's GHG emissions

According to Kenya's Updated NDC published in 2020, Kenya's total Greenhouse Gas emissions have increased from 56.8 $MtCO_2e$ in 1995 to 93.7 $MtCO_2e$ in 2015 and are projected to increase to 143 $MtCO_2e$ by 2030 in the absence of targeted interventions.[9] This represents an increase of 82% over the period. Overall, in 2015, Kenya's emissions are less than 0.1% of the 2015 global emissions.[10]

Agriculture was the leading source of emissions in 2015, at 40% of the total national emissions. This was mostly due to livestock enteric fermentation, manure left on pasture and agricultural soils and fertiliser application. This was closely followed by LULUCF at 33%, transport at 11%, and energy demand (excluding transport) at 9%. The remaining emissions are from industrial processes and product use (IPPU) at 4%, waste management at 3%, and electricity generation at 1%.

While Kenya has abundant renewable energy resources such as geothermal, solar, wind and hydro for electricity generation, the country also has over 400 million tonnes of coal reserves which are yet to be exploited. Coal mining, in particular open-pit mining as planned for Mui basin, has significant environmental, economic and social impacts, and will require large scale resettlement plans. The exploitation and use of the above resources will significantly increase future Greenhouse Gas emissions.

1.6.2 The impacts of climate change

Kenya's economy and population are increasingly vulnerable to rises in average global temperatures and sea levels caused by climate change. Over 84% of Kenya's land area is arid and semi-arid, with pre-existing development challenges and poor infrastructure. This leaves less than 16% of the total land area to support over 80% of the population.[11] Higher frequencies and intensities of heat, drought, and flood events in Kenya are triggering major environmental and economic disruptions as well as increasingly harming human health and lives.

The effects of climate change are already being felt and are creating significant socioeconomic consequences in developing countries, including Kenya. Socio-economic losses associated with climate change over the past decade amount to between 3% and 5% of GDP per annum.[12] Modelling estimates, detailed in section 3.4, suggest that Kenya's loses could rise from 6.5%- 8.5% GDP per annum between 2021-2050. The economy, which relies heavily on agriculture, and tourism, is particularly exposed to the effects of climate change, which will become more severe even under the most optimistic scenarios. As the economy and population grows, so too will exposure to climate-related disasters.

The increased intensity and frequency of climate related disaster events in Kenya also cause harm to human health and lives. Of these extreme weather events, floods have led to the greatest climate-change related displacement and loss of human lives in Kenya. In early 2019 alone, flooding displaced more than 225,000 people and closed over 700 schools. The 2014-2018 drought is estimated to have forced 3.4 million Kenyans into food insecurity and to have deprived 500,000 people of access to water.[13] Climate related disasters can also aggravate conflicts, mostly over natural resources. A fundamental driver of clan conflict within northeast counties in Kenya, for example, is often the scarcity of natural resources such as water, pasture, and land.[14] Section 3 analyses the major climate risks affecting each sector and proposes adaptation interventions to address them over the long-term.

1.6.3 Approach

Moving towards net zero emissions by 2050 requires implementing ambitious mitigation policies and is partly dependent on the development of new technologies. Mitigation modelling is key to assess the impacts of mitigation interventions across the six sectors of interest, namely energy, industry, transport, waste, agriculture, and forestry, up to 2050 and in different scenarios. The quantitative modelling uses the Low Emissions Analysis Platform (LEAP), with separate modelling for land use & forestry.

In developing this LTS, two mitigation scenarios were assessed:[15]

1. **Business-as-Usual (BAU)** scenario assumes historical trends will persist until 2050. It is used to benchmark the outcomes of the other two scenarios.
2. A more ambitious LTS **"Towards Net Zero"** scenario which heads towards net zero emissions by 2050, with a series of sectoral policy targets.

Although some assumptions and emission outputs might slightly differ, the BAU and National Plan Scenarios are broadly comparable to the NCCAP baseline and NDC 2020 emission reduction scenario, respectively, up to 2030.

Emissions projections have been modelled predominantly using the Low Emissions Analysis Platform (LEAP), based on the macroeconomic projections, and a set of common forestry assumptions. Forestry emissions were modelled separately and then incorporated into LEAP. The sector deserves attention as it alone accounted for around a third of the total GHG emissions in 2015. If targeted interventions are introduced and new technologies are developed, the sector can serve as carbon sink and can help Kenya approach net zero emissions by mid-century.

The LEAP model is an integrated energy-environment tool used to conduct energy policy analysis and climate change mitigation assessment to identify priority mitigation opportunities. This tool is used to model mitigation actions against a baseline to determine the emissions, costs, and other energy sector impacts of the policies. Both top-down and bottom-up approaches for emission analysis can be used in LEAP, enhancing its versatility in areas with low data access. The tool uses activity level parameters such as number of households, vehicle kilometres, GDP contribution, livestock population and respective energy and emission intensities (GJ/household, litres of gasoline per vehicle kilometre, tCO_2/GJ, tCO_2e/Ton cement produced etc.) for final energy demand emissions analysis. Typically, it applies the IPCC methodology in building emission inventory and assesses mitigation pathways scenarios, making it suitable for national planning and policy development.

The forestry model draws on land use inventories and international emissions factors for different land use categories to estimate current baseline emissions. The land use categories deployed in the model reflect Kenya's crop mix and other land use practices. These emissions are projected forward under business as usual based on historical trends and assumptions for how demand for land use will evolve in future. Mitigation options are then incorporated through their impacts on land use, land use change and emissions factors, to provide a quantified estimate of the impact of different options. Emissions from the forestry sector were estimated separately and incorporated into the LEAP model to allow for comparisons and interactions between the mitigation sectors.

The figures over historical emissions and emissions to 2030 in the LTS and the updated NDC differ for several reasons. Due to differences in the underlying assumptions of the LEAP model and the analysis in the NDC, the LEAP model estimations of emissions from 2010 to 2030 differ from the figures in the NDC. For the IPPU sector, the LEAP model incorporates additional subsector, leading to higher historical and future emissions. Projected emissions from electricity supply are considerably lower in the LTS compared to the NDC due to differences in the assumptions regarding the contribution of renewable energy in the electricity mix. In addition, the LULUCF sector analysis is based on updated data sources, which suggests that emissions from the sector are higher compared to what has been previously estimated. Similarly, the NDC

[6] Kenya National Bureau of Statistics, 2019. Population and Housing Finance. Available at https://www.knbs.or.ke/?page_id=3142#. Last accessed 2021-11-12.
[7] World Bank Kenya, 2021. https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=KE, last accessed 2021-11-12
[8] Kenya Vision, 2030.Available at http://vision2030.go.ke/. Last accessed 2021-11-12
[9] Republic of Kenya, 2020. Updated Nationally Determined Contribution, Technical Analysis Report, Table 3.1.
[10] Our World in Data. Available at https://ourworldindata.org/co2/country/kenya. Last accessed 2021-12-05
[11] Republic of Kenya,2020. Kenya Updated Nationally Determined Contribution, 2020.
[12] Republic of Kenya, 2020. Kenya Updated Nationally Determined Contribution, 2020.
[13] Republic of Kenya, National Climate Change Action Plan 2018-2022
[14] UK DFID, 2019. Climate change, vulnerability to viloent extremism and conflict in Kenya. Available at https://assets.publishing.service.gov.uk/media/5d9b4db740f0b607f3e67941/639_Climate_Change_and_Violence_in_Kenya.pdf. Last accessed 2021-11-12
[15] For specific sectors, projections of the mitigation potential of existing policies have been included where appropriate

estimates emissions from the agricultural sector that are about 20% lower compared to the LTS due to improved data access and availability in the LTS preparation process.

The mitigation actions are complemented by a detailed adaptation strategy at the sectoral level. This is set out in section 3. The adaptation chapter includes detailed analysis into the core drivers of climate risk in each sector and, where possible, estimates of overall financial losses over 2020-2050. To address losses associated with climate change, estimates of the annual investment requirements for adaptation interventions, informed by top-down modelling, are included in the strategy.

Photo Credit: CCD

02

Mitigation

Photo Credit: CCD

2.1 Introduction

Kenya's total Greenhouse Gas emissions have increased significantly since 1995, driven mainly by forestry and agriculture emissions. This represents a rise of 82% over the period. In 2015, the leading source of emissions was agriculture at 40% of the total national emissions, mostly due to livestock enteric fermentation, manure left on pasture and agricultural soils, and fertiliser application. This was closely followed by LULUCF at 33% due to deforestation and energy demand including transport at 20%. The remaining emissions come from industrial processes and product use (IPPU) at 4%, waste management at 3% and electricity generation at 1%. In the absence of targeted interventions, projections show that GHG emissions could reach to 143 $MtCO_2e$ by 2030. Accounting for 29% of total GHG emissions, energy can be the leading contributor to emissions because of rising consumption of fossil fuels in generating electricity and demand from transport as well as domestic, commercial, and industrial heating.[16]

Kenya seeks to undertake an ambitious mitigation contribution towards its low-carbon, climate resilient development pathway. Climate change mitigation actions refer to human interventions taken to prevent or slow down atmospheric Greenhouse Gas concentrations by limiting

[16]Republic of Kenya, 2020. Updated Nationally Determined Contribution, Technical Analysis Report, Table 3.1.

current or future emissions and/or enhancing carbon sinks for Greenhouse Gases. In contrast to carbon sources, carbon sinks are forests and other ecosystems that absorb more carbon than they release, thereby removing it from the atmosphere and offsetting CO_2 emissions.

The mitigation contribution of Kenya's initial NDC intended to abate GHG emissions by 2030 relative to the BAU of 143MtCO_2e, as shown in Figure 2.1. These findings formed the basis of Kenya's mitigation NDC that was set at 50% of the technical emissions reduction potential, or a reduction of 42.9 MtCO_2e by 2030. This technical potential provided the basis for determining the overall 30% emission reduction target for Kenya, with each sector being considered for its widely differentiated potential and costs.[17]

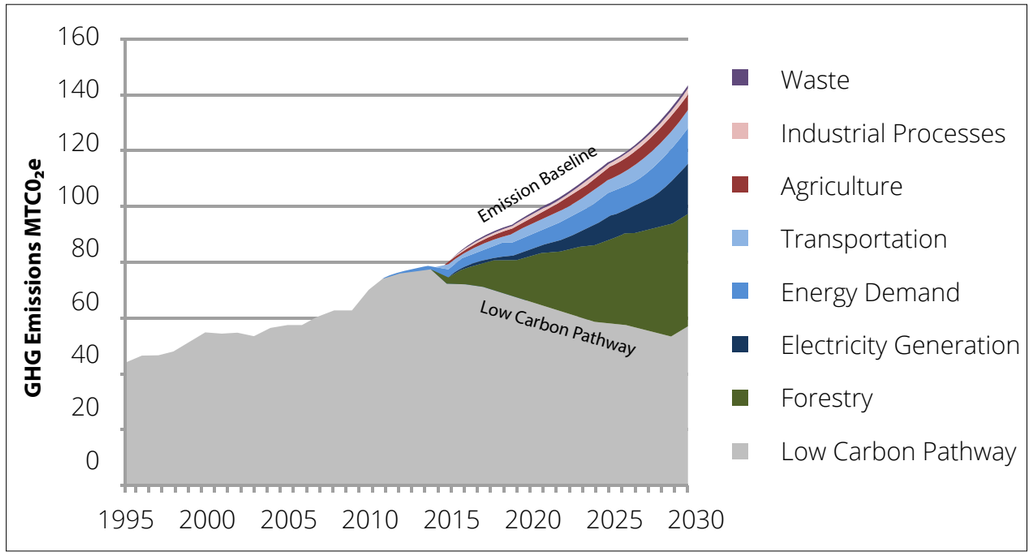


Figure 2.1 Kenya's Baseline Emissions and Technical Mitigation potential for the Sectors (MtCO_2e)

Source: GoK; NCCAP 2013-2017

[17]Republic of Kenya,2020. Updated Nationally Determined Contribution, Technical Analysis Report, Figure 3.2, and Table 3.2.

The 2020 update to Kenya's Nationally Determined Contribution set out a more ambitious emissions reduction target of 32% (46 MtCO_2e) relative to the business as usual (BAU) scenario of 143 MtCO_2e by 2030. The updated NDC which includes adaptation contribution is in line with sustainable development objectives.[18] The bulk of proposed emission reductions will come from the energy sector, which is projected to reduce overall emissions by 24 MtCO_2e by 2030, followed by LULUCF, which will contribute to the overall reduction in emissions by up to 12 MtCO_2e by 2030.

Significant international support, such as finance, capacity building and technology development and transfers, is required to reach those targets. International support required to unlock the emissions reduction potential range between 25% to 80% of the total budget, depending on the sector. Table 2.1 details the mitigation potential of each sector up to 2030, costs associated with it, and international support required.

Table 2.1 Summary of the Discounted Mitigation Potential of the Actions Prioritised for the Updated NDC

Sector	Annual Emission Reduction Target (MtCO_2e)			Estimated Budget (Million USD)	International Support required (% Budget)
	Action up to 2022	Action up to 2025	Action up to 2030		
Energy	11.6	16.5	24.1	8,890	80
Transport	1.0	1.5	2.4	4,240	80
LULUCF	5.9	8.2	11.9	4,126	80
Agriculture	1.6	3.2	5.8	250	80
IPPU	0.5	0.8	1.4	180	25
Waste	0.4	0.4	0.5	39	25
Total	**21.0**	**30.6**	**46.0**	**17,725**	**79.3**

The LTS sets out sectoral mitigation pathways consistent with a 'towards net-zero' goal by 2050, while seeking to maintain robust economic development.

[18]Kenya's Updated Nationally Determined Contribution (NDC), 2020.

Photo Credit: CCD

2.2 Energy

Within the energy sector, LTS follows the sector grouping in NCCAP 2018-2022 and NDC 2020 and considers emissions from:

- Electricity generation: changes in the level and mix of on-grid electricity generation; and
- Energy demand: changes in energy demand from residential, industry, and service sectors.
  - An increase in energy demand can be met by electricity, fossil fuels (such as oil, coal, gas, firewood, charcoal, kerosene, and LPG) and low carbon fuels (such as hydrogen).
  - Off-grid electricity generation, such as the use of diesel in home generators, is also considered under energy demand.

2.2.1 Energy demand: end users from the residential, industrial, service and agriculture sectors

End user emissions are comprised of combustion emissions of the residential, industrial, service and agriculture sectors. Process emissions from industry and transport sector emissions are excluded here and covered in sections 2.3 and 2.4.

In line with economic growth and industrialisation, final energy demand has been steadily rising since 2000, reaching 589 PJ/year in 2018 (see Figure 2.2).[19] If we include transport, this reaches 720 PJ/year. The residential sector accounts for the largest energy consumption (excluding transport), with 88% of the final energy demand, followed by the industry sector (10%), whereas the services and agriculture sectors together account for around 1%. In absolute terms, energy demand of the residential sector grew fastest over 2000-2020, given the high demographic growth and urbanisation rate.

During the period 2015-2020, energy demand emissions have marginally increased from 3.5 $MtCO_2e$ in 2015 to 3.6 $MtCO_2e$ in 2020. In 2015, coal was the largest contributor to energy demand emissions at 51%, followed by kerosene at 38% and LPG at 11%. A major contributor to this increase is the rise in annual coal consumption by the cement sector over the period. The proportionate NDC emission targets for the energy demand sub-sector have consistently been exceeded since 2015, mostly due to reduction in annual kerosene consumption with a corresponding increase in Liquefied Petroleum Gas (LPG) use.[20]

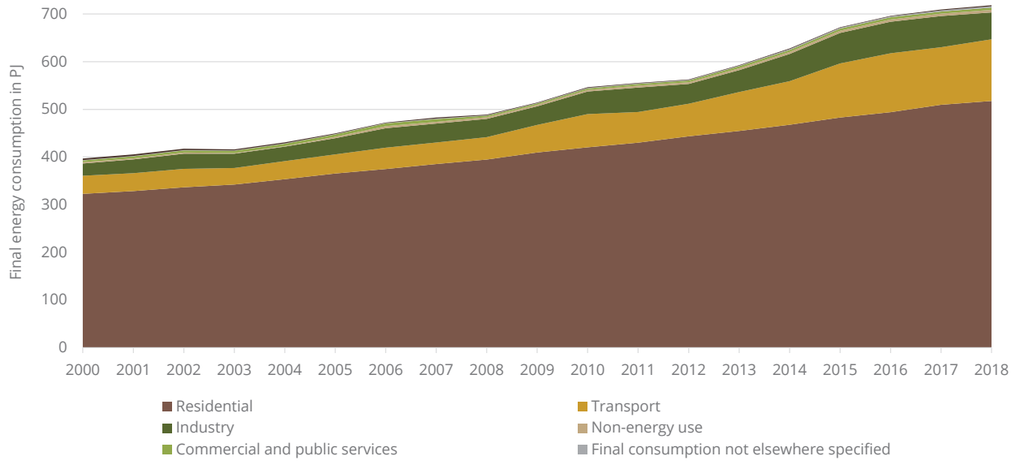


Figure 2.2 Final energy demand by sector, over 2000-2018, PJ/year

Source: IEA World energy balances (2020)

[19]IEA World energy balances (2020), based on data from among others Kenya Central Bureau of Statistics and Kenya Power
[20]Kenya's Updated Nationally Determined Contribution (NDC), 2020. Table 3.8.

In the residential sector, biomass (mainly wood) and agriculture residues served 71% of the energy demand in 2018 (see Figure 2.3). firewood and agriculture residues traditionally cater basic energy needs of rural communities and urban poor, and the informal sector, used mostly for cooking and heating. Over 2000-2018, the shares of firewood (around 70%) and charcoal (around 23%) remained constant in total residential energy demand, as shown in Figure 2.3.[21] Other sources such as kerosene, electricity, and liquefied petroleum gases (LPG) made up 5% of total energy demand. For cooking, 55% of households in Kenya were still cooking with firewood in 2015, while 15% used charcoal, 14% used kerosene and 13% used LPG. In recent years, LPG has seen particularly high uptake. Its use increased almost four-fold in absolute terms since 2008 due to Kenya's policy to transition to clean cooking but still represents a low overall share of demand.[22]

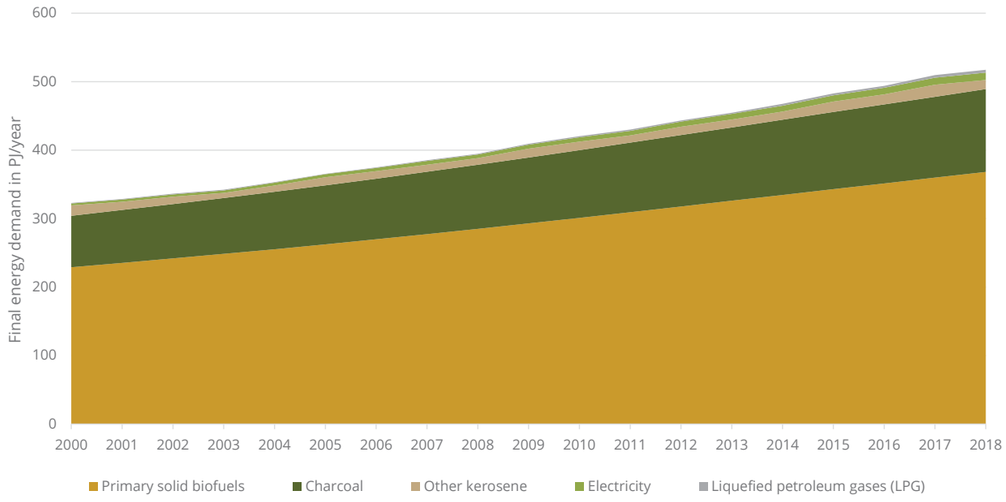


Figure 2.3 Residential sector: final energy demand by source, over 2000-2018, PJ/year

Source: IEA World energy balances (2020)

The industrial sector relies on gas and diesel oil (34%), electricity (29%) and bituminous coal (19%) to serve its energy demand. The industrial energy demand increased steadily over 2000-2018 as the economy gradually industrialised and more of the workforce moved from agriculture to industry. Contrary to the residential sector, there was more substitution between energy sources. The share of fuel oil decreased from 34% in 2000 to 9% in 2018, while the share of bituminous coal peaked in 2014 at 34% before plummeting. The share of electricity in overall industrial energy demand remained rather constant since 2000.

[21]IEA World Energy Balance, 2020, based on data from among others Kenya Central Bureau of Statistics and Kenya Power
[22]Ibid.

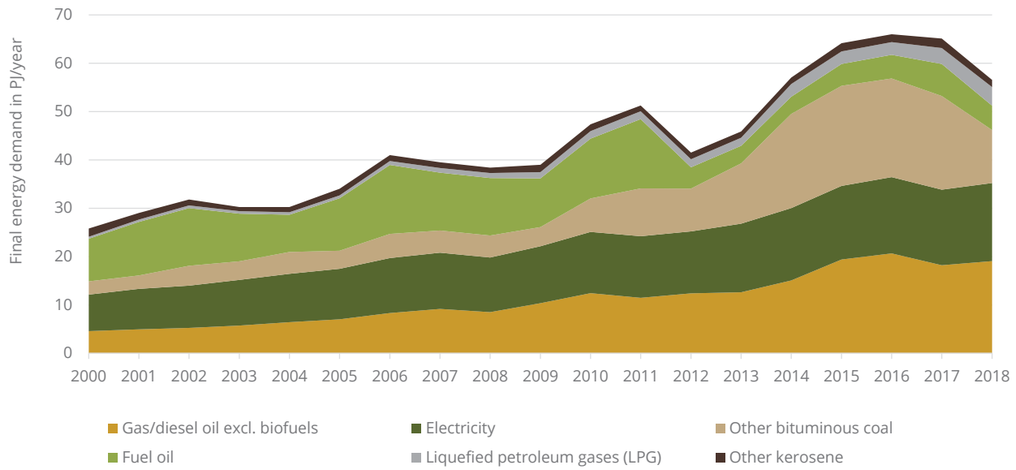


Figure 2.4 Industrial sector: final energy demand by source, over 2000-2018, PJ/year

Source: IEA World energy balances (2020)

Kenya is the most industrially advanced country in East Africa, with potential for further industrialisation due to untapped reserves of oil, coal, gas, iron ore, limestone, and rare earth minerals.[23] The industrial sector is expected to play a key role in achieving the Economic Pillar of Vision 2030 and further growth and development thereafter. The ministry responsible for industrialization and enterprise development therefore prioritizes developing this sector to serve as Kenya's growth engine by 2030, aiming to revitalize the manufacturing sector through the Industrial Transformation Programme. In particular, the key resource-based industries identified in the National Industrial Transformation Programme included cement, buildings and construction, and iron and steel.[24]

Given the national priorities for both industrial growth and low carbon, climate resilient development, the expansion of key industrial sectors will likely need to be accompanied by a significant reduction in their emissions intensity. Energy demand emissions from industry stood at 3.2 $MtCO_2$ in 2018, averaging 3.8 $MtCO_2$ from 2014 to 2018.[25] The breakdown of final combustion emissions from industry is also variable throughout the years. From 2014 to 2018, 45% of emissions were associated with non-metallic minerals (mostly cement, lime and soda ash production), while 55% were associated with other unspecified industrial uses.[26] In 2018 however, 72% of emissions were associated with non-metallic minerals, and 28% with other unspecified industrial uses.

Without targeted interventions, economic growth and population increase will increase energy demand and emissions from the residential, industrial, and service sectors. Over 2020-2050, energy demand from these sectors will increase from 276 PJ/year to 1208 PJ/year and their emissions could increase fivefold from 7.2 $MtCO_2e$/year to 35.1 $MtCO_2e$/year (see Figure 2.5) if they follow a business-as-usual development pathway. Emissions from the residential sector would reach to 5.2 $MtCO_2e$/year without targeted interventions, almost doubling from their 2020 level. In the industrial sector, emissions would increase more than six-fold, reaching 24.3 $MtCO_2e$/year, as the economy industrialises further and energy demand of manufacturing and construction grows, driven by continued use of heavy fuel oil and coal in cement and lime production. Lastly, the service sector would emerge as another significant energy consumer and would contribute a similar amount of emissions to the residential sector by 2050 (5.1 $MtCO_2e$/year).

[23]Kenya's Updated Nationally Determined Contribution (NDC), 2020.

[24]Kenya Ministry of Industrialization, Trade and Enterprise Development, 2021. Kenya's Industrial Transformation Programme. Available at https://www.industrialization.go.ke/index.php/downloads/282-kenya-s-industrial-transformation-programme. Last accessed on 12 November 2021.

[25]IEA World Energy Balances (2020). based on data from among others Kenya Central Bureau of Statistics and Kenya Power

[26]IEA World Energy Balance (2020) reports zero emissions for the following industrial sub-sectors: mining and quarrying, and construction, and the following manufacturing sub-sectors: iron and steel, chemical and petrochemical, non-ferrous metals, transport equipment, and machinery.

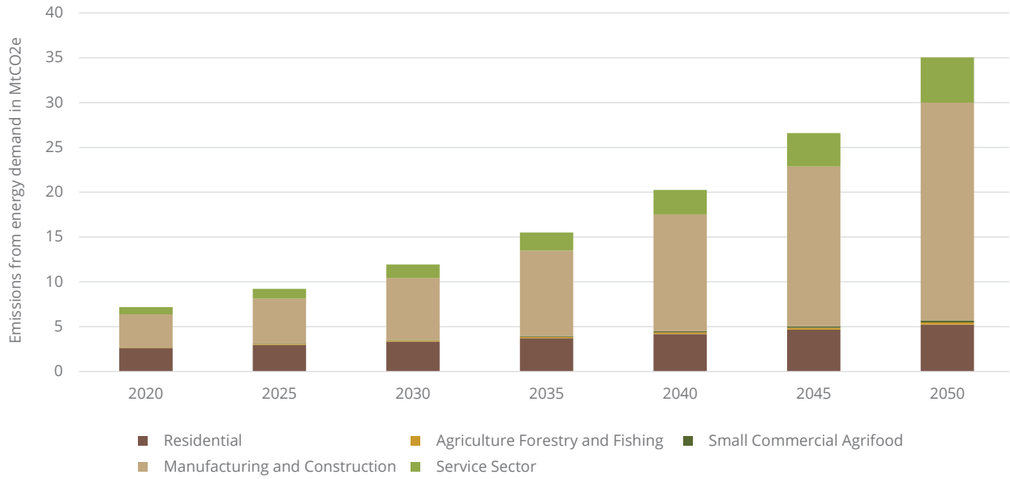


Figure 2.5: Emissions from energy demand in absence of targeted interventions, over 2021-2050, $MtCO_2e$/year

Source: LEAP modelling.

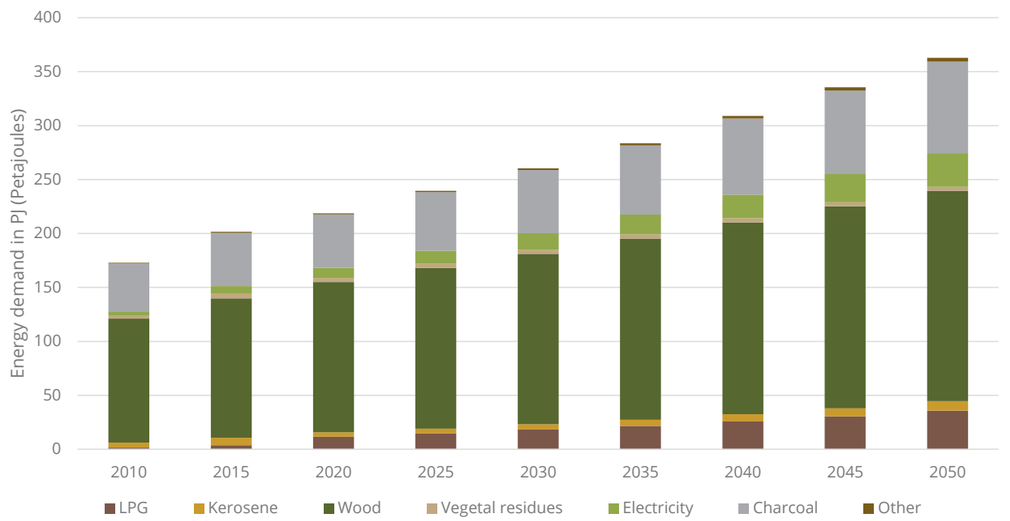


Figure 2.6 Energy mix of the residential sector, in absence of targeted interventions, over 2021-2050, in PJ/year

Note: 'Other' includes charcoal briquettes, ethanol, solar, biogas, mini-grid electricity

Source: LEAP modelling.

NCCAP 2018-2022 and the 2020 Update to the NDC have already introduced priority interventions to manage emissions from energy demand. These interventions together would deliver an emissions reduction of 10.8 $MtCO_2e$/year by 2050, lowering total emissions from energy demand to 24.3 $MtCO_2e$ in 2050. These priority interventions are:

- for the residential sector:
  - Achieve 100% electrification of urban areas by 2022
  - Achieve 100% electrification of rural areas (including through off-grid technologies) by 2030
  - Develop and distribute improved biomass cookstoves and clean cookstoves
  - Adopt biogas for cooking and LPG and ethanol as fuel in urban and rural areas
  - Replace inefficient incandescent bulbs with efficient LEDS and CFLs
- for the industrial sector:
  - Increase energy efficiency through promoting participation in energy efficiency initiatives developing Minimum Energy Efficiency Standards for appliances.
  - Promote optimisation of manufacturing and production processes
  - Scale-up of industrial symbiosis and environmentally sound technologies and practices in existing and upcoming Industrial Zones
  - Promote innovation through a Sustainable Consumption and Production Networking Facility (SCPNF) for Micro, Small and Medium Enterprises (MSME)
  - Raise awareness to promote resource efficiency within the private sector
  - Apply special economic zones legislation to enhance shared industrial efficiency measures and the regulatory framework governing treatment and management of industrial effluent

This long-term strategy seeks to go further than the commitments. In addition to the updated NDC and the targets articulated in the NCCAP, the long-term strategy will seek to:

- Amongst residential energy consumers, increase the adoption of electric stoves as primary cooking technology to 50% in urban areas
- In rural households, achieve 100% electrification and 100% transition to clean cooking
- Increase use of electricity in cooking to 40% and LPG to 30% in hotels and restaurants. In schools, use biofuels for 60% and LPG for 30% of cooking
- Achieve 30% energy efficiency gain in industry
- Replace 40% of coal with hydrogen in the production of cement, whilst biomass replaces a further 17%
- In food and beverage manufacturing, replace 15% of heavy fuel oil used with electricity and hydrogen. In other industries, hydrogen replaces 70% of heavy fuels
- Eliminate the use of diesel generators as a backup

Together, these objectives can achieve emissions reductions from energy demand by over 70% to just 9.8 $MtCO_2e$/year (see Figure 2.7). In 2050, the industrial sector would account for the lion's share of energy demand (5.1 $MtCO_2e$/year), followed by the services and residential sectors (2.3 $MtCO_2e$/year and 2.2 $MtCO_2e$/year, respectively). Figure 2.7 presents the fuel mix serving energy demand from 2020 to 2050:

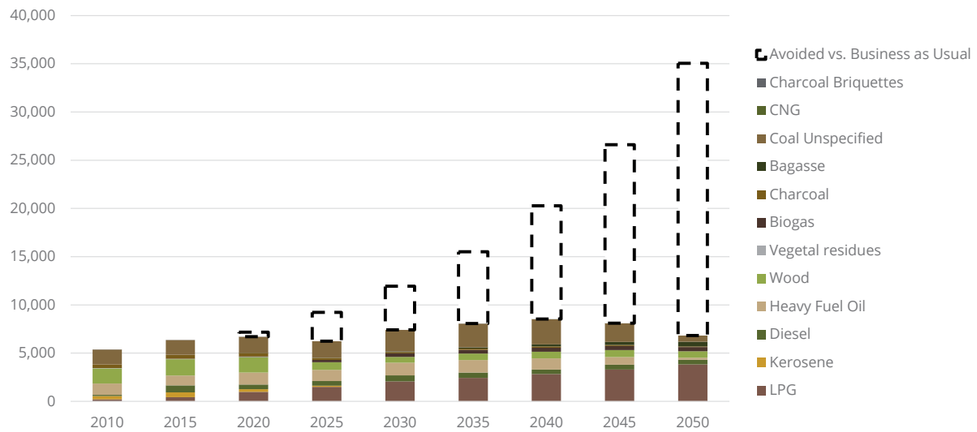


Figure 2.7 Energy demand emissions ($MtCO_2e$/year) in the Long-Term Strategy (LTS), by energy source

Source: LEAP modelling.

2.2.2 Energy supply

Between 2000 and 2018, electricity output increased by almost three-fold, reaching 11.8 TWh. This growth has been driven by a rapid increase in demand, due to the electrification of rural areas, population growth, urbanisation, and economic activity moving away from agriculture to the services and industrial sectors. Kenya has seen one of the fastest increase in electrification rates within sub-Saharan Africa. The effective Rural Electrification Authority's Last Mile Connectivity campaign and a thriving off-grid solar market have pushed electricity access from roughly 42% in 2015 to 75% from both grid and off-grid options in 2018.[27]

The National Electrification Strategy[28], as well as the Rural Electrification Authority's Last Mile Connectivity Project[29], aim to deliver universal access to all households and businesses at acceptable quality of service levels. The grid would be the principal least-cost solution for most of the population still lacking access to electricity, with off-grid solar targeted specifically at rural and hard-to-reach areas. As more sectors rely on electricity as an energy source in an LTS scenario, there will be a continued increase in electricity demand, reaching 101 TWh by 2050. This level of demand is more than the double of 54.7 TWh/year that would be expected based on historic trends without targeted interventions.

Electricity generation is currently powered predominantly by clean sources, led by hydro and geothermal energy. Hydro and geothermal together accounted for around 80% of total electricity generated in 2018 (Figure 2.8). Oil accounts for 18% of the electricity mix and makes up the shortfall in times of poor rain and drought, with small contributions from other renewables, biofuels, and waste. Due to the high share of renewables in the electricity mix, there is limited reliance on expensive imported fossil fuels, resulting in low generation costs and a low intensity emissions of electricity generation.

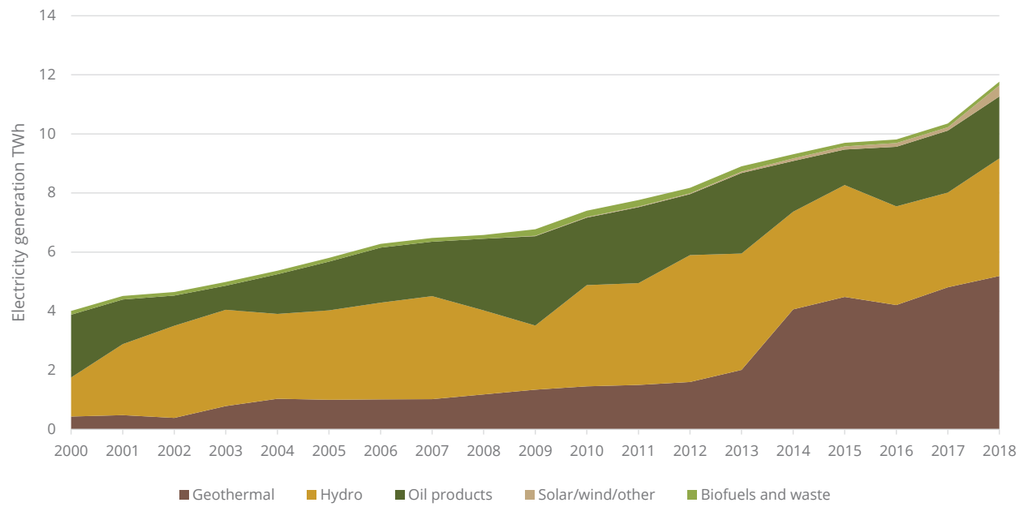


Figure 2.8 Electricity Generation by source, 2000-2018

Source: IEA World Energy Balances (2020)

[27]Multi-Tier Framework Survey Report: February 2018; World Bank. Available at: https://datacatalog.worldbank.org/dataset/kenya-multi-tier-framework-mtf-survey. Last accessed 2021-11-12

[28]Kenya National Electrification Strategy, 2018. Available at: https://pubdocs.worldbank.org/en/413001554284496731/Kenya-National-Electrification-
[29]Strategy-KNES-Key-Highlights-2018.pdf. Last accessed 2021-11-12

Kenya Power. Last Mile Connectivity. Available at: https://www.kplc.co.ke/content/item/1120/last-mile-connectivity. Last accessed 2021-11-12

The ambition to achieve 100% electrification, and the expected increase in demand for electricity means that generation capacity will need to increase substantially over the next three decades, with demand reaching 57.5 TWh in 2050. The population is projected to increase by 93%, from 53.8 million to 100.3 million by 2050, supporting economic growth of over 200% over the same period.[30]

NCCAP 2018-2022 and the 2020 Update to NDC have already presented ambitious priority actions to mitigate emissions from electricity supply significantly while ensuring affordable and universal access to electricity. To meet the growing demand for electricity, the Least Cost Power Development Plan (LCPDP) 2021 has identified geothermal energy as the most cost-effective technology. Geothermal resources, mainly located in the Rift Valley, are estimated to be able to provide over 10,000 MW of installed capacity.[31] LCPDP 2021 estimates that geothermal energy can provide around 25% of total electricity generation capacity in 2030, followed by hydropower at 20%.[32]

Increasing generation capacity while keeping emissions low can be a challenge in the absence of targeted interventions. If Kenya continues to rely on fossil fuels and fails to implement targeted interventions to capitalise on the cost-effective geothermal resources, the share of renewables in the electricity mix could fall to 41% in 2050 (see Figure 2.9), which is a significant decrease from 80% in 2018. Meanwhile, fossil fuels, such as oil and coal, would be relied on to fill the gap and increase with their shares in the electricity mix rising to 54%. This would lead to a significant increase in emissions from electricity generation from 0.5 $MtCO_2e$/year in 2020 to 23.7 $MtCO_2e$/year in 2050.

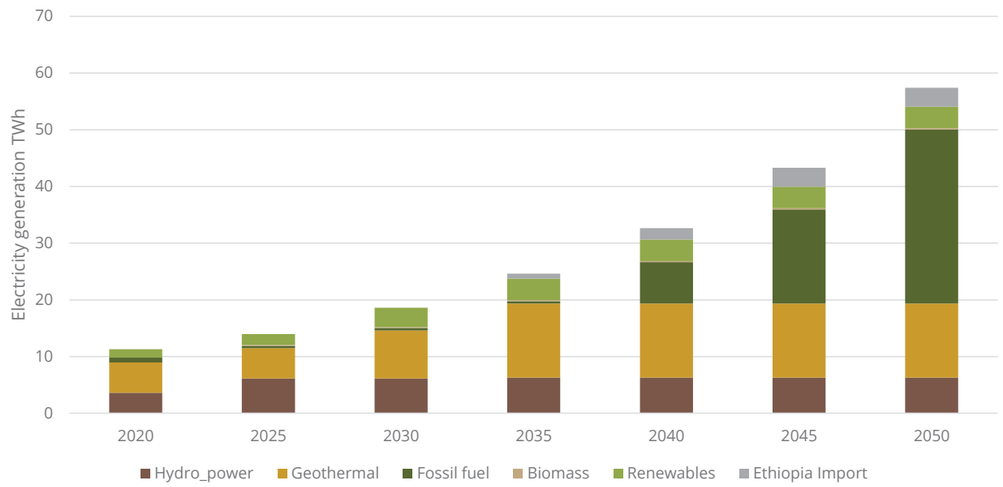


Figure 2.9 Electricity generation by fuel in the absence of targeted interventions, over 2020-2050, TWh/year

Source: LEAP modelling

Should targets announced in the current national plans be achieved, emissions from electricity generation would reach 13 $MtCO_2e$/year in 2050, instead of the 23.7 $MtCO_2e$/year in the absence of targeted interventions.

In support of Kenya's overall commitment to transition towards a net zero economy, the long-term strategy aims to eliminate almost all emissions from the electricity sector by 2050. Renewable energy will replace fossil fuels in the electricity mix. Additionally, a holistic long-term strategy towards net zero would not be limited to electricity generation alone; rather, widespread use of renewable energy will require further investment in electricity storage, including pump hydro and utility scale batteries.

[30]Based on the results of the macro modelling done for the LTS. The results are validated by the Kenyan Government.

[31]Geothermal Outlook in East Africa: Perspectives of Geothermal Development, 2018. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Events/2018/Jan/Geothermal-financing/S1-p1-IRENA-IGA-Presentation-31-01-2018.pdf?la=en&hash=52618994FFFF6833CFF3B51C6199982BC042741C Last accessed 2021-11-12

[32]IEA/IRENA Renewable Policies database, 2016. Available at: https://www.iea.org/policies/5634-least-cost-power-development-plan-2011-2031. Last accessed 2021-11-12

Therefore, building on the NCCAP 2018-2022 and the 2020 NDC Update, the LTS proposes additional interventions towards abating emissions from electricity generation by 2050. As part of the strategy, a deliberate effort to decommission all fossil-based power plants and move towards a 100% renewable will be desirable.

- All fossil fuel plants will be retired by 2047 and no new fossil fuel generation plants will be built
- The continued development of Kenya's electricity system with widespread renewable sources will require further investment in electricity storage, including pump hydro and utility scale batteries
- 50% of biogas from biogas plants will be used to produce 50MW of electricity from waste
  - The remaining 50% of biogas from biogas plants will be used locally within abattoirs for process captive energy or for heating
- Nuclear power will join the electricity mix to supply the base load

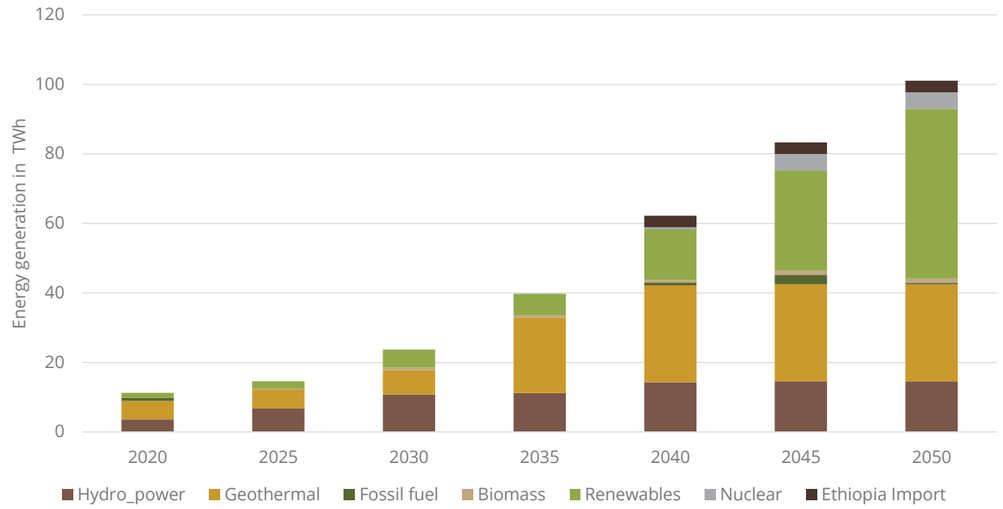


Figure 2.10 Electricity generation by fuel in the presence of targeted interventions to reach net zero emissions, over 2020-2050, TWh/year

Source: LEAP modelling


Photo Credit: CCD

Taken together, the ambition will be to lower emissions related to electricity generation to 0.23 $MtCO_2e$/year by 2050 whilst supporting a significant increase in electricity demand and access (see Figure 2.11).[32]

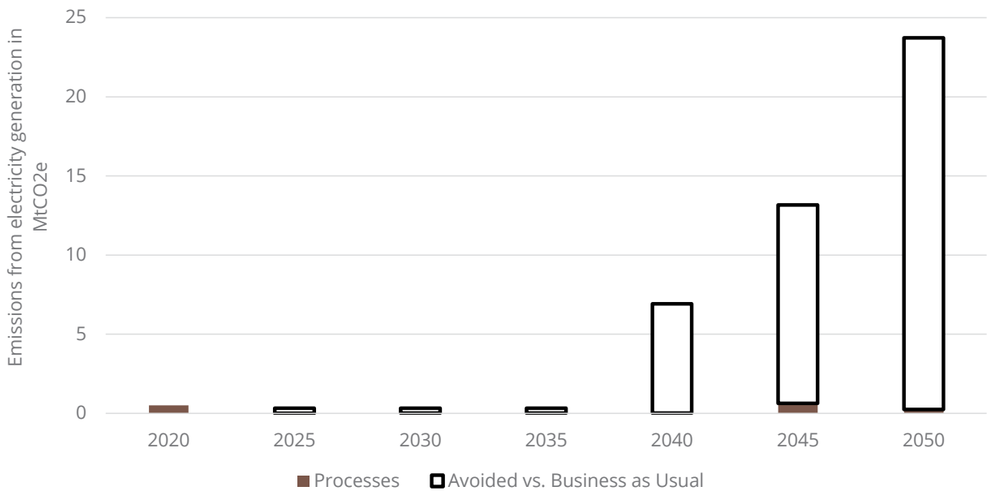


Figure 2.11 Emissions from electricity supply, over 2020-2050, $MtCO_2e$/year

Note: The white column shows the avoided emissions by the electricity sector thanks to the targeted interventions.

Source: LEAP modelling

[32]Due to differences in the assumptions on the share of renewable energy in the electricity mix, the LTS reports lower estimated emissions from electricity generation compared to the Updated NDC.

Photo Credit: CCD

2.3 Industry (Industrial Processes and Product Use, IPPU)

The main sources of IPPU emissions are minerals and chemicals processes, charcoal production, and consumption of HFCs. Figure 2.12 shows that process emissions increased rapidly from 3.8 $MtCO_2e$/year in 2010 to 5.4 $MtCO_2e$/year in 2020 as the economy and industrial activity saw strong growth. At 5.4 $MtCO_2e$/year, IPPU emissions represented roughly 7% of Kenya's total emissions in 2020. In that year, minerals led process emissions (3 $MtCO_2e$/year), followed by charcoal production (2.1 $MtCO_2e$/year), consumption of HFCs (0.2 $MtCO_2e$/year) and chemicals (0.1 $MtCO_2e$/year).

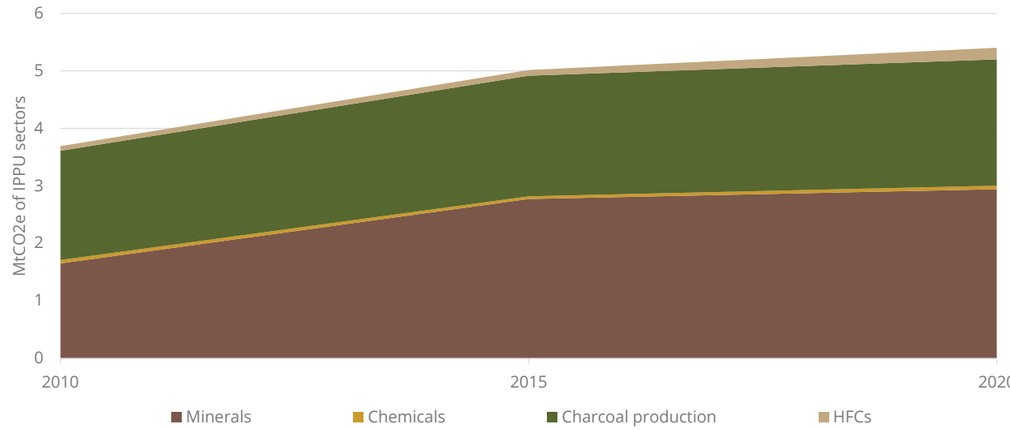


Figure 2.12 Historical IPPU emissions by sector

Source: IEA World Energy Balances (2020)

Cement manufacturing is a core industrial sub-sector of Kenya's economy. It is also the leading emitter of greenhouses in the industrial sector in Kenya.[34] The cement sub-sector is estimated to contribute to nearly 80% of industry sector emissions between 2010 and 2030, due to growing demand for cement within Kenya and in neighbouring countries.[35] Two aspects of cement production drive emissions: first, the chemical reaction involved in the production of clinker, the main component of cement, as carbonates are broken down into oxides and CO_2 by the addition of heat; and second, the combustion of fossil fuels to generate the significant energy required to heat the inputs to over 1,0000C.[36]

Cement in Kenya is classified into three main categories based on its raw material inputs and uses. Ordinary Portland Cement (OPC) is the product generally used for construction. It accounts for 14% of total cement production in Kenya. Portland Pozzolana Cement (PPC) is the most widely used type of cement in Kenya, accounting for 83% of total production. It is produced by mixing Pozzolana material with ordinary cement and is mainly used in infrastructural construction. The primary raw materials used for this cement are limestone and clay. The third type, Portland Limestone Cement (PLC), is produced with higher limestone contents. The production of PLC cement is mainly driven by the need to reduce the environmental footprint of cement production. Starting with the ordinary cement emission factor of 494kg CO_2 per ton of production (IPCC 2006a), PPC is 426kg CO_2 per ton of production as PLC is 395 kg CO_2 per ton of cement. As a result, PLC is the preferable type of cement for general use in the low carbon pathway.

[34]GoK, 2015. Ministry of Environment and Natural Resources; SNC

[35]NDC Updated Technical Report, 2020.

[36]Some of the cement manufacturers in Kenya use coal to fire their kilns in order to reduce energy costs, a practice which increases GHG emissions from the sector.

Charcoal is an important part of the Kenyan informal economy and serves as a primary source of income for rural and low-income population. Currently, 50% of households living in dryland areas (which accounts for 80% of the land area in Kenya) rely upon charcoal production as their main source of income. It has been estimated that the charcoal industry employs over 700,000 people and generates over US$400 million ever year in Kenya.[37] Charcoal production is expected to decline as other types of fuel sources such as liquified petroleum gas become more accessible, yet it is still a widely produced source of fuel. The charcoal production sub-sector accounts for the second highest source of IPPU emissions following only cement production.

Kenya has taken action to lower emissions associated with the production of charcoal. Emissions in the charcoal sub-sector can be reduced by using sustainably sourced biomass feedstock, improved kilns and efficient cookstoves, an approach which is the basis of the Nationally Appropriate Mitigation Action (NAMA) for the Charcoal Sector in Kenya. Implementation of the Charcoal NAMA requires the active involvement of National government, county governments, and local resource users such as the Charcoal Producer Associations (CPAs) and Charcoal Producer Groups (CPGs). The NAMA has been integrated with existing policies and sectoral planning tools, such as the Vision 2030, the Energy Policy and Act, and the REDD+ Strategy.

Guided by the Kenya 2030 Vision, Kenya has an ambition to become an industrialised country and expand the sector's contribution to GDP.[38] Consequently, in the absence of targeted interventions, IPPU emissions are expected to increase in line with increased industrial activity and population growth. As per Figure 2.13, over 2020-2050, total IPPU emissions from minerals and chemicals processes, charcoal production, and consumption of HFCs are expected to increase by 160% from 5.4 $MtCO_2e$/year in 2020 to 14 $MtCO_2e$/year in 2050. Of these, minerals processes and charcoal production are expected to make up about 40% each, whereas HFCs will account for 11%, and chemicals processes will emit less than 1%.

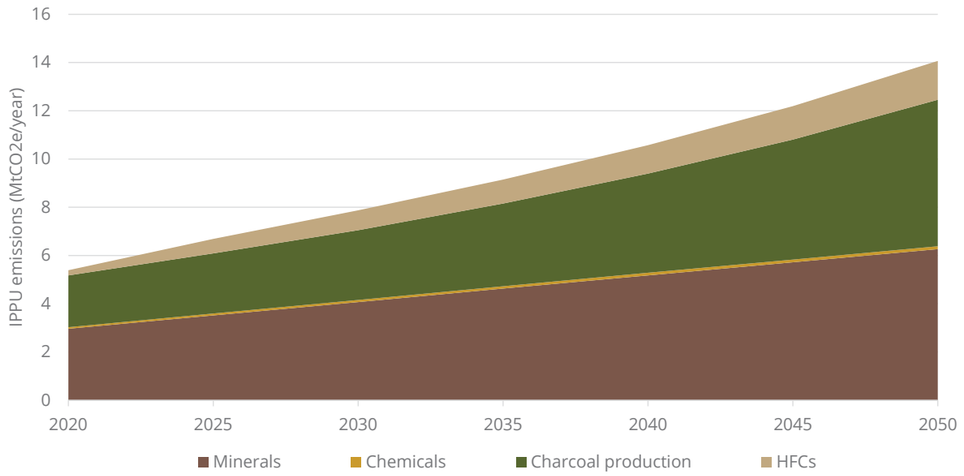


Figure 2.13 In the absence of targeted interventions, IPPU emissions can increase by 160% from 5.4 $MtCO_2e$ in 2020 to 14 $MtCO_2e$ in 2050 ($MtCO_2e$/year).

Source: LEAP modelling

Targeted interventions can lower IPPU emissions further and support the national transition towards net zero by 2050. These include:

- Transition from traditional charcoal to alternative energies in the residential sub-sector
- Reduce consumption of cement products by using innovative construction technologies such as interlocking bricks and composite tiles (natural rubber resins and sisal reinforcement)
- Adopting the Kigali Amendment and enhancing the building envelopes to reduce the need for cooling,[39] using low and zero GWP alternatives in all new equipment, and reducing HFCs leaks through better design, manufacturing, and servicing[40]
- Reduce GHG emissions by 25% through innovation such as carbon capture and storage technologies

The 2020 Update to the NDC also proposes implementation of the National Cooling Strategy (NCS) through the Green Cooling Initiative. The NCS is based on four key strategies to reduce direct and indirect emissions. These are:

- Increasing energy efficiency of appliances and equipment
- Transitioning to low-GWP natural refrigerants such as hydrocarbons
- Ensuring installation and servicing technicians are properly qualified to maintain appliances and equipment safety and energy efficiency
- Establishing a Measurement, Reporting and Verification (MRV) system to ensure best data on sector development

In total, targeted interventions in the industry sector can reduce about 9.6 $MtCO_2e$/year by 2050 and decrease total IPPU emissions to 4.45 $MtCO_2e$ by that time (see Figure 2.14).[41] Due to the implementation of NAMA and NCS, IPPU emissions from charcoal production and cooling will be largely eliminated. Meanwhile, IPPU emissions from mineral processes, such as cement, will slightly increase relative to 2020, despite saving 2.2 $MtCO_2e$/year in 2050 from the introduction of efficiency measures and innovative construction technologies. This is because cement demand will continue to rise in line with the economic growth.

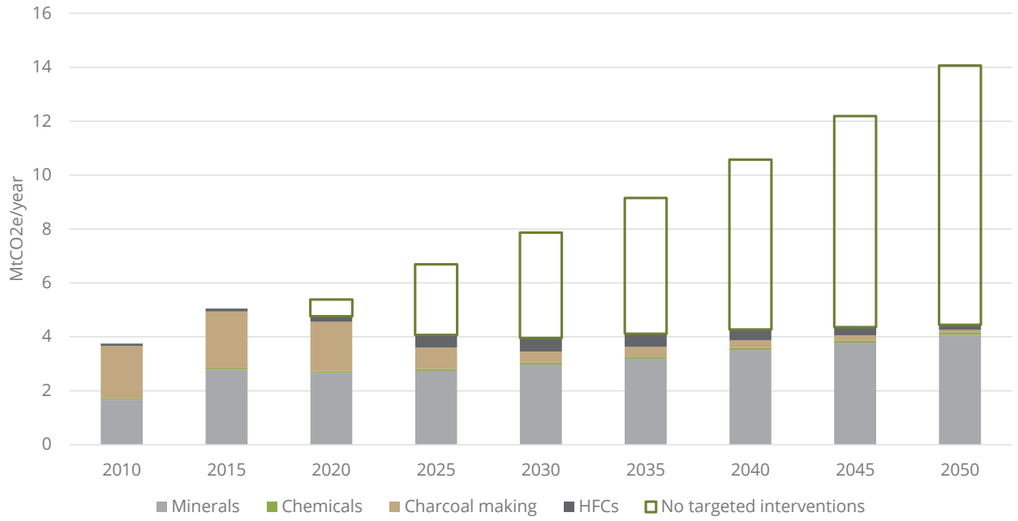


Figure 2.14 Targeted interventions can save about 9.6 $MtCO_2e$/year in IPPU emissions by 2050

Source: LEAP modelling

The rollout of circular economy principles across the industrial sector is an important step to achieving the modelled emissions reductions. A circular economy is one in which products and materials are recycled, repaired, and reused rather than thrown away, and in which waste from one industrial process becomes a valued input into another. In practice, this implies changes at each stage of the value chain. Starting with the production stage, it means changes to the sourcing of materials used in the manufacturing processes as well as the products design. At the use stage, circular economy principles apply changes to the typical use of products by the application of circular consumption modes and circular economy business models (e.g., sharing, product service or life extension models). At the end of use stage, it requires quality improvements in terms of the collection, trade and reprocessing of industrial waste.

[37]GoK, 2013. Ministry of Environment, Water and Natural Resources; Analysis of the Charcoal Value Chain in Kenya

[38]Ministry of Industrialization and Enterprise Development (2015) Kenya's industrial transformation programme. Available from: https://www.industrialization.go.ke/images/downloads/kenya-s-industrial-transformation-programme.pdf

[39]Building envelopes refers to the boundary between the interior and the exterior of a building and includes components such as external walls, floors, roofs and windows that are important for the energy efficiency of the building (IEA (2013) Technology Roadmap - Energy Efficient Building Envelopes. Available from: https://www.iea.org/reports/technology-roadmap-energy-efficient-building-envelopes)

[40]United Nations Environment Programme and International Energy Agency, 2020.

[41]In the Updated NDC charcoal and HFC were not reported in the estimations of IPPU emission, which leads to the emissions from the IPPU sector to differ in the LTS compared to the NDC.

2.4 Transport

The energy demand of the transport sector grew by 240% between 2010 and 2018 and reached 0.13 EJ in 2018. The rapidly expanding transportation sector is a key enabler and driver of economic development. Kenya is a commercial hub for eastern Africa, requiring a modern and resilient transportation infrastructure to support both national and regional economic growth.[42] Thus, the sector is both important in improving the competitiveness of products from Kenya and the region and for being a significant basis upon which the economic, social, and political pillars of the long-term development strategy will be built.

The transport sector in Kenya is a significant source of GHG emissions, accounting for 11.7 $MtCO_2$ in 2020. Emissions from the transport sector represented roughly 15% of total emissions in Kenya in 2020. Road transport accounts for the lion's share of the energy demand in the transport sector (99%).[43] Within road transport, passenger transport accounts for about three quarters of the emissions, whereas one quarter is from freight transport. The transport sector relies exclusively on fossil fuels with oil products accounting for 100% of fuel consumption from 2000 to 2018 (see Figure 2.15).

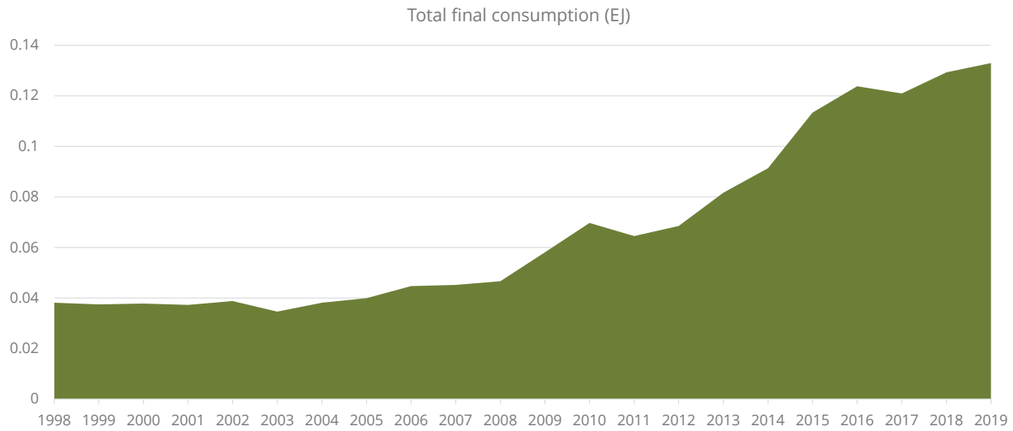


Figure 2.15 Total transport energy consumption by source, EJ/year, Kenya 2000-2018

Source: IEA World Energy Balances (2020)

The emissions associated with the energy demand in the transport sector are expected to grow rapidly in parallel with economic growth. Without targeted interventions to reduce the transport sector's energy and emissions intensity, the sector's energy demand will grow steadily and reach 1,050 PJ by 2050, resulting in emissions that could exceed 75.7 $MtCO_2$/year by 2050. The increase in emissions will be driven by the increased use of oil products given the exclusive use of oil in the sector. Based on current trends, in 2050, gasoline and diesel will account for nearly the entirety of fuel demands in the transport sector, with each fuel source accounting for roughly half of the total.

[42]Kenya - Second National Communication to the United Nations Framework Convention on Climate Change, 2015. Available at: https://unfccc.int/resource/docs/natc/kennc2es.pdf. Last accessed 2021-11-12

[43]IEA World Energy Balances, 2020.

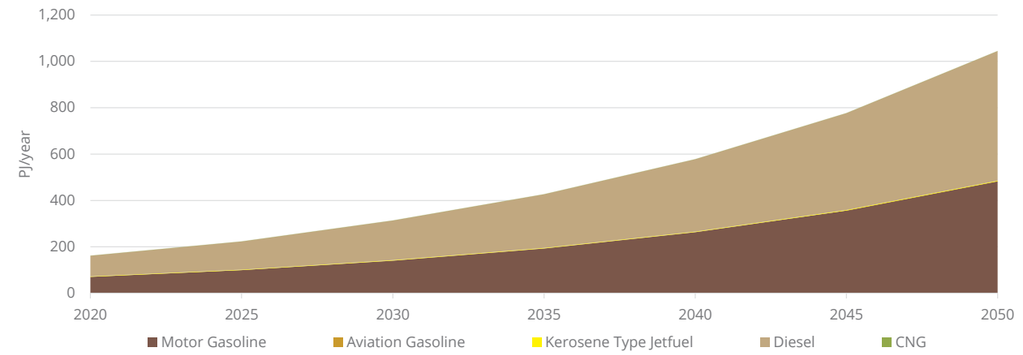


Figure 2.16 Fuel mix of the transport sector under BAU scenario, 2020- 2050

Source: LEAP modelling

The sector's rapid growth demonstrates its importance as a key lever for climate mitigation policies. From 2015-2020, transport emissions grew at about 32.9% from 8.8 $MtCO_2e$ to 11.7 $MtCO_2e$. The BaU modelling scenario estimates continued growth in emissions from the transport sector, leading to about 75.7 $MtCO_2e$ from the sector by 2050. Of these, 79% of emissions are likely to come from passenger transport, 20% from freight, and about 1% from other forms of transport.[44] The National Transport and Safety Authority (NTSA) projects that between 2020 and 2030 Kenya will have between 4.1 and 5 million vehicles, 46% of which will be privately owned cars, a trend which is consistent with the growing economy and rising income levels. At the same time, the registration of motorcycles has also been rising rapidly.

Kenya has already taken steps to reduce its emissions from the transport sector. To improve public transport services and reduce emissions, Kenya is working towards the development of a Mass Rapid Transit System (MRTS) for the Nairobi Metropolitan Area. As well, the National Climate Change Action Plan (NCCAP) 2018-2022 and its supporting Mitigation Technical Analysis Report prioritise the following short-, medium- and long-term mitigation actions for the transport sector.[45] These interventions from the NCCAP 2018-2022 are expected to deliver about 11 $MtCO_2$/year of emissions reduction by 2050.

- Target a reduction of emissions of 1.8 and 4.7 $MtCO_2e$/year by 2022 and 2030, respectively
- Electrification of the Mombasa-Nairobi railway and transfer of freight from road to rail (target: 30%)
- Extend the standard gauge railway (SGR) from Nairobi to Naivasha
- Invest in a Bus Rapid Transit (BRT) system for the Nairobi metropolitan area
- Increase efficiency of light- and heavy-duty trucks by implementing infrastructure improvements, developing strict vehicle standards, promoting fuel-efficient driving
- Provide power infrastructure in ports, substituting the use of ship engines during landing
- Enable the use of sustainable aviation fuels and foster the deployment of solar photovoltaics and biodiesel for ground services
- Support domestic research and development of renewable energy for all modes of goods and people transportation

The 2020 Update to Kenya's Nationally Determined Contributions (NDC) further outline the following priority 2030 mitigation targets for the transport sector:[46]

- Develop an electric bus transit system connecting Nairobi central business district (CBD) and the capital's airport
- Upgrades to the Nairobi Commuter Rail service, comprising new stations and rolling stock
- Include passenger transportation in the planning for the electrification of the Mombasa-Nairobi SGR
- Establish a new Air Navigation Control Centre to optimise air routes and reduce congestions
- A shift from truck-based transportation of oil to a pipeline-based system

[44]Mitigation Technical Analysis Report (MTAR 2018-22). Available at: http://www.environment.go.ke/wp-content/uploads/2020/03/MTAR-2018-2022-Final-v3.pdf.Last accessed 2021-11-12

[45]National Climate Change Action Plan (NCCAP) 2018-2022 – Volume I & II

[46]Nationally Determined Contribution – Updated Technical Report 2020 (Kenya)

With additional targeted interventions, emissions from the transport sector can be significantly reduced to help Kenya approach net zero by 2050, while still enabling the sector to accommodate rapid growth in economic activity and population. Additional targeted interventions include the following:

- Continue and accelerate the decarbonisation of the transport sector by promoting low-emission transportation modes for goods and public transportation for passenger mobility
- Future rail development to accommodate electricity driven locomotives and Extension of SGR from Naivasha-to-Malaba
  - The expansion of the rail network will make the transport sector efficient, resulting in more people opting to use rail instead of road and more people opting to favour use of public rail transport to private transport
  - An estimated balance of 50% public service vehicles will be delivered through BRT and the other 50% via meter gauge rail transport within the cities
- Shift the freight transport from truck to train with the extension of SGR to Malaba
- Transition from fossil fuel to electric and hydrogen fuelled vehicles, with 30% of all vehicles on road to be electric or hydrogen powered by 2050
  - With the extension of SGR to Malaba, it is assumed that most of the freight shall shift from truck to train
  - It is assumed that 90% of truck transport will transition to train and the remaining 10 percent will consist of state-of-the-art trucks on hydrogen fuel cells
- All (100%) motorcycles on roads to be electric by 2050
- Ensure total implementation of urban transport policy in all urban centres, with 100% compliance by 2050
  - More Kenyans will be living in urban centres than anywhere else by 2050
  - This requires planned cities and transport
- Installation of shore power in all berths at the port
- Implementation of the single window system to increase port operations efficiency hence reducing ship dwell time
- Compliance in Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

These targeted interventions can reduce emissions from the transport sector in 2050 from a total of 76 $MtCO_2$ to 9.8 $MtCO_2$ in 2050 (see Figure 2.17). Given that road transport accounts for the majority of emissions from the transport sector, it will account for about 99% of the emissions reduction in 2050. As Figure 2.17 shows, the targeted interventions will reduce the energy demand of the transport sector to 240 PJ/year by 2050, a three-quarters decrease compared to the absence of the targeted interventions. The fuel mix will change dramatically too. In 2050, the total share of gasoline and diesel oil in the fuel mix will be around 45%, whereas electricity will account for 42%. XNG and LPG will make up 12% of the fuel mix, whereas the share of hydrogen will be less than 1%.

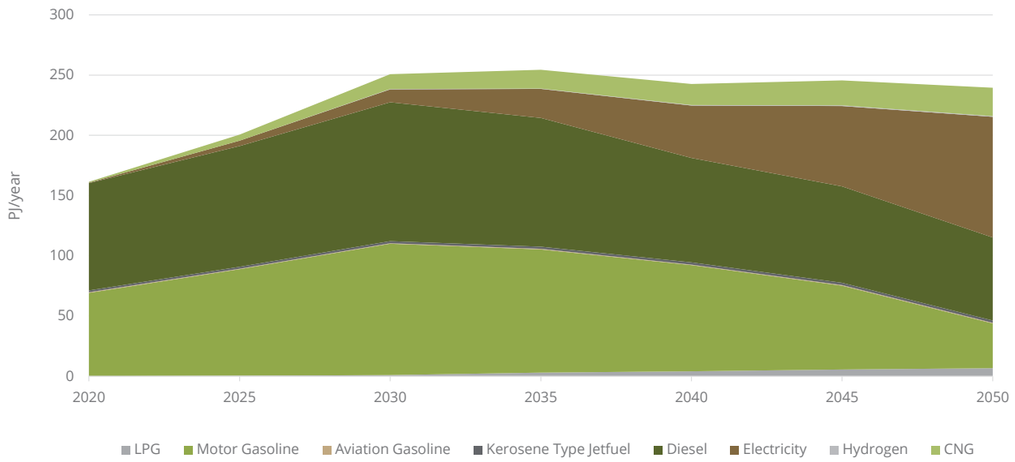


Figure 2.17 Fuel mix of the transport sector under LTS scenario, 2020- 2050

Source: LEAP modelling

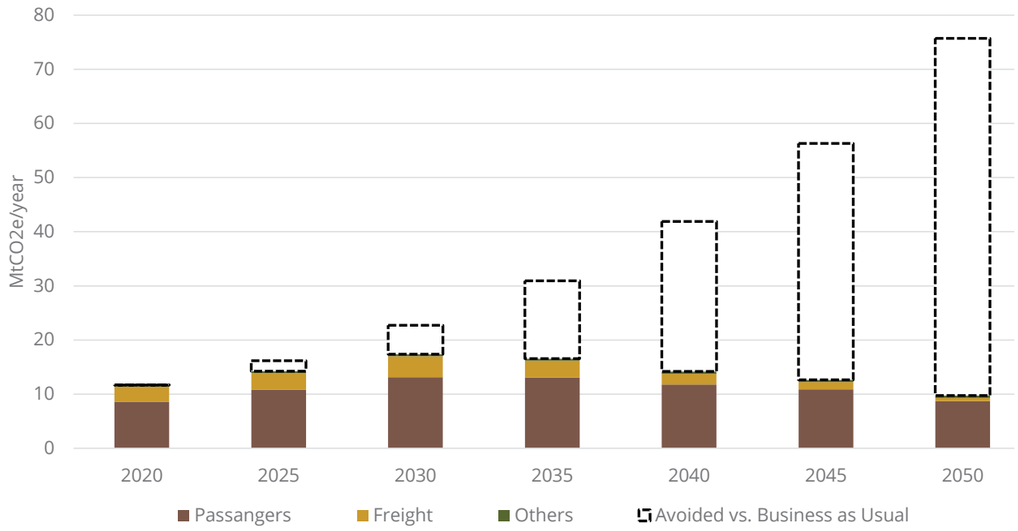


Figure 2.18 Projections of transport emissions savings under the LTS scenario ($MtCO_2e$/year)

Source: LEAP modelling

2.5 Waste

Poor waste management exacerbate emissions from waste incineration, solid waste disposal, open burning of waste, and wastewater treatment. The waste sector in Kenya accounted for about 2.3 $MtCO_2e$ in 2015 and 2.6 $MtCO_2e$ in 2019. Around three quarters of waste emissions result from methane from industrial wastewater.[47]

Improving the climate resilience of waste disposal systems and facilities is important to mitigate hazardous contamination of air, water, and soil that negatively affect human health. If managed improperly, solid wastes can obstruct areas intended for water runoff and flood control, increasing urban population vulnerability to contaminated water. This risk increases as climate change drives more intense and heavy rains in Kenya. Effective waste management can therefore play a significant role in addressing climate change health impacts, reducing risks of water-borne diseases. Waste incineration also contributes significantly to household air pollution. Therefore, improved household waste management systems would contribute positively to environmental objectives by reducing GHG emissions while also having a positive impact on the health of Kenya's urban population.

Rising population growth and urban population density, as well as changes to urban lifestyles, indicate the importance of effective management and decarbonisation of the waste sector. As illustrated in Figure 2.19, waste sector emissions rose by about a half from 2010-2020, increasing from 2.9 $MtCO_2e$ to 4.2 $MtCO_2e$/year, and are projected to reach 16.1 $MtCO_2e$/year by 2050 in the absence of targeted interventions.[48] The majority of these emissions is attributed to methane from industrial wastewater, followed by methane from MSW in landfills, as shown in Figure 2.19b.

[47] Kenya's Updated Nationally Determined Contribution (NDC), 2020; Table 3.53.

[48] The difference between the historical waste sector emissions in the 2020 Update to NDC and the LTS report stems from the different global warming potentials used in the reports, 21 and 28 CO2e/kg methane. Note that the LTS report uses a more disaggregated data compared to the 2020 Update to NDC and additionally considers emissions from wastewater treatment in lagoons.

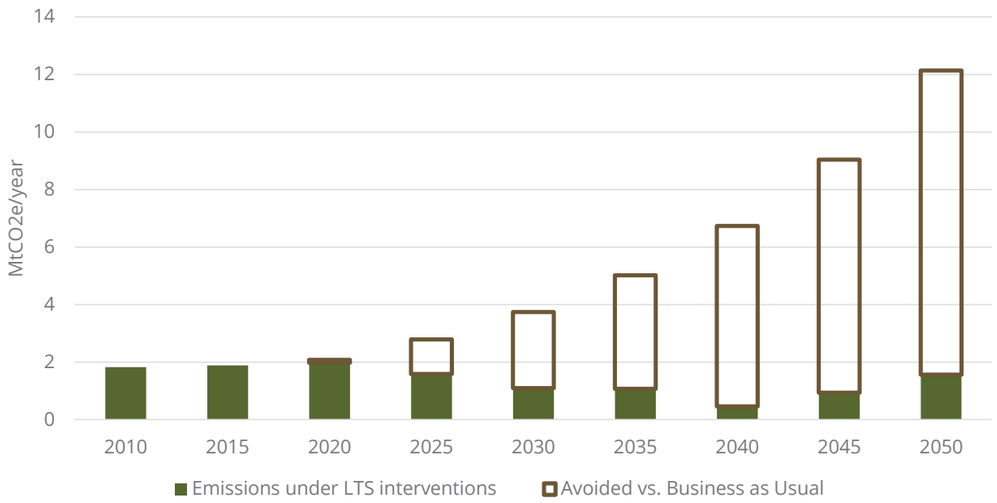


Figure 2.19a Waste sector emissions and mitigation potential, 2020 – 2050, $MtCO_2e$/year

Source: LEAP modelling

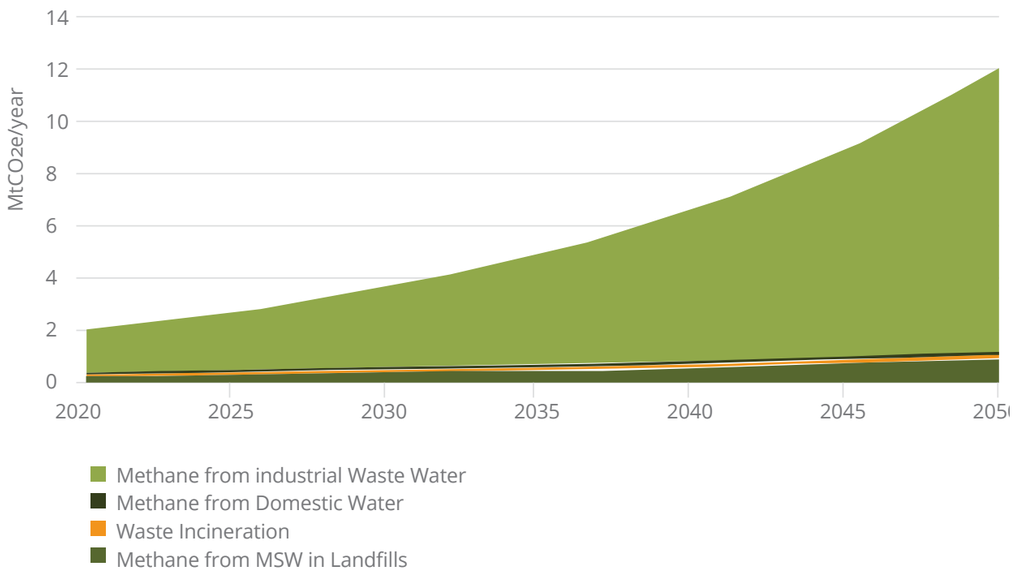


Figure 2.19b Waste sector emissions forecast, 2020 – 2050, $MtCO_2e$/year

Source: LEAP modelling

Kenya has taken steps to decrease its emissions from the waste sector. The key policy in the waste sector is the *Implementation of the Solid Waste NAMA; A Circular Economy Solid Waste Management Approach for Urban Areas in Kenya.*[49] The NAMA, developed in 2016, facilitates the diversion of 90% of waste away from disposal sites and towards various recycling practices. It aims to achieve 30% waste recovery through recycling, land fill and composting, and 70% controlled dumping (tipping, compacting, and recovery) in at least one urban area in 20 counties by 2030. Actions within this plan include the creation of recycling points for waste sorting and subsequent recycling, as well as composting facilities for organic waste treatment. The solid waste NAMA aims for national recycling levels of up to 600 tonnes of waste each day, and ultimately aims to reduce GHG emissions by more than 0.8 $MtCO_2e$ over the 15-year project plan.[50] In addition, the NAMA support project (NSP) will be in place from 2023 and is designed to reduce waste and emissions from post-harvest losses in agricultural sector by expanding solar-powered cold chain services from production to the end market.[51]

The National Climate Change Action Plan 2018-2022 and its supporting Mitigation Technical Analysis Report prioritized the following mitigation actions for the waste sector:

- Promote recycling through the Solid Waste NAMA to divert collected waste away from disposal sites
- Facilitate options for methane capture and power generation at landfill sites
- Explore waste incineration for energy generation, such as the facility currently operated by Bamburi Cement in Mombasa

The 2020 Update to Nationally Determined Contributions (NDC) includes the following additional 2030 mitigation actions for the waste sector:

- Landfill flaring as a second-best alternative to landfill methane capture. With landfill flaring, no electricity is generated, but the captured methane is burned to avoid its release into the atmosphere
- Wastewater treatment in the form of wastewater methane capture and utilisation
- Anaerobic composting for treating organic waste, which can recover energy in the form of biogas and compost in the form of a solid residual

The listed interventions have the potential to reduce GHG emission by about 0.78 $MtCO_2e$ in 2030. However, this is not enough to decrease emissions from the waste significantly. The LTS therefore proposes targeted interventions to lower waste emissions significantly and contribute to Kenya's effort towards net zero by 2050. A comprehensive implementation of waste management is considered in the LTS:

- As proposed in the sustainable waste management policy, 95% of consumer point wastes will undergo recycling and reuse through enhanced industrial symbiosis
  - This leaves only 5% of waste, which will be directed into the material recovery sites.
  - This would further ensure material recovery or enable use in modern incineration lagoons.
  - As such, the greatest challenge exists in reducing emissions associated with wastewater treatment
- Complete collection and treatment of wastewater with methane recovery for electricity generation
  - The residential sector in urban areas will be connected to the national sewer system, discharging the wastewater into national waste management sites

These interventions can lower GHG emissions from the waste sector to 1.7 $MtCO_2e$/year by 2050, a 14.3 $MtCO_2e$/year reduction (89%) compared to the BAU scenario, as shown in Figure 2.19aFigure 2.. The remaining emissions would come from waste incineration and methane from municipal solid waste, and domestic and industrial wastewater. Methane from industrial wastewater is expected to be the largest source of emissions in the waste sector.

[49]Nationally Appropriate Mitigation Action (NAMA) on Circular Economy Solid Waste Management Approach for Urban Areas in Kenya, 2017.
[50]Ibid.
[51]NAMA Facility. Available at: https://www.nama-facility.org/projects/kenya-solar-powered-cold-chain-services/. Last accessed 2021-11-12

2.6 Agriculture

Increasing the resilience to climate change is crucial to ensure food security and can also limit emissions from the agricultural sector. Food insecurity in Kenya is currently high, with 1.3 million Kenyans in arid and semi-arid regions having food insecurity causing acute malnutrition, or only being able to marginally meet minimum food needs by depleting essential livelihood assets.[52] Climate change, combined with rapid population growth, could exacerbate food insecurity as the agricultural sector is highly vulnerable to climate change related risks such as increasing temperatures and changing precipitation patterns. The priority for the agricultural sector is therefore to increase output and build resilience to climate change to ensure that the food supply is sufficient to sustain a growing population. There are opportunities to address these challenges whilst reducing the carbon intensity of the sector, for example by improving the productivity of livestock, increased use of low carbon cropping techniques that do not compromise food insecurity and switching diets.[53]

Agriculture being a key sector for Kenya's economy directly contributed 33% of Kenya's GDP in 2020 and employed 40% of the total population.[54] It also accounted for an additional 27% of GDP through linkages to other sectors such as manufacturing, distribution and services. Agriculture is an important component in the balance of trade, generating around two-thirds of merchandise exports and 60% of foreign exchange earnings.[55] [56]t is a major source of livelihood and food security, especially for the majority of the rural population who are smallholder farmers. The agriculture sector encompasses three key subsectors: crops, livestock and fisheries. Major cultivated crops include tea, coffee, maize, and wheat.

Cultivation of crops has the largest contribution to agricultural GDP while the livestock subsector is the largest source of agricultural employment. In total, food crops, industrial crops[57] and horticulture accounts for more than 75% of agricultural GDP. The livestock subsector employs about 50% of the agricultural labour force and is the main agricultural enterprise for over 10 million Kenyans living in the arid and semi-arid lands. In addition, the fishery sector employs around 300,000 people and provides livelihood for 4 million people.[58] Fish currently accounts for less than 10% of animal protein intake[59] but is a growing share of food source in Kenya and can provide a low carbon alternative protein source.

Emissions from the agricultural sector has increased rapidly over the past decades. Emissions from the agricultural sector reached 50.5 $MtCO_2e$ in 2020, an increase by 53% since 2010.[60] Figure 2.20 shows the agriculture emissions over the same period and provides a breakdown by subsector. Enteric fermentation and manure management accounts for the largest share of agricultural emissions, increasing 76% from 20.5 $MtCO_2e$ in 2010 to 36.1 $MtCO_2e$ in 2020. The second largest source of agricultural emissions, mineralisation of soil organic matter, increased by 13% over the same time-period, reaching 13.7 $MtCO_2e$ in 2020. Enteric fermentation and mineralisation of soil organic matter together accounted for 99% of total emissions from agriculture in 2020, with fertiliser application and rice cultivation amounting to just 1% of total emissions.

The increase in emissions from the livestock sector coincided with a doubling of the number of livestock between 2009 and 2019. The increase in livestock was largely driven by a rise in the number of ruminant livestock (cattle, sheep, and goats)[61], a major source of emissions from enteric fermentation. Ruminant livestock increased from 35 million animals in 2009 to 66 million in 2019 and accounted for 91% of all livestock in 2019.[62]

[52]IPC, Famine Facts. Available at: http://www.ipcinfo.org/famine-facts/en/ . Last accessed 2021-11-12

[53]NAMA facility. Available at: https://www.nama-facility.org/projects/kenya-solar-powered-cold-chain-services/ . Last accessed 2021-11-12

[54]USAID, Kenya, Agriculture and Food Security, 2021. Available at: https://www.usaid.gov/kenya/agriculture-and-food-security. Last accessed 2021-11-12

[55]Government of Kenya, 2018. Agricultural Sector Transformation and Growth Strategy. Available at: https://www.agck.or.ke/Downloads/ASTGS-Full-Version-1.pdf. Last accessed 2021-11-12

[56]World Bank, Open Knowledge Repository, Kenya: Agricultural Sector Risk Assessment, 2015. Available at: https://openknowledge.worldbank.org/handle/10986/23350. Last access 2021-11-12

[57]Crops not normally sold directly for consumption. Main industrial crops in Kenya include tea, coffee, sugarcane, sunflower and cotton (Kenya Climate Smart Agriculture Implementation Framework (2018-2027), Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Industrial_crops, Last accessed 2021-11-12)

[58]Kenya Climate Smart Agriculture Implementation Framework (2018-2027)

[59]FAO, 2019. High aquaculture growth needed to improve food security and nutrition. Available at: https://www.fao.org/3/ca4693en/ca4693en.pdf. Last accessed 2021-11-12

[60]LEAP modelling

[61]Gibbs, J.M et al. CH4 Emissions from Enteric Fermentation. Available at: https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/4_1_CH4_Enteric_Fermentation.pdf. Last accessed 2021-11-12

[62]LEAP modelling

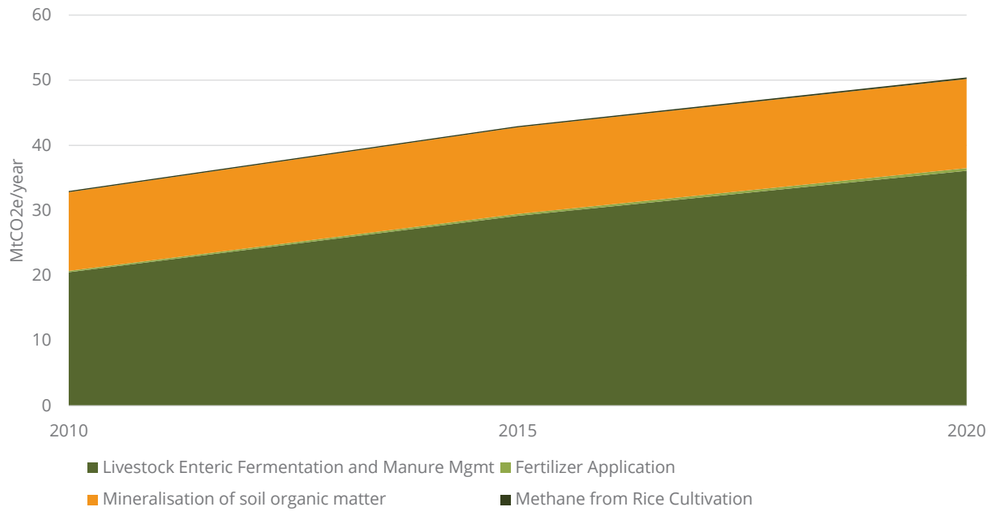


Figure 2.20 Emissions from the agricultural sector, over 2010-2020, MtCO2e/year

Source: LEAP modelling

Emissions from the agricultural sector are expected to continue to rise in the absence of targeted interventions. If Kenya follows the current development pattern, agricultural emissions could increase by 73% by 2050 relative to 2020 levels, reaching 87.2 $MtCO_2e$ in 2050. Emissions from enteric fermentation and manure management would account for 69% of total agricultural emissions in 2050 (59.9 $MtCO_2e$/year), an increase by 23.8 $MtCO_2e$/year relative to 2020. Mineralisation of soil organic matter would account for another 30%, with rice cultivation and fertiliser application together remaining at around 1% of agricultural emissions.

To mitigate emissions from the agricultural sector, the NCCAP 2018-2022 and the 2020 Update of Kenya's NDC sets out a range of targets and actions.

- Implementing the Nationally Appropriate Mitigation Action (NAMA) for the dairy sub-sector
- Increasing the total area under agroforestry at farm level by 200,000 acres (81,000 Hectares) by 2022 and 400,000 acres (162,000 Hectares) by 2030
- Increasing the farm area under sustainable land management by 250,000 acres (101,000 Hectares) by 2022 and 500,000 acres (202,000 hectares) by 2030
- Putting 50% of the 30,000 hectares under rice production into efficient production technologies by 2022
- Increasing the area under rain-fed rice production from 400 hectares to 600 hectares by 2022
- Increasing deep/offshore fishing fleet from 9 to 68 boats by 2022
- Increasing the number of farmers using low carbon (recirculation) aquaculture systems from 20 to 180 by 2022

The Low Carbon, Climate Resilient Agricultural Development Pathways for Kenya proposes an ambitious plan to stabilise emissions from the agricultural sector. The pathway envisages a paradigm shift in mitigation interventions, adopting of more ambitious green growth policies and climate actions. The focus is on livestock management, restoration of degraded agricultural landscapes and agronomic practices which are main sources of emissions. Beyond intensification of dairy production, additional actions include sustainable rice production and methane recovery from sustainable manure management:

- Adopting biogas production for cooking by 20% of farmers under zero grazing
- Using biogas from 200 abattoirs to self-generate electricity and connecting them to grid under the feed in tariff policy
  - An assumed average capacity of 500kW per abattoir

50% delivered to grid by 2025 and another 50% by 2030

Further interventions are required to support Kenya to peak and stabilise emissions from the agricultural sector by 2050 while ensuring food security for a growing population. This LTS builds on the actions aiming at improved efficiency in the livestock sector and modern production technologies. Through efficiency increases in livestock breeding, increased biogas generation, modern rice production practices and improved manure management, the long-term strategy sets out a trajectory for substantial emission reductions in the agricultural sector.

- Breeding livestock for heat tolerance as well as increase productivity to reduce methane emissions
- Optimising waste to energy production with potential utilisation of 50% total abattoir waste to electricity generation
- Shifting to modern rice production practices with intermittent irrigation
- Improving manure management and utilising advancements in biogas technology and capacity building and improved dung collection and feeding to generate biogas for residential demand
- Increase the land under conservation agriculture (minimum or no-tillage) to 30% of total land under cultivation

Soil organic carbon stocks may offer additional mitigation potential in the agriculture sector but are currently poorly understood in the Kenyan context. No data or academic work on their sequestration potential in Kenya has been published since a 2007 study by Kamoni et al. That study found significant variation in soil organic carbon stocks for the year 2000, depending on which model is used.[63] Given this uncertainty, soil organic carbon is omitted from mitigation estimates until better data is available, to be incorporated into future editions of the LTS. It is also excluded from estimates as the LEAP model forecasts emissions and not sequestration.

Agricultural productivity needs to increase to sustain a larger population while limiting emissions from the sector. To provide food security to an increasing population while limiting agricultural emissions, agricultural output must increase. If growth in agricultural output leads to increased conversion of forest land to cropland, it would decrease the mitigation potential of the forestry sector. Thus, the increase in cropland needs to be constrained. Maize, the largest crop in terms of harvested area, is expected to increase by up to 64% by 2050 relative to the 2020 level. In contrast, tea, coffee, and sugarcane can increase by around 20%. Rice cultivation combined with a switch to modern production practices with intermittent irrigation, means that cultivated rice area can double by 2050, but will account for just 1% of total harvested area.

Limiting the emissions from the livestock subsector will require increased productivity of the sector and constrained growth in animal numbers. This can be achieved by increasing the productivity of livestock and their resilience to climate shocks, and by shifting consumption towards lower-carbon sources of protein, such as fish. Within the livestock subsector, sheep and goats will need to see the largest decline in the number of animals relative to the business-as-usual (BAU) projections and reach 2 million and 3 million animals by 2050 respectively, a decrease by more than 50% by 2050 relative to the BAU. Dairy and non-dairy cattle, a major source of enteric fermentation, will also need to decline substantially relative to the BAU and reach a level almost 40% lower relative to the business-as-usual projections at 6 and 16 million animals respectively. In contrast, as a low-carbon meat option, the number of poultry will see a reduction of just 9% relative to the business-as usual-level.

Although the interventions set out in the LTS reflect significant emission reductions relative to the business-as-usual projections, agricultural emissions are still expected to grow. Implementation of the targets in the long-term strategy is estimated to lead to a decrease in agricultural emissions of 23.5 $MtCO_2e$ in 2050, relative to the BAU.[64] However, agricultural emissions are still expected to increase by 26% relative to the 2020 BAU level. Enteric fermentation and manure management is estimated to reach 35.6 $MtCO_2e$ in 2050, a decrease by 41% relative to the 2050 level in the absence of any interventions. Emissions from fertiliser application and rice cultivation are estimated to remain similar to the levels in the absence of any interventions but are projected to amount to just 0.5 $MtCO_2e$ and 0.2 $MtCO_2e$ in 2050 respectively. In contrast, emissions from mineralisation of soil organic matter are estimated to increase by 4% 2050 due to increased agricultural land use, leading to a net abatement of 23.5 $MtCO_2e$ in 2050.

[63]Kamoni et al. (2007), 'Predicted soil organic carbon stocks and changes in Kenya between 1990 and 2030', Agriculture, Ecosystems and Environment 122 (2007) 105–113.

[64]Due to improved data availability, the LTS estimates higher emissions from the agricultural sector compared to the estimated emissions in the updated NDC.

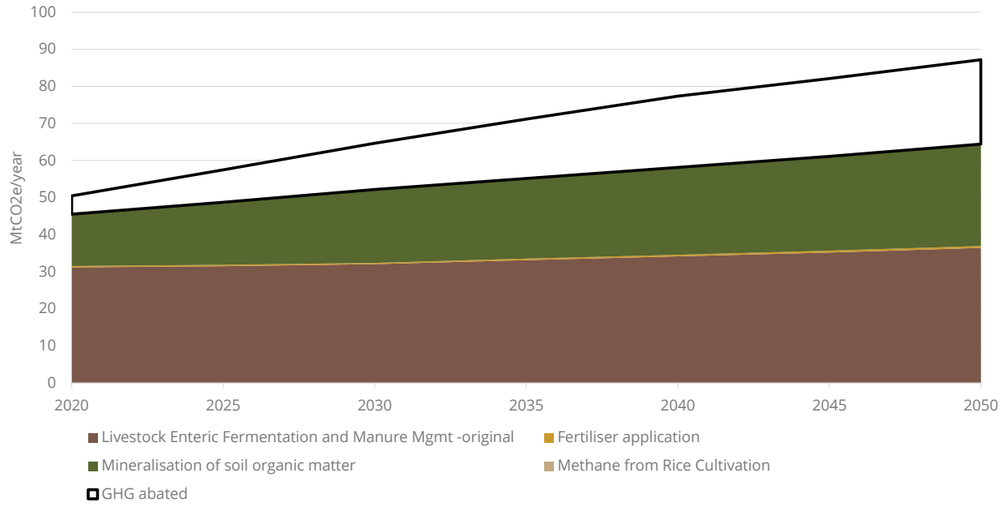


Figure 2.21 Emission abatement in agriculture under the long-term strategy

Source: LEAP modelling

Photo Credit: CCD

2.7 Land use, land use change, and forestry

This chapter relies on data from the National Forest Reference Level (2019). This data is compiled using 30m x 30m satellite images and estimated forest cover in 2018 at 5.9%. Since the preparation of this LTS, a new survey of national tree cover has been carried out using much more granular satellite data (0.5m x 0.5m) which estimated national forest cover at 8.9% in 2021.[65] Whilst the latter data may be more accurate, thanks to the higher resolution, it only provides a single point-in-time estimate and cannot be used to assess changes in forest cover over time, which is essential for estimating emissions. We therefore rely on the FRL data to estimate deforestation trends and emissions but acknowledge that future updates to the LTS may need to reflect the latest data available and re-estimate rates of deforestation and associated emissions.

Kenya's forest cover accounted for 5.9% of total land area in 2018 and comprises of three forest ecozones, namely Dryland forest areas, Montane and Western Rain forest areas and Coastal and Mangrove forest areas. Forest cover has decreased over the past decades from 6.2% in 2002,[66] driven by clearance for agriculture, increased urbanisation, and unsustainable utilisation of forest resources.[67] Both the deforestation and afforestation rates have been high over the past decades. Between 2002 and 2018 on average 339,000 ha of forest land was deforested each year, whereas 327,000 ha were afforested per year over the same time-period, leading to a slow decrease in the forest cover. Dryland forests experienced both the highest afforestation and deforestation rates of 210,000 ha and 211,000 ha respectively, causing dryland forests to decrease by just 1% between 2002 and 2018. Montane and western rainforests and coastal and mangrove forests experienced lower rates of deforestation in absolute terms. However, a relatively larger difference between afforestation and deforestation compared to dryland forest led to decreases in land cover by 8.6% and 8.9% respectively between 2002 and 2018 for these two forest types.[68]

While significant changes in policy and legislation have been undertaken over the last decade that seek to strengthen sustainable forest management and conservation, Kenya's forest resources continue to experience severe pressure. Challenges such as an expansion of agricultural land and increased urbanisation might reduce the potential to realise commitments to national and international forest goals made by country unless these challenges are addressed. However, improved governance of the sector arising from the devolution and public participation in forest management may contribute to a stronger protection of Kenya's forests. This is, however, expected to take some time as capacities within county governments are strengthened to assume expanded responsibilities.

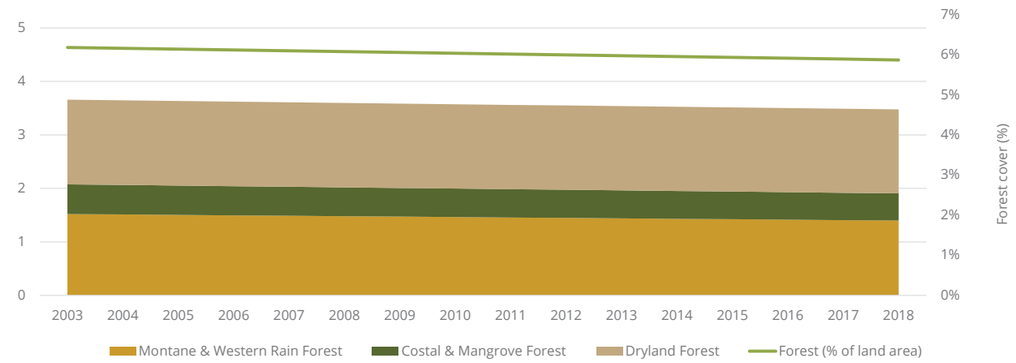


Figure 2.22 Kenya's forest cover fell from 6.2% of total land area in 2002 to 5.9% in 2018

Source: *LEAP modelling*

[65]National Forest Resources Assessment Report, 2021
[66]Ministry of Environment and Forestry, 2019. National Forest Reference Level for REDD+ Implementation
[67]Ibid.
[68]Ibid.

The estimates of emissions from the forest sector are highly dependent on the definition of forests and assumptions regarding forest cover. The long-term strategy follows the definition of forest cover set out in the National Forest Reference Level for REDD+ Implementation and classifies forest as land with a minimum of 15% canopy cover, minimum land area of 0.5 ha and with the potential to reach a minimum height of 2 meters.[69] As Kenya has a large amount of bushlands with patches of low trees, the classification of forests as land with trees over 2 meters and of more than 0.5 ha, implies that large land areas are at the margin of this definition. Consequently, land areas might fluctuate between being classified as forest and non-forests, which will exaggerate the apparent changes in land use. Combined with uncertainties over the current forest cover, this creates substantial uncertainty in the emission estimates, leading to significant revisions of historic emissions from the forestry sector in the updated NDC. Any future reclassifications of forest land, and associated measures of afforestation and deforestation, may have significant impacts on the historic, projected, and potential emissions reductions and sequestration from the LULUCF sector.[70] The estimated historical and future emissions from the LULUCF sector differ between the Updated NDC and the LTS. Whereas emissions from the sector are estimated to have been approximately twice as high between 2010 and 2020 in the LTS compared to the Updated NDC, the inclusion of carbon sequestration in the LTS leads to the sector becoming a carbon sink from 2030 in the LTS.

Deforestation has meant that land use, land-use change, and forestry have been a significant contributor to Kenya's emissions, amounting to 52.2 $MtCO_2e$/year between 2002 and 2018.[71] Deforestation is the largest source of emissions from the forestry sector and amounted to on average 48.2 $MtCO_2e$/year between 2002 and 2018. Forest degradation accounted for an additional 10.9 $MtCO_2e$/year and sustainable management of plantation forests contributed with 2.7 $MtCO_2e$/year, bringing total emissions from the forestry sector to 61.7 $MtCO_2e$/year. The emissions from the forest sector are partially offset by efforts to increase the forest cover through afforestation and forest enhancement. Between 2002 and 2018, sequestration associated with afforestation and forest enhancement contributed to emission removals of 9.5 $MtCO_2e$/year, reducing net emissions from the forestry sector to 52.2 $MtCO_2e$/year.

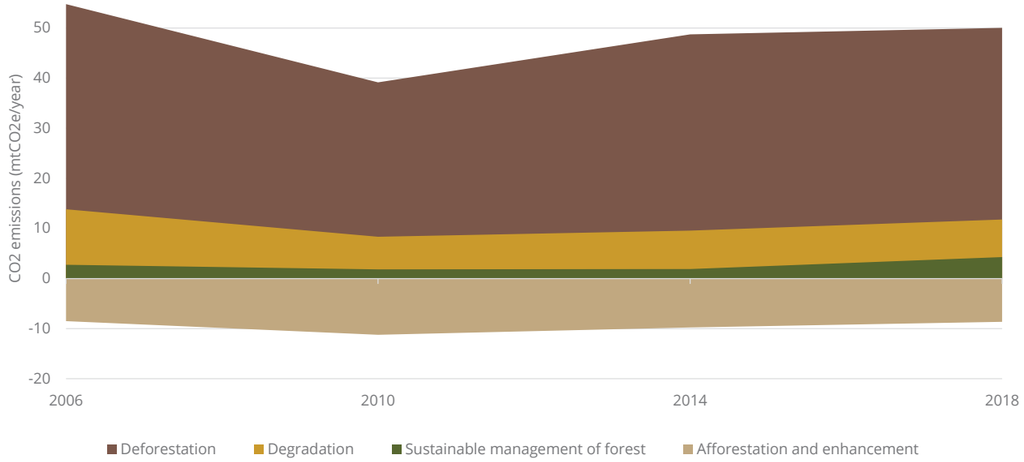


Figure 2.23 After a fall between 2006 and 2010, emissions from deforestation have increased

Note: Afforestation and enhancement of forests leads to negative emissions as forests sequester carbon

Source: *Ministry of Environment and Forestry (2019) National Forest Reference Level for REDD+ Implementation*

[69]Ministry of Environment and Forestry (2019) National Forest Reference Level for REDD+ Implementation
[70]Following the analysis conducted as part of the LTS preparation process, revised forestry data has become available which indicates that the forest cover in Kenya is higher than the figures used in the LTS. In future revisions of the LTS, these updated figures should be used as the basis for the analysis.
[71]Ministry of Environment and Forestry (2019) National Forest Reference Level for REDD+ Implementation

Between 2002 and 2018, montane forests accounted for the largest source of emissions. Deforestation of montane forests have historically been the main driver of emissions from the forest sector due to montane forests' high capacity to sequester carbon, which leads to large emissions when it is deforested. Despite only accounting for 14% of the average annual deforestation between 2002 and 2018, montane forests accounted for on an average more than 60% of the emissions associated with deforestation over the same time-period, as shown in Figure 2.24. In contrast, despite a significantly higher rate of deforestation of dryland forests due to conversion of dryland forests into arable land for agricultural use, the forest type accounted for just 25% of total emissions from deforestation.

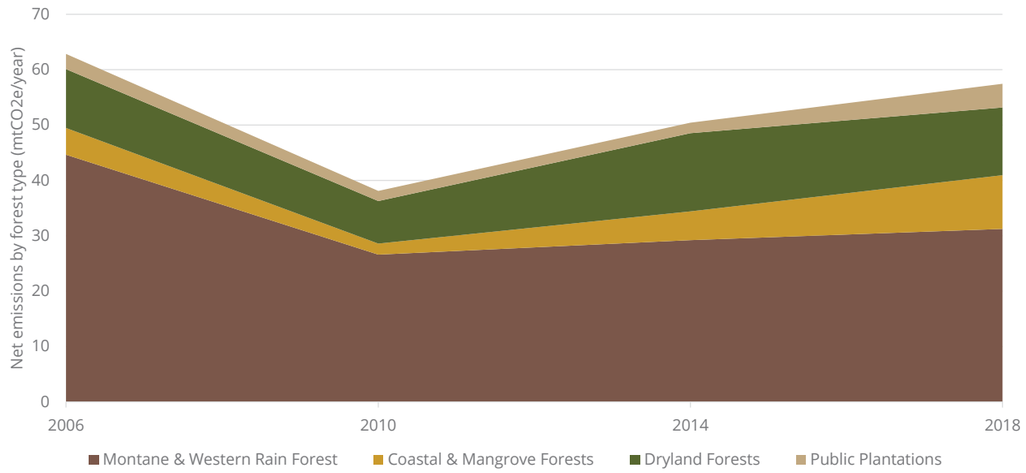


Figure 2.24 Montane and Western rainforests accounted for the largest share of emissions between 2006 and 2018

Source: *Ministry of Environment and Forestry (2019) National Forest Reference Level for REDD+ Implementation*

If the current trends of deforestation and afforestation continues to 2050, Kenya's forest cover is estimated to fall from the 2018 level of just under 5.9% to 5.3% in 2050.[72] An expansion of the land area used for agricultural practices, increases in settlements due to a growing population and unsustainable use of forest resources are key reasons for the continued fall in forest cover. Deforestation is not only causing emissions from the forest sector to remain at a high level but is also a threat to biodiversity and is a main cause of land degradation. A loss in forest cover also reduces the resilience to climate change, as forests for example can reduce the impacts of flooding and reduce soil erosion and water loss.[73] Deforestation also affects water resources, as deforestation can lead to both increased surface runoff as well as increased groundwater recharge.[74] Reverting the trend of a falling forest area is crucial not only for mitigation but also to prevent detrimental side effects of deforestation on natural habitats and the resilience to climate change.

Kenya has already taken action to address climate change in the forestry sector through several long-term frameworks, programmes, and initiatives. The REDD+ Readiness Plan and Analysis (2013-2017) was set out to enable Kenya to participate in reducing emissions from deforestation and forest degradation and to enhance conservation, sustainable management of forests and forest carbon stocks, as a climate change mitigation process.[75] The National Forest Programme (2016–2030) has also been set up as a cross-sectoral and multi-stakeholder national framework for developing and coordinating forest development. It builds on the constitutional values and principles of the Kenya Vision 2030, and advances forest development to 2030.[76] Kenya has also committed to the Bonn Challenge, which is a global effort to restore 150 million hectares of the world's degraded and deforested lands by 2020 and 350 million hectares by 2030.[77] As part of the Bonn Challenge, Kenya has set a target to restore a total of 5.1 million ha of degraded and deforested land by 2030.[78] The 2020 Update to the NDC retains the priority interventions from NCCAP 2018-2022 and focuses on a reduction in deforestation, increased afforestation, and restoration of degraded forest land. Table 2.2 lists interventions from these documents and initiatives.

Table 2.2 Summary of the discounted mitigation potential of the actions prioritised for the updated NDC in the forestry sector

Prioritised mitigation actions	Annual emission reduction ($MtCO_2e$)		
	Action up to 2022	Action up to 2025	Action up to 2030
Reduce deforestation and forest degradation by protection of additional 100,000 ha of natural forests (including mangroves) by 2022	2	2	2
Afforestation/reforestation/agroforestry of additional 100,000 ha of land by 2022	2	3.1	4.8
Restoration of 200,000 ha of forest on degraded landscapes (ASALs, rangelands) by 2022	5.4	8.3	13
Increase area under private sector-based commercial and industrial plantation from 71,000 ha to at least 121,000 ha	1	1	1
Total Sector Emission Reduction Potential of the Prioritised Actions	**10.4**	**14.4**	**20.8**

Note: Figures are in $MtCO_2e$/year

Sources: *NCCAP 2018-2022, NDC Update Technical Report*

The 2030 targets set out in the NDC will not be enough towards net zero emissions by 2050. Although other sectors can take actions to reduce their emissions, emissions will remain positive. In addition, in some sectors such as agriculture, mitigation is not the primary objective and emissions are projected to increase over the upcoming decades. The forest sector represents an opportunity for Kenya to create a carbon sink which offsets residual emissions by 2050. However, the trends in the forest sector have been in the wrong direction over the past decades, resulting in a falling forest cover and significant emissions from the forest sector. The NDC does not go far enough in terms of reverting these negative trends. As shown in Figure 2.25, the cumulative mitigation potential from the four priority actions in the forestry sector is estimated to 20.8 $MtCO_2e$/year by 2030, compared to net emissions of 52.2 $MtCO_2e$ /year in the absence of interventions. Further actions aimed at reducing deforestation and increasing afforestation and reforestation are therefore needed for the forest sector to be a net carbon sink.

[72]LULUCF emissions will remain at 52 MT CO2 per year until 2050 under the BAU scenario

[73]PROFOR, 2015. How Forests Enhance Resilience to Climate Change

[74]Owuor et al, 2016. Groundwater recharge rates and surface runoff response to land use and land cover changes in semi-arid environments. Available at: https://ecologicalprocesses.springeropen.com/articles/10.1186/s13717-016-0060-6. Last accessed 2021-11-12

[75]Ministry of Environment and Forestry, 2019. The National Forest Reference Level for REDD+ Implementation. Available at: https://redd.unfccc.int/files/national_frl_report_for_redd__in_kenya.pdf. Last accessed 2021-11-12

[76]National Forest Programme, 2016-2020. Available at: https://kwcakenya.com/download/kenya-national-forest-programme-2016-2030/?wpdmdl=10306&refresh=61545a4e54ad81632918094. Last accessed 2021-11-12

[77]Bonn Challenge, 2016. Kenya. Available at: http://www.bonnchallenge.org/flr-desk/kenya, Last accessed 2021-11-12

[78]NCCAP 2018-2022

The targeted interventions proposed by the LTS are:

- Increase tree and forest cover by increasing afforestation to 580,000[79] ha per year by 2030 and sustain afforestation efforts to 2050
- Reverse forest degradation by reducing deforestation to 120,000[80] ha per year, a 65% decrease relative to the 2002-2018 level

In addition, the LTS proposes the following interventions to strengthen the enabling environment:

- Enhance forest based economic, social, and environmental benefits
- Enhance capacity development, research, and adoption of technologies
- Increase investment in forest development and sustainable management
- Enhance good governance and policy in forest conservation and management in response to climate change
- Improved Forest standardization
- Develop a Forest sector specific LTS

The targeted interventions can deliver 41 $MtCO_2e$/year negative emissions by 2050, serving as a carbon sink. Decreasing deforestation by 50% by 2030 and by 65% by 2050 relative to the 2002 and 2018 average, would lower emissions from deforestation to 18 $MtCO_2e$ in 2050. Conversion of grasslands to forests lead to some emissions as grasslands sequester carbon but would amount to less than 3 $MtCO_2e$ in 2050. By 2050, the sustained afforestation efforts since 2022 are estimated to lead to carbon sequestration of 60.5 $MtCO_2e$/year by 2050. In addition to afforestation, no tillage agriculture leads to carbon sequestration, albeit at a low level. Increases in the area covered by mangroves and improved conservation of seagrass would bring emissions from the blue economy to close to zero by 2050.

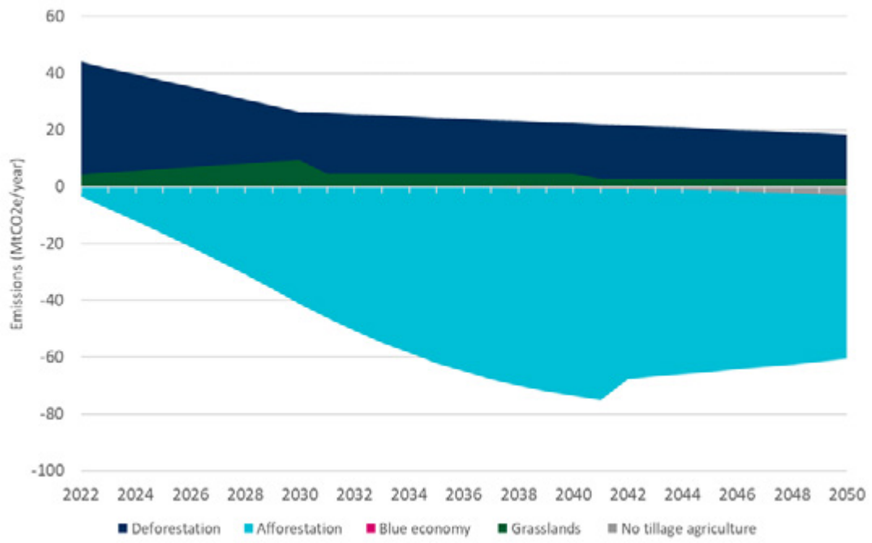


Figure 2.25 Emissions resulting from LTS interventions

Note: Modelled emissions reductions for afforestation and deforestation are based on sequestration factors that incorporate both above and below-ground biomass. These do not incorporate possible additional sequestration from soil organic carbon stocks. For reasons outlined in section 2.6, these are omitted from current estimates and will be revisited in future LTS iterations when better data is available.

Source: Vivid Economics, Ministry of Environment and Forestry (2019) National Forest Reference Level for REDD+ Implementation.

[79]Due to the definition of forest cover as land with 15% tree cover > 2m, some of the afforestation may be caused by land at the margin of this definition switching categories and may not be real afforestation

[80]Due to the definition of forest cover as land with 15% tree cover > 2m, some of the deforestation may be caused by land at the margin of this definition switching categories and may not be real deforestation

2.8 Summary

Together, these targets represent an ambitious plan to move Kenya towards a net-zero economy in 2050. These actions build upon the commitments Kenya has already made in the 2020 update to the NDC, to reduce her emissions by 32% against the business as usual by 2030, with a focus on the period 2030-2050. These include the near complete elimination of emissions from electricity generation, a rapid transition from traditional carbon-based fuels towards LPG and electricity in the home, and decarbonisation of the manufacturing and construction sectors. In the transport sector, most of the freight would need to be moved by rail, with high penetration of electric vehicles and hydrogen fuels.

The agricultural sector will continue to be the main source of emissions, but adopting the Agricultural LTS can ensure modest growth of livestock numbers and land converted to agriculture. If croplands attained similar levels of emissions from mineralisation as global averages by 2050, crops would continue to emit some 27 $MtCO_2e$ in 2050. The Ministry of Livestock, Fisheries and Co-operatives contend that current emissions are well below these global averages because of the low nitrogen content in the soil, and as such Kenya is currently overreporting these emissions. However, if growth in agricultural productivity can be achieved without significantly increasing emissions from their suspected low current levels, through sustainable farming and conservation agriculture, there may be further abatement potential and even the potential for carbon sequestration. Under these assumptions, emissions from economic sectors (i.e., excluding land use, land use change and forestry, LULUCF) could be reduced to around 89 $MtCO_2e$ against a BAU scenario of 248 $MtCO_2e$. Excluding emissions from crop soils, this falls to 62 $MtCO_2e$.

Kenya's forests provide an opportunity to create a carbon sink which removes emissions from the atmosphere. Over the past 20 years, deforestation and shrinking forest cover has meant LULUCF have been a net emitter. In 2018, they contributed 52 $MtCO_2e$ of emissions. By reducing deforestation and increasing afforestation, LULUCF could become a carbon sink which removes 41 $MtCO_2e$ per year.

Taken together, these would reduce net emissions by 84%, from 300 $MtCO_2e$ (including emissions from economic sectors and the impact of LULUCF) to just 48 $MtCO_2e$, or by 93% to just 21 $MtCO_2e$ if emissions from soil mineralisation can be avoided. This brings Kenya to within touching distance of net zero.

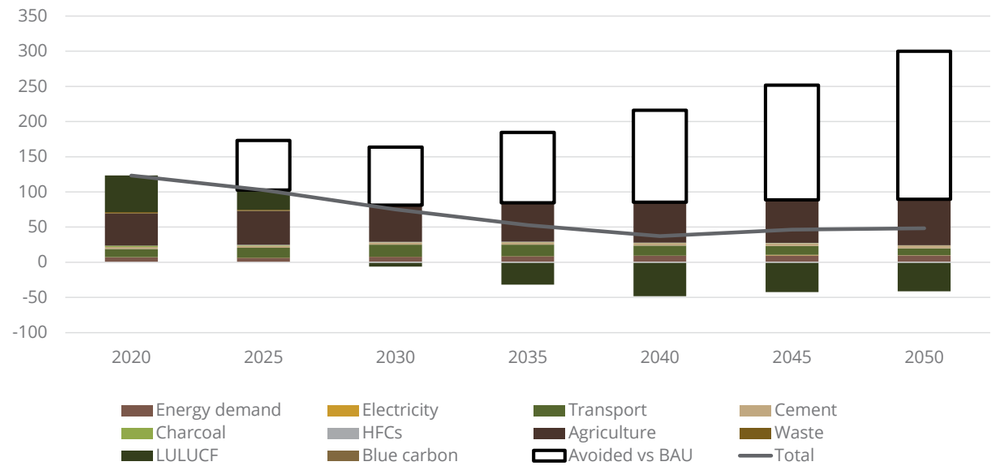


Figure 2.26 Emission projections including soil mineralisation [81]

Source: Consultant analysis based on LEAP

[81]As described in the Introduction to this document and in the sector chapters, the estimated emissions for 2010-2020 and projected emissions to 2030 in the LTS differ to the figures in the 2020 Updated NDC due to differences in methodological approaches and data sources. The largest source of the discrepancy between 2010 and 2030 is the LULUCF sector, for which the LTS reports emissions twice as high as in the Updated NDC.

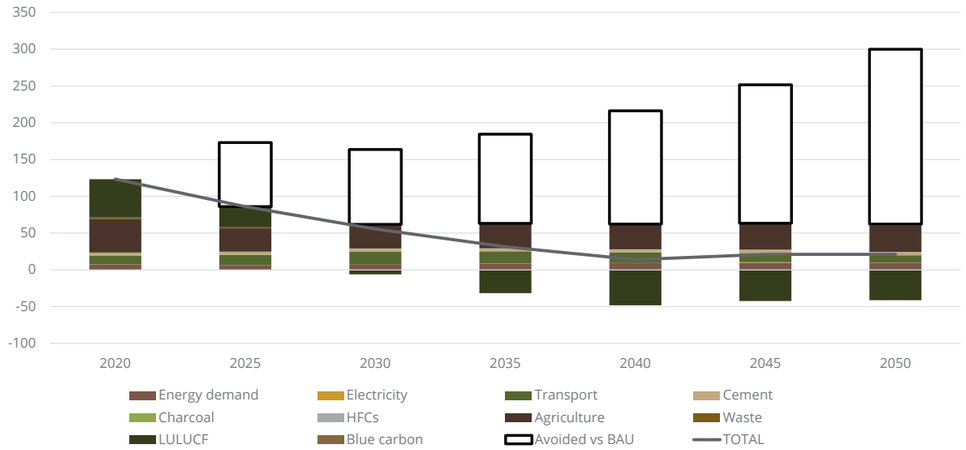


Figure 2.27 Emission projections excluding soil mineralisation

Source: Consultant analysis based on LEAP

Kenya's long-term strategy could cost approximately 170 billion USD, as shown in Table 2.3.[82] The transport sector will account for the lion's share of the estimated budget, USD 117 billion, followed by followed by LULUCF 32.2 Billion USD. The results of this approach must be taken with caution as the overall budget could be overestimated. Indeed, while the abated emissions over 2030-2050 increase by a factor of 5 compared to the abated emissions in the period 2020-2030, the estimated budget increases by around 10 times. The reasons leading to an overestimation are mainly two-folded, on the one hand the approach is top-down and does not reflect the differences between the NDC and the LTS. For instance, in the NDC the abatement cost of the transport sector is based on the cost of large infrastructures, while in the LTS light passenger vehicle, also play a relevant role. Moreover, the approach assumes marginal abatement cost is linear throughout the time horizon, which is highly unlikely. Factors such as economies of scale and technology development among others will lead the abatement cost to decrease over the long-term. However, this can be counterbalanced by an increase in marginal abatement cost as low cost interventions are exhausted and high cost interventions need to be introduced to meet the abatement target, such as industrial electrification. Therefore, the cost figures presented here need to be taken with caution. In the next iterations of the LTS a more in-depth approach will be developed, and the estimation will be refined.

Table 2.3 Cost estimation for implemenation of Kenya's LTS

Sector	NDC 2020-2030		LTS 2030-2050	
	Abated emissions 2030 ($MtCO_2e$)	Estimated Budget (Million USD)	Abated emissions 2050 ($MtCO_2e$)	Estimated Budget (Million USD)
Energy	24.1	8,890	48.7	17,978
Transport	2.4	4,240	66.0	116,514
LULUCF	11.9	4,126	93.3	32,358
Agriculture	5.8	250	23.5	1,014
IPPU	1.4	180	9.6	1,237
Waste	0.5	39	10.6	825
Total	**46.0**	**17,725**	**251.7**	**169,926**

Notes: It is assumed that the cost of abating 1 $MtCO_2e$ over 2020-2030 as reported in NDC is the same as over 2030-2050. To calculate the cost of mitigation over 2030-2050 in LTS, the cost of abating 1 $MtCO_2e$ is multiplied by abated emissions over 2030-2050.

Source: Vivid Economics, Technical Analysis Report Updated Nationally Determined Contribution Kenya March 2020

[82]It is assumed that the cost of abating 1 $MtCO_2e$ over 2020-2030 as reported in NDC remains the same over 2030-2050. To calculate the cost of mitigation in LTS, the cost of abating 1 $MtCO_2e$ is multiplied by abated emissions over 2030-2050.

Photo Credit: CCD

3.1 Introduction

The impacts of climate change are already being felt in Kenya and have significant negative socioeconomic impacts. Socio-economic losses associated with climate change over the past decade amount to between 3% and 5% of GDP.[83] Modelling estimates, detailed in section 3.4, suggest that Kenya could lose an additional 4% GDP per annum, on average, between 2021-2050. The economy, which relies heavily on agriculture, and tourism, is particularly exposed to the effects of climate change, which will become more severe even under the most optimistic scenarios. As the economy and population grows, so too will exposure to climate-related disasters.

Climate change will increase the frequency and intensity of flooding and drought in Kenya and will also result in rising of temperatures and sea levels. These climate hazards all impact multiple strategically important sectors. Droughts are highly detrimental to the agricultural, health, and energy sectors. Floods occur frequently and cause significant damage to critical infrastructure, which has knock-on effects in other sectors including but not limited to energy, manufacturing and trade, and transport. Sea level rise has negative implications for ecosystems and coastal economies.

Kenya must adapt to both the current and future challenges of climate change via a climate-resilient pathway for economic development. The importance of climate-dependent natural resources in key sectors, such as agriculture and energy, mean that development may be significantly hampered by climate change. Adaptation is a national priority, and this section sets out the key risk of climate change and sector-level strategies for adaptation and highlights the importance of investing in adaptation measures through cost-benefit analyses wherever possible.

Modelling suggests sizeable socioeconomic losses in the absence of adaptation interventions. As shown in Figure 3.7, Kenya stands to lose up to $11 billion annually because of climate change, around a third of which can be averted through adaptation interventions. The annual investment requirement for these interventions is approximately $1.5 billion.

All investments are indicative and require separate validation by sector leads.

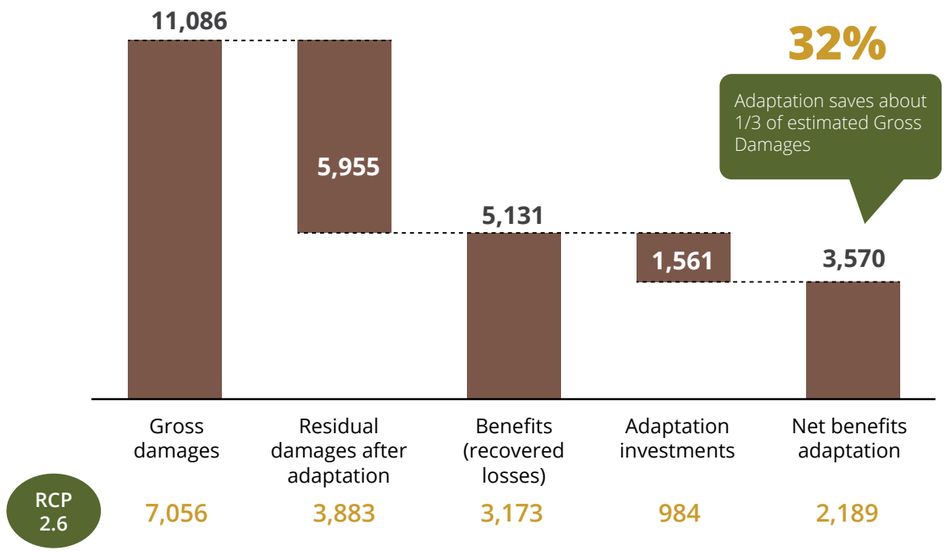


Figure 3.1 Overall damages and net benefits from adaptation, 2020-2050 (Annual averages, 2020 USD millions)

Note: Totals are deflated at 2020 prices and are annual averages for the period 2020-2050. Bars are results for RCP 8.5, with comparators for RCP 2.6 in yellow below.

Sources: Modelling based on AfDB (2019) and UNISDR (2018)

[83]Government of Kenya, 2020. NDC Update.

3.2 Climate Change Risks and Impacts

Climate change is already a reality in Kenya. Average temperature has been increasing since 1960, a trend that is expected to continue in the coming decades. Although average precipitation has not varied significantly, rainfall patterns have changed, with the long rainy season becoming shorter and dryer and the short rainy season longer and wetter. Droughts have intensified in terms of frequency, severity, and coverage over the past few decades and, rainfall in arid zones is projected to decrease, as the period between heavy rainfall events increases, thereby increasing the likelihood of droughts in certain regions.[84] The frequency of rainfall events causing floods has increased in East Africa from an average of less than three events per year in the 1980s to over seven events per year in the 1990s and 10 events per year from 2000 to 2006. Extreme rainfall events are expected to increase by the end of the century. Sea levels are also rising along Kenya's Indian Ocean coast, increasing the risk of flooding in coastal cities, and affecting coastal flora and fauna, particularly coral reefs.

Increased temperatures, erratic rainfall, increased frequency and intensity of droughts and sea level rise are already impacting costing Kenya's economy 3-5% of annual GDP. Kenya's economy is very dependent on climate-sensitive sectors such as agriculture, water, energy, tourism, wildlife, and health, which increases vulnerability. Increased heat and drought are also impacting food production systems, food security and livelihoods of millions of Kenyans who depend on agriculture. For example, an estimated 2.1 million people in Kenya's Arid and SemiArid Lands (ASAL) are experiencing high levels of acute food insecurity between July and October 2021, which increased about 34 percent compared to the same period in 2020.[85] Extreme weather events have led to loss of lives, increased prevalence of pests and water borne diseases, and damaged infrastructure. Increased incidence of extreme weather may also induce migration and aggravate conflict over natural resources.[86]

Adapting to these climate risks requires coordinated action, at the local and national level. Figure 3.2 illustrates the relationship between climate risk, potential damages, and the sectors likely to be affected. The interdependencies between sectors imply that climate damages can have significant knock-on effects across areas, as shown in the linkages below.

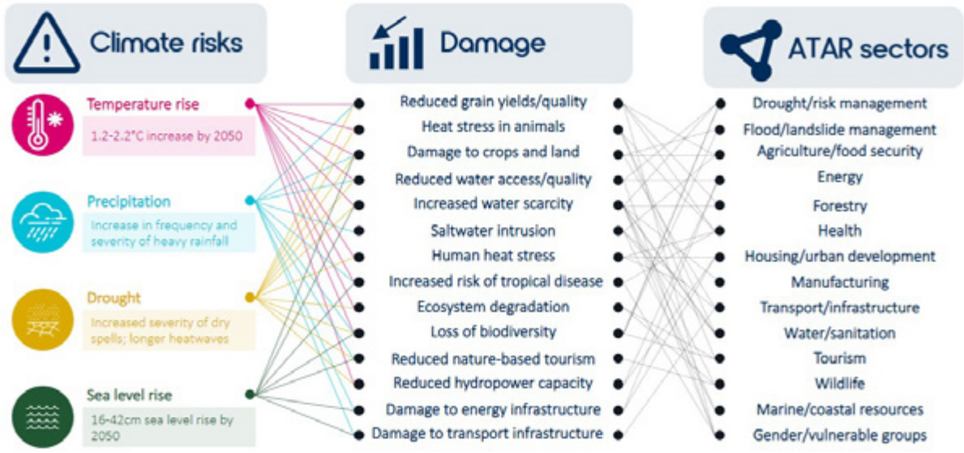


Figure 3.2 Nexus between primary climate risks, potential damages, and adaptation interventions

Source: Sector lead workshops

[84]Ibid.

[85]Govt. Kenya, IPC. Kenya: IPC Acute Food Insecurity Analysis and Acute Malnutrition Analysis (July 2021 - January 2022). Available at: https://www.ipcinfo.org/ipcinfo-website/alerts-archive/issue-47/en/#:~:text=Kenya%3A%20About%202.1%20million%20people%20in%20Kenya's%20ASAL%20region%20are,lactating%20women%20are%20acutely%20malnourished Last accessed 2021-11-12

[86]Human Development Report, 2007. Climate change and forced migration: Observations, Projections and Implications. Available at: http://hdr.undp.org/sites/default/files/brown_oli.pdf. Last accessed 2021-11-12

3.2.1 Temperature

Temperature rise is already causing severe socioeconomic and health consequences in Kenya. These include unpredictable weather patterns, increased incidence of disease and heat stress, pests, and poorer harvests for key crops, including maize, wheat, rice and potatoes. For example, in a 2021 Reuters survey of 700 tea plantation workers in Kenya, more than 40% of respondents reported changes to weather patterns and plantation season lengths, with many fearing for their long-term livelihoods.[87] Furthermore, the Lancet reports that malaria has returned to Kenya's Highlands, despite being largely eradicated in the 1960s through widespread insecticide rollout.[88] Although the rollout of malaria vaccines may mitigate losses in the healthcare sector,[89] increased incidence of vector-borne is nonetheless a likely consequence of increased temperature and humidity associated with climate change (see section 3.4.6). Adapting to rising temperatures is therefore already a crucial challenge for Kenya, as it seeks to build a sustainable, resilient pathway for economic development.

The latest IPCC estimates suggest that annual temperatures in Kenya have risen by about 1.0°C since 1960. This trend, highlighted in the IPCC's Sixth Assessment Report, will continue in the absence of meaningful global efforts to reduce emissions.[90] Under the RCP8.5 business-as-usual scenario temperature, are projected to increase from an average of 1.7°C by the 2050s and approximately 3.5°C by the end of the century.[91] The CMIP5 projections, used for the IPCC 5th Assessment Report, provide ranges of mean monthly temperature increases (relative to the 1986-2005 baseline under the 8.5 scenario) of 0.5 °C to 1.4 °C by 2040, 1.2-2.4°C by 2060s and 2.7-5.1°C by the end of the century.[92] All seasons in Kenya are expected to have an increase in temperature, with East Africa overall experiencing increased mean temperatures and a shift toward extreme heat characteristics, as projected in the IPCC Sixth Assessment Report.[93] According to the IPCC this increase in temperature will be observed particularly in the more arid regions of Africa.

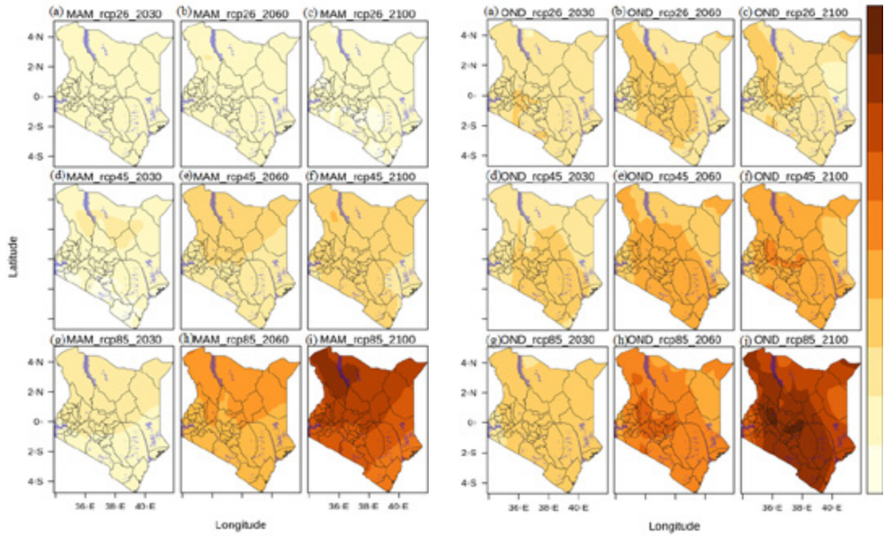


Figure 3.3 Projected temperature scenarios to 2100 for MAM and OND using RCP 2.6, 4.5 and 8.5

Source: Situational Analysis Study for the Agriculture Sector in Kenya (2020)

[87]Reuters, 2021. As Climate change threatens Kenyan tea, millions of workers seen at risk. Available at: https://www.reuters.com/article/us-climate-change-kenya-tea-idUSKBN2CR1Q6. Last accessed: 2021-11-12

[88]The Lancet, 2007. Malaria returns to Kenya highlands as temperatures rise. Available at: https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(07)61428-7/fulltext. Last accessed 2021-11-12

[89]WHO, 'My journey with the malaria vaccine in Kenya', https://www.who.int/news-room/commentaries/detail/my-journey-with-the-malaria-vaccine-in-kenya, last accessed 2022-04-04.

[90]IPCC, 2021. IPCC's Sixth Assessment Report. Available at: https://www.ipcc.ch/assessment-report/ar6/. Last accessed: 2021-11-12

[91]WBG Climate Change Knowledge Portal (CCKP, 2020), Kenya Dashboard.

[92]Ibid.

[90]IPCC. 2021. Climate Change 2021: The Physical Science Basis. Working Group I contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Available at: https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf. Last accessed 2021-11-12

Figure 3.3 shows the mean surface temperature over Kenya under different scenarios. The surface temperature trends in some counties also show warming of more than 2.5°C by 2030 under all the RCPs, which surpasses the Paris Agreement that aims at strengthening the global response to the threat of climate change, by keeping the rise in global temperature during this century to well below 2°C above pre-Industrial levels.[94]

Future iterations of the LTS will incorporate internal projects from GoK data, which were not available at the time of writing.

3.2.2 Precipitation

Climate change is already causing severe disruptions to Kenya's rainfall patterns, with potentially devastating consequences for agriculture, tourism, and other sectors. A 2019 study found that Kenya's long rains – which typically last from March to May – had not begun in most of the country by the end of April.[95] Overall, there has been a change in the profiles of the rainy seasons, with the long rainy season becoming shorter and dryer and the short rainy season longer and wetter. Because 98% of Kenya's agriculture is rainfed, changes in rainfall patterns may significantly impact on crop yields and rural livelihoods.[96] Climate change is also increasing the unpredictability and acuteness of rainfall. Reuters report that unpredictable rainfall patterns are already hindering the ability of tea farmers to expand cultivation into new regions.[97] Changes in rainfall patterns are therefore already impacting on livelihoods in rural communities, highlighting the urgency of adaptive measures.

Whilst there is a consensus on increasing temperatures across the RCP models, the precipitation projections are more uncertain. While the magnitude of rainfall projections differs between scenarios, projections suggest a uniform picture of increasing dryness in water-scarce regions with more intense rains in other counties. Rainfall will therefore most likely become less frequent and geographically uniform by 2050, but more intense in specific regions. Figure 3.4 summarises rainfall projections under RCP 2.6, 4.5 and 8.5 respectively.[98]

[94]Situational Analysis Study for the Agriculture Sector in Kenya, 2020.Available at: https://cgspace.cgiar.org/bitstream/handle/10568/111687/Kenya_report.pdf. Last accessed 2021-11-12

[95]The Conversation 2019. Why Kenya's seasonal rains keep failing and what needs to be done. Available at: https://theconversation.com/why-kenyas-seasonal-rains-keep-failing-and-what-needs-to-be-done-115635. Last accessed:2021-11-12

[96]UNDP, Kenya. Kenya Climate Smart Agriculture Implementation Framework, 2018. Available at: https://www.ke.undp.org/content/kenya/en/home/library/environment_energy/Climate-smart-Agriculture-Framework.html. Last accessed 2021-11-12

[97]Reuters, 2021. As Climate change threatens Kenyan tea, millions of workers seen at risk. Available at: https://www.reuters.com/article/us-climate-change-kenya-tea-idUSKBN2CR1Q6. Last accessed: 2021-11-12

[98]Situational Analysis Study for the Agriculture Sector in Kenya, 2020. Available at: https://cgspace.cgiar.org/bitstream/handle/10568/111687/Kenya_report.pdf. Last accessed 2021-11-12

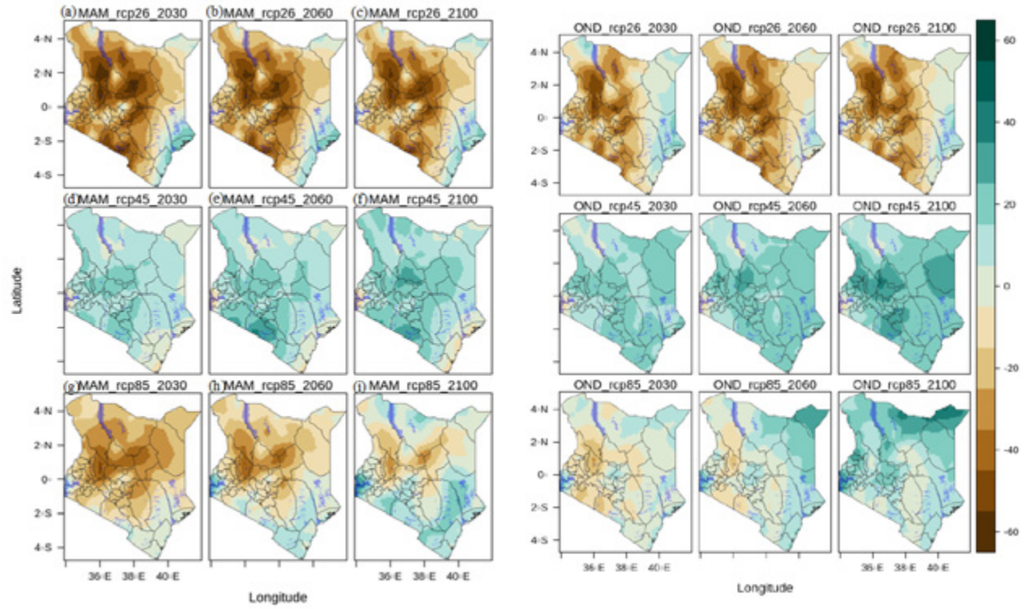


Figure 3.4 Projected rainfall scenarios for MAM and OND using RCP 2.6, 4.5 and 8.5

Source: Situational Analysis Study for the Agriculture Sector in Kenya (2020)

3.2.3 Droughts

Droughts are increasingly frequent in Kenya, with devastating consequences for agricultural production and food security. Closely linked to rising temperatures, drought is the most significant climate hazard facing Kenya over the long term. The severity of associated risks cannot be overstated. Between September and November 2021, Kenya's northern countries received less than 30% of their expected annual rainfall. According to Al Jazeera, the recent drought in 2021 pushed 2.4 million people to the brink of starvation.[99] Overall, approximately 5 million people are exposed to such risk and these events have destroyed livelihoods, triggered local conflicts over scarce resources, and eroded the ability of communities to cope. Droughts also cause changes in the migratory patterns of animals and increase conflicts between people and large mammals like elephants.[100]

Droughts have intensified in terms of frequency, severity, and coverage over the past few decades. As many as 28 droughts have been recorded in the past 100 years, and appear to be increasing in frequency, occurring every 2-3 years instead of every 5-10 years. Further, droughts are often experienced nationwide, with particularly severe impacts on the country's highly arid zones. The 2014-2018 drought, for example, was declared a national emergency in February 2017 affecting 23 out of the 47 Counties, with counties in ASALs experiencing the most severe impacts.[101]

Droughts can cause significant economic disruption and health impacts. The 2008-2011 drought, which impacted 3.7 million people in Kenya, cost the economy $12.1 billion in socioeconomic losses, and over $1.7 billion in recovery and reconstruction needs.[102] At least 3.4 million Kenyans were severely food insecure, and an estimated 500,000 people did not have access to water. An estimated 482,882 children, mainly from 23 ASAL Counties, required treatment for acute malnutrition and school attendance dropped in counties that were impacted by the drought. Droughts also cause changes in the migratory patterns of animals and increase human wildlife conflicts like elephants.[103] Furthermore, it contributed to the reduction of the growth rate of Kenya's GDP from an average of 6.5 per cent between 2006 and 2007, to an average of 3.8 per cent between 2008 and 2012.[104] In addition, the 2016-2017 drought has left 3.4 million Kenyans in need of food aid and 480,000 children requiring treatment for acute malnutrition.[105]

According to the UN Disaster Risk Assessment for Kenya, the share of population exposed to drought will reach 34% by 2050, from 13% in 2016.[106] Kenya has previously committed to several policy interventions to address future risks. These are detailed in The National Climate Change Action Plan (NCCAP) 2018-2022 and are listed in the Appendix, section 6.4.1.

3.2.4 Floods

Floods occur increasingly regularly in Kenya because of climate change, damaging or destroying infrastructure in both rural and urban areas. Flash floods or riverbanks bursting now occur most years, with recent flooding in May 2021 displacing 25,000 and destroying more than 400 homes.[107] More widespread flooding in early 2018 claimed 183 lives, displaced more than 225,000 people, including over 145,000 children, and led to closure of over 700 schools. There are also numerous health consequences associated with flooding, including malaria and dengue fever, with outbreaks typically reported during flooding episodes. Between 1990 and 2020, a total of 45 flood disasters happened in Kenya.[108] On average, each riverine and flash flood disaster affected 60,300 and 24,200 people respectively.[109]

Urban floods are increasingly common and regularly damage or destroy infrastructure in towns and cities. Urban flooding occurs when rainfall downpour is quickly turning into runoff due to the concrete paved land. The runoff is increased due to lack of infiltration and percolation. Inadequate man-made drainage culverts may overflow and flood low-lying urban settlements.[110] Flooding destroys the limited assets of poor and vulnerable households, displaces residents, halts economic activity, contaminates water supply and can lead to disease outbreaks.[111] Floods are common in major cities and towns, including Nairobi, Mombasa, Kisumu, Nakuru and Garissa.

The frequency of inland floods in rural areas has also increased, with serious consequences for communities close to inland water bodies. This risk is particularly acute for communities surrounding the Rift Valley Lakes, Turkwel Gorge Dam and Lake Victoria. According to a 2021 scoping report, conducted by the Government of Kenya with assistance from UNDP, rising inland water levels have already displaced 75,987 households, with approximately 400,000 people requiring urgent humanitarian assistance.[112]

Climate change will worsen the risk of flooding in both urban and rural areas, displacing greater numbers of people and damaging core infrastructure. According to Kebede et al. (2015), up to 400,000 people in the Mombasa District could be exposed to regular flood risk by 2050, due to extreme weather and rising sea levels. Kenya has previous committed to several policy interventions to address future risks of floods. These are detailed in The National Climate Change Action Plan (NCCAP) 2018-2022 and are listed in the Appendix, section 6.4.2.

[99]Aljazeera, 2021. Available at: https://www.aljazeera.com/news/2021/11/17/we-will-all-die-in-kenya-prolonged-drought-takes-heavy-toll. Last accessed 2021-11-12

[100]NCCAP, 2018-2022.

[101]ATAR, 2018-2022.

[102]GFDRR (2020). Kenya Overview. Available at: https://www.gfdrr.org/en/kenya. Last accessed 2021-11-12

[103]Africanews, '62 elephants starve to death in Kenya', https://www.africanews.com/2022/03/04/62-elephants-starve-to-death-in-kenya//, last accessed 2022-04-04.

[104]Ibid.

[105]The New Humanitarian, 2018. Consecutive droughts spell disaster and hunger for Kenya in 2018.

[106]UNISDR and CIMA, 2018. Kenya Disaster Risk Profile. Nairobi: United Nations Office for Disaster Risk Reduction and CIMA Research Foundation.

[107]Floodlist, 2021. Available at: https://floodlist.com/africa/kenya-floods-may-2021. Last accessed 2021-11-12

[108]EM-DAT: The emergency Events Database - Universite catholique de Louvain (UCL) - CRED. D. Guha-Sapir, Brussels, Belgium. Available at: http://emdat.be/emdat_db/. Last accessed 2021-11-12

[109]NCCAP, 2018-2022.

[110]Wachira, S. W., 2016. Assessment of Flash Floods in The Streets of Nairobi City, Their Relationship with Rainfall and Surface Runoff Drainage and their Impacts to its residents. Available at: https://meteorology.uonbi.ac.ke/sites/default/files/cbps/sps/meteorology/Silvia.pdf Last accessed 2021-11-12

[111]UNFCC, Building Urban Flood Resilience: Integrating Community Perspectives in Kiberia – Kenya. Available at: https://unfccc.int/climate-action/momentum-for-change/activity-database/building-urban-flood-resilience-integrating-community-perspectives-in-kibera. Last accessed 2021-11-12

[112]Government of Kenya and UNDP, 2021. Rising Water Levels in Kenya's Rift Valley Lakes, Turkwel Gorge Dam and Lake Victoria: A Scoping Report

3.2.5 Sea level rises, temperature increases, and coral bleaching

Sea level rise has risen consistently over the last three decades, with already noticeable consequences for tourism, biodiversity, and core infrastructure. Mean sea level measurements in Kenya, show gradual increase in mean sea level over the period 1986 – 2012 (Figure 3.5). The over 30 years' sea level data observed by the Mombasa tide gauge reveals a rising trend of about 3 mm per year which is consistent with projections by the Intergovernmental Panel on Climate Change.[113] Rising sea levels increase the frequency of severe tides, which have the potential to damage or destroy transport and port infrastructure along the coast. Furthermore, sea level rise may also spur soil erosion and biodiversity loss across Kenya's pristine coastline, which may impact on its attractiveness as a tourist destination.[114] A potential decline in coastal tourism will affect the livelihood of millions: as of 2019, approximately 10% of total employment in Kenya was linked to travel and tourism.[115] Minimising the impacts of sea level rise through adaptive measures is therefore crucial to maintaining long-run economic growth in Kenya.

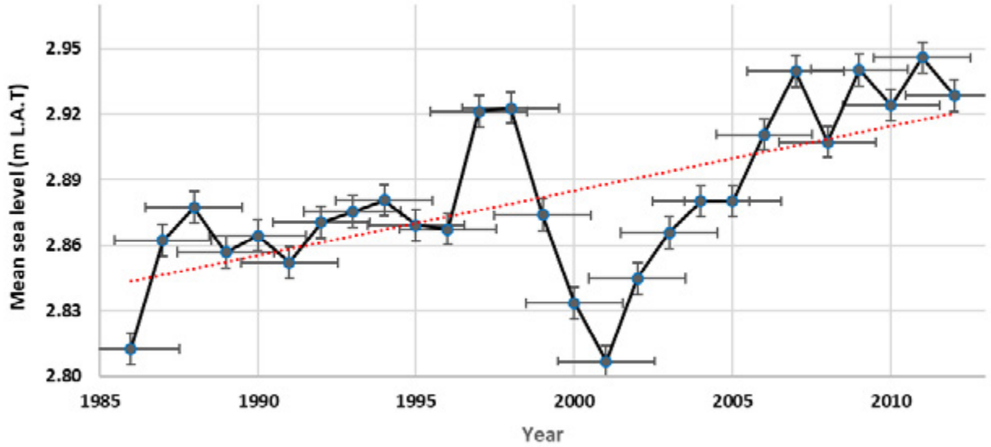


Figure 3.5 Mean monthly sea level variation at the KMFRI GLOSS Mombasa tide gauge station 1986 to 2012

Source: KMFRI, 2019

Sea-level rise will also increase the risk of coastal flooding, particularly in Mombasa. Estimates show that 267,000 Kenyans will be at risk from coastal flooding by 2030, because of sea level rise and irregular weather patterns. An increase of 30 cm of sea water at the Kenyan coast is capable of submerging Mombasa and 17% of coastal areas.[116] This could threaten the movement of imports and exports by Kenya and countries that use the port of Mombasa, as the area supports tourism and fishing industries.

[113]IPCC, 2019. The Ocean and Cryosphere in a Changing Climate. Available at: https://www.ipcc.ch/srocc/home/. Last accessed 2021-11-12

[114]Business daily, 2021. Available at:https://www.businessdailyafrica.com/bd/data-hub/how-rising-sea-level-threatens-livelihoods-coastline-3276444. Last accessed 2021-11-12

[115]Ministry of Tourism and Wildlife, 2020. Enhancing Resilience and Sustainable Tourism in Kenya. Available at: https://www.tourism.go.ke/wp-content/uploads/2020/09/28th-August-National-Tourism-Policy-Review.pdf. Last accessed 2021-11-12

[116]Awuor et. Al, 2018. 'Climate change and coastal cities: the case of Mombasa, Kenya', Environment and Urbanisation 20(1), 231-42.

3.3 Modelling approach

The IPCC framework for climate risk informs the adaptation modelling conducted for this LTS. According to the IPCC, there are three core drivers of damages associated with climate risks:

- **Hazards:** these flow directly from temperature increase, drought, precipitation, and sea level rise. These include both acute risks (e.g.: rarer hurricanes becoming more frequent) and chronic risks (e.g.: gradual decreases in crop yields as temperatures rise).
- **Exposure:** this is determined by the location of a business activity, asset, or human settlement, and whether this coincides with increased likelihood of climate hazards. For example, coastal settlements and buildings will become increasingly exposed to risks associated with rising sea levels.
- **Vulnerability:** according to the IPCC's 2001 Synthesis Report,[117] vulnerability "is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes." Vulnerability is determined, in part, by the capacity of industries and governments to adapt to the effects of climate change.

The IPCC framework is summarised in Figure 3.6:

Figure 3.6 Damages are a function of climate hazards, exposure, and vulnerability

Source: IPCC 'Determinants of Risk: Exposure and Vulnerability', https://www.ipcc.ch/site/assets/uploads/2018/03/SREX-Chap2_FINAL-1.pdf. Last accessed 2021-10-25.

This LTS employs two adaptation modelling approaches based on this framework, which are used to translate climate hazards into quantifiable socioeconomic losses:

- **Top-down:** overall estimates of losses at the sectoral level, as well as investment requirements for adaptation, are modelled using estimates from secondary literature and internal forecasts of key macroeconomic variables. A description of the modelling approach is provided in section 3.3.1. A worked example of the modelling calculation can be viewed in the Technical Appendix, section 6.3.1.
- **Bottom-up:** the relative costs and benefits of selected adaptation interventions are assessed using detailed, bottom-up assessments of losses associated with specific climate hazards and cost data for single adaptation interventions. A description of the modelling approach is provided in section 3.3.2. A worked example of the modelling calculation can be viewed in the Technical Appendix, section 6.3.2.

[117]IPCC, 2001. Synthesis Report. Available at: https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_TAR_full_report.pdf, ;last accessed 2021-11-22.

3.3.1 Top-down modelling approach

The top-down model provides estimates of overall losses at the sectoral level, as well as investment requirements for adaptation interventions. The modelling approach is as follows:

1. **GDP forecasting.** The top-down model relies on Government of Kenya, real GDP forecasts, which are used to convert predicted percentage impacts on GDP to 2020 USD equivalents.
2. **Extraction of headline losses and adaptation investment requirements.** Point estimates of headline losses and adaptation investment requirements at the sectoral level are sourced from credible secondary literature. The most used source is the African Development Bank study 'Climate Change Impacts on Africa's Growth'.[118] This provides % GDP impacts of climate change on different sectors for the years 2030, 2040 and 2050, along with associated adaptation investment requirements by sector. These figures correspond to a high emissions scenario and are mapped to the RCP 8.5 to ensure consistency throughout the LTS.

   The AfDB estimates are supplemented with figures sourced from the UN's Disaster Risk Assessment for Kenya[119] and other credible secondary literature where appropriate. For example, because the AfDB only reports losses direct damages to water infrastructure (rather than the overall economic cost of water scarcity), Kenya Market Trust estimates costing universal water access are used to estimate investment requirements in that sector (see section 3.4.2).
3. **Conversion of loss and investment requirements to 2020 USD equivalents.** Using % GDP impacts calculated in step 2 and the GDP impacts forecasted in step 1, the top-down damages by sector are converted to 2020 USD equivalents from percentages.
4. **Linear interpolation of intervening years.** The estimates for 2030, 2040 and 2050 are used as a basis for estimating the intervening years, which are calculated using standard linear interpolation between estimates.
5. **Conversion to annual averages.** The total losses, adaptation investments and residual damages are summed between 2021 and 2050, and divided by 30, to produce the annual averages shown in.

The results of this modelling exercise are represented visually for each adaptation sector in the LTS, as well as for the economy overall. Kenya risks losing up to $11 billion annually from climate change across the economy, as shown in the first bar of Figure 3.7. Adaptation investments worth approximately $1.5 billion per annum – or 0.4% of GDP – could save approximately $3.5 billion of these losses each year. This is shown in the fifth bar of Figure 3.7. The bars in each chart refer to RCP 8.5 figures, with RCP 2.6 figures included for comparison below.

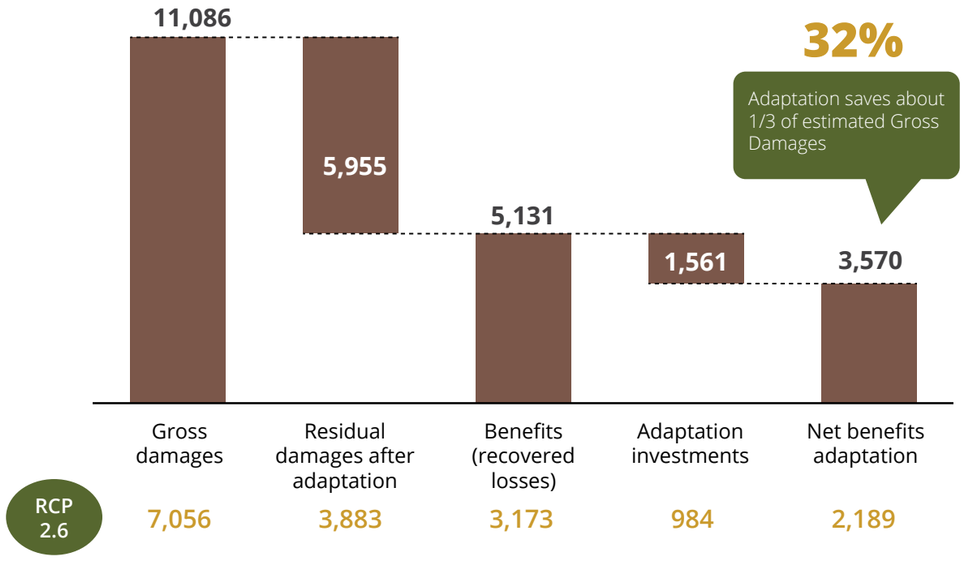
These figures should be treated as preliminary and will be reviewed in forthcoming editions of the LTS, when better data is available.

A worked example of the top-down modelling approach in practice is provided in the Technical Appendix, section 6.3.1. The same modelling approach is replicated for each adaptation sector where estimates of losses are available.

[118]AfDB, 'Climate Change Impacts on Africa's Growth', Available at: https://www.afdb.org/en/documents/climate-change-impacts-africas-economic-growth, Last accessed 2021-11-26

[119]UNISDR, 2018. 'Disaster Risk Profile: Kenya'. Available at: https://www.preventionweb.net/files/64257_kenyareportreviewedweb.pdf, Last accessed 2021-12-09.

Figure 3.7 Overall damages and net benefits from adaptation, 2020-2050 (Annual averages, 2020 USD millions)



Note: Totals are deflated at 2020 prices and are annual averages for the period 2020-2050. Bars are results for RCP 8.5, with comparators for RCP 2.6 in yellow below.

Sources: Modelling based on AfDB (2019) and UNISDR (2018)

3.3.2 Bottom-up modelling approach

In addition to top-down damage estimates, this LTS includes three cost-benefit analyses for individual adaptation interventions. These are detailed in Box 1, Box 2 and Box 3. In each case, a cost-benefit analysis is undertaken to establish whether the chosen intervention is a cost-optimal way of addressing the identified climate hazard. The cost-benefit methodology closely follows the IPCC framework described in Figure 3.6 above.[120] The modelling approach is as follows:

1. **Assessment of headline losses.** Point estimates of losses associated with specific climate risks associated with each sector are sourced from secondary literature (see section 3.3). Secondary literature typically provides multiple loss estimates based on different climate scenarios. These scenarios are mapped to RCP 2.6 and RCP 8.5 to ensure consistency.
2. **Conversion of losses to USD equivalents.** In all three models, secondary sources provided non-financial estimates of loss (for example, yield decreases for key crops in 2050). These are converted to 2020 USD equivalents based on exposure, vulnerability, and available price data, based on the IPCC framework (see Figure 3.6 above).
3. **Calculation of 2050 losses.** All outputs are forecasted from their base year to 2050 using the same macroeconomic projects used elsewhere in this report, such as population and GDP growth.
4. **Bottom-up costing of adaptation interventions.** Unit costs of interventions (e.g.: the rollout cost per hectare) are extracted from secondary literature and used to estimate cost of offsetting losses calculated in step 3. The same macroeconomic projections are used to forecast variables where necessary.
5. **Calculation of BC ratios.** Estimated damages and intervention costs for 2050 are used to calculate a benefits-to-cost ratio which, if greater than one, indicates a cost-optimal adaptation intervention. All three interventions modelled are cost optimal.

The key characteristics and results of the three bottom-up models are summarised in Table 3.1. A worked example of the bottom-up modelling calculation is included in the Technical Appendix, section 6.3.2.

[120]See IPCC, 2018. 'Determinants of Climate Risk'. Available at: https://www.ipcc.ch/site/assets/uploads/2018/03/SREX-Chap2_FINAL-1.pdf. Last accessed 2021-10-05.

Table 3.1 Bottom-up modelling summary

LTS sector	Climate hazards	Modelled damages	Interventions costed	BC ratio	Secondary sources used
Agriculture, food, and nutrition security	Temperature, droughts	Yields losses for maize, wheat, and dry beans	Offsetting yield losses through the rollout of sustainable agricultural land management techniques (SALM)	5.2-5.3	World Bank (2015)
Health	Temperature	Dollar value of losses associated with increased prevalence of malaria	Offsetting risk of malaria with preventative measures such as treated nets and IRS	.64 (treated nets) - 2.4 (IRS)	Sicuri et al. (2013), Guyatt et al. (2003), WHO (2015)
Human settlement, urban development, and housing	Floods, precipitation, sea level rise	Dollar value of losses associated with increased flooding in Mombasa	Offsetting risk of flooding with flood defence mechanisms	1.25	Kebede et al. (2012)

See IPCC, 2018. 'Determinants of Climate Risk'. Available at: https://www.ipcc.ch/site/assets/uploads/2018/03/SREX-Chap2_FINAL-1.pdf. Last accessed 2021-10-05.

3.4 Sector-level impacts

Climate change is already negatively impacting Kenya's economy, and these impacts are likely to increase in future. Top-down modelling conducted for this LTS suggests that Kenya could lose an additional 4% GDP per annum, between 2021-2050, over and above the historical losses detailed in section 3.1. This amounts to an annual average loss of approximately $11 billion per annum, at 2020 prices.

The greatest costs of climate change will be felt in the health sector, through increased morbidity and mortality. The inclusion of mortality in health sector estimates is the driving force behind its large share of damages. Under RCP 8.5, more than half of potential losses are associated with increased mortality. Increased mortality is a consequence of multiple factors, including starvation, water scarcity, heat stress and flooding. Other high-risk sectors include agriculture and tourism, which are particularly vulnerable to the effects of drought and irregular weather patterns. While it is important to recognise these estimates are only indicative, they do indicate the significant of rising temperatures and drought for Kenya's long-term development prospects, the two climate hazards driving losses in the health and agriculture sectors.

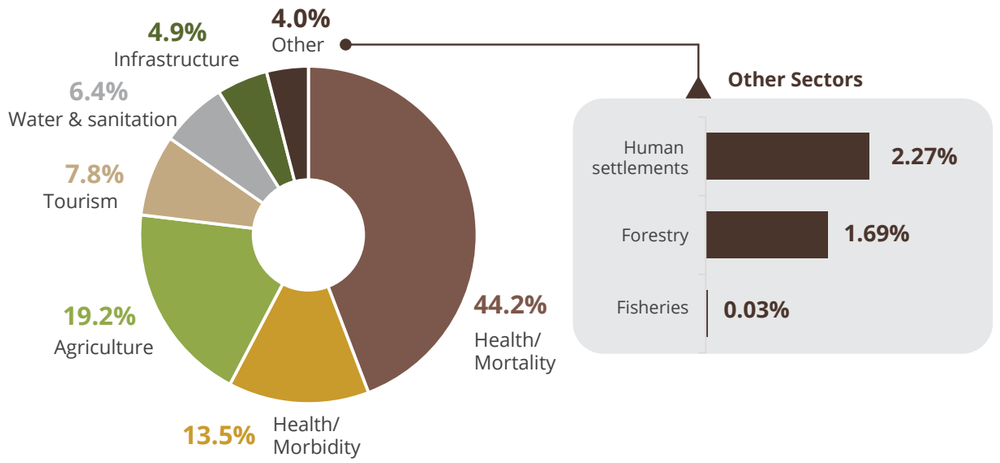


Figure 3.8 Distribution of losses by sector under RCP 8.5, 2050, %

Note: See section 3.3.1 for overview of modelling approach and the Technical Appendix, section 6.3.1, for worked example of calculation.

Source: Modelling based on AfDB (2019) and UNISDR (2018)

3.4.1 Agriculture, Food and Nutrition Security

Kenya's agriculture is already experiencing the impacts of droughts and rising temperatures. This LTS set out a vision for the sector to adapt to the effects of rising temperatures and drought, so that food security and rural livelihoods are maintained. As shown in section 3.1, droughts and rising temperatures are already harming crop yields and threatening rural livelihoods and food security. 95% of agriculture is currently rainfed, and hence highly exposed to drought risk. Introducing adaptive measures in the agricultural sector is therefore critical to ensuring Kenya's long-term economic prospects.

The agriculture sector is crucial to Kenya's current and future economic prospects. In 2020, the agricultural sector accounted for 33% of GDP and approximately half of total employment.[121] Moreover, it facilitates additional 27% of GDP through linkages to other sectors such as manufacturing, distribution, and services.[122] It employs more than 70% of the rural population.[123] Charting the future of agriculture is therefore a core component of this LTS and Kenya's broader economic development strategy.

[121]USAID, Kenya: Agriculture and Food Security. Available at: https://www.usaid.gov/kenya/agriculture-and-food-security, Last accessed 2021-10-29. Employment estimates match World Bank and ILO data from https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=KE, last accessed 2022-04-04.

[122]Government of Kenya. 2018. Agricultural Sector Transformation and Growth Strategy. Available at: https://www.agck.or.ke/Downloads/ASTGS-Full-Version-1.pdf. Last accessed 2021-10-29

[123]FAO, Kenya. Available at: http://www.fao.org/kenya/fao-in-kenya/kenya-at-a-glance/en/.Last accessed 2021-10-29

Agricultural production is concentrated in smallholder, who account for roughly three-quarters of total agricultural output.[124] Small-scale farming (average farm size 0.2-0.3 ha) accounts for 70% of maize, 65% of coffee, 50% of tea, 70% of beef and 80% of milk production. Large-scale farming mainly involves industrial crops such as tea, coffee, maize, sugarcane, and wheat. Employment in the sector is heavily concentrated within the livestock sub-sector, which employs 50% of the agricultural labour force and is the main agricultural enterprise for over 10 million Kenyans living in the arid and semi-arid lands. These lands, predominantly inhabited by pastoralists, host approximately 70% of the livestock herd and agricultural production worth approximately Ksh 70 billion.[125]

Maize is the dominant crop but delivers lower value per hectare than other crops. It accounts for 40% of cultivated land area in 2020. According to the National Investment Plan (2019-2024), maize accounted for approximately 3% of the sector's value in Ksh in 2016, despite accounting for the lion's share of cultivated land. Tea and cattle farming are the highest value components of the Kenyan agricultural sector, followed by flowers and sugar cane.[126] FAOSTAT data (see Figure 3.9) projects that this trend will continue 2050, in the absence of policy measures incentivising land use changes.

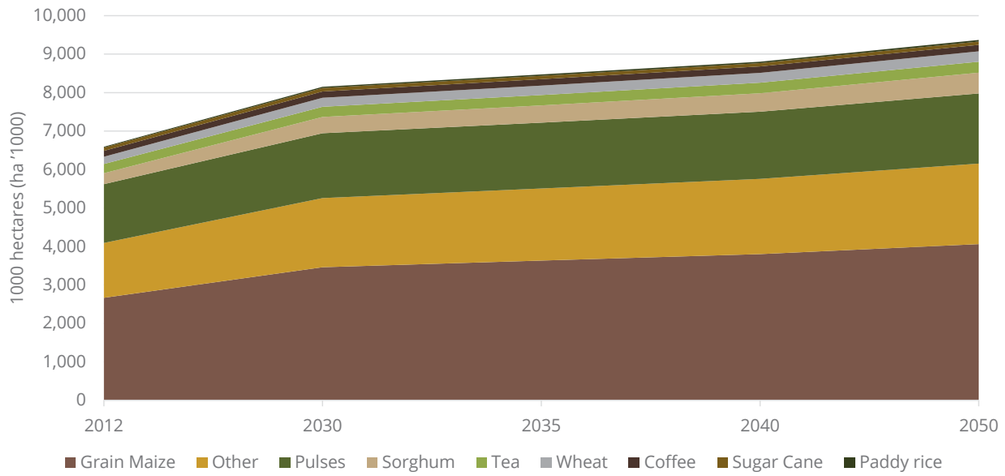


Figure 3.9 Composition of crop production under Business-As-Usual

Note: Data points modelled using linear interpolation where raw data is not available.

Source: Modelling based FAOSTAT, D'Alessandro, Caballero, Lichte & Simpkin (2015), consistent with agricultural LTS (2018)

[124]Stephen, D'Alessandro, Caballero, Lichte, and Simpkin, 2015. Kenya. Agricultural Sector Risk Assessment

[125]Kenya Climate Smart Agriculture Implementation Framework, 2018-2027.

[126]National Agriculture Investment Plan 2019-2024. Investing in Kenya's Agricultural Sector Transformation. Towards Sustainable Agricultural transformation and Food Security in Kenya.

Agriculture is heavily exposed to the impacts of drought, heavy precipitation, and rising temperatures. The sector is characterised by a limited availability of productive land, heavily reliant on rainfall, increasing the vulnerability of production. Only 17% of land receives the 800 mm minimum annual rainfall required for rainfed agriculture.[127] Recently, below-average rains across eastern and northern Kenya have resulted in below-average crop production activities.[128] Drought has significant potential to reduce crop yields, whilst rising temperatures can simultaneously reduce yields and encourage the proliferation of pests.[129] Dependence on rainfed agriculture and high poverty rates among smallholder farmers render local farmers particularly vulnerable to water scarcity.[130] This will lead to significant yield decreases, and hence financial losses.

UNISDR further estimates that the share of the livestock sector exposed to drought will increase to 36% by 2050, from a 2016 baseline of 16%.[131] As with crop farming, livestock and animal farming are extremely vulnerable to water scarcity and high temperatures. Rising temperatures and variability in precipitation will increase livestock morbidity due to lower quality forage and the increased prevalence of vector borne diseases. Cattle farming, the largest livestock sector in terms of sales value, is heavily dependent on regular rainfall to maintain good quality grassland and is hence extremely vulnerable to drought. Moreover, the increased prevalence of extreme weather may lead to flash flooding and associated livestock losses, as well as substitution towards crop farming in regions lucky enough to experience rainfall increases.

Production losses in the crop and livestock sector translate into average annual losses of between $1.3 billion and $2.1 billion over the period 2021-2050, as shown in Figure 3.10. This total incorporates multiple sources of damages, including land degradation due to droughts and flooding, decreased crop yields because of water scarcity and rising temperatures, and increased livestock mortality and morbidity.

A range of short, medium, and long-term adaptation interventions in the agriculture sector are detailed in the National Climate Change Action Plan (2018-2022), the National Adaptation Plan and the updated NDC Technical Report. The full list of interventions is detailed in the Technical Appendix, section 6.5.1. Existing commitments to adaptation interventions can be grouped into three broad themes:

1. **Increasing crop and livestock productivity through climate-smart agriculture (CSA).** This includes the roll-out of sustainable land management, irrigation and soil tilling systems in the crop and livestock sector, as well as the adoption of cages and fishponds in the fisheries sector.
2. **Building resilience in the agricultural value chain.** This includes the conducting of climate risk and vulnerability assessments across the supply chain, as well as the promotion of diversification in the crop and livestock sectors.
3. **General capacity building and cooperation.** This includes the promotion of public-private sector partnerships in the rollout of CSA techniques, as well as promoting access to information and best practice amongst farmers.

The LTS builds on prior commitments, with a view to enhancing longer term resilience in the agriculture sector until 2050. The full list of interventions is provided in Table 3.3. Interventions are grouped into two broad categories: land use changes and regulatory interventions. Land use changes are afforded higher priority, as these directly reduce the effects of climate hazards if successfully adopted.

Within land use changes, there are separate recommended interventions for crop and livestock farming. The interventions for crop farming include the promotion of intercropping techniques to reduce land degradation and the promotion of climate-smart agriculture (CSA) to increase crop yields. The promotion of locally adapted crop varieties will reduce the effects of drought, with an emphasis on indigenous varieties. Box 1 shows that the widespread rollout of sustainable agriculture land management techniques (SALM), a subset of CSA, may successfully negate yield losses for key cash crops such as maize and dry beans.

[127]Stephen, D'Alessandro, Caballero, Lichte, and Simpkin, 2015. Kenya. Agricultural Sector Risk Assessment

[128]WFP, Kenya Food Security Outlook, 2021.Available at: https://reliefweb.int/sites/reliefweb.int/files/resources/KENYA_Food_Security_Outlook_June%202021_Final.pdf. Last accessed 2021-11-12

[139]Global Circulation Models (GCMs)

[130]Stephen, D'Alessandro, Caballero, Lichte, and Simpkin, 2015. Kenya. Agricultural Sector Risk Assessment

[131]UNISDR. Disaster Risk Profile: Kenya (2018)

Box 1 Crop yield losses can be cost-effectively addressed through SALM rollout

Although adaptation interventions will not negate all financial losses associated with climate change, bottom-up modelling suggests that mass rollout of sustainable agriculture land management (SALM) techniques may negate yield losses for key crops. For crop farming, SALM encompasses climate-smart practices in nutrient management, irrigation, tillage, and residue pest management.[132] The Kenya Agricultural Carbon Project, a World Bank pilot study, showed that SALM techniques can increase crop yields by 15-20%[133] and could successfully offset projected yield losses in three key cash crops: maize, wheat and dry beans. Table 3.2 illustrates that for both RCP 8.5 and 2.6, possible losses far outweigh the costs of SALM rollout across Kenya:

Table 3.2 Cost-benefit analysis: addressing crop yield losses through SALM rollout

Scenario	RCP 8.5 (2020 $m)	RCP 2.6 (2020 $m)
2050 losses	122	47
2050 intervention costs	23	9
Benefit-cost ratio	5.36	5.21

Source: Consultant analysis based on World Bank (2015)

Livestock farming interventions focus on reducing the threat of land degradation and enhancing resilience in the animal population to drought and heat stress. They include the adoption of the SALM techniques of precision feeding and grazing, as well as improving pasture and grazing management. To enhance resilience, the LTS recommends enhancing livestock access to water, conserving forages, and targeted breeding to promote heat tolerant species, amongst other interventions.

Regulatory interventions include policy changes to promote efficiency in the value chain, as well as the promotion of access to information on agricultural best practice. These include funding increases for research and development, rolling out early warning systems for crop failures and promoting targeted agricultural subsidies. These will create an enabling policy environment for the targeted land-use interventions above.

Table 3.3 lists the LTS adaptation interventions for the Agriculture, Food and Nutrition Security sector:

[132]VI Agroforestry, 2014. SALM. Available at: https://viagroforestry.org/app/uploads/2018/11/Vi_SALM-Training-Manual_Chapter-1-to-3.pdf, Last accessed 2021-10-26

[133]World Bank, 2014. 'Kenyans Earn First Ever Carbon Credits from Sustainable Farming'. Available at: https://www.worldbank.org/en/news/press-release/2014/01/21/kenyans-earn-first-ever-carbon-credits-from-sustainable-farming, Last accessed 2021-10-26.

Table 3.3 Priority adaptation actions for Agriculture, Food and Nutrition Security

Intervention type	Subsectors	Intervention
Land use changes	Crop farming	Increase crop yields through mass rollout of CSA techniques
		Promote crop rotation and intercropping
		Improve locally adapted varieties, with emphasis on indigenous varieties
	Livestock farming	Increase adoption of SALM techniques of precision feeding and watering, including drip irrigation
		Improve pasture and grazing management through uptake of SALM techniques
		Breed livestock for greater tolerance to heat and increased productivity
		Diversify livestock and forage species to increase resilience
		Breed forages which can tolerate high temperature and have high growth and regeneration rates
		Minimize disease spread through vaccinations and improve shelters
		Enhance livestock access to water
		Enhance livestock pasture production and storage (e.g., having a strategic pasture reserve)
Regulatory interventions	Livestock farming	Enhance efficiency of the livestock value chain
	Crop and livestock farming	Enhance co-production, access, and use of climate information services and early warning systems to minimize loss and maximize production in the livestock sector
		Promote the uptake of climate-oriented agricultural subsidies, risk transfers, early action interventions and other safety nets.
		Increase funding for research and development

Overall investment needs in the sector will average around $340 million annually over the next 30 years. According to African Development Bank estimates, approximately 12% of the $2.1 billion annual average losses can be avoided through the rollout of adaptation interventions. These interventions include the adoption of resilient crop varieties, the rollout of climate-smart irrigation techniques and the adoption of sustainable animal husbandry.

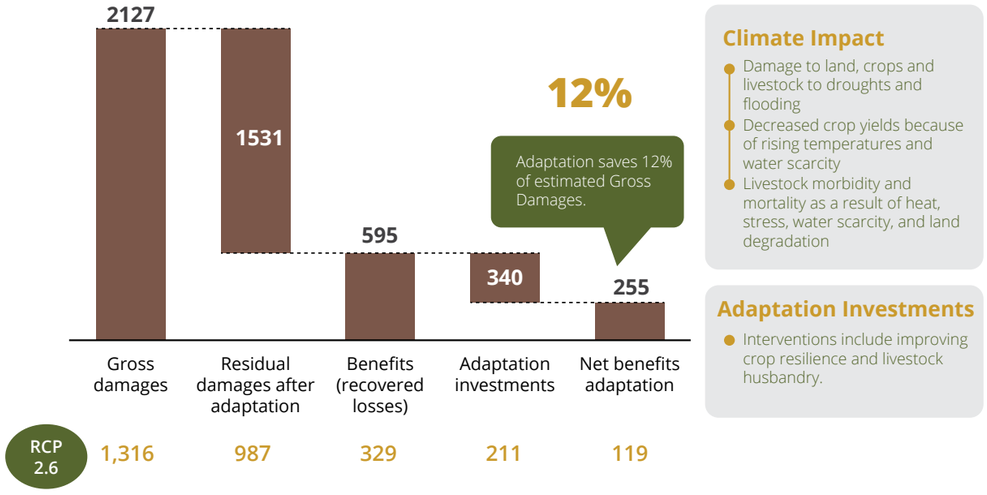


Figure 3.10 Agriculture, Food and Nutrition Security: overall damages and net benefits from adaptation, 2020-2050 (Annual averages, 2020 USD millions)

Note: See section 3.3.1 for overview of modelling approach and the Technical Appendix, section 6.3.1, for worked example of calculation. Totals are deflated at 2020 prices and are annual averages for the period 2020-2050. Bars are results for RCP 8.5, with comparators for RCP 2.6 in yellow below.

Source: Modelling based on AfDB (2019) and UNISDR (2018)

3.4.2 Water and Sanitation

Kenya requires significant investment to ensure universal water access and security, a challenge made more difficult by increased incidence of droughts and flooding related to climate change. UN Sustainable Development Goal number 6 seeks to ensure "clean water and sanitation" for all.[134] However, Kenya's average per capita water consumption in 2010 was 586m3, well below the global threshold for chronic water scarcity (1,000m3).[135] Reasons for this shortfall include severe droughts, unsustainable use and management of water supply, contamination and increasing demand, low storage capacities and interventions in the natural course of rivers to build dams for power generation.[136]

A significant share of the population lacks access to reliable water supply and basic sanitation. 32% of Kenyans rely on unimproved water sources, such as ponds, shallow wells and rivers, while 48% of Kenyans lack access to basic sanitation solutions. Only 25% have hand-washing facilities with soap and water at home. 9.9 million people drink directly from contaminated surface water sources and an estimated five million people practice open defecation.[137] These challenges are especially evident in rural areas and urban slums where people are often unable to connect to piped water infrastructure. However, there are many areas where piped water connections do not supply a reliable, constant flow of water. Solutions like borehole wells and rainwater harvesting tanks are also needed in urban and peri-urban areas.[138]

Independently of climate change, the water stress level will increase with rapid population growth and urbanization. The water sector contributed about 0.7% to GDP in 2017, employing over 200,000 people[139]. Given that development partners now contribute more than half of financing, an increase in mobilizing new sources of financing, including commercial financing for commercially viable investments, is required.[140]

From the early 2000s, several policy changes have sought to address water security. The Ministry of Water and Sanitation now oversees the sector within government. The Water Act of 2002 introduced important reforms in the sector that improved governance, operational efficiency, and retained revenues within the sector for reinvestment. The Water Services Regulatory Board also introduced significant reforms to utility tariffs in 2009. The 2014 Kenya's National Water Master Plan, based on Vision 2030, proposed additional improvements for the water sector.[141] These are geared towards digitising core water indicators, such as setting up a database monitoring water scarcity. The Master plan also sets specific water quality targets for essential water bodies and seeks to improve general monitoring of hydrometeorological information.

Further reforms were undertaken in 2016. Following decentralization of the sector, the Water Act of 2016 was passed to align the sector with the provisions of the 2010 Constitution, which retains provisions for debt financing for investment.[142] Four sanitation and hygiene policies were developed to align with the Sustainable Development Goals, as well as the country's other global and regional WASH initiatives.

However, despite these policy advances, the water sector remains heavily exposed to the effects of climate change. USAID predict that water access will continue to drop, with a predicted per capita water consumption of only 293m3 by 2050. This is a consequence of rising temperatures, increased drought, and irregular precipitation patterns (see section 3.2 for more details). These climate hazards have the dual consequence of drying out supply channels like rivers, dams, and wells, as well as rendering other water supplies unpotable through flooding and contamination. Increased water scarcity also has the potential to induce human migration from arid areas.

Increased water scarcity associated with climate change will have multiple socioeconomic impacts. Lack of clean water supply impedes basic hygiene like handwashing or washing of fruit and vegetables, which may promote the spread of illness. Children and the old are especially affected by potentially fatal diseases like diarrhoea.[143] [144]Women, the main collectors of water for drinking and cooking, are hit particularly hard as they need to walk longer distances to obtain clean water, in addition to generally insufficient supply.[145] Water scarcity has direct adverse effects on agricultural output and food supply, with the potential to exacerbate existing economic and social inequalities and gender discrimination.[146]

The effects of water scarcity will translate into average annual losses of between $140 million and $226 million over the period 2021-2050, as shown in Figure 3.11. This total incorporates multiple sources of damages, including a reduction in water availability for households and businesses due to drought, disruption and pollution of water supplies due to increased flooding, and increased demand for scarce water from households, agriculture, and industry. They exclude, however, the impacts of drought on the agricultural sector, which are discussed in section 3.4.1 above.

A range of short, medium, and long-term adaptation interventions in the water sector are detailed in the National Climate Change Action Plan (2018-2022), the National Adaptation Plan and the Updated NDC Technical Report. The full list of interventions is detailed in the Appendix, section 6.5.2. Existing commitments to adaptation interventions can be grouped into four broad themes:

1. **Expanding water supply:** This includes construction of infrastructure such as dams, as well as conducting groundwater surveys and implementing wetland protection schemes
2. **Promotion of water efficiency:** This includes climate-proofing existing infrastructure, and the promotion of climate-smart water saving techniques such as water harvesting, with a focus on gender equity.
3. **General capacity building, information gathering and cooperation.** This includes capacity institution-building and training for government bodies carrying out water policies, as well as information campaigns on water efficiency.

[134]UN Sustainable Development Goals. Available at: https://www.un.org/sustainabledevelopment/sustainable-development-goals/ . Last access 2021-11-12

[135]USAID, 2018. Climate risk profile

[136]Marshall, S, 2011. The water crisis in Kenya: Causes, effects, and solutions, in: Global Majority (2); National Climate Change Action Plan (NCCAP) 2018-2022 – Volume I

[137]UNICEF, Water Sanitation and Hygiene. Available at: https://www.unicef.org/kenya/water-sanitation-and-hygiene. Last accessed 2021-11-12

[138]Water.org Kenya. Available at: https://water.org/our-impact/where-we-work/kenya/ . Last accessed 2021-11-12

[139]Kenya Market Trust, 2019. The journey of changing water services delivery in Kenya. Available at: https://www.kenyamarkets.org/wp-content/uploads/2020/04/water-industry-research-in-kenya-service-delivery.pdf, Last accessed 2021-11-12

[140]The World Bank, 2018. Kenya: Using private financing to improve water services. Available at: https://www.worldbank.org/en/about/partners/brief/kenya-using-private-financing-to-improve-water-services. Last accessed 2021-11-12

[141]Republic of Kenya (Ministry of Environment, Water and Natural Resources) – National Water Master Plan, Available at: https://wasreb.go.ke/downloads/National%20Water%20Master%20Plan%202030%20Exec.%20Summary%20Vol.%201%20Main%201.pdf. Last accessed 2021-11-12

[142]https://www.worldbank.org/en/about/partners/brief/kenya-using-private-financing-to-improve-water-services

[143]WHO, 2019. Drinking Water. Available at: https://www.who.int/news-room/fact-sheets/detail/drinking-water. Last accessed 2021-11-12

[144]CDC,2020. Health implications of drought. Available at: https://www.cdc.gov/nceh/drought/implications.htm. Last accessed 2021-11-12

[145]National Climate Change Action Plan (NCCAP) 2018-2022 – Volume I

[146]Nationally Determined Contribution – Update Technical Report 2020 (Kenya)

The LTS builds on these prior commitments, with a view to enhancing longer term resilience in the water sector until 2050. Interventions are grouped into two broad categories: water access measures and regulatory interventions. Water access measures are given higher priority, as these directly reduce the effects of climate hazards if successfully adopted.

Within water access measures, there are separate interventions recommended for resource management and sanitation improvement. The resource management interventions are designed to climate-proof existing water infrastructure and encourage resource efficiency, thereby reducing the vulnerability of dependent communities to future water scarcity associated with drought and rising temperatures. Construction and climate-proofing of dams and flood walls seek to secure and expand existing supply, while the rollout of climate-smart policies such as water harvesting will encourage efficient use of rainwater and existing water bodies. Measures for improving sanitation include increasing the coverage of sewers, as well as implementing holding stations for sewer management.

Regulatory interventions compliment the resource management policies by creating an enabling policy environment and encouraging investment in the sector. Mainstreaming climate-change into sub-catchment management plans will ensure resource-efficiency is at the core of policy delivery, while the strengthening bilateral efforts to manage transboundary water issues will encourage a collaborative approach between country partners to addressing climate risk. The sanitation interventions include promoting a favourable investment environment for PPPs, as well as capacity building and information campaigns on wastewater treatment technologies

Table 3.4 Priority adaptation actions for Water and Sanitation

Intervention type	Subsectors	Intervention
Water access measures	Resource management	Promote water harvesting and storage at household and regional levels
		Build resilient infrastructure for the protection of dams and dikes and river lines
		Build multipurpose dams
		Building climate smart infrastructure for the protection of dams, water pans and other water storage facilities to prevent water loss through evaporation caused by the increasing global temperatures
		Increase water availability per capita, through artificial water recharging of aquifers among others
		Promote water efficiency by reducing non-revenue water, reusing, and recycling of wastewater
	Sanitation improvement	Increase sewer coverage with focus on promoting onsite sanitation technologies
		Implement holding stations for sewer management
Regulatory interventions	Resource management	Conduct climate and risk assessments on transboundary water resource management and develop adaptation plans incorporating nature-based solutions
		Establish/strengthen bilateral efforts to manage transboundary water resource management issues
		Mainstream climate change into sub-catchment management plans.
	Sanitation improvement	Develop a favourable financial model for sanitation, whereby the government should subsidize sanitation services to transport effluents from the remote residential areas to city waste treatment plants
		Create a favourable environment for PPP to encourage private sector involvement in the sanitation service industries
		Capacity building and awareness on onsite wastewater treatment technologies
		Implement holding stations for sewer management

Approximately $980 million annual investment will be required to provide universal water and sanitation access by 2030.[147] Yet, only slightly more than one-third of that amount is allocated under current budget plans - public spending on water supply amounts to about 2% of the national budget.[148] In addition, African Development Bank estimates show that existing infrastructure may suffer damages of approximately $714 million per annum from climate change over the next thirty years. Approximately 80% of these losses can be avoided through adaptation expenditure, at a cost of approximately $53 million per annum to climate-proof existing infrastructure.

The long-term investment requirements for the water sector are therefore approximately $1 billion per annum over the next thirty years.

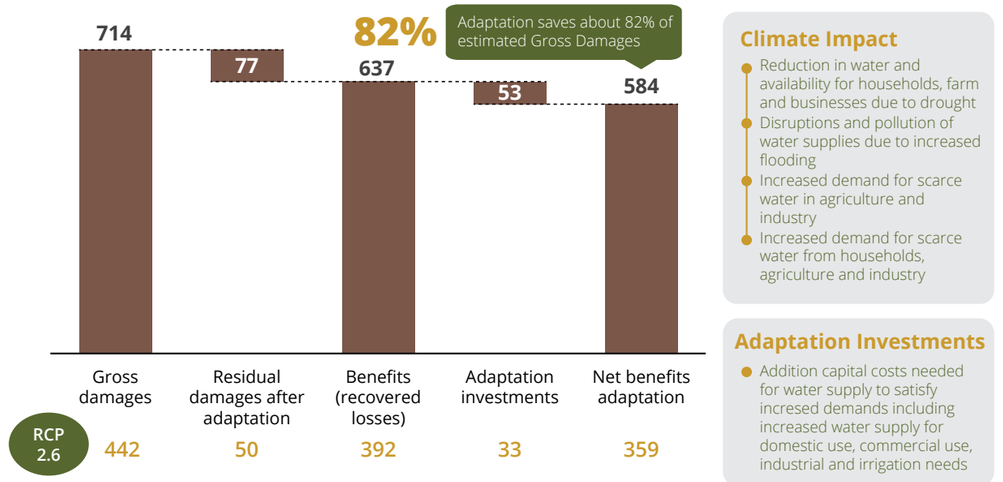


Figure 3.11 Water and Sanitation: overall damages and net benefits from adaptation, 2020-2050 (Annual averages, 2020 USD millions)

Note: See section 3.3.1 for overview of modelling approach and the Technical Appendix, section 6.3.1, for worked example of calculation. Totals are deflated at 2020 prices and are annual averages for the period 2020-2050. Bars are results for RCP 8.5, with comparators for RCP 2.6 in yellow below.

Source: Modelling based on AfDB (2019) and UNISDR (2018)

[147]Kenya Market Trust, 2019. The journey of changing water services delivery in Kenya. Available at: https://www.kenyamarkets.org/wp-content/uploads/2020/04/water-industry-research-in-kenya-service-delivery.pdf. Last accessed 2021-11-12

[148]Republic of Kenya, 2019. Financing water sector in Kenya, available at: https://www.waterreforms.go.ke/financing-water-sector-in-kenya/. Last accessed 2021-11-12

3.4.3 Fisheries and the Blue Economy

The fisheries and blue economy sector are significant sources of food and income in Kenya. Fisheries alone contributes about 5% to Kenya's GDP and employs approximately one million people across the value chain.[149] Most fish catch comes from inland water bodies, especially Lake Victoria, which accounts for 62.5% of fishery output in 2019.[150] Marine fishing only plays a minor role, mainly due to a lack of vessels and equipment suited for fishing deep waters. The fisheries sector is dominated by small-scale fishing, accounting for 95% of the total catch.[151] Mombasa, which hosts the largest seaport in East Africa, is a major hub for regional trade and the base for Kenya's deep-sea fishing fleet.[152]

Moreover, associated coastal storm damage and flooding on local flora and fauna can lead to loss of food for various marine fauna, particularly on coral reefs. Coral reefs and rocky shore ecosystems occur all along the coast except at the mouths of the major rivers, the Tana and Sabaki rivers. They harbour rich biodiversity of birds, fish, crustaceans, molluscs, and echinoderms. In turn, the rich biodiversity supports people's livelihood through fisheries, tourism, and cultural heritage. The impact of coral bleaching and mortality induced by warming of sea surface temperature is a major driver of coral declines worldwide. There is evidence of climate-induced events affecting indirectly coral reef fish abundance and in the long-term ocean warming alters the distribution of organisms and may drive some species to extinction.[153] A recent coral bleaching event was observed during the April – May 2016 period, in which approximately 60% of all coral colonies assessed were bleached and up to 20% mortality was observed in some sites.[154] Changes in sedimentation patterns and decreased light penetration to benthic organisms are also possible to observe.

Under the leadership of the Ministry of Agriculture, Livestock, Fisheries and Irrigation and the Ministry of Transport, Infrastructure, Housing and Urban Development, Kenya has established a "Blue Economy" task force.[155] Its primary objectives are to:

- Encourage sustainable use patterns of marine and aquatic resources
- Promote the use of ocean and freshwater resources as a source of economic growth
- Create people-centred and inclusive strategies for developing a sustainable blue economy
- Mobilise financial resources to support research, pilot projects and the implementation of sustainable ways of harnessing the benefits of the blue economy

However, despite these policy advances, the fisheries and blue economy sector remains vulnerable to the effects of climate change. Marine and aquatic ecosystems are particularly susceptible to global warming with adverse effects for biodiversity, livestock and economic activity like fishery or tourism. Sea temperatures in the Western Indian Ocean have increased by about 0.6°C since 1950 and even higher temperature rises can be observed for inland water bodies.[156] Rising temperatures translate into socioeconomic losses through declining fish stocks and expensive adaptation measures. Rising water temperatures force fishers to move to colder and deeper waters, requiring substantial investment in vessels, equipment, and port infrastructure. At the same time, fishing productivity decreases due to lower stocks. Climate change-induced damage to marine and aquatic ecosystems, like coral reef bleaching, has additional negative spill-over effects on other sectors such as tourism.

Freshwater inland water bodies, the backbone of Kenya's fishery sector, are hit more than ocean systems. This is due to their relative shallowness and the resulting lower capacity to buffer higher temperature and acidification caused by climate change or increasing water pollution.[157] In addition, increased evaporation increases the risk of lakes and rivers drying out. This has adverse effects on the availability of nesting and feeding grounds, increases the risk of alien invasive species, and has the potential to reduce catch potential significantly in the future. Catches are already decreasing today, due to declining fish populations and drying of rivers and lakes. Climate change will worsen this trend: the maximum catch potential is expected to decrease by between 2.8% and 12% by 2050, from a 2020 baseline.[158]

[149]Kenya National Adaption Plan, 2015-2030.

[150]Nationally Determined Contribution – Update Technical Report 2020 (Kenya)

[151]Kenya National Adaption Plan (2015-2030)

[152]Nationally Determined Contribution – Update Technical Report 2020 (Kenya)

[153]National Climate Change Action Plan (NCCAP) 2018-2022 – Volume I & II

[154]Mwaura, J., Umezawa, Y., Furaha, J., Kimeli, A., Kamau, J., Aura, C.M.,2017. Spatial variability of scleractinian coral bleaching susceptibility in 2010 El Nino-Southern Oscillation between northern and southern reefs, Kenya. Coastal Marine Science

[155]UNEP (2021), New programme to support Kenya's coast and blue economy, Available at: https://www.unep.org/nairobiconvention/kenya-promoting-blue-economy-home-and-abroad. Last accessed 2021-11-12

[156]National Climate Change Action Plan (NCCAP) 2018-2022 – Volume I

[157]Nationally Determined Contribution – Update Technical Report 2020 (Kenya)

[158]GoK, 2020. Low Carbon Agriculture Development Pathways, Kenya.

The effects of rising temperatures on the fisheries sector will translate into average annual losses of approximately $3 million over the period 2021-2050, as shown in Figure 3.12. This reflects multiple sources of damage, including the depletion of ocean stocks from coral bleaching, intrusion of saline water into freshwater fisheries and reduction of stock due to overfishing and water scarcity.

A range of short, medium, and long-term adaptation interventions in the fisheries sector are detailed in the National Climate Change Action Plan (2018-2022), the National Adaptation Plan and the Updated NDC Technical Report. The full list of interventions is detailed in the Appendix, section 6.5.3. Existing commitments to adaptation interventions can be grouped into three broad themes:

1. **Supply increases:** These include the expansion of fishing zones in coastal and inland communities, as well as the rollout of infrastructure such as ponds and cages.
2. **Increasing resilience:** This includes promoting uptake of adaptive species and the adoption of climate-smart infrastructure and equipment. Interventions also include the promotion of water efficiency techniques such as harvesting (see section 3.4.2 above).
3. **Capacity building and awareness:** This includes training for responsible officials and institutions, detailed and regular risk assessments, and information campaigns on blue carbon readiness for affected communities.

The LTS builds on prior commitments, with a view to enhancing longer term resilience in the fisheries and blue economy sector until 2050. Interventions seek to safeguard existing fish stocks and blue natural capital through the promotion of sustainable fishing practices. Such measures include the introduction of fishing permits and stricter quotas, along with behavioural interventions to shift consumer diets towards sustainably sourced fish. The LTS also prioritises long-term resilience in the sector, through the breeding of climate-resilient fish and seaweed species, and the rehabilitation of coral reefs. These interventions have the dual benefits of safeguarding existing natural capital, while also reducing the risk of species destruction and coastal flooding.

The LTS also prioritises creating an enabling policy environment for a resilient and sustainable blue economy, through expanded capacity building for responsible policy makers and dependent communities. Policies seek to promote an ecosystem approach to fisheries management, as well as regulatory measures to prevent overfishing.

Table 3.5 lists the LTS adaptation interventions for the Fisheries and the Blue Economy sector:

Photo Credit: CLD

Table 3.5 Priority adaptation actions for Fisheries and the Blue Economy

Intervention type	Intervention
Sustainable fishing	Upscale sustainable offshore aquaculture
	Introduce improved fishing infrastructure and technologies
	Create incentives to shift diets toward low carbon marine sources such as sustainably harvested fish, and seaweed, as a replacement for emissions intensive land-based sources of protein
	Introduce regulations such as permits and stricter fishing quotas to prevent over-fishing.
	Implement Port State Measures Agreement to minimize illegal unregulated and unreported (IUUs) fishing
	Empower fisher community through education, capacity building, and livelihood diversifications
	Provide a framework for incentives that promote investment in low carbon development in fisheries and blue economy
	Establish a sustainable financing mechanism for fisheries and blue economy sectors
Resilience	Expand seaweed farming beyond Kwale County of Kenya
	Increase feeds and seed in the ecological food chain of aquaculture through improved technology and capacity building
	Rehabilitate coral reefs
	Introduce targeted breeding of resilient species
	Conduct a risks and vulnerability assessment of the fisheries subsector
	Review, strengthen and deploy adaptation capacity in fisheries and blue economy
	Strengthen ecosystem approach to fisheries management
	Strengthen monitoring capacity to prevent over-fishing for both inland and EEZ

Overall investment needs in the sector will average around $2 million annually over the next 30 years. An additional $10 million per year is proposed by the Nature Conservatory to preserve an additional 10,000 hectares of mangroves and $9 million to preserve around 3,000 hectares of sea grass in Lamu. According to African Development Bank estimates, approximately 43% of the $3.3 million annual average losses can be avoided through the rollout of adaptation interventions. These interventions include the rollout of improved fishing technology and the breeding of climate resilient species.

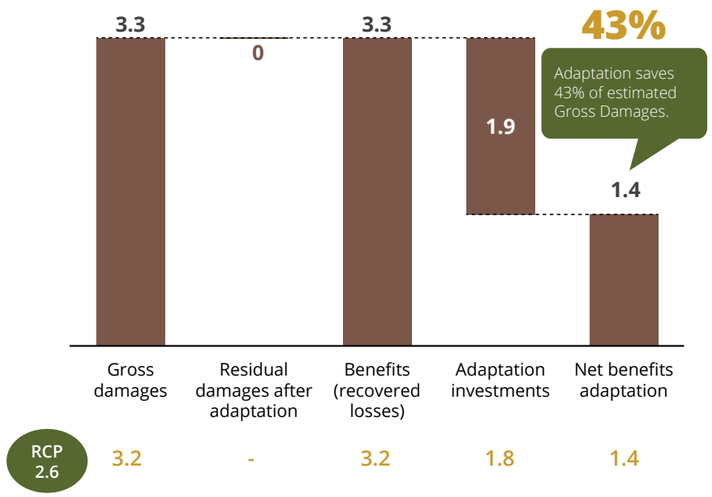


Figure 3.12 Fisheries and the Blue Economy: overall damages and net benefits from adaptation, 2020-2050 (Annual averages, 2020 USD millions)

Note: See section 3.3.1 for overview of modelling approach and the Technical Appendix, section 6.3.1, for worked example of calculation. Totals are deflated at 2020 prices and are annual averages for the period 2020-2050. Bars are results for RCP 8.5, with comparators for RCP 2.6 in yellow below.

Source: Modelling based on AfDB (2019) and UNISDR (2018)

3.4.4 Forestry

Kenyan forests are diverse and constitute an important asset for the country. Forests are dynamic ecosystems consisting of plants, animals, and microorganisms. Kenya is endowed with a wide range of forest ecosystems ranging from montane rainforests; savannah woodlands; dryland forests; and coastal forests, which include mangroves and Kayas. Kenyan forests have high species richness and endemism, which has made the country be classified as mega diverse. They rank high as the country's natural capital due to their environmental, life supporting functions, and the provision of diverse ecological and economic goods and services.[159]

Forests make a significant contribution to the economy. They play critical ecological, social, cultural, and economic functions and contribute directly and indirectly to the national, regional and local ecosystems and economies through climate stabilisation, revenue generation and wealth creation. It is estimated that forestry contributes 3.6% to Kenya's GDP, excluding charcoal and direct subsistence uses. Forests also support most productive and service sectors in the country, particularly agriculture, fisheries, livestock, energy, wildlife, water, tourism, recreation, trade and industry that together contribute between 33% to 39 % of the country's GDP. Biomass comprises about 80% of all energy used in the country. Forests also provide a

[159]Ministry of Environment and Forestry, 2020. Draft National Forest Policy. Available at: http://www.environment.go.ke/wp-content/uploads/2020/06/Draft-Forest-Policy-19May-2020-.pdf. Last accessed 2021-11-12

variety of goods, which support subsistence livelihoods of many communities.[160] Forests comprise the country's water towers and catchments, where over 75% of the country's renewable surface water originates, and therefore serve critical water regulation roles, which are important for human livelihoods, irrigated agriculture, and production of hydroelectric power.[161]

Kenya aims to increase its forest cover, implying reduced deforestation and increasing reforestation efforts. The Constitution and the economic blueprint Vision 2030 require the country to work towards achieving a forest cover of at least 10% of the land area to ensure sustainable resource use, growth, and employment creation. As of 2018, the forest accounted for 5.9% of the land area of the country is still below the constitutional requirement of 10%. Net deforestation in Kenya is estimated at 50,000 hectares annually, with a consequent yearly loss to the economy of over USD 19 million.[163] [163]

Improving forest governance has been an implicit governance objective over the past ten years. The Forests Act (2005) introduced participatory forest management, through the engagement of local communities, and the promotion of private sector investment in gazetted forest reserves, accompanied by concomitant institutional and organizational change, notably the establishment of the Kenya Forest Service (KFS), and the formation of Community Forest Associations. The Forest Management Act was enacted in 2016 to implement forest-related provisions of the 2010 Constitution.[164]

A draft Forest Policy was published in 2020 to further these aims, but it has not yet been finalised. The Policy will provide the basis for governance, administrative and legislative reforms in the sector. It seeks to balance the needs of the people of Kenya with opportunities for sustainable forest conservation, management, and utilisation. It is informed by various pieces of legislation, including the Constitution, the National Land Policy, Transition to Devolved Government Act (2012), the Inter-governmental Relations Act (2012), the Land Act (2016), the Physical Planning and Land Use Act (2019). It has also been influenced by various climate commitments, such as National Climate Change Action Plan, Nationally Determined Contributions commitments, the National Land Use Plan, the National Forest Programme, the Green Economy Strategy Implementation Plan and the Sustainable Development Goals.[165]

Although there is clear policy commitment to addressing the risk of deforestation, climate change risks worsening existing deforestation patterns. The distribution of forests is largely determined by rain patterns, which means that changing precipitation patterns may threaten the sector's survival in the future. Water scarcity and irregular rainfall will result in reduced biodiversity capacity to deliver important forest goods and services. A study conducted in Laikipia shows that rainfall decreases and temperature increases are already inducing land use changes, resulting in a forest cover decrease of 24% in the last three decades.[166] Another study in Arambulo Sokoke determined that there was a relationship between tree biomass, temperature and rainfall variability based on the use of RCP 4.5 and 8.5. This study concluded that there was a shift in species and niche reduction. Because of this, the study recommended that communities that relied on forests for their livelihoods diversify their income sources to reduce dependence on forests.[167] Finally, analysis of satellite imagery in the Lake Victoria Basis from 2001-2009 shows that areas under woody savanna have increased at the expense of forest cover, partly because of lower rainfall. This could have negative impacts on the growing cycle and alter vegetation cover, which affect wildlife habitat and livestock pasture, leading to increased competition between species. Changes in grasslands and marine ecosystems also are noticeable with effects on pastoralism and fisheries.[168]

According to the IPCC AR5, the risks facing Kenya are mirrored elsewhere in sub-Saharan Africa. Across sub-Saharan Africa, a 57% increase in agricultural areas and a 15% increase in barren areas was accompanied by a decrease in total forest and non-forest cover. Increasing CO2, changing precipitation patterns, and increasing temperatures have driven the climate change component of these changes. At the individual country level, on Mt. Kilimanjaro, increased vulnerability to anthropogenic fires has driven a 9% decrease in montane forest and an 83% decrease in subalpine forest. Changing precipitation patterns and increasing temperatures have driven the climate change component of these changes.[169]

[160]Ibid.

[161]Ministry of Environment and Forestry, 2020. Draft National Forest Policy. Available at: http://www.environment.go.ke/wp-content/uploads/2020/06/Draft-Forest-Policy-19May-2020-.pdf. Last accessed 2021-11-12

[162]Average net decrease in forest area between 2010 and 2018. Available at: https://redd.unfccc.int/files/national_frl_report_for_redd__in_kenya.pdf: Last accessed 2021-11-12

[163]Ministry of Environment and Forestry, 2020. Draft National Forest Policy. Available at: http://www.environment.go.ke/wp-content/uploads/2020/06/Draft-Forest-Policy-19May-2020-.pdf. Last accessed 2021-11-12

[164]Ibid.

[165]Ibid.

[166]M'mboroki, G.K., Wandiga, S. & Oriaso, O. S., 2018. Climate change impacts detection in dry forested ecosystem as indicated by vegetation cover change in —Laikipia, of Kenya. Available at: https://link.springer.com/article/10.1007/s10661-018-6630-6. Last accessed 2021-11-12

[167]Kipkorir, G.T., 2018. Modelling Impacts of Climate Change on Tree Biomass and Distribution in Arabuko Sokoke Forest Reserve, Kenya. Available at: http://erepository.uonbi.ac.ke/bitstream/handle/11295/101441/Kipkorir_Modelling%20Impacts%20Of%20Climate%20Change%20On%20Tree%20Biomass%20And%20Distribution%20In%20Arabuko%20Sokoke%20Forest%20Reserve,%20Kenya.pdf?isAllowed=y&sequence=1 Last accessed 2021-11-12

[168]Ibid.

[169]Thiaw, I. ,2015. Is the Climate changing African Ecosystems. Available at: https://esajournals.onlinelibrary.wiley.com/doi/pdf/10.1890/EHS14-0025.1. Last accessed 2021-11-12

Forest dwelling communities are risk of zoonotic diseases and forest fires. As climate changes, populations living within fragmented forests stand a higher risk of contracting zoonotic infectious diseases such as anthrax, trypanosomiasis, rabies, brucellosis and Rift Valley fever (RVF), arising out of increased contact with vectors at the forest edges. Furthermore, when temperatures rise to a critical level, forest fires are expected to occur more frequently, causing various respiratory diseases associated with smoke inhalation, such as asthma and bronchitis.[170]

The effects of changes in land use and weather patterns on the forestry sector will translate into average annual losses of between $66 million and $187 million, in the absence of adaptation interventions. This is shown in Figure 3.13. The key driver of these losses is land use changes in response to climate risks, which deforestation and the destruction of associated livelihoods.

In response to these risks, a range of short, medium and long-term adaptation interventions for the forestry sector are detailed in the National Climate Change Action Plan (2018-2022), the National Adaptation Plan and the Updated NDC Technical Report. The full list of commitments provided in the Appendix, section 6.5.4. The interventions can be grouped into three broad themes:

1. **Reducing deforestation:** This includes conservation of selected areas for wildlife, policy measures encouraging afforestation and reducing deforestation, as well as community land management projects.
2. **Expanding forest cover:** This includes various targets for increasing forest cover, on both public and private land.
3. **Research and risk management:** This includes regular risk assessments, further research into the drivers of deforestation and engagement with forest-dependent communities.

The LTS builds on prior commitments, with a view to enhancing longer term resilience in the forestry sector until 2050. Interventions to increase forest productivity include the promotion of high-quality germplasm and appropriate silvicultural practices. The LTS also targets increases in forested areas, as well as several consultation initiatives targeted at dependent communities. There are recommendations for planning reform, targeting sustainable forest management and more regular forest planning. These measures seek to address deforestation risks through promoting forest productivity and coverage, as well as improving management of the sector.

Table 3.6 lists the LTS adaptation interventions for the Forestry sector:

Table 3.6 Priority adaptation actions for Forestry

Intervention type	Intervention
Increase forest productivity	Increase forest productivity using high quality germplasm and appropriate silvicultural practices
Improve forest management	Implement a forest management plan.
	Support participation of public institution in plantation programmes.
	Support participation of non-state actors in public plantation programmes.
	Streamline the participation of communities in the plantation establishment and Livelihood improvement Scheme (PELIS) and enhanced enforcement of 10% farm forest rule
	Increase area under private sector-based commercial and industrial plantations from 71,000 ha to at least 121,000 ha
	Support sustainable management of public plantation forests to enhance productivity

[170]Graczyk (2002); Molyneux (2003) IN Saalu, F.N.,Oriaso, S. & Gyampoh, B. (2020). Effects of a changing climate on livelihoods of forest dependent communities. Evidence from Buyangu community proximal to Kakamega tropical rain forest in Kenya. International Journal of Climate Change Strategies and Management Vol. 12 No. 1, 2020 pp. 1-21 Emerald Publishing Limited 1756-8692 DOI 10.1108/IJCCSM-01-2018-0002.

Overall investment needs in the sector will average around $34 million annually over the next 30 years. According to modelling based on African Development Bank and World Bank estimates, approximately 82% of the $187 million annual average losses can be avoided through the rollout of adaptation interventions. These interventions are geared towards improving the productivity and management of forests, consistent with the recommended interventions above.

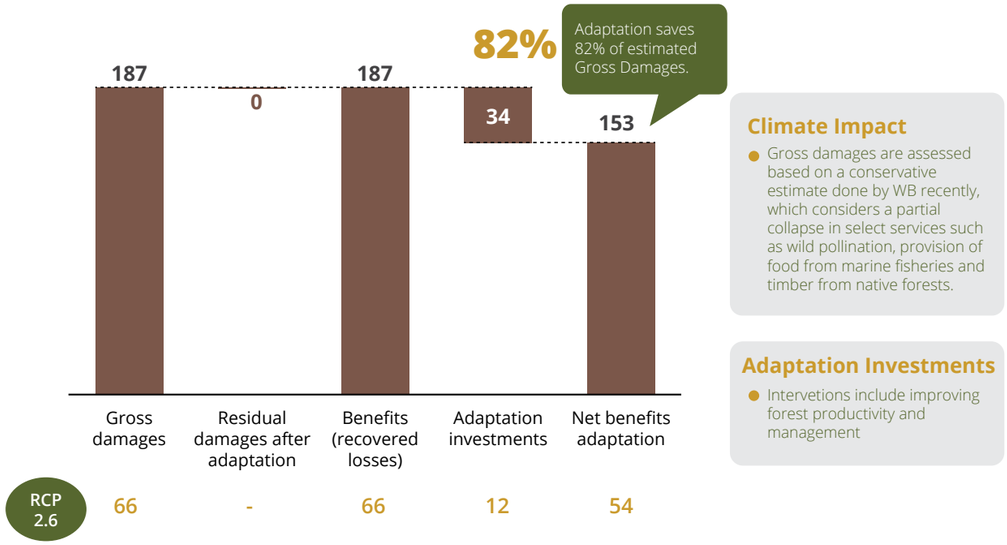


Figure 3.13 Forestry: overall damages and net benefits from adaptation, 2020-2050 (Annual averages, 2020 USD millions)

Note: See section 3.3.1 for overview of modelling approach and the Technical Appendix, section 6.3.1, for worked example of calculation. Totals are deflated at 2020 prices and are annual averages for the period 2020-2050. Bars are results for RCP 8.5, with comparators for RCP 4.5 in blue below.

Source: Modelling based on AfDB (2019); UNISDR (2018) and World Bank (2019)

Photo Credit: CCD

3.4.5 Tourism and Wildlife

The tourism sector is a significant contributor to Kenya's economy. Kenya is well-endowed with exquisite natural assets, including wild game and coastal beaches, which drive the success of the tourism sector. According to Tourism Kenya, it accounted for approximately 9% of GDP in 2019, generating $ 7.9 billion of value in 2018. Moreover, the sector has high multiplier effects, as its growth stimulates further development in other activities, such as surrounding industry and agriculture. The sector accounts for over 10% of total employment, 18% foreign exchange and 11% of government revenue, taxes, duties, licence fee, park entry fees among others.[171] The wildlife sector is a key driver of international tourism, with thousands flocking to national and game reserved, including Maasai Mara each year.[172] In 2019, more than two million international tourists visited Kenya.[173] The success of the tourism and wildlife sector is therefore crucial to the long-term prospects of Kenya's economy.

Promoting and increasing tourism is a key government priority. Several new policy initiatives have been undertaken in the last decade to reform administration of the sector and increase international visitors. The 2011 Tourism Act reformed government administration of the sector, while the National Tourism Blueprint 2030 seeks to modernise the sector's management. The government has also developed the Tourism Sector Plan 2018-2022 that aims to actualize the implementation of vision 2030. The East African Tourism Strategy, Inter-governmental Authority on Development (IGAD) and Agenda Africa 2063 are all tools developed to guide regional tourism promotion in the region.[174]

There are also several policy and legal instruments aimed protecting animal stocks and increasing wildlife tourism. These include The National Wildlife Conservation and Management Policy, Wildlife Conservation and Management Act 2013, Environmental Management and Conservation Act (EMCA) 1999 and Climate Change Act 2016 as well as Public Private Partnership Act 2013.[175] In 2020, the Ministry of Tourism and Wildlife published the 'Revised National Tourism Policy, 2020 on Enhancing Resilience and Sustainable Tourism in Kenya'.

Climate change directly impacts on the natural assets that drive tourism in Kenya. According to USAID, approximately $1.2 billion worth of tourism revenue in East Africa was directly linked to natural landscapes at risk of destruction from climate change and land use patterns.[176] Temperature change, drought, precipitation, and sea level rise all have the potential to affect tourism demand. Sea level rise risks degrading tourist attractions such as beaches and wetlands, while whether changes and drought may impact on wildlife stocks and biodiversity. Health hazards related to rising temperatures, such as vector borne diseases, may also deter foreign tourists from visiting the country. All climate risks may impact on the landscape aesthetic and increase land degradation, which may also reduce tourism demand.

The effects of climate change on the sector are already apparent. Glaciers on Mt. Kenya and Mt. Kilimanjaro are vanishing and the effects of sea level rise on coastal erosion are already evident. People and the environment are increasingly suffering from the effects of natural disasters such as floods, landslides, and prolonged droughts. There is an urgent need to prioritise sustainable tourism to mitigate the issues of climate change.[177] Wildlife population numbers derived from aerial sample survey data in 2019 show that most wildlife species in the Kenyan rangelands declined in 2019 compared with the population recorded in 2018. The decline is attributable to unfavourable weather conditions, a trend that can only worsen as the effects of climate change are felt.[178]

The tourism and wildlife sector is particularly vulnerable to losses associated with climate change. It is projected to account for approximately 10% of overall losses in 2050 (see Figure 3.8 above). Over the next thirty years, it is estimated to suffer socioeconomic losses of between $535 million and $864 million annually, in the absence of adaptation interventions. This is shown in Figure 3.14. These losses are driven by a reduction of international tourism to coastal areas and wildlife hotspots, as well as the depletion of wildlife stocks and the associated impacts on dependent communities.

[171] Ministry of Tourism and Wildlife, 20210. Enhancing Resilience and Sustainable Tourism in Kenya. Available at: https://www.tourism.go.ke/wp-content/uploads/2020/09/28th-August-National-Tourism-Policy-Review.pdf. Last accessed 2021-11-12

[172] Conservation.org, 2020. Available at: https://www.conservation.org/blog/kenya%E2%80%99s-wildlife-tourism-a-casualty-of-covid-gets-a-lifeline Last accessed 2021-11-12

[173] Kenya Tourism Sector Performance Report, 2019. Available at: https://www.atta.travel/media/17456/kenya-tourism-sector-perfomance-report-2019-v1.pdf Last accessed 2021-11-12

[174] Ministry of Tourism and Wildlife, 20210. Enhancing Resilience and Sustainable Tourism in Kenya. Available at: https://www.tourism.go.ke/wp-content/uploads/2020/09/28th-August-National-Tourism-Policy-Review.pdf. Last accessed 2021-11-12

[175] Ibid.

[176] USAID, 2021.East Africa Regional Development Cooperation Strategy (2016-2021), 2021. Available at: https://www.usaid.gov/sites/default/files/documents/1860/East_Africa_RDCS_July_2021.pdf. Last accessed: 2021-11-12

[177] Ministry of Tourism and Wildlife, 20210. Enhancing Resilience and Sustainable Tourism in Kenya. Available at: https://www.tourism.go.ke/wp-content/uploads/2020/09/28th-August-National-Tourism-Policy-Review.pdf. Last accessed 2021-11-12

[178] KNBS (2020). Economic Survey.

Cognisant of these risks, a range of short, medium, and long-term adaptation interventions for the tourism and wildlife sector are detailed in the National Climate Change Action Plan (2018-2022), the National Adaptation Plan and the Updated NDC Technical Report. The full list of commitments provided in the Technical Appendix, section 6.5.5. The interventions can be grouped into two broad themes:

1. **Climate-proofing the sector:** This involves investing in resilient infrastructure, as well as safeguarding tourist sites from the effects of climate change (such as coastal erosion and wildlife depletion)
2. **Planning and risk assessment:** This involves the rollout of various pilot projects in sustainable tourism, regular risk assessments and the design of localised adaptation strategies.

The LTS builds on prior commitments, with a view to promoting sustainable tourism and enhancing long-term resilience in the sector. Because depletion of wildlife stocks and land degradation are central to the sector's long-term success, many recommended interventions focus on conservation and encouraging biodiversity financing. This includes the expansion of partnerships, research and development and financing efforts in the biodiversity space. Interventions also recommend investing in climate-proof infrastructure and diversifying tourist attractions away from climate-sensitive sectors. These interventions are designed to reduce the dependency of the sector on communities, regions and activities that are highly exposed to climate risk.

Table 3.7 lists the LTS adaptation interventions for the Tourism and Wildlife sector:

Table 3.7 Priority adaptation actions for Tourism and Wildlife

Intervention type	Intervention
Improving biodiversity management	Enhance Existing Land Protection and Ecosystem management, including afforestation of the catchment areas
	Provision of strategic watering points for wildlife
	Improve Species Conservation and Management
	Enhance governance of wildlife and natural resource management
Increasing innovation and financing for biodiversity	Enhance research, technology development, innovations and knowledge management
	Mobilize financial resources for conservation
	Improve partnerships, collaborations and coordination of adaptation actions
Climate-proofing infrastructure	Reduce vulnerability of tourism industry by promoting sustainable tourist activity that are not climate sensitive

Although adaptation investment needs in the sector will average around $115 million annually over the next 30 years, the costs of restoring degraded natural capital could be significantly higher. USAID suggest that existing spending on natural capital restoration projects, such as afforestation and climate smart agriculture, will need to triple to stave off landscape destruction.[179] According to African Development Bank and World Bank estimates, approximately 4% of the $846 million direct losses can be avoided through the rollout of adaptation interventions. These interventions are geared towards promoting sustainable tourism and diversification of the sector away from climate-exposed activities and show that adaptation in the sector in the face of significant climate change will be challenging.

[179]USAID, 'Protecting East Africa's Natural Capital The cost of inaction', September 2020.

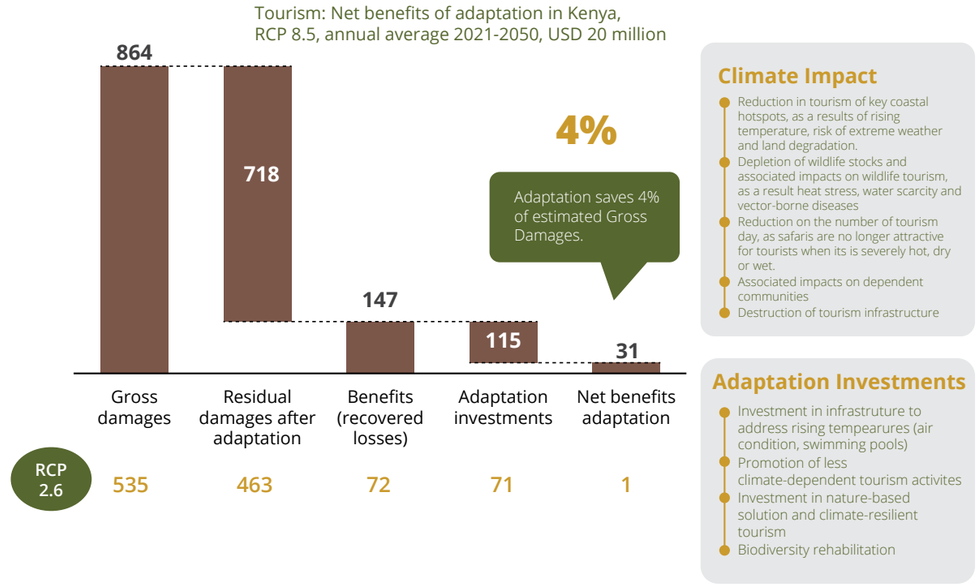


Figure 3.14 Tourism and Wildlife: overall damages and net benefits from adaptation, 2020-2050 (Annual averages, 2020 USD millions)

Note: See section 3.3.1 for overview of modelling approach and the Technical Appendix, section 6.3.1, for worked example of calculation. Totals are deflated at 2020 prices and are annual averages for the period 2020-2050. Bars are results for RCP 8.5, with comparators for RCP 2.6 in yellow below.

Source: Modelling based on AfDB (2019) and UNISDR (2018)

3.4.6 Health

Kenya's health sector is large and led by the public sector. The healthcare system can be divided into three categories: public providers, private non-profit organisations (including faith-based and mission hospitals as well as local and international NGOs) and private for-profit health care providers. Health services are provided through a network of health facilities, with the public sector system accounting for about 51% of these facilities.[180] Current healthcare expenditure is approximately 5.1% of GDP as a share of Kenya's GDP. The public sector accounted for 61% of total healthcare spending in 2014.[181]

Public health has major challenges but has made significant progresses in recent years. Malaria remains a significant public health concern: three-quarters of the population are at risk of infection and prevalence is highest, at 11%, among children aged 10–14 years. Between 2012 and 2016, 95% of deaths were due to preventable diseases, with HIV, lower respiratory-tract infections and malaria causing 12%, 9% and 5%, respectively, of all deaths.[182] The system has also been plagued by issues such as low-quality and counterfeit medication and high health risks related to the likelihood of contracting preventable diseases and to extreme heat conditions. The health sector has made remarkable progress in reducing the burden of disease despite these challenges. This includes reductions of 15% and 16% in the under-5 and infant mortality rates, respectively, during the period 2014 to 2017.[183]

The healthcare system suffers from a mismatch between the need and availability of medical care, particularly specialist care. Additional pressures associated with climate change, such as a predicted increase in the incidence of vector-borne disease, may exacerbate this mismatch further.

[180]WHO, 2017.Primary Healthcare systems, Case study from Kenya. Available at: https://www.who.int/alliance-hpsr/projects/alliancehpsr_kenyaabridgedprimasys.pdf?ua=1. Last accessed 2021-11-12

[181]Pharmaccess, 2018. Available at: https://www.pharmaccess.org/wp-content/uploads/2018/01/The-healthcare-system-in-Kenya.pdf. Last accessed 2021-11-12

[182]Ministry of Health Kenya, 2018. Mortality Trends in Kenya 2012–2016: Cause of death, trends, and data quality.

[183]Institute for Health Metrics and Evaluation, 2017. Findings from the Global Burden of Disease Study 2017. Available at: https://www.healthdata.org/sites/default/files/files/policy_report/2019/GBD_2017_Booklet_Issuu_2.pdf. Last accessed 2021-11-12

There is a disparity between the healthcare systems available in urban areas relative to the rural areas. Rural areas have for a long time relied on community health volunteers and nurses in public dispensaries. Economically, the poor and low-income classes are unable to access medical care due to high medical costs and bills. In fact, it is estimated that less than 20% of Kenya's population has medical insurance, meaning that the private healthcare system mainly serves the relatively small middle class.[184]

Healthcare is at the centre of Vision 2030.[185] Vision 2030 aims to transform Kenya into a globally competitive and prosperous country with a high quality of life by 2030, while the constitution introduces critical principles around attainment of the right to health and devolution of health services management. The 2014-2030 Kenya Health Policy has six primary objectives:

- Eliminate communicable conditions
- Halt and reverse the rising burden of non-communicable conditions and mental disorders
- Reduce the burden of violence and injuries
- Provide essential healthcare
- Minimise exposure to health risk factors
- Strengthen collaboration with private and other sectors that have an impact on health

There are eight orientations, or key action areas, where investments will need to be made to facilitate attainment of the policy objectives:

- Organisation of Service Delivery: Organisational arrangements required for delivery of services
- Health Leadership and Governance: Oversight required for delivery of services
- Health Workforce: Human resources required for provision of services
- Health Financing: Financial arrangements required for provision of services
- Health Products and Technologies: Essential medicines, medical supplies, vaccines, health technologies, and public health commodities required for provision of services
- Health Information: Systems for generation, collation, analysis, dissemination, and utilisation of health-related information required for provision of services
- Health Infrastructure: Physical infrastructure, equipment, transport, and information communication technology (ICT) needed for provision of services
- Research and Development: Creation of a culture in which research plays a significant role in guiding policy formulation and action to improve the health and development of the people of Kenya

The 2014-2030 Health Policy also delineates implementation responsibilities to the different branches of government. The Ministry of Health oversees the policy development in the sector. The policy was developed through a participatory process involving all stakeholders in health including government ministries, departments and agencies, clients, counties, constitutional bodies, development partners (multilateral and bilateral) and implementing partners (faith-based, private sector, and civil society). Within this framework, the Kenya Sector Strategic and Investment Plan 2014-2017 and the Kenya Health Sector Strategic Plan 2018-2022 have been developed to meet medium term objectives of the 2014-2030 policy and Vision 2030.

Although a robust policy framework is now in place, climate change threatens to undo recent gains made in reducing the disease burden, particularly for vector-borne diseases. The four climate risks detailed in section 3.2 have the capacity to reduce water quality, threaten food security and induce human migration, all of which has potential adverse health consequences. These and many other potential impacts require not only continued investment and focus on climate sensitive health issues, but also full integration of climate change into Kenya's many existing health programmes and policies.

The risk of malaria and other vector-borne diseases are projected to increase in future years due to changing climate conditions. More severe and frequent flooding may displace communities and increase the risk of water-borne diseases, and higher temperatures may threaten food and nutritional security, agricultural livelihoods, and increase heat-related deaths in the elderly. Approaching 2070, under both RCP 2.6 and RCP 8.5 emissions scenarios, approximately 83 million people are projected to be at risk of malaria.[186] Kamuyu also finds that extreme minimum and maximum temperature negatively affect malaria and pneumonia mortality.[187] Dengue fever transmission is projected to increase slightly towards 2070 under both a high and low emissions scenario.

The effects of climate change are not restricted to increased incidence of vector-borne disease. The increased frequency of extreme weather under both RCP 2.6 and RCP 8.5 will increase the number of deaths from cardiovascular and respiratory diseases, infectious diseases, and malnutrition, whilst undermining water and food supplies, infrastructure, health systems and social protection systems. Heat-related deaths (see Figure 3.15) in the elderly (65+ years) are also projected to increase to about 45 deaths per 100,000 by 2080 under a high emissions scenario, compared to the estimated baseline of under 2 deaths per 100,000 annually between 1961 and 1990.[188]

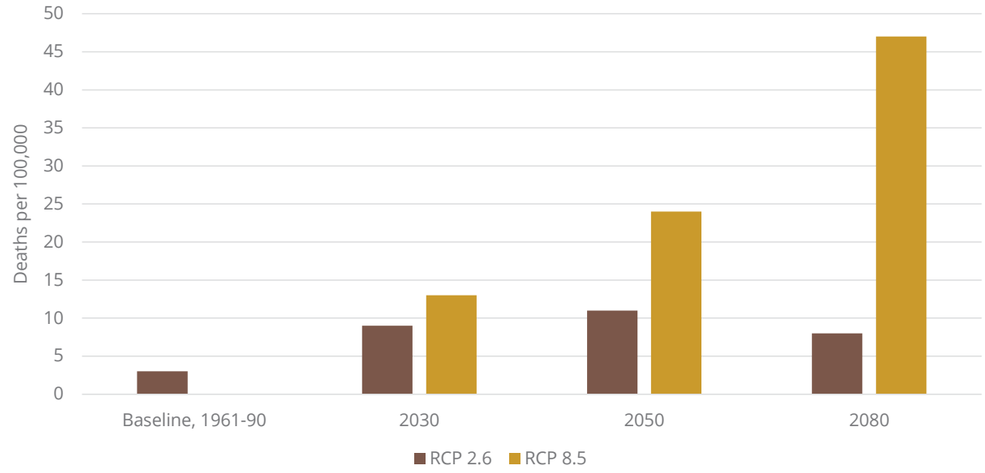


Figure 3.15 Heat-related mortality in the elderly population

Source: WHO (2015)

Given the risks detailed above, it is not surprising that the largest socio-economic losses associated climate change will be felt in the health sector. Projections from the African Development Bank disaggregate these losses into deaths associated with climate change, and a greater disease burden (morbidity). These collectively account for more than half of total projected losses, as shown in Figure 3.8. The inclusion of mortality in AfDB's headline estimates is the primary driver of its large share of overall damages, as excess deaths result in several socioeconomic spillover effects (see Figure 3.2).

Without adaptation, socioeconomic losses in the health sector over the next thirty years are estimated at between $3 billion and $4 billion per year. The losses under different climate scenarios are summarised in Figure 3.16. There are multiple contributors to these losses, including reduced labour productivity, increased morbidity and mortality from vector-borne diseases and the effects of heat stress.

Managing the impacts of climate change on the health sector is already a policy priority. A range of short, medium, and long-term adaptation interventions for the health sector are detailed in the National Climate Change Action Plan (2018-2022), the National Adaptation Plan and the Updated NDC Technical Report. The full list of commitments provided in the Appendix, section 6.5.6. The interventions can be grouped into two broad themes:

1. **Reducing the disease burden:** This includes targeted interventions for key diseases, which includes the mass rollout of insecticide treated nets and indoor residual spray.
   - The adaptation interventions include a range of quantitative targets, such as reducing the incidence of malaria.
2. **Coordination and risk management:** Various interventions relate to developing new health protocols to manage climate-sensitive diseases, regular targeted risk assessments and community engagement.
   - This also includes the modernisation and streamlining of surveillance and response mechanisms.

[184]KPMG, 2021. Exploring the fiscal space of the health sector in Kenya. Available at: https://assets.kpmg/content/dam/kpmg/ke/pdf/tax/Exploring%20the%20fiscal%20space%20of%20the%20health%20sector%20in%20Kenya%20-%20SN.pdf. Last accessed 2021-11-12

[185]Kenya Health Policy, 2014. Available at: http://publications.universalhealth2030.org/uploads/kenya_health_policy_2014_to_2030.pdf. Last accessed 2021-11-12

[186]WHO, 2015. Climate And Health Country Profile – 2015 KENYA. Available at: https://apps.who.int/iris/bitstream/handle/10665/246133/WHO-FWC-PHE-EPE-15.23-eng.pdf;sequence=1. Last accessed 2021-11-12

[187]Kamuyu, 2017. Effect of climate extremes on health outcomes in Kenya. Available at: http://erepository.uonbi.ac.ke/bitstream/handle/11295/102255/Kamuyu%20W%20Rosemary%206-12.pdf?sequence=1. Last accessed 2021-11-12

[188]Ibid.

The LTS builds on prior commitments, with a view to reducing to enhancing the long-term resiliency of the heath sector and reducing the burden of climate-sensitive diseases. The bulk of LTS interventions relate to capacity building to tackle the most climate-sensitive diseases, such as malaria. Recommendations include strengthening the current disease surveillance system and the scaling up of treatment and prevention mechanisms. These include the mass rollout of indoor residual spray (IRS) and insecticide treated nets (ITNS). Box 2 shows that ITNS is a more cost-effective mechanism for reducing the burden of malaria.

Box 2 IRS rollout is a cost-effective means to reduce the spread of malaria

IRS and ITNS rollout are already part of Kenya's existing commitments to reduce the impacts of climate change, as detailed in the Updated NDC Technical Report. Malaria incidence projections from the WHO and financial estimates of the disease burden from Sicuri et al. (2013) were combined in a bottom-up model to estimate the additional financial burden on the healthcare sector in 2050. Unit cost estimates sourced from Guyatt et al. (2002) suggest that IRS is a more cost-effective way of addressing these losses than ITNS, whose unit costs are approximately five times greater. IRS is also easier to distribute to outlying areas, suggesting it may be the most optimal method for addressing increased malaria incidence.

Table 3.8 Cost-benefit analysis: addressing health consequences of malaria through ITNS and IRS

Scenario	RCP 2.6 and 8.5 ($m, 2020)
2050 losses	225
2050 ITNS rollout costs	264
Benefit-cost ratio	0.64
2050 IRS costs	65
Benefit-cost ratio	2.43

Source: Consultant analysis based on Sicuri et al. (2013), Guyatt et al. (2003), WHO (2015)

LTS interventions are geared towards reducing the burden of non-vector-borne diseases, such as malnutrition. As detailed in section 3.4.1, climate change will impact on food security in the absence of adaptation measures, which raises the healthcare risk of malnutrition. Recommended interventions to address this risk, along with the associated risk of obesity, include the active promotion of healthy diets and the scale-up of acute malnutrition management facilities. The LTS also recommends specific interventions to address climate-induced diseases, such as malaria, which will increase in prevalence as temperatures rise.

Table 3.9 lists the priority adaptation interventions for the health sector.

Table 3.9 Priority adaptation actions for Health

Intervention type	Intervention
Capacity building in the health sector	Conduct research into diseases associated with climate change and implement recommendations. Examples include Chikungunya, Rift Valley fever, Dengue haemorrhagic fever
	Build capacity of public health systems in early identification, diagnosis, and management of climate related diseases and health issues
	Implement public awareness and social mobilization strategy on climate health impacts
	Build capacity and infrastructure of public health systems to enhance response to climate related diseases
	Strengthen the current disease surveillance system to incorporate pathogen surveillance
	Develop models for early warning of other vector borne diseases especially chikungunya, dengue haemorrhagic fever, kalazar, lymphatic filiarisis, elephantiasis, hydrocell and rift valley fever
	Build capacity for community health volunteers and workers on early warnings, proper diagnosis and reporting of climate related diseases
	Implement malaria larval source management
	Scale up mass distribution of Insecticide Treated Nets (ITNS)
	Scale up Indoor Residual Spray (IRS)
	Outdoor residual spray for sandflies
	Expand environmental and mechanical control and management of the vectors
Reduce disease incidence	Reduce the quadruple burden of malnutrition, under nutrition, over nutrition and micronutrient deficiencies: Over nutrition – promotion of healthy diets to prevent the burden of non-communicable diseases. Under nutrition- scale up integrated management of acute malnutrition. Micronutrient malnutrition – scale up micronutrient supplementation and food fortification
	Reduce Incidences of aflatoxicosis through: surveillance and laboratory analysis, capacity building on good storage practices among food business operators and households
	Reduce incidences of foodborne diseases

Overall investment needs in the sector will average around $715 million annually over the next 30 years. According to African Development Bank estimates, approximately 31% of the $4.9 billion annual average losses can be avoided through the rollout of adaptation interventions. These interventions include IRS and ITNS rollout, as well as general upgrading and expansion of healthcare facilities across Kenya.

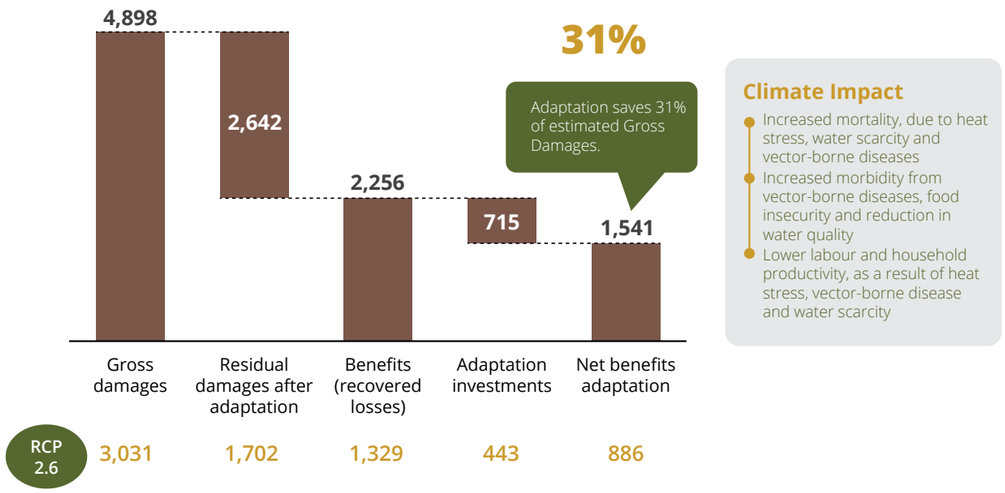


Figure 3.16 *Health: overall damages and net benefits from adaptation, 2020-2050 (Annual averages, 2020 USD millions)*

Note: See section 3.3.1 for overview of modelling approach and the Technical Appendix, section 6.3.1, for worked example of calculation. Totals are deflated at 2020 prices and are annual averages for the period 2020-2050. Bars are results for RCP 8.5, with comparators for RCP 2.6 in yellow below.

Source: *Modelling based on AfDB (2019) and UNISDR (2018)*

Photo Credit: CCD

3.4.7 Human Settlement, Urban Development and Housing

Climate change is already impacting on housing provision in Kenya, primarily through increased incidence of coastal and inland flooding. As shown in section 3.2, the frequency and severity of flooding has increased in both urban and rural areas. According to Kebede et al. (2015), up to 400,000 people in the Mombasa District could be exposed to regular flood risk by 2050, due to extreme weather and rising sea levels. Furthermore, rising inland water levels have already displaced 75,987 households, with approximately 400,000 people requiring urgent humanitarian assistance.[189] The economic consequences of damage to housing and associated human displacement are particularly severe, and are associated with multiple secondary socioeconomic impacts. These include waterborne disease outbreaks, as well as economic losses associated with lost business or crop harvests. Protecting the human settlement sector from the effects of flooding is therefore crucial to Kenya's long-term economic strategy and forms a core part of this LTS.

The housing and construction sectors are key drivers of economic growth. Collectively, these accounted for an average of 6% of GDP over the period 2015-2019.[190] [191] Moreover, public expenditure on housing and community amenities increased from 5.3% of total expenditure to 9.6% between 2016-2020.[192] The sector's future economic importance is directly linked to projections of population growth and rural-urban migration. While the share of urban population was approximately 20% in 2000 (6.3 million people), it has increased to almost 28% in 2020 (15 million people) and it is projected to increase to 46% by 2050 (44 million people).[193-194]

Independent of the effects of climate change, the provision of adequate housing remains a significant challenge. Current urban housing supply is not meeting increased demand. This has resulted in slum proliferation and increased homelessness within urban areas. In 2018, approximately half the urban population lived in slums.[195] Kenya has a housing deficit of approximately two million units. Estimates from the housing charity REALL suggest that this deficit is rising at a rate of 200,000 units per year.[196] Vision 2030 projected the provision of 200,000 housing units per year by 2012 but only 50,000 per year were supplied as of 2017.[197] [198]

The National Housing Policy was reviewed in 2016 with the overall objective of providing housing and improved living conditions.[199] The government's most significant policy package is the Affordable Housing Programme. It seeks to put in place mechanism to provide adequate and affordable housing and to meet increased demand. This is part of the "Big Four Action Plan", announced by the Presidency in 2017. The plan focuses on the four core objectives of affordable housing, affordable healthcare, expanded manufacturing and food security.[200] As part of this plan, the government set a target of 500,000 affordable homes over a five-year period.

Climate change may result in annual losses of between $200 million and $250 million over the next thirty years, in the absence of adaptation interventions. This is shown in Figure 3.17. Flooding is the key driver of these losses, which are felt primarily through asset depreciation and destruction.

Through its international climate commitments and local climate policy, Kenya is already taking action to build climate resiliency within the housing sector. A range of short, medium and long-term adaptation interventions for the tourism and wildlife sector are detailed in the National Climate Change Action Plan (2018-2022), the National Adaptation Plan and the Updated NDC Technical Report. The full list of commitments provided in the Appendix, section 6.5.7.

[189] Government of Kenya and UNDP, 2021. Rising Water Levels in Kenya's Rift Valley Lakes, Turkwel Gorge Dam and Lake Victoria: A Scoping Report

[190] International Trade Administration,2021. Kenya – Country Commercial Guide. Available at: https://www.trade.gov/country-commercial-guides/kenya-design-and-construction; Last accessed 2021-11-12

[191] Kenya National Bureau of Statistics (2020). Quarterly Gross Domestic Product Report. First Quarter, 2020. https://www.knbs.or.ke/?wpdmpro=quarterly-gross-domestic-product-report-first-quarter. Last accessed 2021-11-12

[192] Kenya National Bureau of Statistics, 2020. Economic Survey 2020. Available at: https://www.knbs.or.ke/?wpdmpro=economic-survey-2020. Last accessed 2021-11-12

[193] UN-HABITAT, 2018. Urban Planning for City Leaders: A handbook for Kenya. UN-habitat Support to Sustainable Urban Development in Kenya. Available at: https://unhabitat.org/sites/default/files/2020/08/upcl_kenya_handbook_-_updated.pdf . Last accessed 2021-11-12

[194] World Bank Data. Available at: https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=KE. Last accessed 2021-11-12

[195] Ibid.

[196] REALL, 2021. Kenya. Available at: https://reall.net/data-dashboard/kenya/. Last accessed 2021-12-09.

[197] World Bank, 2017. Kenya Needs 2 Million More Low-income Homes: Building Them Would Boost Its Economic Growth. Available at: https://www.worldbank.org/en/country/kenya/publication/kenya-needs-2-million-more-low-income-homes-building-them-would-boost-its-economic-growth. Last accessed 2021-11-12

[198] Kenya Vision 2030. Available at: https://vision2030.go.ke/social-pillar/#68, Last accessed 2021-12-09.

[199] Republic of Kenya, 2016. National Housing Policy for Kenya. Available at: https://www.housingandurban.go.ke/wp-content/uploads/2019/10/Updated-Sessional-Paper-No.3-of-2016-National-Housing-Policy.pdf . Last accessed 2021-12-09.

[200] Hudumba Namba. Available at: https://www.hudumanamba.go.ke/the-big-4/. Last accessed 2021-12-09.

The interventions can be grouped into three broad themes:

1. Flood controls: This involves the expansion and improvement of flood warning systems and construction of flood protection infrastructure, such as sea walls and mangrove forests.
   - A detailed discussion of the risks associated with inland flooding, in both rural and urban areas, is provided in section 3.2.4.
2. Updating and enforcement of building regulations: This includes better enforcement of existing regulations and updating them to encourage green buildings and improve resilience.
3. Public awareness and capacity building: Interventions include the development of a public awareness strategy on the impact of climate change in urban areas, as well as several commitments to improve the adaptive capacity of the urban poor.

The LTS builds on prior commitments, with a view to reducing the housing deficit and improving climate resilience within the sector. Priority interventions are designed to address the acute risk of flooding, through the construction of protective infrastructure in coastal urban areas. As noted above, the financial and socioeconomic consequences of this risk are particularly in acute in Mombasa, Kenya's major port city and strategically crucial economic hub. Nature based solutions are the most cost-effective means to protect the coastlines. Additionally, chosen for data constraints, Box 3 shows that constructing flood defences along the Mombasa coastline is also a cost-effective example to reduce flood risk and associated damage.

Box 2 IRS rollout is a cost-effective means to reduce the spread of malaria

IRS and ITNS rollout are already part of Kenya's existing commitments to reduce the impacts of climate change, as detailed in the Updated NDC Technical Report. Malaria incidence projections from the WHO and financial estimates of the disease burden from Sicuri et al. (2013) were combined in a bottom-up model to estimate the additional financial burden on the healthcare sector in 2050. Unit cost estimates sourced from Guyatt et al. (2002) suggest that IRS is a more cost-effective way of addressing these losses than ITNS, whose unit costs are approximately five times greater. IRS is also easier to distribute to outlying areas, suggesting it may be the most optimal method for addressing increased malaria incidence.

Table 3.10 Cost-benefit analysis: floodwall construction in Mombasa

Scenario	RCP 2.6 and 8.5 ($m, 2020)
2050 losses	236
2050 intervention costs	189
Benefit-cost ratio	1.25

Source: Consultant analysis based on Kebede et al. (2012) and IPCC RCP 2.6 and RCP 8.5

The LTS also restates and strengthens existing commitments to enforce building regulations and update these to facilitate resilience. Table 3.11 lists the priority interventions for the Human Settlement, Urban Development and Housing sector.

Table 3.11 Priority adaptation actions for Human Settlement, Urban Development and Housing

Intervention type	Intervention
Flood defence mechanisms	Introduce nature-based solutions in flood control, especially around informal settlements and selected urban areas. These include mangrove restoration along the coastline, restoring salt marshes and peat bogs, and building hedges near water bodies in inland areas.
	Introduce practice of beach nourishment (widening of coastlines by importing sand and compacting beach) to combat erosion
	Build and maintain flood defence mechanisms such as a sea wall, particularly around strategically important port cities such as Mombasa
Improving building resilience	Enforce green and resilient building standards in new buildings and promote retrofit/climate proofing of older buildings

Note: A detailed discussion of the risks associated with inland flooding, in both rural and urban areas, is provided in section 3.2.4.

Overall investment needs in the sector will average around $37 million annually over the next 30 years. According to African Development Bank estimates, these interventions will save roughly 20% of the approximately $250 million annual losses over the next thirty years. These interventions include floodwall construction, and nature-based solutions such as mangrove forest restoration and beach nourishment.

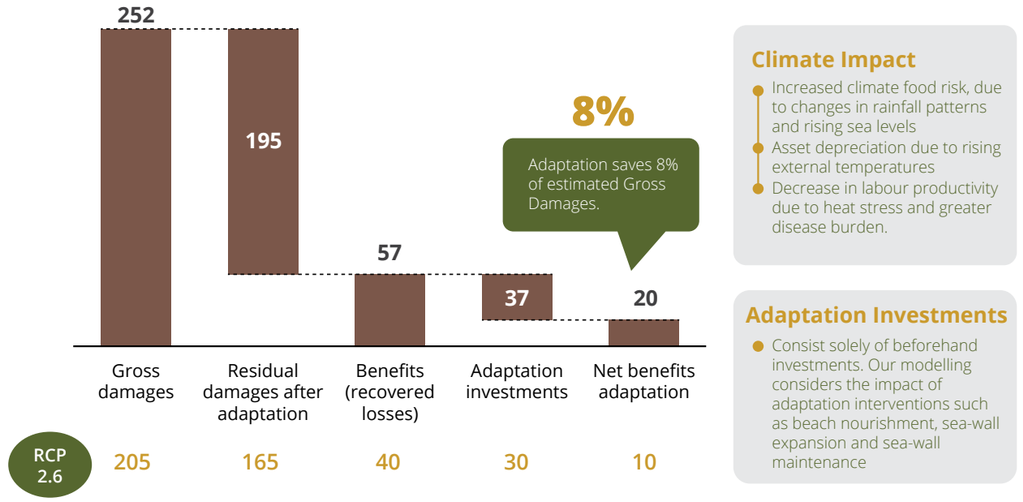


Figure 3.17 Human Settlement, Urban Development and Housing: overall damages and net benefits from adaptation, 2020-2050 (Annual averages, 2020 USD millions)

Note: See section 3.3.1 for overview of modelling approach and the Technical Appendix, section 6.3.1, for worked example of calculation. Totals are deflated at 2020 prices and are annual averages for the period 2020-2050. Bars are results for RCP 8.5, with comparators for RCP 2.6 in yellow below.

Source: Modelling based on AfDB (2019) and UNISDR (2018)

3.4.8 Manufacturing and Trade

Economic diversification is at the heart of the adaptation strategy, given the long-term vulnerability of the agriculture sector to climate change. The long-term growth path of the manufacturing and trade sector is intimately connected to labour force projections in the agriculture sector. Over half the work force currently work in agricultural sector, yet it only accounts for around one-quarter of GDP. For Kenya to achieve upper-middle income status by 2030 and high-income status by 2050, overall growth will need to continue at 8-9% annually. This means that significant shifts in the sectoral make-up of the economy, in which a large share of the labour is currently employed in agriculture, will need to take place. Specifically, one of the following changes will need to occur:

1. **Agricultural yields need sustained high growth rates.** This will increase exposure to climate risks, such as drought, flooding, and rising temperatures.
2. **Significantly more land needs to be dedicated to agriculture.** This will hamper mitigation and adaptation, as it risks worsening land degradation.
3. **The share of the workforce in the agricultural sector must shrink rapidly, with jobs flowing to industry and other high value-added sectors.** This will support mitigation and reduce exposure with a more diversified economy.

Option 3 is the most suitable path for long-term, sustainable growth and will result in a significantly higher share of the population being employed in manufacturing and trade. The manufacturing sector is small relative to GDP but is crucial to its long-term economic prospects. Kenya is characterised as the largest commercial hub in East Africa, but manufacturing accounts for only about 9% of Kenyan GDP as of 2019, based on estimates from the African Development Bank.[201] [202]This share is relatively low given Kenya's high exports of agricultural goods, which require little processing, compared to other exports such as plastic and rubber products, industrial chemicals, paper goods, clothing and textiles, and furniture.

The success of the manufacturing sector is also closely tied to other sectors, such as energy and transportation. Energy affordability and access is crucial to the sectors prospects, underlying the importance of the mitigation strategy presented in this LTS (see section 2.2). The competitiveness of industrial producers is already limited due to challenges such as poor infrastructure and limited access to energy. In the past, due to high costs, limited access, and unreliable supply of energy, industrial producers have invested in alternative fuels such as biomass, which has shown to be an unsustainable practice due to the depletion of forest resources.

The trade sector has expanded rapidly since the 1990s, rendering Kenya the regional trade hub of East Africa.[203] However, economic growth associated with trade expansion has also worsened dependence on food imports, despite optimal conditions for agriculture. Sub-Saharan Africa faces increased net food imports due to growing populations, faster economic growth, and growing urbanisation, coupled with slow improvement in agricultural productivity.[204] This means that the sector is increasingly dependent on international food production, which may also be harmed by the climate crisis.

Existing policy seeks to support the growth of value-adding manufacturing within Kenya over the coming decades. The National Industrialisation Policy (2012) framework aims at providing strategic direction for the sector growth and development.[205] It focuses on value addition for both primary and high valued goods; and linkages between industrial sub-sectors and other productive sectors to drive the industrialization process. Its vision is to turn Kenya "the leading industrialized nation in Africa with a robust, diversified and globally competitive manufacturing sector". Its mission is "to promote and sustain a vibrant, globally competitive and diversified industrial sector for generation of wealth and employment through the creation of an enabling environment". The policy recognizes the need to promote sustainable industrial development that upholds environmental protection, management and efficient resource utilization. Manufacturing is also a key focus of Vision 2030, which aims to increase competitiveness of industries that use domestic raw materials and increase value addition to exports.[206]

Extreme weather and flooding associated with climate change will damage transportation and energy infrastructure in the absence of adaptation interventions, which will indirectly impact manufacturing. Extreme weather events such as heat waves, floods, droughts and storms and rising temperatures are expected to strengthen coastal winds and storms, which will affect ship navigation and other port operations. Motor vehicle assembly, machinery, electronics and other industries that depend on export and import services are likely to be negatively affected. Greater risk of plant, product and infrastructure damage and supply chain disruptions from diverse weather events will also impact local and regional trade. The eight-month 1997-1998 El-Niño rains caused damage of Ksh 62 billion to transportation infrastructure resulting in higher unit costs for industrial firms.[207] Manufacturing is also one of the biggest casualties of reduced generation capacity of hydropower dams because of droughts and reduced rainfall. For instance, the 1998- 2000 droughts caused extended power cuts across the country, with lost industrial production due to inadequate power amounting to Ksh 110 billion.[208]

Climate change will also further increase dependence on food imports, resulting in additional pressure on Kenya's trading infrastructure.

Figure 3.18 shows changes in net cereal and maize trade under alternative climate scenarios for Kenya for 2050. Under climate change, maize and total cereal imports would be much higher for two out of the three scenarios examined, by between 21% and 44%, thus increasing the future dependency and vulnerability of local food systems under climate change.[209]

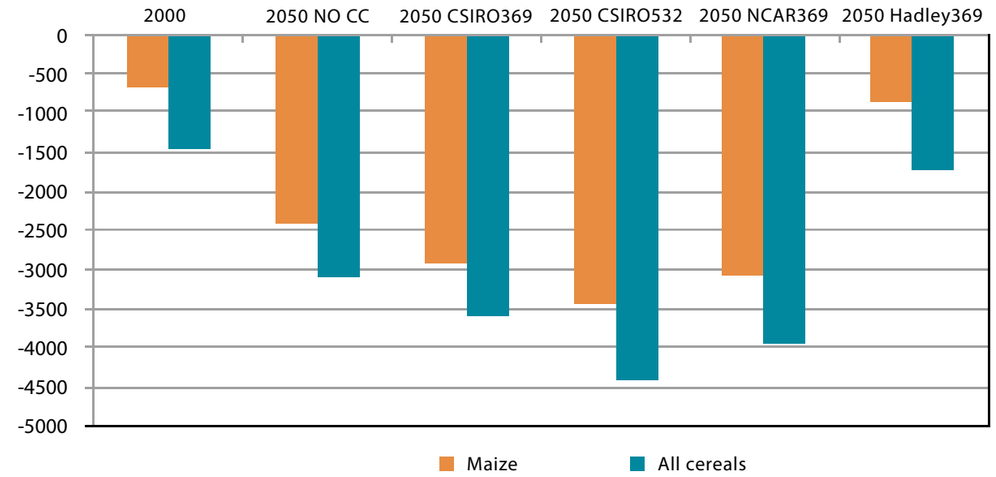


Figure 3.18 Change in net cereal and maize trade for Kenya (thousand tonnes), under alternative climate change scenarios

Note: Negative numbers indicate net imports

Source: IFPRI, 2009 cited in Herrero et al., 2010

[201]UNDP. n.d. Available at: https://www.adaptation-undp.org/explore/eastern-africa/kenya; Last accessed 2021-11-12

[202]AFDB. n.d. Available at: https://www.afdb.org/en/countries-east-africa-kenya/kenya-economic-outloo. Last accessed 2021-11-12

[203]CDKN, 2015. Available at:https://cdkn.org/wp-content/uploads/2015/04/Climate-Change-and-Trade.pdf Last accessed 2021-12-09.

[204]M. Herrero, P.K. Thornton, A.M. Notenbaert, S. Wood, S. Msangi, H.A. Freeman, D. Bossio, J. Dixon, M. Peters, J. van de Steeg, J. Lynam, P.P.Rao, S. Macmillan, B. Gerard, J. McDermott, C. Seré, M. Rosegrant, 2010. Smart investments in sustainable food production: revisiting mixed crop-livestock systems. Science, 327 (2010), pp. 822-825.

[206]National Industrialisation Policy, 2012. Framework for Kenya. Available at: https://www.industrialization.go.ke/images/downloads/policies/the-national-industrialization-policy.pdf. Last accessed 2021-11-09

[207]CDN, 2013. Low carbon competitiveness in Kenya. Available at: https://cdn.odi.org/media/documents/8593.pdf. Last accessed 2021-11-09

[207]Ibid.

[208]LTS International and Acclimatise, 2012. Adaptation Technical Analysis Report, prepared for Kenya's National Climate Change Action Plan, page 40

[209]M. Herrero, P.K. Thornton, A.M. Notenbaert, S. Wood, S. Msangi, H.A. Freeman, D. Bossio, J. Dixon, M. Peters, J. van de Steeg, J. Lynam, P.P.Rao, S. Macmillan, B. Gerard, J. McDermott, C. Seré, M. Rosegrant, 2010. Smart investments in sustainable food production: revisiting mixed crop-livestock systems. Science, 327 (2010), pp. 822-825.

Because manufacturing and trade are so interlinked with transportation, agriculture and energy, separate estimates of total damages are not included in this LTS. Nonetheless, Kenya is has already committed to several policies aimed at enhancing the resilience of the manufacturing and trade sector. A range of short, medium and long-term adaptation interventions for the tourism and wildlife sector are detailed in the National Climate Change Action Plan (2018-2022), the National Adaptation Plan and the Updated NDC Technical Report. The full list of commitments provided in the Appendix, section 6.5.8. The interventions can be grouped into three broad themes:

1. **Climate-proofing assets:** This includes several policies aimed at promoting business cases for adaptation investments and climate proofing industrial waste infrastructure
2. **Adapting to energy transition:** Various interventions are geared towards assisting industries to adapt to the energy transition. These link closely to the mitigation strategy for energy and include measures to encourage efficiency and the rollout of the government's Green Business Agenda (2018-2022)
3. **Capacity building:** This includes empowering the private sector to invest in adaptation, as well as assisting businesses identify climate-resilient product opportunities.

The LTS builds on prior commitments, with a view to enhancing energy efficiency and resilience across Kenya's manufacturing and Trade. Several recommendations aim to reduce the vulnerability of industry to climate change and include investments in climate-smart technologies. Interventions also build upon prior commitments to enhance energy efficiency by incorporating water efficiency into the LTS. Table 3.12 lists the recommended priority interventions for the Manufacturing and Trade sector.

Table 3.12 Priority adaptation actions for Manufacturing and Trade

Intervention type	Intervention
Encouraging sustainable resource management	Increase the number of companies participating in efficient water use
Facilitating resilience	Climate-proof industrial plants and infrastructure to avoid operational and supply chain disruptions
	Embedded planning for supply disruptions to industrial codes and practice, through measures such insurance rollout, risk reporting and dual sourcing of inputs
	Support investment in climate smart and climate resilient capital by the private sector.

Photo Credit: CCD

3.4.9 Energy

Energy access is vital to Kenya's development and affects virtually all other sectors of the economy. Basic electricity services are necessary for industries, facilities, and key infrastructure to operate. Furthermore, reliable supply from clean energy sources ensures that households do not rely on highly pollutive and inefficient sources of energy such as biomass. Outages and other disruptions to energy supply disrupt both daily domestic and wider economic activities and can have severe consequences on human health and productivity. Currently, the share of population with reliable access to energy is estimated at about 75%, but the Last Mile Connectivity Project of the Rural Electrification authority aims to achieve universal energy access by 2022.[210] [211] High quality energy access is therefore a national priority for Kenya's development.

Ensuring a reliable supply of clean and affordable energy is key policy priority for Kenya over the next decade. The National Energy Policy, in line with the overall Vision 2030 strategy, sets forth recommendations for various subsectors including coal, renewable energy, electricity, energy efficiency, land use, health and safety, energy services, financing, pricing, and socioeconomic considerations.[212] Overall, Kenya's energy policy aims to ensure the affordable, reliable, and sustainable supply of energy to support national and local development goals at least cost.[213] The sector is overseen by the Ministry of Energy and Petroleum (MoEP). Other important actors include the Energy and Petroleum Regulatory Authority (EPRA), Rural Electrification Authority (REA), and other institutional actors, as well as state corporations such as the Kenya Pipeline Company (KPC), Kenya Electricity Generating Company (KenGen), and Kenya Power and Lighting Company.[214]

Kenya's National Energy Policy, in line with the Vision 2030 strategy, establishes the national policy framework for the energy sector. This sets forth recommendations for various subsectors including coal, renewable energy, electricity, energy efficiency, land use, health and safety, energy services, financing, pricing, and socioeconomic considerations.[215] Overall, Kenya's energy policy aims to ensure the affordable, reliable, and sustainable supply of energy to support national and local development goals at least cost.[216]

Although the energy sector is central to Kenya's mitigation strategy, it is less exposed to climate hazards than other sectors. Hydropower is vulnerable to drought and rising temperatures, which may reduce dam and river levels used in generation. In the past, droughts have led to an increased use of diesel-powered generators and an increase in the price of electricity in the past.[217] There is the potential for extreme weather to damage hydropower infrastructure, but IEA projections suggest that this risk is limited. A comparison of Kenya's projected future hydropower generation with other African countries is provided in Figure 3.19.

[210] COMESA, 2021. Available at: https://www.comesa.int/kenya-lauded-for-achieving-75-electricity-access-rate/#:~:text=Kenya%20has%20dramatically%20increased%20electricity,access%20rate%20of%20over%2075%25. Last accessed 2021-11-12

[211] IEA. n.d. Available at: https://www.iea.org/countries/kenya. Last accessed 2021-11-12

[212] IEA. n.d. Available at: https://www.iea.org/policies/5286-national-energy-policy. Last accessed 2021-11-12

[213] Republic of Kenya Ministry of Energy and Petroleum, 2014. Draft National Energy Policy. Available at: https://www.greengrowthknowledge.org/sites/default/files/downloads/policy-database/KENYA%29%20National%20Energy%20Policy%2C%202014.pdf. Last accessed 2021-11-12

[214] KPC. n.d. Available at: https://www.kpc.co.ke/moep/. Last accessed 2021-11-12

[215] IEA. n.d. Available at: https://www.iea.org/policies/5286-national-energy-policy. Last accessed 2021-11-12

[216] Republic of Kenya Ministry of Energy and Petroleum, 2014. Draft National Energy Policy. Available at: https://www.greengrowthknowledge.org/sites/default/files/downloads/policy-database/KENYA%29%20National%20Energy%20Policy%2C%202014.pdf. Last accessed 2021-11-12

[217] Kenya Ministry Of Environment And Forestry (2018), "National Climate Change Action Plan (NCCAP) 2018-2022, Volume I"

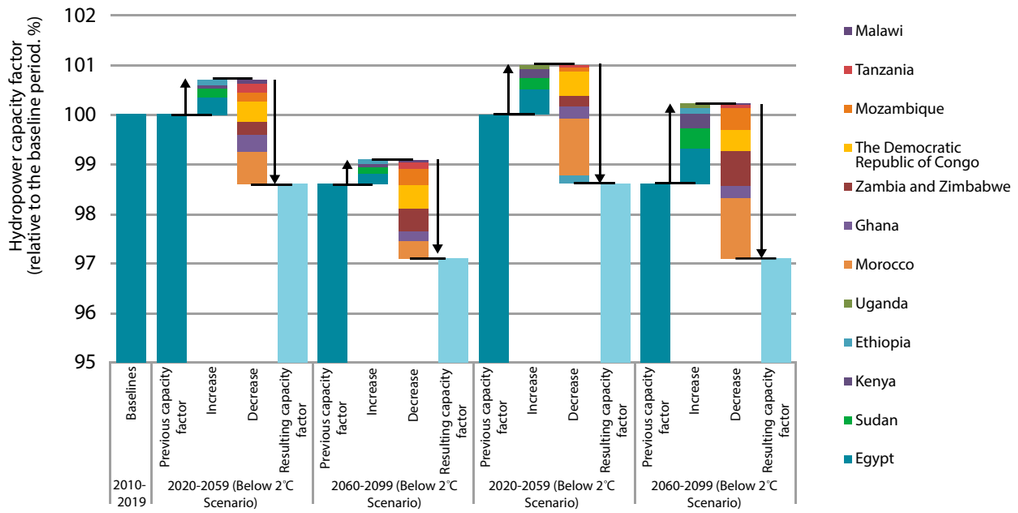


Figure 3.19 *Projected hydropower capacity changes for selected African countries*

Source: International Energy Agency

Geothermal, wind and solar power are also sensitive to climate change but, as its impacts will affect technologies differently and unlikely simultaneously, which means they can complement each other. Geothermal energy is less vulnerable to the impacts of climate change, although higher average temperatures reduce thermal efficiency and the lesser volume and higher temperature of water in nearby rivers and lakes affects cooling efficiency and water availability for cooling.[218] The major weather hazard for wind energy installations is too much wind, which can destroy the structural integrity of wind turbines and damage various turbine components. The vulnerability of solar power is uncertain, with more atmospheric moisture and increasing cloudiness as the main factors that can reduce the conversion efficiency and electricity output of solar technologies. Extreme weather events can impose damage on solar energy installations, but material and technologies are available to reduce their vulnerability to these events.

The priority LTS interventions are therefore geared towards increasing investment in the sector, particularly in renewable energy, as well as climate-proofing infrastructure based on individualised risk assessments. This strategy seeks to safeguard Kenya's long-term energy needs in a sustainable way, and to project infrastructure at risk of climate disasters on a case-by-case basis. The strategy also supports the expansion of off-grid renewables such as solar and wind, as well as the provision of clean, reliable energy sources for small traders and households to be used for cooking and lighting. These interventions link directly to the mitigation strategy detailed in section 2.

[218]IAEA, 2019. Adapting the Energy Sector to Climate Change. Available at: https://www-pub.iaea.org/MTCD/Publications/PDF/P1847_web.pdf. Last accessed 2021-11-12

Table 3.13 Details the priority LTS interventions for the Energy sector.

Intervention type	Intervention
Climate-proofing Masinga	Based on risk and vulnerability and impact assessments, climate-proof all new energy infrastructure, and adapt and upgrade existing energy infrastructure become climate-proof
Promote private investment in renewable energy, in line with Least Cost Power Development Plan[219]	Increase energy investment amounts to around $60 billion through to 2040 (based on existing policy frameworks and today's announced policy intentions, i.e., the IEA's "Stated Policies Scenario"), with renewables and electricity networks accounting for half of this.[220] In the more ambitious Africa Case scenario, investments in renewables and electricity networks need to double.
	Aim to maintain and continue diversification of the energy system to reduce vulnerability to climate change impacts.
	Continue to attract private investment, which will be crucial to expand the energy system to meet increasing demand, while also sustaining a diverse affordable reliable and accessible energy mix
Support roll-out of off-grid renewable technologies (off-grid solar, small-hydro, geothermal) to support climate-smart agriculture (in line with NAP)	Support roll-out of off-grid renewable energy technologies, which will be crucial to ensure energy is climate smart and used productively. This includes the continued rehabilitation of water catchment areas.
Energy service for productive use	Expand provision of clean, reliable energy sources for small traders and households to be used for cooking and lighting

[219]Government of Kenya, 'Least Cost Power Development Plan: 2021-2030. Available at https://communications.bowmanslaw.com/REACTION/emsdocuments/LCPD%202021.pdf, Last accessed 2021-11-12

[220]https://iea.blob.core.windows.net/assets/44389eb7-6060-4640-91f8-583994972026/AEO2019_KENYA.pdf

3.4.10 Transport and other Infrastructure

Kenya's transport sector, which is vital to the daily lives of its population and functioning of its modern economy, must grow in line with its rapid urbanisation and economic development. A well-functioning transportation system ensures the efficient flow of goods and services within, to, and from the country. Furthermore, given that Kenya is a key economic, commercial, and financial hub for eastern Africa, its transport sector is vital for supporting trade to and from other countries.[221] Therefore, Vision 2030 aims to support improvement of transport infrastructure, reduce transport costs, facilitate investment into the sector, and improve the efficiency of transport service delivery.

Potential disruptions in transport or damage to infrastructure would lead to a significant loss of productivity in various other sectors. Although the transportation and infrastructure sector consist of all modes of transport and related services, road infrastructure is especially important given that roads account for greater than 80% of Kenya's total passenger and freight transport.

Kenya's national transport policy aims to improve transport connections within the country, as well as networks to and from neighbouring countries. The governmental body which oversees the sector is the Ministry of Transport, Infrastructure, Housing, Urban Development and Public Works. The Integrated National Transport Policy (INTP) of 2009 set the framework to enhance service delivery, attract private sector participation, and strengthen the role of the public sector in the transport sector.

The INTP was revised in 2019 to incorporate the effects of climate change on transport infrastructure, recognising the risks that it will pose to the sector in the future. Several climate hazards have the potential to compromise infrastructure design, function, and performance across a range of settings. For example, the Mombasa Airport is under threat due to climate related events, such as landslides which have caused cracks in the Dongo Kundu Bypass and the second runway at the airport. Sea level rise and storm surges also threaten infrastructure located on the coast.

Flooding and poses a significant risk to road and rail transport networks, as detailed in section 3.2.4. Destruction of infrastructure including roads and bridges during storms, which is increasingly becoming a common phenomenon during extreme weather events. Floods have had devastating consequences in recent years. 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 in damage to transport infrastructure. These risks may increase as the effects of climate change progress, in the absence of significant adaptation interventions. Coastal communities and assets will also be exposed to damages linked to sea level rise and extreme weather events. Port and transport infrastructure[222] is particularly exposed, together with tourism assets and settlements situated close to the coast. The risk of period flooding in Mombasa and estimates of associated losses are detailed in Box 3, section 3.4.7.

Climate change may result in annual losses of between $350 million and $550 million over the next thirty years, in the absence of adaptation interventions. This is shown in Figure 3.20. Flooding and extreme weather are the key drivers of these losses, which are felt primarily through asset depreciation and destruction.

Cognisant of these risks, a range of short, medium and long-term adaptation interventions for the transport sector are detailed in the National Climate Change Action Plan (2018-2022), the National Adaptation Plan and the Updated NDC Technical Report. The full list of commitments provided in the Appendix, section 6.5.10. The interventions can be grouped into two broad themes:

1. **Climate-proofing the sector:** This includes public investment in technologies less exposed to climate risks, such as bus rapid transit systems and expanded rail networks. There are also plans to invest in the rehabilitation and resilience of road infrastructure to reduce risks associated with flooding.
2. **Planning and capacity building:** This involves regular climate-risks assessments on road, rail, air and sea transportation infrastructure, as well as supporting local research and development for sustainable fuels and transport.

The LTS builds on prior commitments, with a few to enhancing long-term resilience in the sector. The interventions seek to climate-proof the sector by rehabilitating infrastructure and investing in expanded, multimodal transport. These measures will reduce the risk of longer-term infrastructure damage and are supported by expanded planning capacity, such as the developing of a 50-year Transport Master Plan (TMP), in line with Kenya's broader climate targets.

[221]Kenya - Second National Communication to the United Nations Framework Convention on Climate Change (2015). Available at: https://unfccc.int/resource/docs/natc/kennc2es.pdf. Last accessed 2021-11-12

[222]KEPSA, (2014). Climate Change and the Transport Sector. Available at:https://cdkn.org/wp-content/uploads/2015/04/Climate-Change-and-the-Transport-Sector.pdf . Last accessed 2021-11-12

Table 3.14 lists the priority adaptation interventions for Transport and Other Infrastructure.

Table 3.14 Priority adaptation actions for Transport and other Infrastructure

Intervention type	Intervention
Improve resilience of transport infrastructure	Integrate climate information in the next 20-year Roads Master Plan to ensure climate-resilient and future-proof infrastructure with a low risk of stranded assets.
	Invest in climate resilient rail, air and maritime infrastructure.
	Develop the 50-year Transport Master Plan (TMP) in line with climate targets.
	Emphasise the focus on building an integrated and multimodal transportation system for Kenya.
	Climate-proof roads by using asphalt mix and permeable road surfaces in road construction, enhancing drainage systems, and upgrading gravel and dirt road networks to increase tolerance to high temperature and heavy rainfall

Overall investment needs in the sector will average around $51 million annually over the next 30 years. According to African Development Bank estimates, these interventions will save 87% of the approximately $550 million annual losses over the next thirty years. These interventions include climate-proofing new and existing building infrastructure and upgrading road networks using asphalt mix and permeable surfaces to reduce the possibility of damages from flooding and precipitation.

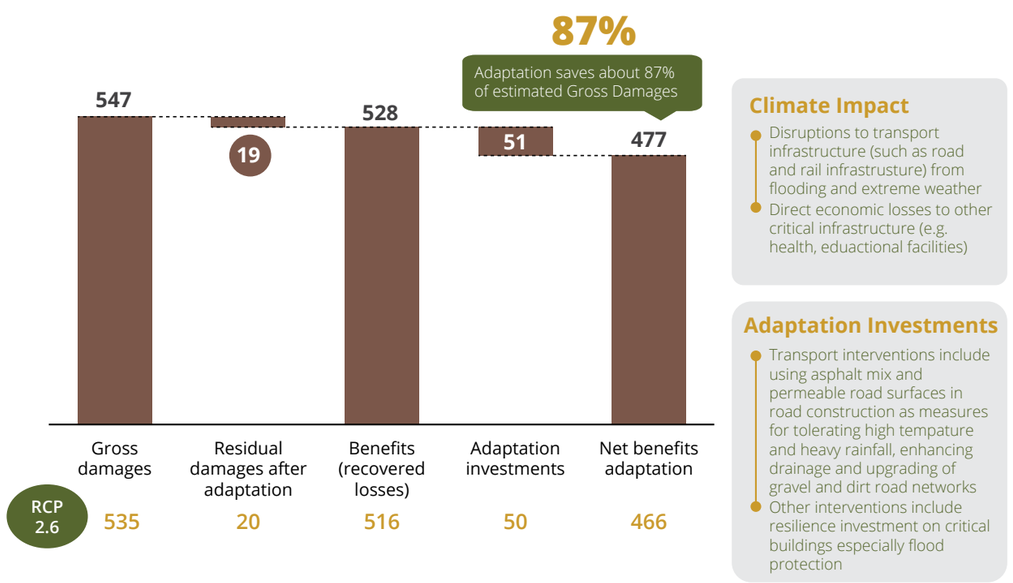


Figure 3.20 Transport and Other Infrastructure: overall damages and net benefits from adaptation, 2020-2050 (Annual averages, 2020 USD millions)

Note: See section 3.3.1 for overview of modelling approach and the Technical Appendix, section 6.3.1, for worked example of calculation. Totals are deflated at 2020 prices and are annual averages for the period 2020-2050. Bars are results for RCP 8.5, with comparators for RCP 2.6 in yellow below.

Source: Modelling based on AfDB (2019) and UNISDR (2018)

3.4.11 Gender, Youth and Other Vulnerable Groups

Vulnerable and marginalised groups, such as women, children, the poor, the aged, those living with long-term illness and the disabled, tend to have worse access to economic, social, and even natural resources. For example, women and girls are particularly affected by adverse economic conditions, gender inequality, and regressive gender norms, and tend to be more heavily reliant on their natural environment for their livelihoods. Vulnerable groups, including females and young people, tend to have worse access to economic, social, and even natural resources.

However, the education and empowerment of these groups are key to Kenya's long-term economic development and the improvement in quality of life. Empowerment of vulnerable and marginalised groups is key to increasing labour force participation, boosting productivity, improving income inequality, improving human health and well-being, and introducing greater diversity into government and key sectors of the economy. Kenya has therefore put significant emphasis on empowering vulnerable groups through policy, legal, and institutional reforms, child protection programmes, youth programmes, gender mainstreaming, and upscaling of financing under its Vision 2030 strategy.[223]

Article 10 of Kenya's Constitution establishes principles of governance such as equality, equity, inclusivity, and non-discrimination, which serve as a basis for Kenya's Policy on Gender and Development. The Policy on Gender and Development aims to increase participation of vulnerable and marginalised groups in achieving sustainable development, building upon the National Policy for Gender and Development of 2000, and Sessional Paper No. 2 of 2006 on Gender Equality and Development.[224] Meanwhile, governmental bodies relevant for upholding the principles enshrined in Article 10 include the Ministry of Public Service, Youth and Gender, Ministry of Labour and Social Protection, and Ministry of Education.

Incremental and extreme climate changes are likely to negatively affect living and working conditions, particularly among the most vulnerable, for example women and children. When it comes to adapting to climate change, it is the poor, the aged, women, children, those living with long-term illness and the disabled who will be the most vulnerable to the impacts of sudden climate-related events. Members of these groups are typically less able to cope with climate shocks and stresses as they have restricted access to and control over resources such as capital, credit, and land (i.e., lower adaptive capacity), and frequently live in the most vulnerable areas (e.g., low-lying, and arid lands). As a result, climate change will likely exacerbate current geographical and social inequalities (e.g., gender, educational, poverty).

Drought and associated water scarcity have the potential to exacerbate existing inequalities. Women in Kenya have are 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, vulnerable and the elderly.[225] Migration is also expected as an indirect consequence of these climate drivers, together with poor educational development due to temporary dropouts and irregular attendance in schools as a result of pressure on children to contribute to the survival of the families through domestic chores (like fetching water).[226] The longer-term impact for children who drop out altogether is that they lose their learning opportunity at that age, which impacts the healthy development of the child and the long-term growth of the community.

Lower food accessibility due to increased commodity prices is likely to translate in increases in malnutrition, especially of young children. In modelling work undertaken by IFPRI using the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model and published in Herrero et al. (2010), the effects of climate change on human well-being outcomes (malnutrition, kilo-calorie availability) are examined, with depressed food demand translating into direct increases in malnutrition levels, and often irreversible consequences for young children.[227] Projections show that climate change increases the share of malnourished children in both 2025 and 2050, compared to a non-climate change scenario.[228] Figure 3.21 shows that without climate change, the share of malnourished children is projected to decline from 19% in 2000 to 15% by 2025 and 11% by 2050. Under climate change, child malnutrition levels increase under all alternative climate change scenarios. These effects will probably be exacerbated in areas of high vulnerability, like in the ASALs.[229]

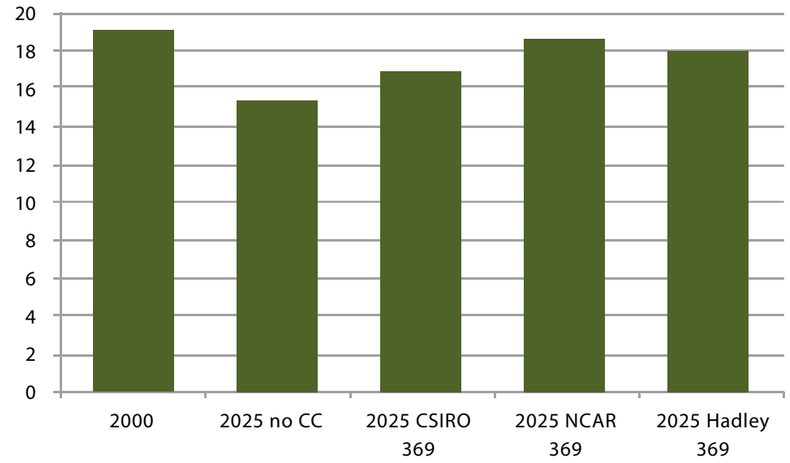


Figure 3.21: Kenya: share of malnourished children (%), historic climate and alternative climate change scenarios, 2025 (top) and 2050 (bottom)

Source: IFPRI Impact Simulations, 2009 in Herrero et al., 2010

[223]Vision 2030. Available at: https://vision2030.go.ke/sectors/gender_youth_and_vulnerable_groups/. Last accessed 2021-11-12

[224]Republic of Kenya, 2019. Available at: http://psyg.go.ke/wp-content/uploads/2019/12/NATIONAL-POLICY-ON-GENDER-AND-DEVELOPMENT.pdf. Last accessed 2021-11-12

[225]UNDP and GoK (2012), Kenya: Gender Analysis, https://www1.undp.org/content/dam/LECB/docs/pubs-reports/undp-ndcsp-kenya-gender-analysis-report.pdf?download, last accessed 2021-12-10.

[226]Ibid.

[227]M. Herrero, P.K. Thornton, A.M. Notenbaert, S. Wood, S. Msangi, H.A. Freeman, D. Bossio, J. Dixon, M. Peters, J. van de Steeg, J. Lynam, P.P.Rao, S. Macmillan, B. Gerard, J. McDermott, C. Seré, M. Rosegrant, 2010. Smart investments in sustainable food production: revisiting mixed crop-livestock systems. Science, 327 (2010), pp. 822-825.

[228]Ibid.

[229]Ibid.

As this sector is cross cutting, losses associated with climate change are not reported separately to other sectors. However, vulnerable and marginalised groups such as women, children, the poor, the aged, those living with long-term illness and the disabled are particularly susceptible to the effects of climate change, including:

- Possible disruptions to housing and food security due to drought and water scarcity
- Insecurity of tenure to land use changes
- Unemployment or decreased incomes due to lower labour productivity
- Job losses or livelihood disruption because of mitigation actions elsewhere

Cognisant of these risks, a range of short, medium, and long-term adaptation interventions for the gender, youth and other vulnerable groups sector are detailed in the National Climate Change Action Plan (2018-2022), the National Adaptation Plan and the Updated NDC Technical Report. The full list of commitments provided in the Appendix, section 6.5.11. The interventions can be grouped into two broad themes:

1. **Expanding the social safety net:** Previous policy documents commit to expanding social welfare and economic opportunities for vulnerable groups, through expanded welfare systems and community participation in decision making.
2. **Participation in the green economy:** Prior policy interventions suggest a holistic approach to inclusion of vulnerable groups in the wider green economy, through the promotion of economic opportunity, education and access to finance.

The LTS builds on prior interventions and seeks to ensure that the transition to a green economy is just and equitable. The LTS emphasises the importance of expanded education and access to finance, so that women, youth and other vulnerable groups are protected from the adverse effects of climate change and able to access opportunities associated with the green transition.

The recommended LTS interventions for the Gender, Youth and Other Vulnerable Groups sector are detailed in Table 3.15.

Table 3.15 Priority adaptation actions for Gender, Youth and Other Vulnerable Groups

Intervention type	Intervention
Improve socioeconomic security of vulnerable groups	Continue to support economic diversification, through promotion and support to SMEs, particularly in the rural economy, including through access to finance.
	Implement early warning systems for climate risk, specifically targeted at vulnerable groups
	Strengthen social safety nets, including insurance products for climate related events and broader social security.
Targeted education and engagement of vulnerable groups	Implement targeted education, training and skills development programmes, particularly for women and other vulnerable groups.

3.5 Overall benefits of adaptation investments

Adaptation investments worth 0.4% of GDP could reduce damages equivalent to 1.8% of GDP, over the period 2020-2050. In absolute terms, these benefits would amount to approximately $3.5 billion per annum over the period 2020-2050.

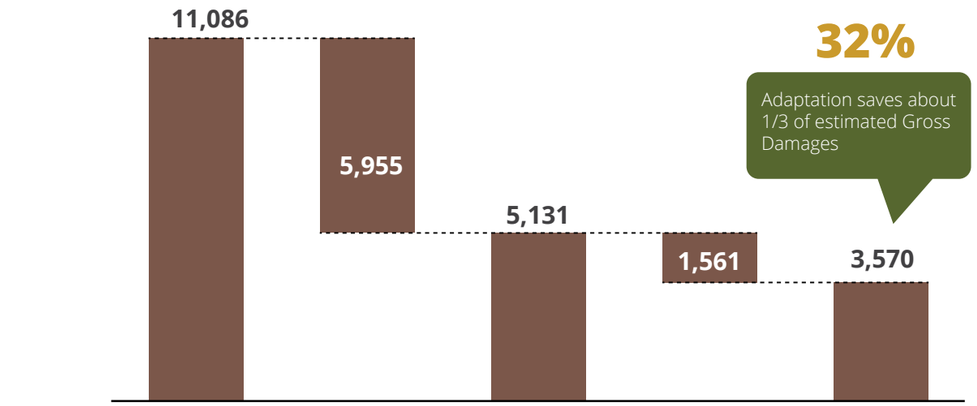


Figure 3.22 Overall damages and net benefits from adaptation, 2020-2050 (Annual averages, 2020 USD millions)

Note: See section 3.3.1 for overview of modelling approach and the Technical Appendix, section 6.3.1, for worked example of calculation. Totals are deflated at 2020 prices and are annual averages for the period 2020-2050. Bars are results for RCP 8.5, with comparators for RCP 2.6 in yellow below.

Source: Modelling based on AfDB (2019) and UNISDR (2018)

This result confirms that adaptation investments are, on average, a cost-optimal way to address a significant share of damages associated with climate change.

Photo Credit: CCD

04

IMPLEMENTATION PLAN

4.1 Mitigation

Action	Intervention	Responsible authority	Timeframe	Priority	Investment cost
1. Agriculture					
1.1	Implement the dairy NAMA by 2030	Department of Livestock	Medium term	High	Medium
1.2	Biogas generation for electricity in abattoirs	Department of Livestock	Medium term	Medium	Medium
1.3	Enhanced manure management	Department of Livestock	Short term	Medium	Low
1.4	Shift to modern rice production with intermittent irrigation	Department of Crops	Medium term	Medium	High
1.5	Increase area under conservation agriculture (no or low tillage)	Department of Crops	Long term	High	High
1.6	Increase fish as a source of protein	Department of Fisheries	Long term	High	High
2. Energy					
2.1 Residential: 2.1.1. Electricity access					
2.1.1.1	Provide universal access to electricity in urban areas by 2022	Department of Energy	Short term	High	High
2.1.1.2	Provide universal access to electricity in rural areas by 2030	Department of Energy	Medium term	High	High
2.1.1.3	Tier 3 electricity access in rural by 2030 (>365kWh/hhd/year)	Department of Energy	Medium term	Medium	High
2.1.1.4	Tier 4 electricity access in urban areas in 2030 (>1250kWh/hhd/year)	Department of Energy	Medium term	Medium	High
2.1 Residential: 2.1.2 Clean cooking					
2.1.2.1	Increase rural households using biogas for cooking	Department of Energy	Medium term	Medium	Medium
2.1.2.2	Increase use of ethanol fuel for cooking in rural areas	Department of Energy	Medium term	Medium	Medium
2.1.2.3	Increase use of LPG for cooking in rural households	Department of Energy	Long term	Medium	Medium
2.1.2.4	Reduce LPG use intensity in rural households	Department of Energy	Long term	Medium	Medium
2.1.2.5	Adoption of electric stoves in rural households	Department of Energy	Long term	Medium	High
2.1.2.6	Reduce ownership of charcoal and firewood cooking in rural households	Department of Energy	Long term	Medium	Medium
2.1.2.7	Reduce use of charcoal and firewood in rural households	Department of Energy	Long term	Medium	Medium
2.1.2.8	Eliminate use / ownership of kerosene stoves in rural households	Department of Energy	Long term	Medium	Medium
2.1.2.9	Increase use of ethanol fuel for cooking in urban areas	Department of Energy	Medium term	Medium	Medium
2.1.2.10	Increase ownership of LPG cookstoves in urban households	Department of Energy	Long term	Medium	Medium
2.1.2.11	Reduce LPG use intensity in urban households	Department of Energy	Long term	Medium	Medium
2.1.2.12	Adoption of electric stoves in urban households	Department of Energy	Long term	Medium	High
2.1.2.13	Reduce use of charcoal for cooking in urban areas	Department of Energy	Long term	Medium	Low
2.1 Residential: 2.1.3 Energy efficiency and conservation					
2.1.3.1	Replacement of inefficient incandescent bulbs with efficient LEDs and CFLs	Department of Housing and Urban Development	Long term	Medium	Medium
2.1.3.2	Ensure 25% of new buildings under the affordable housing government programme are green by 2025	Department of Housing and Urban Development	Short term	Medium	High
2.2 Industrial Energy Use: 2.2.1 Industry					
2.2.1.1	15% reduction in energy use intensity by 2025 and 30% energy saving by 2050 through state-of-the-art equipment and processes	Department of Industrialisation	Short term	High	High
2.2.1.2	Increase share of final energy demand coming from hydrogen in the cement industry	Department of Industrialisation	Long term	Medium	High
2.2.1.3	Increase share of final energy demand coming from sustainable biomass in the cement industry	Department of Industrialisation	Long term	Medium	High
2.2.1.4	Phase out of diesel use in the beverage and tobacco industry and replace by electricity and hydrogen fuel	Department of Industrialisation	Long term	Medium	Medium
2.2.1.5	Increase use of green hydrogen in large industries, including chemicals, paints, steel, pharmaceuticals	Department of Industrialisation	Long term	Medium	High
2.2.1.6	Install solar PV under the net metering system	Department of Industrialisation	Long term	Medium	High
2.2 Industrial Energy Use: 2.2.2 Services					
2.2.2.1	Use of electricity for cooking in hotels and restaurants	Department of Industrialisation	Long term	Medium	High
2.2.2.2	Increase adoption rate of biomass pellets for cooking in schools	Department for Education	Long term	Medium	High
2.2.2.3	Increase adoption rate of LPG pellets for cooking in schools	Department for Education	Long term	Medium	High
2.3: Electricity Generation					
2.3.1	Increase generating capacity through renewable sources	Department for Renewable Energy	Long term	High	High
3. Land Use, Land Use Change and Forestry					
3.1	Reduce deforestation and forest degradation	State Department of Environment and Forestry	Medium term	High	High
3.2	Afforestation/reforestation/agroforestry	State Department of Environment and Forestry	Medium term	High	Medium
3.3	Restoration of forest on degraded landscapes (ASALs, rangelands)	State Department of Environment and Forestry	Medium term	High	High
3.4	Increase area under private sector-based commercial and industrial plantations	State Department of Environment and Forestry	Medium term	High	Medium

Action	Intervention	Responsible authority	Timeframe	Priority	Investment cost
4. Industrial Processes					
4.1	Implementation of the charcoal NAMA: transition from traditional charcoal kilns to improved charcoal kilns.	Ministry of Environment, Water and Natural Resources	Long term	High	Medium
4.2	Reduce consumption of cement product by adopting innovative construction technologies such as interlocking bricks, composite tiles (natural rubber resins and sisal reinforcement).	State Department of Industrialisation	Long term	Medium	High
4.3	Adopting the Kigali amendment and enhancing the building envelopes to reduce need for cooling, using low and zero GWP alternatives in all new equipment, reducing HFCs leaks through better design, manufacturing, and servicing	State Department of Industrialisation	Long term	Medium	High
4.4	Reduced GHG production by 25% through carbon capture and storage technologies. Carbon capture and storage (CCS) has been proposed and implemented in some developed countries and several others are in planning and study phases.	State Department of Industrialisation	Long term	Low	High
5. Transport					
5.1	Installation of shore power in all berths at the port	State Department of Shipping and Maritime Affairs	Long term	Medium	High
5.2	Implementation of the single window system	State Department of International Trade	Long term	Medium	Low
5.3	Compliance in Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)	Department of Transport	Long term	Medium	Low
5.4	Future rail development to design with electricity driven locomotives and Extension of SGR from Naivasha-to-Malaba.	Department of Transport	Long term	Medium	Medium
5.5	Transition from fossil fuel to electric and hydrogen fuelled vehicles 30% of all vehicles on road to be electric or hydrogen powered by 2050.	Department of Transport	Long term	Medium	Medium
5.6	Shift to 100% of motorcycles to be electric by 2050	Department of Transport	Long term	Medium	High
5.7	Shift most of the freight shall shift from truck to train	Department of Transport	Long term	Medium	High
5.8	Ensure total implementation of urban transport policy in all urban centres 100% compliance by 2050.	Department of Transport	Long term	Medium	High
5.9	Continue and accelerate the decarbonisation of the transport sector by promoting low-emission transportation modes for goods and public transportation for passenger mobility.	Department of Transport	Long term	Medium	High
5.10	Increase efficiency of trucks	Department of Transport	Short term	Medium	Medium
5.11	Increase use of railway	Department of Transport	Long term	High	High
6. Waste					
6.1	Install waste-to-energy generation capacity	State Department of Renewable Energy	Long term	Medium	High
6.2	Material Recovery Facilities installed in each country by 2023		Short term	Medium	Medium
6.3	Increase recycling		Short term	Medium	Medium
6.4	Full collection and treatment of wastewater in deep anaerobic lagoons with methane recovery for electricity generation	State Department of Renewable Energy	Long term	High	High
6.5	Connect residential sector in urban areas to national sewer system discharging the wastewater into national waste management sites	State Department of Water and Sanitation	Long term	High	High

Photo Credit: CCD

4.2 Adaptation

Action	Intervention	Responsible authority	Timeframe	Priority	Investment cost
1. Agriculture, Food and Nutrition Security					
1.1 Land use changes: 1.1.1 Crop farming					
1.1.1.1	Increase crop yields through mass rollout of CSA techniques	State Department of Crop Development	Long term	High	High
1.1.1.2	Promote crop rotation and intercropping	State Department of Crop Development	Medium term	High	Low
1.1.1.3	Improve locally adapted varieties, with emphasis on indigenous varieties	State Department of Crop Development	Medium term	High	Low
1.1 Land use changes: 1.1.2 Livestock farming					
1.1.2.1	Increase adoption of SALM techniques of precision feeding and watering, including drip irrigation	State Department of Crop Development	Medium term	High	Low
1.1.2.2	Improve pasture and grazing management through uptake of SALM techniques	Department of Livestock	Medium term	High	Low
1.1.2.3	Breed livestock for greater tolerance to heat and increased productivity	Department of Livestock	Long term	High	Low
1.1.2.4	Diversify livestock and forage species to increase resilience	Department of Livestock	Medium term	High	Low
1.1.2.5	Breed forages which can tolerate high temperature and have high growth and regeneration rates	Department of Livestock	Long term	High	Low
1.1.2.6	Minimize disease spread through vaccinations and improve shelters	State Department of Agricultural Research	Medium term	High	Medium
1.1.2.7	Enhance livestock access to water	Department of Livestock	Medium term	High	Medium
1.1.2.8	Enhance livestock pasture production and storage (e.g., having a strategic pasture reserve)	Department of Livestock	Medium term	High	Medium
1.2 Regulatory interventions: 1.2.1 Livestock farming					
1.2.1.1	Enhance efficiency of the livestock value chain	Department of Livestock	Short term	Medium	Low
1.2 Regulatory interventions: 1.2.2 Crop and livestock breeding					
1.2.2.1	Enhance co-production, access, and use of climate information services and early warning systems to minimize loss and maximize production in the livestock sector	Department of Livestock	Short term	Medium	Medium
1.2.2.2	Promote the uptake of climate-oriented agricultural subsidies, risk transfers, early action interventions and other safety nets.	State Department of Agricultural Research	Short term	Medium	High
1.2.2.3	Increase funding for research and development	State Department of Agricultural Research	Short term	Medium	High
2. Water and sanitation					
2.1 Water access measures: 2.1.1 Resource management					
2.1.1.1	Promote water harvesting and storage at regional and household levels	State Department of Water and Sanitation	Medium term	High	Medium
2.1.1.2	Build resilient infrastructure for the protection of dams and dikes and river lines	State Department of Infrastructure	Medium term	High	Medium
2.1.1.3	Build multipurpose dams	State Department of Water and Sanitation	Medium term	High	Medium
2.1.1.4	Building climate smart infrastructure for the protection of dams, water pans and other water storage facilities to prevent water loss through evaporation caused by the increasing global temperatures	State Department of Infrastructure	Medium term	High	High
2.1.1.5	Increase water availability per capita, through artificial water recharging of aquifers	State Department of Water and Sanitation	Medium term	High	High
2.1.1.6	Promote water efficiency by reducing non-revenue water, reusing, and recycling of wastewater	State Department of Water and Sanitation	Medium term	High	Medium
2.1 Water access measures: 2.1.2 Sanitation improvement					
2.1.2.1	Increase sewer coverage with focus on promoting onsite sanitation technologies	State Department of Water and Sanitation	Medium term	High	High
2.1.2.2	Implement holding stations for sewer management	State Department of Water and Sanitation	Medium term	High	Medium
2.2 Regulatory interventions: 2.2.1 Resource management					
2.2.1.1	Conduct climate and risk assessments on transboundary water resource management and develop adaptation plans incorporating nature-based solutions	State Department of Water and Sanitation	Short term	Medium	Low
2.2.1.2	Establish/strengthen bilateral efforts to manage transboundary water resource management issues	State Department of Water and Sanitation	Short term	Medium	Medium
2.2.1.3	Mainstream climate change into sub-catchment management plans.	State Department of Water and Sanitation	Short term	Medium	Low
2.2 Regulatory interventions: 2.2.2 Sanitation improvement					
2.2.2.1	Develop a favourable financial model for sanitation, whereby the government should subsidize sanitation services to transport effluents from the remote residential areas to city waste treatment plants	State Department of Water and Sanitation	Short term	Medium	Medium
2.2.2.2	Create a favourable environment for PPP to encourage private sector involvement in the sanitation service industries	State Department of Water and Sanitation	Short term	Medium	Low
2.2.2.3	Capacity building and awareness on onsite wastewater treatment technologies	State Department of Water and Sanitation	Medium term	Medium	Low
2.2.2.4	Implement holding stations for sewer management	State Department of Water and Sanitation	Medium term	Medium	Medium
3. Fisheries and the Blue Economy					
3.1 Resource management: 3.1.1 Sustainable fishing					
3.1.1.1	Upscale sustainable offshore aquaculture	State Department of Fisheries	Short term	High	Medium
3.1.1.2	Introduce improved fishing infrastructure and technologies	State Department of Fisheries	Medium term	High	Medium
3.1.1.3	Create incentives to shift diets toward low carbon marine sources such as sustainably harvested fish, and seaweed, as a replacement for emissions intensive land-based sources of protein	State Department of Fisheries	Short term	High	Low
3.1 Resource management: 3.1.2 Resilience					
3.1.2.1	Expand seaweed farming beyond Kwale County of Kenya	State Department of Fisheries	Medium term	High	Medium
3.1.2.2	Increase feeds and seed in the ecological food chain of aquaculture through improved technology and capacity building	State Department of Fisheries	Long term	High	Medium
3.1.2.3	Rehabilitate coral reefs	State Department of Fisheries	Medium term	High	Medium
3.1.2.4	Introduce targeted breeding of resilient species	State Department of Fisheries	Long term	High	Low

Action	Intervention	Responsible authority	Timeframe	Priority	Investment cost
3.2 Regulatory interventions: 3.2.1 Sustainable fishing					
3.2.1.1	Introduce regulations such as permits and stricter fishing quotas to prevent over-fishing.	State Department of Fisheries	Short term	Medium	Low
3.2.1.2	Implement Port State Measures Agreement to minimize illegal unregulated and unreported (IUUs) fishing	State Department of Fisheries	Short term	Medium	Low
3.2.1.3	Empower fisher community through education, capacity building, and livelihood diversifications	State Department of Fisheries	Medium term	Medium	Low
3.2.1.4	Provide a framework for incentives that promote investment in low carbon development in fisheries and blue economy	State Department of Fisheries	Short term	Medium	Low
3.2.1.5	Establish a sustainable financing mechanism for fisheries and blue economy sectors	Establish a sustainable financing mechanism for fisheries and blue economy sectors	Short term	Medium	Medium
3.2 Regulatory interventions: 3.2.2 Resilience					
3.2.2.1	Conduct a risks and vulnerability assessment of the fisheries subsector	State Department of Fisheries	Short term	Medium	Low
3.2.2.2	Review, strengthen and deploy adaptation capacity in fisheries and blue economy	State Department of Fisheries	Short term	Medium	Low
3.2.2.3	Strengthen ecosystem approach to fisheries management	State Department of Fisheries	Short term	Medium	Low
3.2.2.4	Strengthen monitoring capacity to prevent over-fishing for both inland and EEZ	State Department of Fisheries	Medium term	Medium	Low
4. Forestry					
4.1 Increase forest productivity					
4.1.1	Increase forest productivity using high quality germplasm and appropriate silvicultural practices	State Department of Environment and Forestry	Long term	High	Medium
4.2 Improve forest management					
4.2.1	Implement a forest management plan.	State Department of Environment and Forestry	Short term	High	Low
4.2.2	Support participation of public institution in plantation programmes.	State Department of Environment and Forestry	Short term	High	Low
4.2.3	Support participation of non-state actors in public plantation programmes.	State Department of Environment and Forestry	Short term	High	Low
4.2.4	Streamline the participation of communities in the plantation establishment and Livelihood improvement Scheme (PELIS) and enhanced enforcement of 10% farm forest rule	State Department of Environment and Forestry	Short term	High	Low
4.2.5	Increase area under private sector-based commercial and industrial plantations from 71,000 ha to at least 121,000 ha	State Department of Environment and Forestry	Short term	High	High
4.2.6	Support sustainable management of public plantation forests to enhance productivity	State Department of Environment and Forestry	Short term	High	Medium
5. Tourism and Wildlife					
5.1 Improving biodiversity management					
5.1.1	Enhance Existing Land Protection and Ecosystem management	State Department of Lands	Short term	High	Medium
5.1.2	Improve Species Conservation and Management	State Department of Tourism	Short term	High	Medium
5.1.3	Review governance of wildlife and natural resource management	State Department of Tourism	Short term	High	Low
5.2 Increasing innovation and financing for biodiversity					
5.2.1	Enhance research, technology development, innovations and knowledge management	State Department of Tourism	Short term	High	Medium
5.2.2	Mobilize financial resources for conservation	State Department of Tourism	Short term	High	Low
5.2.3	Improve partnerships, collaborations and coordination of adaptation actions	State Department of Tourism	Short term	High	Low
5.3 Climate-proofing the sector					
5.3.1	Reduce damages to the tourism industry by implementing sustainable tourist activities which are not dependent on the natural environment	State Department of Tourism	Medium term	High	Medium
6. Health					
6.1 Capacity building in the health sector					
6.1.1	Conduct research into diseases associated with climate change and implement recommendations. Examples include Chikungunya, Rift Valley fever, Dengue haemorrhagic fever	State Department of Health	Short term	High	Low
6.1.2	Build capacity of public health systems in early identification, diagnosis, and management of climate related diseases and health issues	State Department of Health	Medium term	Medium	Medium
6.1.3	Implement public awareness and social mobilization strategy on climate health impacts	State Department of Health	Short term	Medium	Low
6.1.4	Build capacity and infrastructure of public health systems to enhance response to climate related diseases	State Department of Health	Medium term	Medium	Medium
6.1.5	Strengthen the current disease surveillance system to incorporate pathogen surveillance	State Department of Health	Short term	Medium	Low
6.1.6	Develop models for early warning of other vector borne diseases especially chikungunya, dengue haemorrhagic fever, kalazar, lymphatic filiarisis, elephantiasis, hydrocell and rift valley fever	State Department of Health	Short term	High	Low
6.1.7	Build capacity for community health volunteers and workers on early warnings, proper diagnosis and reporting of climate related diseases	State Department of Health	Medium term	Medium	Low
6.1.8	Implement malaria larval source management	State Department of Health	Medium term	High	Low
6.1.9	Scale up mass distribution of Insecticide Treated Nets (ITNS)	State Department of Health	Medium term	High	Medium
6.1.10	Scale up mass distribution of Indoor Residual Spray (IRS)	State Department of Health	Medium term	High	Low
6.1.11	Scale up mass distribution of outdoor residual spray for sandflies	State Department of Health	Medium term	High	Low
6.1.12	Expand environmental and mechanical control and management of the vectors	State Department of Health	Medium term	High	Medium

Action	Intervention	Responsible authority	Timeframe	Priority	Investment cost
6.2 Reduce disease incidence					
6.2.1	Reduce over nutrition by promoting healthy diets to prevent the burden of non-communicable diseases.	State Department of Health	Short term	High	Low
6.2.2	Reduce under nutrition by scaling up integrated management of acute malnutrition.	State Department of Health	Medium term	High	Medium
6.2.3	Reduce micronutrient malnutrition by scaling up micronutrient supplementation and food fortification	State Department of Health	Medium term	Medium	Medium
6.2.4	Reduce incidences of aflatoxicosis through surveillance and laboratory analysis, capacity building on good storage practices among food business operators and households	State Department of Health	Medium term	Medium	Medium
6.2.5	Reduce incidences of foodborne diseases	State Department of Health	Medium term	Medium	Medium
7. Human Settlement, Urban Development and Housing					
7.1 Flood defence mechanisms					
7.1.1	Introduce nature-based solutions in flood control, especially around informal settlements and selected urban areas	State Department of Housing and Urban Development	Medium term	High	Medium
7.1.2	Introduce practice of beach nourishment to combat coastal erosion	State Department of Environment and Forestry	Medium term	High	Medium
7.1.3	Build and maintain flood defence mechanisms such as a sea wall, particularly around strategically important port cities such as Mombasa	State Department of Public Works	Medium term	High	High
7.2 Improved building resilience					
7.2.1	Enforce green and resilient building standards in new buildings and promote retrofit/climate proofing of older buildings	State Department of Housing and Urban Development	Medium	High	Low
8. Manufacturing and trade					
8.1 Encouraging sustainable resource management					
8.1.1	Increase the number of companies participating in efficient water use initiatives	State Department of Industrialisation	Short term	High	Low
8.2 Facilitating resilience					
8.2.1	Climate-proof industrial plants and infrastructure to avoid operational and supply chain disruptions	State Department of Industrialisation	Medium term	High	Medium
8.2.2	Plan for supply chain disruptions via preparatory measures such as dual sourcing, increased supplier resilience, and insurance	State Department of Industrialisation	Short term	High	Low
9. Energy					
9.1	Climate-proof all new energy infrastructure and upgrade existing energy infrastructure	State Department of Energy	Medium term	High	High
9.2	Continue to attract private investment for renewable energy projects, to meet future demand and reach universal access, and maintain and continue diversification of the (future) energy system	State Department of Renewable Energy	Short term	High	Low
9.3	Support roll-out of off-grid renewable technologies (off-grid solar, small-hydro, geothermal) to support climate-smart agriculture (in line with NAP)	State Department of Renewable Energy	Medium term	High	High
10. Transport and other Infrastructure					
10.1	Integrate climate information in the next 20-year Roads Master Plan to ensure climate-resilient and future-proof infrastructure with a low risk of stranded assets.	State Department of Transport	Short term	High	Low
10.2	Develop the 50-year Transport Master Plan (TMP) in line with climate targets.	State Department of Transport	Short term	High	Low
10.3	Emphasise the focus on building an integrated and multimodal transportation system for Kenya.	State Department of Transport	Short term	High	Low
10.4	Make roads climate-proof by using asphalt mix and permeable road surfaces in road construction, enhancing drainage systems, and upgrading gravel and dirt road networks to increase tolerance to high temperature and heavy rainfall.	State Department of Transport	Medium term	High	High
11. Gender, Youth and Other Vulnerable Groups					
11.1 Improve financial security of vulnerable groups					
11.1.1	Continue to support economic diversification, through promotion and support to SMEs, particularly in the rural economy, including through access to finance	State Department of Industrialisation	Medium term	High	Medium
11.1.2	Strengthen social safety nets, including insurance products for climate related events and broader social security	State Department of Social Protection, Pensions and Senior Citizens Affairs	Medium term	High	High
11.2 Targeted education and engagement of vulnerable groups					
11.2.1	Implement targeted education, training and skills development programmes, particularly for women and other vulnerable groups	State Department of Post Training and Skills Development	Medium term	High	High

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05

MONITORING PLAN

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5.1 Mitigation

Action	Intervention	Key indicators	Targets	2030	2040	2050
1. Agriculture						
1.1	Implement the dairy NAMA by 2030	Reduce emissions from dairy sector by 8.8MTCO2e by 2030		8.8		
1.2	Biogas generation for electricity in abattoirs	Abattoirs generating electricity with average capacity of 500kW		200		
1.3	Enhanced manure management	Proportion of farmers using zero-low emission manure management techniques		20%		
1.4	Shift to modern rice production with intermittent irrigation	Total hectares used for efficient modern rice production		15,000		100%
1.5	Increase area under conservation agriculture (no or low tillage)	Proportion of croplands farmed under CA (low or no-tillage)				30%
1.6	Increase fish as a source of protein	Fish consumption per capita				
2. Energy						
2.1 Residential: 2.1.1. Electricity access						
2.1.1.1	Provide universal access to electricity in urban areas by 2022	Urban electricity access	100% by 2022	100%	100%	100%
2.1.1.2	Provide universal access to electricity in rural areas by 2030	Rural electricity access		100%	100%	100%
2.1.1.3	Tier 3 electricity access in rural by 2030 (>365kWh/hhd/year)	Rural electricity consumption per household (kWh per household per year)		365		
2.1.1.4	Tier 4 electricity access in urban areas in 2030 (>1250kWh/hhd/year)	Urban electricity consumption per household (kWh per household per year)		1,250		
2.1 Residential: 2.1.2 Clean cooking						
2.1.2.1	Increase rural households using biogas for cooking	Percentage of rural households using biogas for cooking	25% by 2028	25%		30%
2.1.2.2	Increase use of ethanol fuel for cooking in rural areas	Percentage of rural population that uses ethanol fuel as primary energy	25% by 2028	25%	25%	25%
2.1.2.3	Increase use of LPG for cooking in rural households	LPG adoption in rural households	50% by 2028	50%		65%
2.1.2.4	Reduce LPG use intensity in rural households	LPG cookstove use intensity reductions				60%
2.1.2.5	Adoption of electric stoves in rural households	Use electric stoves as a primary cooking technology by rural households				20%
2.1.2.6	Reduce ownership of charcoal and firewood cooking in rural households	Reduced ownership of charcoal / firewood cookstoves in rural households				50%
2.1.2.7	Reduce use of charcoal and firewood in rural households	Reduced use of charcoal / firewood cookstoves in rural households				90%
2.1.2.8	Eliminate use / ownership of kerosene stoves in rural households	Reduced ownership / use of kerosene cookstoves in rural households				100%
2.1.2.9	Increase use of ethanol fuel for cooking in urban areas	Percentage of urban population that uses ethanol fuel as primary energy	25% by 2025	25%		40%
2.1.2.10	Increase ownership of LPG cookstoves in urban households	LPG cookstove ownership		70%		90%
2.1.2.11	Reduce LPG use intensity in urban households	LPG cookstove use intensity reductions				70%
2.1.2.12	Adoption of electric stoves in urban households	Percentage of urban population that uses electric stoves as a primary cooking technology				70%
2.1.2.13	Reduce use of charcoal for cooking in urban areas	Percent of households using charcoal for grilling in urban areas				5%
2.1 Residential: 2.1.3 Energy efficiency and conservation						
2.1.3.1	Replacement of inefficient incandescent bulbs with efficient LEDs and CFLs	Proportion of incandescent bulbs replaced by either LEDs or CFLs				100%
2.1.3.2	Ensure 25% of new buildings under the affordable housing government programme are green by 2025	Proportion of buildings under the affordable housing government programme that are green	25% by 2025	25%		
2.2 Industrial Energy Use: 2.2.1 Industry						
2.2.1.1	15% reduction in energy use intensity by 2025 and 30% energy saving by 2050 through state-of-the-art equipment and processes	Reduction in energy use intensity	15% by 2025	15%		30%
2.2.1.2	Increase share of final energy demand coming from hydrogen in the cement industry	Share of hydrogen fuel in final energy demand in cement sector			10%	40%
2.2.1.3	Increase share of final energy demand coming from sustainable biomass in the cement industry	Share of sustainable biomass in final energy demand in cement sector				17%
2.2.1.4	Phase out of diesel use in the beverage and tobacco industry and replace by electricity and hydrogen fuel	Diesel use replaced by electricity and hydrogen in the beverage, tobacco and tea sectors				100%
2.2.1.5	Increase use of green hydrogen in large industries, including chemicals, paints, steel, pharmaceuticals	Share of diesel replaced by green hydrogen				70%
2.2.1.6	Install solar PV under the net metering system	Power coming from solar PV				
2.2 Industrial Energy Use: 2.2.2 Services						
2.2.2.1	Use of electricity for cooking in hotels and restaurants	Share of electricity in energy consumption				40%
2.2.2.2	Increase adoption rate of biomass pellets for cooking in schools	Share of schools using biomass pellets as primary cooking fuel				60%
2.2.2.3	Increase adoption rate of LPG pellets for cooking in schools	Share of schools using LPG as primary cooking fuel				30%
2.3: Electricity Generation						
2.3.1	Increase generating capacity through renewable sources	Share of electricity generated from renewable sources		100%	100%	100%

Action	Intervention	Key indicators	Targets	2030	2040	2050
3. Land Use, Land Use Change and Forestry						
3.1	Reduce deforestation and forest degradation	Annual deforestation (gross)		100,000	100,000	100,000
3.2	Afforestation/reforestation/agroforestry	Total area afforested/reforested/converted into agroforestry (gross)		100,000		
3.3	Restoration of forest on degraded landscapes (ASALs, rangelands)	Forest area restored on degraded landscapes (hectares)		200,000		
3.4	Increase area under private sector-based commercial and industrial plantations	Area under private sector based commercial and industrial plantations (hectares)				121,000
4. Industrial Processes						
4.1	Implementation of the charcoal NAMA: transition from traditional charcoal kilns to improved charcoal kilns.	Share of charcoal kilns that are modern and efficient				100%
4.2	Reduce consumption of cement product by adopting innovative construction technologies such as interlocking bricks, composite tiles (natural rubber resins and sisal reinforcement).	Reduction in the use of cement in construction				
4.3	Adopting the Kigali amendment and enhancing the building envelopes to reduce need for cooling, using low and zero GWP alternatives in all new equipment, reducing HFCs leaks through better design, manufacturing, and servicing	Reduce GHG emissions associated with cooling and number of HFCs leaks				88%
4.4	Reduced GHG production by 25% through carbon capture and storage technologies. Carbon capture and storage (CCS) has been proposed and implemented in some developed countries and several others are in planning and study phases.	Proportion of GHG emissions captured and stored				25%
5. Transport						
5.1	Installation of shore power in all berths at the port	Berths with shore power				100%
5.2	Implementation of the single window system	Presence of single window system				Yes
5.3	Compliance in Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)	In compliance				Yes
5.4	Future rail development to design with electricity driven locomotives and Extension of SGR from Naivasha-to-Malaba.	Kms of rail electrified				
5.5	Transition from fossil fuel to electric and hydrogen fuelled vehicles 30% of all vehicles on road to be electric or hydrogen powered by 2050.	Share of on-road vehicles which are electric, or hydrogen powered				30%
5.6	Shift to 100% of motorcycles to be electric by 2050	Share of motorcycles which are electric				100%
5.7	Shift most of the freight shall shift from truck to train	Share of freight moved by rail		30%	40%	90%
5.8	Ensure total implementation of urban transport policy in all urban centres 100% compliance by 2050.	Urban centres in compliance with urban transport policy				100%
5.9	Continue and accelerate the decarbonisation of the transport sector by promoting low-emission transportation modes for goods and public transportation for passenger mobility.	Shift of passenger journeys to BRT				50%
5.10	Increase efficiency of trucks	Increase in heavy duty truck efficiency	15% by 2025	15%		
5.11	Increase use of railway	Shift of commuting journeys to rail				
6. Waste						
6.1	Install waste-to-energy generation capacity	W2E generation capacity (MW)				40
6.2	Material Recovery Facilities installed in each country by 2023	Countries with Material Recovery Facility	47 by 2023	47	47	47
6.3	Increase recycling	Percentage of post-consumer materials undergoing full life cycle	95% by 2025	95%	95%	95%
6.4	Full collection and treatment of wastewater in deep anaerobic lagoons with methane recovery for electricity generation	Volume collected and treated waster				100%
6.5	Connect residential sector in urban areas to national sewer system discharging the wastewater into national waste management sites	Percentage of connected houses				

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5.2 Adaptation

Action	Intervention	Key indicators	Targets		
			2030 (from Updated NDC Technical Report and/or NAP)	2040	2050
1. Agriculture, Food and Nutrition Security					
1.1 Land use changes: 1.1.1 Crop farming					
1.1.1.1	Increase crop yields through mass rollout of CSA techniques	% of farmers that uses CSA techniques			
		Increase reclamation of degraded land (ha)			
		Increase area under integrated soil nutrient management (acres)			
		Increase farm area under conservation agriculture incorporating minimum/no tillage (acres)	250,000		
		Increase total area under agroforestry at farm level (acres)			
		Percentage reduction in agricultural pre- and post-harvest losses			
1.1.1.2	Promote crop rotation and intercropping	Percentage of farmers that employs crop rotation and intercropping practices			
1.1.1.3	Improve locally adapted varieties, with emphasis on indigenous varieties	Increase yields of locally adapted varieties			
1.1 Land use changes: 1.1.2 Livestock farming					
1.1.2.1	Increase adoption of SALM techniques of precision feeding and watering, including drip irrigation	Percentage increase of farmers that rely on precision feeding and watering			
1.1.2.2	Improve pasture and grazing management through uptake of SALM techniques	Percentage increase of livestock farmers that employ SALM techniques			
		Increase area of rangeland re-seeded in ASAL counties			
1.1.2.3	Breed livestock for greater tolerance to heat and increased productivity	Increase livestock productivity / ha			
1.1.2.4	Diversify livestock and forage species to increase resilience	Improve diversity index livestock and forage species			
1.1.2.5	Breed forages which can tolerate high temperature and have high growth and regeneration rates	Increase forage yield			
		Percentage increase of value in forage and in livestock chains	20%		
		Reduce share of impact of abiotic and biotic stress on adaptive livestock	20%		
1.1.2.6	Minimize disease spread through vaccinations and improve shelters	Decrease number of diseases			
1.1.2.7	Enhance livestock access to water	Increase percentage of livestock that has sufficient access to water			
1.2 Regulatory interventions: 1.2.1 Livestock farming					
1.2.1.1	Enhance efficiency of the livestock value chain	Increase output / ha			
1.2 Regulatory interventions: 1.2.2 Crop and livestock breeding					
1.2.2.1	Enhance co-production, access, and use of climate information services and early warning systems to minimize loss and maximize production in the livestock sector	Increase net output (production minus losses)			
1.2.2.2	Promote the uptake of climate-oriented agricultural subsidies, risk transfers, early action interventions and other safety nets.	Increase number of beneficiaries accessing climate-oriented crop insurance			
		Increase number of farmers accessing subsidies for appropriate agricultural inputs			
		Increase number of customers/ beneficiaries farmers accessing climate-oriented livestock insurance			
1.2.2.3	Increase funding for research and development	Increase total funds allocated			

Action	Intervention	Key indicators	Targets		
			2030 (from Updated NDC Technical Report and/or NAP)	2040	2050
2. Water and sanitation					
2.1 Water access measures: 2.1.1 Resource management					
2.1.1.1	Promote water harvesting and storage at regional and household levels	Increase litre water stored or harvested			
		Increase per capita water availability (m3) (Including water harvested, abstracted and stored)			
		Increase number of farm ponds installed			
		Increase area of degraded land where livelihood systems are improved through the development of water pans and ponds			
		Increase number of institutions/value chain actors and interventions households harvesting water for agricultural use/production			
		Develop and implement sub-catchment management plans to assist local communities to protect wetlands, lakes and other water catchment areas			
2.1.1.2	Build resilient infrastructure for the protection of dams and dikes and river lines	Increase capacity of resilient infrastructure			
2.1.1.3	Build multipurpose dams	Increase construction of multipurpose dams			
2.1.1.4	Building climate smart infrastructure for the protection of dams, water pans and other water storage facilities to prevent water loss through evaporation caused by the increasing global temperatures	Reduce total water loss			
2.1.1.5	Increase water availability per capita, through artificial water recharging of aquifers	Increase water availability / capita (m3) through artificial water recharging of aquifers			
2.1.1.6	Promote water efficiency by reducing non-revenue water, reusing, and recycling of wastewater	Increase water productivity (crop yield / water use)			
		Awareness programme for water efficiency			
		Percentage reduction of water wastage and non-revenue water			
		Additional acres of small scale under efficient irrigation	40,000		
2.1 Water access measures: 2.1.2 Sanitation improvement					
2.1.2.1	Increase sewer coverage with focus on promoting onsite sanitation technologies	Increase capacity sewer system			
2.1.2.2	Implement holding stations for sewer management	Additional number of holding stations			
2.2 Regulatory interventions: 2.2.1 Resource management					
2.2.1.1	Conduct climate and risk assessments on transboundary water resource management and develop adaptation plans incorporating nature-based solutions	Additional number of assessments and adaptation plans			
2.2.1.2	Establish/strengthen bilateral efforts to manage transboundary water resource management issues	Reduction in the number of remaining transboundary water resource management issues			
2.2.1.3	Mainstream climate change into sub-catchment management plans.	Inclusion of climate change in sub-catchment management plans			
2.2 Regulatory interventions: 2.2.2 Sanitation improvement					
2.2.2.1	Develop a favourable financial model for sanitation, whereby the government should subsidize sanitation services to transport effluents from the	Presence of a favourable financial model			

Action	Intervention	Key indicators	Targets		
			2030 (from Updated NDC Technical Report and/or NAP)	2040	2050
	remote residential areas to city waste treatment plants				
2.2.2.2	Create a favourable environment for PPP to encourage private sector involvement in the sanitation service industries	Increase total public sector investments in sanitation service industries			
2.2.2.3	Capacity building and awareness on onsite wastewater treatment technologies	Percentage increase in uptake of wastewater treatment technologies			
3. Fisheries and the Blue Economy					
3.1 Resource management: 3.1.1 Sustainable fishing					
3.1.1.1	Upscale sustainable offshore aquaculture	Percentage increase in production aquaculture			
3.1.1.2	Introduce improved fishing infrastructure and technologies	Percentage increase in total capacity of fishing infrastructure and uptake of advanced technologies			
3.1.1.3	Create incentives to shift diets toward low carbon marine sources such as sustainably harvested fish, and seaweed, as a replacement for emissions intensive land-based sources of protein	Increase consumption of low carbon marine sources			
3.1 Resource management: 3.1.2 Resilience					
3.1.2.1	Expand seaweed farming beyond Kwale County of Kenya	Additional area devoted to seaweed farming			
3.1.2.2	Increase feeds and seed in the ecological food chain of aquaculture through improved technology and capacity building	Increase total consumption of feeds and seed in the ecological food chain			
3.1.2.3	Rehabilitate coral reefs	Increase total area rehabilitated			
3.1.2.4	Introduce targeted breeding of resilient species	Additional number of resilient species			

Action	Intervention	Key indicators	Targets		
			2030 (from Updated NDC Technical Report and/or NAP)	2040	2050
3.2 Regulatory interventions: 3.2.1 Sustainable fishing					
3.2.1.1	Introduce regulations such as permits and stricter fishing quotas to prevent over-fishing.	Presence of regulation			
3.2.1.2	Implement Port State Measures Agreement to minimize illegal unregulated and unreported (IUUs) fishing	Presence of Port State Measures Agreement			
3.2.1.3	Empower fisher community through education, capacity building, and livelihood diversifications	Empowered fisher community			
3.2.1.4	Provide a framework for incentives that promote investment in low carbon development in fisheries and blue economy	Presence of framework			
3.2.1.5	Establish a sustainable financing mechanism for fisheries and blue economy sectors	Presence of sustainable financing mechanism			
		Increase share of economic effectiveness of research expenditure and commodity development and extension on adaptive crops/livestock/fish value chains	20%		
3.2 Regulatory interventions: 3.2.2 Resilience					
3.2.2.1	Conduct a risks and vulnerability assessment of the fisheries subsector	Successful completion of assessment			
		Additional number of fishponds	16,000		
3.2.2.2	Review, strengthen and deploy adaptation capacity in fisheries and blue economy	Adaptation capacity			
		Reduce share of impact of abiotic and biotic stresses on aquaculture species	By 20% by 2030		
3.2.2.3	Strengthen ecosystem approach to fisheries management	Presence of ecosystem approach in management plans			

Action	Intervention	Key indicators	Targets		
			2030 (from Updated NDC Technical Report and/or NAP)	2040	2050
		Increase number of climate-smart cages for fish farming	From 3,450 to 8,000		
3.2.2.4	Strengthen monitoring capacity to prevent over-fishing for both inland and EEZ	Monitoring capacity			
4. Forestry					
4.1 Increase forest productivity					
4.1.1	Increase forest productivity using high quality germplasm and appropriate silvicultural practices	Increase forest production / ha			
4.2 Improve forest management					
4.2.1	Implement a forest management plan.	Presence of forest management plan			
4.2.2	Support participation of public institution in plantation programmes.	Increase number of public institutions participating in plantation programmes			
4.2.3	Support participation of non-state actors in public plantation programmes.	Increase number of non-state actors participating in plantation programmes			
		Additional area of community forest protected	100,000 hectares		
4.2.4	Streamline the participation of communities in the plantation establishment and Livelihood improvement Scheme (PELIS) and enhanced enforcement of 10% farm forest rule	Increase participation and compliance rate with 10% farm forest rule			
4.2.5	Increase area under private sector-based commercial and industrial plantations	Increase total area of forest plantations under private sector-based commercial and industrial plantations	From 71,000 ha to at least 121,000 ha		
4.2.6	Support sustainable management of public plantation forests to enhance productivity	Increase forest productivity			

Action	Intervention	Key indicators	Targets		
			2030 (from Updated NDC Technical Report and/or NAP)	2040	2050
5. Tourism and Wildlife					
5.1 Improving biodiversity management					
5.1.1	Enhance Existing Land Protection and Ecosystem management	Lower indicators of ecosystem degradation (biodiversity loss, provisioning of ecosystem services)			
5.1.2	Improve Species Conservation and Management	Reduce number of endangered species			
5.1.3	Review governance of wildlife and natural resource management	Increase effectiveness of wildlife and natural resource management			
5.2 Increasing innovation and financing for biodiversity					
5.2.1	Enhance research, technology development, innovations and knowledge management	Increase research output			
5.2.2	Mobilize financial resources for conservation	Additional amount of raised capital			
5.2.3	Improve partnerships, collaborations and coordination of adaptation actions	Increase stakeholder involvement in adaptation actions			
5.3 Climate-proofing the sector					
5.3.1	Reduce damages to the tourism industry by implementing sustainable tourist activities which are not dependent on the natural environment	Reduce degradation of natural environment due to tourism			
6. Health					
6.1 Capacity building in the health sector					
6.1.1	Conduct research into diseases associated with climate change and implement recommendations. Examples include Chikungunya, Rift Valley fever, Dengue haemorrhagic fever	Increase research output			

Action	Intervention	Key indicators	Targets		
			2030 (from Updated NDC Technical Report and/or NAP)	2040	2050
6.1.2	Build capacity of public health systems in early identification, diagnosis, and management of climate related diseases and health issues	Increase capacity of public health systems			
6.1.3	Implement public awareness and social mobilization strategy on climate health impacts	Presence of strategy			
6.1.4	Build capacity and infrastructure of public health systems to enhance response to climate related diseases	Increase capacity public health systems			
6.1.5	Strengthen the current disease surveillance system to incorporate pathogen surveillance	Percentage increase in diagnostic accuracy			
6.1.6	Develop models for early warning of other vector borne diseases especially chikungunya, dengue haemorrhagic fever, kalazar, lymphatic filiarisis, elephantiasis, hydrocell and rift valley fever	Presence of early warning models			
6.1.7	Build capacity for community health volunteers and workers on early warnings, proper diagnosis and reporting of climate related diseases	Additional number of community health volunteers			
6.1.8	Implement malaria larval source management	Successful implementation of management plan			
		Reduce incidences of climate sensitive diseases, as malaria and other vector and water-borne diseases.			
6.1.9	Scale up mass distribution of Insecticide Treated Nets (ITNS)	Additional number of distributed ITNS			
6.1.10	Scale up mass distribution of Indoor Residual Spray (IRS)	Additional number of distributed IRS			
6.1.11	Scale up mass distribution of outdoor residual spray for sandflies	Additional number of outdoor residual sprays			
6.1.12	Expand environmental and mechanical control and management of the vectors	Additional number of vectors			
6.2 Reduce disease incidence					
6.2.1	Reduce over nutrition by promoting healthy diets to prevent the burden of non-communicable diseases.	Reduce prevalence of over nutrition			
6.2.2	Reduce under nutrition by scaling up integrated management of acute malnutrition.	Reduce prevalence of under nutrition			
6.2.3	Reduce micronutrient malnutrition by scaling up micronutrient supplementation and food fortification	Reduce prevalence of micronutrient malnutrition			
6.2.4	Reduce incidences of aflatoxicosis through surveillance and laboratory analysis, capacity building on good storage practices among food business operators and households	Reduce number of aflatoxicosis cases			
6.2.5	Reduce incidences of foodborne diseases	Reduce total number of foodborne diseases			
7. Human Settlement, Urban Development and Housing					
7.1 Flood defence mechanisms					
7.1.1	Introduce nature-based solutions in flood control, especially around informal settlements and selected urban areas	Increase number of successfully implemented nature-based solutions			
		Additional number of nature-based solutions in flood control around informal settlements			

Action	Intervention	Key indicators	Targets		
			2030 (from Updated NDC Technical Report and/or NAP)	2040	2050
7.1.2	Introduce practice of beach nourishment to combat coastal erosion	Increase percentage of uptake of beach nourishment practices			
7.1.3	Build and maintain flood defence mechanisms such as a sea wall, particularly around strategically important port cities such as Mombasa	Presence of flood defence mechanisms			
7.2 Improved building resilience					
7.2.1	Enforce green and resilient building standards in new buildings and promote retrofit/climate proofing of older buildings	Increase compliance rate with building standards			
8. Manufacturing and trade					
8.1 Encouraging sustainable resource management					
8.1.1	Increase the number of companies participating in efficient water use initiatives	Increase number of companies participating in efficient water use initiatives			
8.2 Facilitating resilience					
8.2.1	Climate-proof industrial plants and infrastructure to avoid operational and supply chain disruptions	Increase capacity of climate-proof industrial plants and infrastructure			
8.2.2	Plan for supply chain disruptions via preparatory measures such as dual sourcing, increased supplier resilience, and insurance	Reduce frequency and severity of supply chain disruptions			
9. Energy					
9.1	Climate-proof all new energy infrastructure and upgrade existing energy infrastructure	Reduction in climate risks present in energy infrastructure			
		Increase protection of water catchment areas feeding hydro-generation reservoirs			
9.2	Continue to attract private investment for renewable energy projects, to meet future demand and reach universal access, and maintain and continue diversification of the (future) energy system				
9.3	Support roll-out of off-grid renewable technologies (off-grid solar, small-hydro, geothermal) to support climate-smart agriculture (in line with NAP)	Increase capacity of renewable technologies grid			
		Percentage increase in the number of companies participating in energy efficient water-use initiatives	By 40% from baseline		
10. Transport and other Infrastructure					
10.1	Integrate climate information in the next 20-year Roads Master Plan to ensure climate-resilient and future-proof infrastructure with a low risk of stranded assets.	Integration of climate information in the next Roads Master Plan			
10.2	Develop the 50-year Transport Master Plan (TMP) in line with climate targets.	Presence of 50-year TMP			
10.3	Emphasise the focus on building an integrated and multimodal transportation system for Kenya.	Increase capacity of multimodal transportation system			
		Increase share of freight transferred from road to rail			
10.4	Make roads climate-proof by using asphalt mix and permeable road surfaces in road construction, enhancing drainage systems, and upgrading gravel and dirt road networks to increase tolerance to high temperature and heavy rainfall.	Increase total length of climate-proof roads			
11. Gender, Youth and Other Vulnerable Groups					

Action	Intervention	Key indicators	Targets		
			2030 (from Updated NDC Technical Report and/or NAP)	2040	2050
11.1 Improve financial security of vulnerable groups					
11.1.1	Continue to support economic diversification, through promotion and support to SMEs, particularly in the rural economy, including through access to finance	Improve economic diversity index			
11.1.2	Strengthen social safety nets, including insurance products for climate related events and broader social security	Additional rollout social safety nets			
		Increase number of beneficiaries of social protection mechanisms, and other safeguards (under the Hunger Safety Net Programme)			
		Increase number of households better able to cope with climate change because of receiving benefits from CCCFs			
		Increase number of beneficiaries under the National Safety Net Programme			
11.2 Targeted education and engagement of vulnerable groups					
11.2.1	Implement targeted education, training and skills development programmes, particularly for women and other vulnerable groups	Increase participants' level of knowledge and skills			

06

TECHNICAL APPENDIX

Photo Credit: CCD

6.1 Summary of modelling approaches

The mitigation and adaptation strategies detailed in this report are each informed by robust economic modelling:

1. **Mitigation:** the report relies on the Low Emissions Analysis Platform (LEAP) and the Vivid Economics Land Use and Forestry Model to assess mitigation interventions
2. **Adaptation:** high-level, sectoral estimates of damages and investment requirements are modelled using selected secondary sources, including high level estimates from AfDB. These are supplemented by bespoke, cost-benefit analysis of adaptation interventions, based on the IPCC framework

In addition, both the mitigation and adaptation approaches rely on internal, macroeconomic projections of key socioeconomic variables. These are sourced directly from the Government of Kenya and, in some cases, forecasted to 2050 by Vivid Economics.

Table 6.1 summarises the modelling approaches used in this document.

Table 6.1 Summary of modelling approaches

Modelling strand	Modelling Suite	Sectoral coverage*
Mitigation models	LEAP and Vivid Economics Land Use and Forestry Model	Power, industry, transport, waste, agriculture, and forestry
Adaptation models	Overall sectoral damage modelling, based on AfDB high level estimates and selected secondary sources Bespoke cost-benefit analysis of adaptation interventions, based on the IPCC framework	Agriculture, water, fisheries, forestry, tourism, health, human settlements, manufacturing and trade, energy, transport, vulnerable populations
Macroeconomic models	Macroeconomic projections from the Government of Kenya, supplemented with projections	Economy-wide

6.2 Mitigation modelling

6.2.1 General modelling approach

Reaching net zero emissions by 2050 implies ambitious mitigation policies up to 2030 and beyond. Mitigation modelling is key to assess the impacts of mitigation interventions across the six sectors of interest, namely power, industry, transport, waste, agriculture, and forestry, up to 2050 and in different scenarios. The quantitative modelling uses the Low Emissions Analysis Platform (LEAP), with separate modelling for land use & forestry.

The mitigation modelling considers two scenarios:

1. Business-as-Usual (BAU) scenario assumes historical trends will persist until 2050. It is used to benchmark the outcomes of the other two scenarios.
2. A more ambitious LTS "Towards Net Zero" scenario which heads towards net zero emissions by 2050, with a series of sectoral policy targets.

Although some assumptions and emission outputs might slightly differ, the BAU scenario is broadly comparable to the NCCAP baseline and NDC 2020 emission reduction scenario, respectively, up to 2030.

The Low Emissions Economic Analysis Platform (LEAP) is the primary modelling resource used for mitigation interventions. LEAP is a widely used software tool for energy policy analysis and climate change mitigation assessment developed at the Stockholm Environment Institute.[230] Mitigation pathways from the LEAP a complemented with a set of macroeconomic projections, sourced directly from the Ministry, and a set of common forestry assumptions presented below. Forestry emissions were modelled separately and then incorporated into LEAP.

The LEAP model is an integrated energy-environment tool used to conduct energy policy analysis and climate change mitigation assessment to identify priority mitigation opportunities. This framework is used to model mitigation actions against a baseline to determine the emissions, costs, and other energy sector impacts of the policies. Both top-down and bottom-up approaches for emission analysis can be used in LEAP, enhancing its versatility in areas with low data access. The tool uses activity level parameters such as number of households, vehicle kilometres, GDP contribution, livestock population and respective energy and emission intensities (GJ/household, litres of gasoline per vehicle kilometre, tCO_2/GJ, tCO_2e/Ton cement produced etc.) for final energy demand emissions analysis. Typically, it applies the IPCC methodology in building emission inventory and assesses mitigation pathways scenarios, making it suitable for national planning and policy development.

6.2.2 Land use, land use change and forestry

A bespoke model for the forestry sector was developed to estimate the emission reduction potential from the forestry sector under the three scenarios to 2050. The model estimates the changes in forest cover and the associated emissions from the forest sector, and the required changes in land use needed to achieve targets set under each of the scenarios.

The modelling is based on data from the 2019 National Forest Reference Level for REDD+ Implementation (NFRL) of the Ministry of Forestry and Environment. It covers land use changes for forest and non-forest land between 2002 and 2018. The purpose of the NFRL is to assess the national performance of land use change activities and was established in consistence with Kenya's Greenhouse Gas inventory process.[231] A range of alternative data sources were considered, including the FAO's 2014 Forest Reference Assessment and Kenya's Second National Communication from 2015.The choice of NFRL as the most appropriate data source was made in agreement with stakeholders from Kenya Forest Service.

[230] See LEAP: introduction, Available at: https://leap.sei.org/default.asp?action=introduction, Last accessed 2021-12-02.

[231] Ministry of Environment and Forestry (2019) The National Forest Reference Level for REDD+ Implementation: Available at: https://redd.unfccc.int/files/national_frl_report_for_redd__in_kenya.pdf Last accessed 2021-12-02.

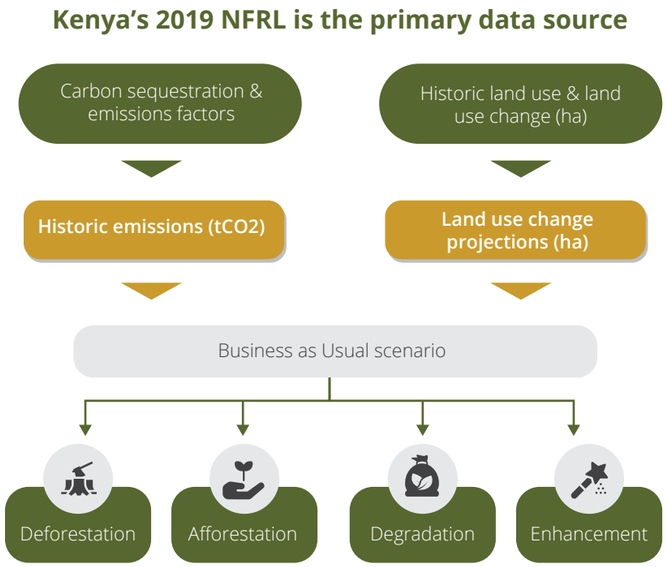

Figure 6.1 Data on historic land use changes and emissions were used to create a baseline scenario

Source: Vivid Economics

The model covers the same forest categories and levels of stratification as in the NFRL 2019. The definition of forests in the NFRL is land with a minimum 15% canopy cover, a minimum land area of 0.5 ha and potential to reach a minimum height of 2 meters.[232] The forestry model considers two levels of stratification: forest type and density. The first level covers four types of forests: montane and western rain forests, dryland forests, coastal and mangrove forests and plantation forests. The second level disaggregates the former three types of forest cover further into dense forests (canopy cover over 65%), moderate forests (canopy cover 40-65%) and open forests (canopy cover 15-40%). Plantation forests are not disaggregated based on density. As Kenya has a large number of bushlands with patches of low trees, the classification of forests as land with trees over 2 meters and of more than 0.5 ha, implies that large land areas are at the margin of this definition. Therefore, land areas might fluctuate between being classified as forest and non-forests, which will exaggerate the apparent changes in land use. Combined with uncertainties over the current forest cover, this creates substantial uncertainty in the emission estimates, leading to significant revisions of historic emissions from the forestry sector in the updated NDC. In addition to forest land, the model considers changes in land area for non-forest land in terms of cropland, grassland, wetlands and settlements/other land. However, the model does not calculate emissions from non-forest land except for emissions associated with removal of grasslands due to afforestation.

Five types of land use change are considered in the model. The changes in land use are divided into five categories: deforestation, degradation, afforestation, enhancement and sustainable management of plantation forests. Deforestation is the conversion of forest land to non-forest land, degradation is a reduction in the canopy cover, afforestation is the conversion of non-forest land to forests and enhancement is an improvement in the canopy cover. In addition, sustainable management of plantation forests considers sustainable harvesting in public plantation forest areas.

It is important to note that the model only considers emissions resulting from changes in land use. The purpose of the modelling exercise is to estimate the potential emission reduction associated with changes in land uses. The model does not take sequestration by the existing forest stock into account but does include the cumulative sequestration from afforestation taking place from 2021 onwards up to 2050. In addition, the model is a mitigation model and does not consider the impact of climate change on forests.

[232]Ibid.

Based on the data from the NFRL, the model calculates a baseline business-as-usual (BAU) projection up to 2050. The tool uses data on land use changes between 2002 and 2018 to calculate the average annual change by forest type and type of land use change. Based on the historical annual changes in land use, the model projects the change in forest cover to 2050 under the assumption that the historical trend in land use changes is assumed to remain constant up to 2050. The model uses sequestration and emission factors for the respective forest types and land use changes to calculate the associated emissions from the BAU.

In addition to the BAU, the model estimates land use changes and associated emissions resulting from Kenya's long-term strategy for the forestry sector. The LTS assumes that deforestation decreased by 50% by 2030 relative to the annual average level between 2002 and 2018 and by 65% by 2050. The remaining deforestation, equivalent to an annual turnover of 2% of the total land area, reflects both remaining deforestation due to for example urbanisation and agricultural practices, as well as deforestation due to natural causes such as forest fires. The rate of afforestation and enhancement rates are assumed to increase to 580,000 ha per year and subsequently fall to a slightly lower level up to 2050.[233] Under these assumptions, the LTS estimates that the forest cover in Kenya will increase significantly.

The assumptions and results under the three scenarios were validated through stakeholder engagement. The assumptions underpinning each of the scenarios and the target for the LTS were discussed and determined in agreement with stakeholders in Kenya's forestry sector. In addition, the results of the modelling exercise were validated in a workshop with key stakeholders and feedback and additional considerations from the stakeholders were incorporated in the final version of the model.

6.3 Adaptation modelling

This section provides worked examples of the technical approach to adaptation modelling. The steps involved in the top-down and bottom-up models are detailed in section 3.3 and reproduced below.

6.3.1 Top-down

The top-down model provides estimates of overall losses at the sectoral level, as well as investment requirements for adaptation interventions. The modelling approach is as follows:

1. **GDP forecasting.** The top-down model relies on Government of Kenya, real GDP forecasts, which are used to convert predicted percentage impacts on GDP to 2020 USD equivalents.
2. **Extraction of headline losses and adaptation investment requirements.** Point estimates of headline losses and adaptation investment requirements at the sectoral level are sourced from credible secondary literature. The most used source is the African Development Bank study 'Climate Change Impacts on Africa's Growth' (2019).[234] This provides % GDP impacts of climate change on different sectors for the years 2030, 2040 and 2050, along with associated adaptation investment requirements by sector. These figures correspond to a high emissions scenario and are mapped to the RCP 8.5 to ensure consistency throughout the LTS.

   The AfDB estimates are supplemented with figures sourced from the UN's Disaster Risk Assessment for Kenya[235] and other credible secondary literature where appropriate. For example, because the AfDB only reports losses direct damages to water infrastructure (rather than the overall economic cost of water scarcity), Kenya Market Trust estimates costing universal water access are used to estimate investment requirements in that sector (see section 3.4.2).
3. **Conversion of loss and investment requirements to 2020 USD equivalents.** Using % GDP impacts calculated in step 2 and the GDP impacts forecasted in step 1, the top-down damages by sector are converted to 2020 USD equivalents from percentages.
4. **Linear interpolation of intervening years.** The estimates for 2030, 2040 and 2050 are used as a basis for estimating the intervening years, which are calculated using standard linear interpolation between estimates.
5. **Conversion to annual averages.** The total losses, adaptation investments and residual damages are summed between 2021 and 2050, and divided by 30, to produce the annual averages shown in Figure 3.7.

[233]Due to the definition of forest cover as land with 15% tree cover > 2m, some of the afforestation may be caused by land at the margin of this definition switching categories and may not be real afforestation

[234]AfDB, 'Climate Change Impacts on Africa's Growth', Available at: https://www.afdb.org/en/documents/climate-change-impacts-africas-economic-growth, Last accessed 2021-11-26

[235]UNISDR, 2018. 'Disaster Risk Profile: Kenya'. Available at: https://www.preventionweb.net/files/64257_kenyareportreviewedweb.pdf, Last accessed 2021-12-09.

The worked example below illustrates how the damages and adaptation requirements for the agriculture sector were calculated and is representative of the general approach to adaptation modelling. These results are detailed in Figure 3.9, section 3.4.1.

Following the approach detailed in section 3.3.1, the calculation proceeds as follows:

1. GDP forecasting. The top-down model relies on Government of Kenya, real GDP forecasts, which are used to convert predicted percentage impacts on GDP to 2020 USD equivalents. The GDP forecasts used in the calculation are shown in Table 6.2:

Table 6.2 GDP projections used in top-down modelling (2020 USD bn)

Year	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050
Nominal GDP (2020 USD bn)	104.29	110.33	117.06	124.79	133.28	179.20	240.94	323.96	435.57	585.65

Source: *Government of Kenya macroeconomic projections*

2. **Extraction of headline losses and adaptation investment requirements.** For the agriculture sector, these % estimates are sourced directly from AfDB. For the year 2050, these are provided in Table 6.3.

Table 6.3 Headline damage estimates and adaptation investment requirements (% GDP, 2050, health sector)

Gross damages	Adaptation investments	Residual damages
0.62%	0.1%	0.46%

Note: Figures only shown for 2050, but estimates are available for 2030, 2040 and 2050.

Source: *AfDB (2019)*

3. **Conversion of loss and investment requirements to USD 2020 equivalents.** For the years 2030, 2040 and 2050, USD 2020 estimates of gross damages, adaptation investments and residual damages are calculated by multiplying the percentage figures shown in Table 6.3 with the GDP forecast for the relevant year, extracted from Table 6.2. These are represented by the equations below:

$Gross\_damages_{usd} = GDP_t * Gross\_damages_{percentage,t}$

$Adaptation\_investments_{usd} = GDP_t * Adaptation\_investments_{percentage,t}$

$Residual\_damages_{usd} = GDP_t * Residual\_damages_{percentage,t}$

This yields the following USD estimates for the year 2050:

Table 6.4 Headline damage estimates and adaptation investment requirements (2050, agriculture sector, 2020 USD bn)

Gross damages	Adaptation investments	Residual damages
3.63	0.59	2.69

Note: Figures only shown for 2050, but estimates are available for 2030, 2040 and 2050.

Source: *AfDB (2019)*

This process is repeated for the years 2030 and 2040.

4. **Linear interpolation for intervening years.** Values for intervening years are calculated using simple linear interpolation.

5. **Conversion to annual averages.** Step 3 is repeated after linear interpolation for all years, in both RCP 8.5. This approach results in the chart shown in Figure 3.16 for the agriculture sector:

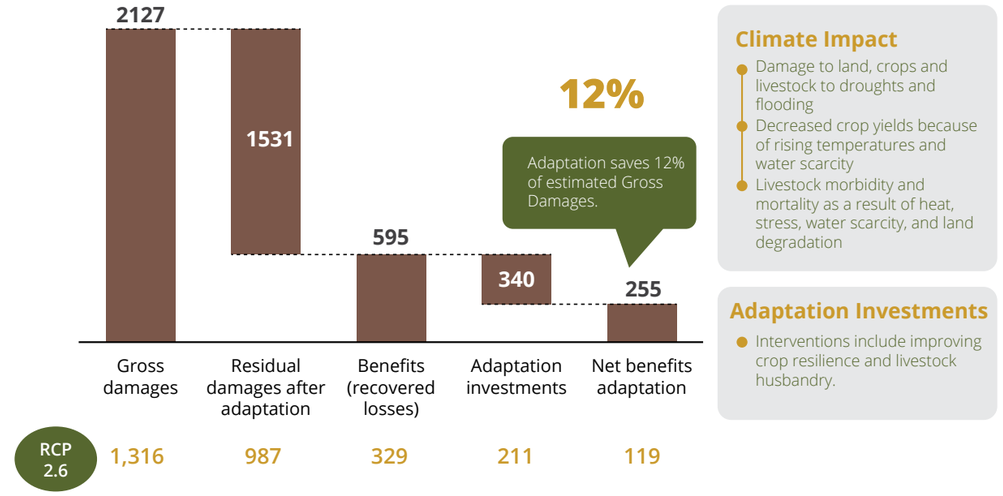

Figure 6.2 Agriculture, Food and Nutrition security: overall damages and net benefits from adaptation, 2020-2050 (Annual averages, 2020 USD millions)

Source: *Modelling based on AfDB (2019) and UNISDR (2018)*

The approach detailed above is replicated for all adaptation sectors where data is available, and for the economy overall.

6.3.2 Bottom-up

In addition to top-down damage estimates, this LTS includes three cost-benefit analyses for individual adaptation interventions. These are detailed in Box 1, Box 2 and Box 3. In each case, a cost-benefit analysis is undertaken to establish whether the chosen intervention is a cost-optimal way of addressing the identified climate hazard.

The approach to bottom-up modelling is summarised in section 3.3 above. Figure 6.3 illustrates how this is applied in practice. This method was followed to calculate the cost-benefit ratios of floodwall construction in Mombasa, detailed in Box 3 above.

Photo Credit: CCD

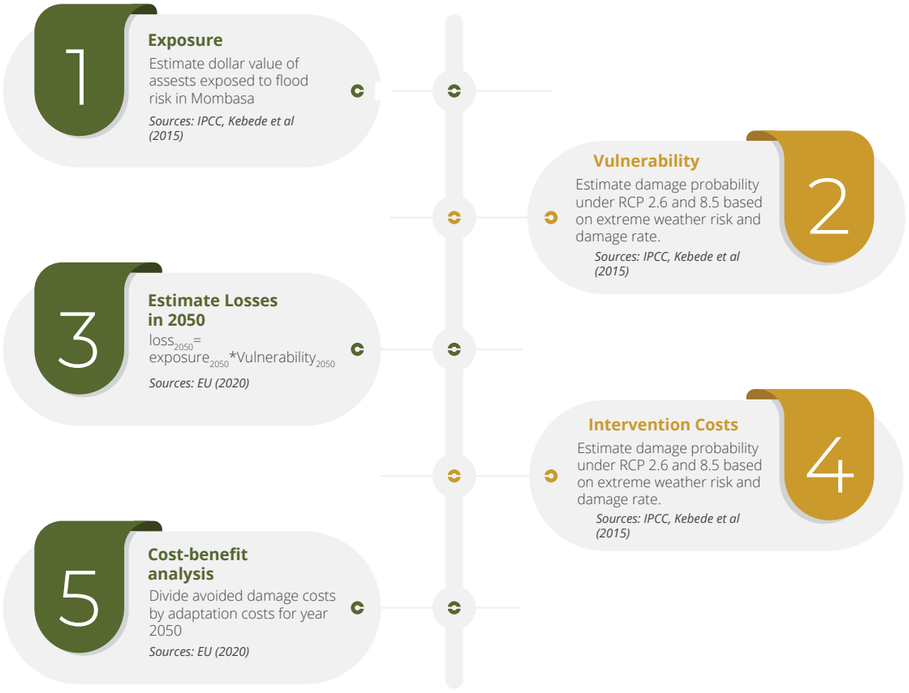

Figure 6.3 Cost-benefit analysis calculation diagram: floodwall construction in Mombasa

Source: Consultant analysis based on Kebede et al. (2012) and IPCC RCP 2.6 and RCP 8.5

The same approach is followed for the bottom-up analysis underpinning Box 1 and Box 2 above.

Photo Credit: CCD

6.4 Existing disaster management commitments

6.4.1 Drought

The National Climate Change Action Plan (NCCAP) 2018-2022 sets the following goals relating to Improve the ability of people to cope with droughts[236]:

- Drought early warning systems improved, including the promotion of people-centred systems at the National and County levels
- Number of recipients of climate information services who use the information in their risk management decisions increased from 1,000,000 to 2,000,000
- Water harvesting and storage
- Operationalise National Drought Emergency Fund (NDEF)

6.4.2 Floods

The National Climate Change Action Plan (NCCAP) 2018-2022 sets the following goals relating to Improve the ability of people to cope with, and infrastructure to withstand, floods:[237]

- Flood early warning systems improved, taking advantage of widespread access to mobile technology that provides avenues for dissemination of information
- The existing 11 integrated flood management plans, for example, water storage, drainage networks, reforestation and rehabilitation of riparian areas, construction of dams, and land use restrictions, implemented
- Dam Safety Control Systems established, including a needs assessment, and development of safety manuals and codes of practice
- Capacity development of at least 50 Water Resources Users Associations (WRUA) that are rights-based groups or community-based organisations with female and male membership
- Water and flood control, including dams or dikes, drainage systems, and water storage

In addition, the NCCAP sets the following goals relating to reduce the vulnerability of communities to flood-related disasters, through improved institutional resilience (preparedness and response) at all levels (National, County, and Community):[238]

- Support the climate-proofing of all National and County flood and landslide control infrastructure (especially for water, energy, transport, and ICT), to enhance their resilience
  - Mainstream climate change adaptation into, and implement, all existing Flood Management Plans
  - Develop and implement climate-proofed design, siting, construction, and maintenance codes and standards for all flood- and landslide-control infrastructure
  - Rehabilitate, strengthen, and protect degraded flood management structures (e.g., check dams, dikes, water pans, river training/dredging, culverts/drainage systems, raised roads, etc.), to harvest, store, and use flood waters upstream
  - Establish a standing arrangement for routine maintenance of flood- and landslide-control structures countrywide
  - Strengthen the capacity of Counties to plan, contract, and supervise the implementation of climate-proofed infrastructure
  - Develop a GIS-based tool for real-time mapping and monitoring of flood hazards
- Increase the number of households better able to cope with flood-induced risks
  - Strengthen the institutional mechanisms for proactive community-based flood early warning systems in flood-prone areas in at least half of the flood-prone Counties by June 2023
  - Expand best-practice social protection mechanisms (adaptive social safety nets), and measures to poor and vulnerable people countrywide by June 2023
  - Promote insurance services for those able to take insurance cover, alongside social protection services

[236]Kenya Ministry Of Environment And Forestry (2018), "National Climate Change Action Plan (NCCAP) 2018-2022, Volume I"
[237]Ibid.
[238]Ibid.

- Strengthen the participation of local community flood management institutions, mechanisms, and processes that build resilience to flood- and landslide-related risks
  - Establish an operational Flood (and Drought) modelling, forecasting, preparedness, and response centre
  - Develop and implement a regulatory Enforcement Plan for flood situations
  - Support an integrated ecosystem-based approach to watershed, drainage basin, flood, and landslide management through enhancement of such structural/ mechanical designs as structural catchment protection in the upper catchments
  - Support Water Resources User Associations and other stakeholders to assist affected communities through Community-Based Flood Management Committee approaches
  - Promote and support at least 100 (at least 2 per county) robust community-based institutions and organizations to strengthen community-led management of flood prone areas (flood risk preparedness and response initiatives)
  - Extend Drought Contingency Fund to cover Floods by initiating policy dialogue to harmonise the various disaster and Contingency Funds into an all-inclusive Fund for all climate-related contingencies

6.5 Existing adaptation commitments

6.5.1 Agriculture, Food and Nutrition Security

The National Climate Change Action Plan (NCCAP) 2018-2022 sets the following goals relating to increase food and nutrition security by enhancing productivity and resilience of the agricultural sector in as low-carbon manner as possible:[239]

- Improve crop productivity through the Implementation of CSA interventions
  - Number of institutions/value chain actors and interventions households harvesting water for agricultural use/production increased to 500,000
  - Agricultural pre- and post-harvest losses reduced from 40% to 15%
  - Number of beneficiaries accessing climate-oriented crop insurance increased from 280,000 farmers to 3,500,000 farmers
  - Number of farmers accessing subsidies for appropriate agricultural inputs increased from 239,000 to 311,300
  - Number of households and acreage under sustainable land management increased for agricultural production:
  - Support for the reclamation of 60,000 hectares of degraded land
  - Area under integrated soil nutrient management increased by 250,000 acres
  - Farm area under conservation agriculture increased to 250,000 acres, incorporating minimum/no tillage
  - Total area under agroforestry at farm level increased by 200,000 acres
- Increase crop productivity through improved irrigation
  - Acreage under irrigation increased from 202,000 hectares to 486,000 hectares
  - Production efficiency from irrigated fields increased from 50% to 90%.
- Improve productivity in the livestock sector through the implementation of CSA interventions
  - Improved productivity of pastoralists:
  - 10,000 hectares of rangelands re-seeded in 23 ASAL counties
  - Annual ASAL's water harvesting, and storage increased by 25%, from 16 million cubic metres (m3) to 20 m3 via small dams and water pans, and 700 m3 through large multipurpose dams
  - Animal disease control and surveillance improved
  - Number of customers/ beneficiaries farmers accessing climate-oriented livestock insurance increased from 18,000 to 105,750
- Improve productivity in the fisheries through implementation of CSA interventions
  - Insurance packages piloted and developed for the fisheries sub-sector and aquaculture production increased
  - Number of cages for fish farming increased from 3,450 to 8,000
  - Number of fishponds increased by 16,000
  - Number of farmers using low-carbon (recirculating) aquaculture systems increased from 20 to 180
- Diversify livelihoods to adjust to a changing climate
  - At least 521,500 households supported to adopt diversified adaptive enterprises/value chains for sustained livelihoods and nutrition security
  - Small-scale farmers, pastoralists, and fisher communities supported to transition to specialised and market-oriented output in 13 priority value chains, including drought-tolerant values chains

The National Adaptation Plan also aims to enhancing the resilience of the agricultural value chain:[240]

- Short-term actions:
  - Promote indigenous knowledge on crops
  - Increase awareness on climate change impacts on the agriculture value chain.
  - Conduct climate risk and vulnerability assessments of the agriculture value chain
  - Coordinate and mainstream climate change adaptation into agricultural extension
  - Promote new food habits
  - Increase awareness on climate change on the livestock sector
  - Strengthen land use management systems including rangeland management, fodder banks and strategic reserves
  - Conduct capacity building in indigenous knowledge, livestock insurance schemes, early warning systems, early action, livestock management and breeding
- Medium-term sub-actions:
  - Establish, maintain, and promote the uptake of climate change related information on agriculture
  - Develop and up-scale specific adaptation actions - promotion and bulking of drought tolerant traditional high value crops; water harvesting for crop production; index-based weather insurance; conservation agriculture; agro-forestry; and Integrated soil fertility management
  - Develop and apply Performance Benefit Measurement methodologies for adaptation and development for the sector
  - Support adaptation of private sector agricultural value chain actors through capacity building efforts.
  - Develop new feed formulation
  - Promote livelihood diversification (camels, indigenous poultry, beekeeping, rabbits, emerging livestock – quails, guinea fowls, ostriches etc.)
  - Establish price stabilisation schemes and strategic livestock-based food reserves
  - Restore degraded grazing lands
- Long-term sub-actions:
  - Promote and implement climate smart agriculture practices.
  - Enhance selection, breeding and management of animals to adapt to climate change

The Updated NDC Technical Report proposes the following additional actions:

- Continue the implementation of the CSA strategy and implementation plan
- Continue the co-production, access and use of climate information in the crop-subsector
- Develop the MRV for the crop subsector
- Harmonise the crop-subsector plans with the crop sub-sector LTs strategies
- Increase the areas under improved adaptive varieties (novel genotype)
- Increase/improve natural resource trends through integrated soil nutrient management practices and farm area under conservation agriculture to 250,000 acres
- Develop 40,000 acres of small scale under efficient irrigation
- Increase value in agri-food chains by 20%
- Promote PPP in crops/livestock/aquaculture postharvest handling, marketing, and market distribution infrastructure, to reduce losses in crops from 40% to 15%
- Promote the uptake of climate-oriented agricultural subsidies and agricultural insurance
- Increase funding in research and commodity development and extension for adaptive crops/livestock/ fish value chains to enhance evidence-based decision-making and increases the economic effectiveness of research expenditure by 20%
- Improve adaptive livestock and aquaculture breeds to reduce the overall impact of abiotic and biotic stresses by 20%
- Integrate rehabilitation of at least 100,000 acres of degraded croplands and grazed grasslands
- Increase value in forage and livestock chains by 20% in 2030

[239]Kenya Ministry Of Environment And Forestry (2018), "National Climate Change Action Plan (NCCAP) 2018-2022, Volume I"

[240]Kenya Ministry of Environment and Forestry (2015), "Kenya National Adaptation Plan 2015-2030". Available at: https://www4.unfccc.int/sites/NAPC/Documents%20NAP/Kenya_NAP_Final.pdf. Last accessed 2021-12-02.

6.5.2 Water and Sanitation

The National Climate Change Action Plan (NCCAP) 2018-2022 sets the following goals relating to enhancing the resilience of the water sector by ensuring adequate access to, and efficient use of, water for water and sanitation:

- Increase annual per capita water availability through the development of water infrastructure (mega dams, small dams, water pans, untapped aquifers)
  - Increase annual per capita water availability (harvested, abstracted and stored) from 647 m3 to 1000 m3 by:
  - Construction of 12 multipurpose dams (Thwake, Thiba, Radat, Gogo, Thuci, Kaiti, Lowaat, Rupingazi, Thambana, Maara, Kithino, Kamumu) (under construction in 2018), accounting for expected climate impacts (climate-proofed infrastructure)
  - National hydrogeological survey undertaken to identify major strategic aquifers
  - Two locations identified and mapped for direct artificial groundwater recharge to increase the supply of ground water
  - Five ground water surveys to establish abstraction levels against recharge
  - 56 sub-catchment management plans developed, and 236 sub-catchment management plans implemented to assist local communities to protect wetlands, lakes, and other water catchment areas
- Ponds livelihoods system, Climate proof water harvesting and water storage infrastructure and improve flood control
- The annual number of climate-proofed water harvesting, flood control and water storage infrastructure increased from 700 to 2,000, through:
  - Integrated catchment approach and ecosystem-based adaptation structural/ mechanical design, e.g., structural catchment protection, especially in the upper catchments
  - Coastal sea walls
  - Development of flood early warning systems in areas susceptible to floods. Linked to Climate Action 1: Disaster Risk Management
- Increase gender responsive affordable water harvesting-based livelihood resilience programmes
- Enhanced household water access and food security through water harvesting, including:
  - 300,000 farm ponds installed
  - Livelihood systems improved on 60,000 ha of degraded land through the development of water pans and ponds
  - Water utility creditworthiness index developed as well as tool kits on commercial lending to the water and sanitation sector to attract Public Private-Partnerships
- Promote water efficiency (monitor, reduce, re-use, recycle and modelling)
  - Reduce water wastage and non-revenue water from the current 43% to 20% through, for example:
  - Innovation in water tracking and leakages identification and reporting
  - Awareness programme for water efficiency
- Improve access to good quality water
  - Increase deep/offshore fishing fleet from 9 to 68 to improve coastal fisheries by addressing overcapacity of artisanal fishing vessels.
  - Rehabilitate and restore mangrove forests
  - Conserve at least 15% of coastal and marine areas, especially areas of importance for biodiversity and ecosystem services
- Climate-proof coastal infrastructure
  - Implement the greening of the Mombasa port plan that builds resilience and mitigates GHG emissions through:
    - Installation of solar panels
    - Waste management
    - Rainwater harvesting

The National Adaptation Plan also aims to enhancing the resilience of the water and sanitation sector:

- Short-term sub-actions:
  - Enhance capacity of institutions and bodies responsible for water and sanitation on climate change impacts and the water sector
  - Promote awareness on climate change impacts and the water sector including promoting public awareness on water conservation (recycling, wastewater management) and efficient water use
  - Mainstream disaster risk reduction measures in the water sector planning and service delivery, particularly in vulnerable, high-risk regions
  - Promote the use of efficient irrigation systems
- Medium-term sub-actions:
  - Enhance collaboration of trans boundary water resource management
  - Strengthen water resource monitoring and assessment for early warning and planning
  - Promote technologies that enhance water resource efficiency
- Long-term sub-actions:
  - Implement the National Water Master Plan

The Updated NDC Technical Report proposes the following additional actions:

- Conduct climate and risk assessments on transboundary water resource management and develop adaptation plans incorporating nature-based solutions
- Conduct and implement recommendations on climate and risk assessments on water, sanitation and irrigation infrastructure
- Build resilience infrastructure for the protection of dams and dikes and river lines
- Promote water harvesting and storage at county and household levels
- Mainstream climate change into water catchment management plans

6.5.3 Fisheries and the Blue Economy

The National Climate Change Action Plan (NCCAP) 2018-2022 sets the following goals relating to enhancing resilience of the blue economy and water sector by ensuring adequate access to and efficient use of water for agriculture, manufacturing, domestic, wildlife, and other uses:

- Improve productivity in the fisheries through Implementation CSA interventions
- Improve resilience of coastal communities

The National Adaptation Plan also aims to enhancing the resilience of fisheries and the blue economy:

- Short term sub-actions:
  - Undertake risk and vulnerability assessment of the fisheries value chain
  - Enhance capacity of the Ministry of Agriculture, Livestock and Fisheries and the Kenya Marine Fisheries Institute on the impacts of climate change on fisheries, fishing communities and the private sector
  - Upscale sustainable aquaculture initiatives
- Medium term sub-actions:
  - Develop and implement a pilot project on climate resilient fish species and the related value chain
- Long term sub-actions:
  - Strengthen monitoring capacity and capability to prevent overfishing and unauthorized exploitation in the inland waters and Exclusive Economic Zone
  - Promote the up scaling of climate resilient strategies/ technologies in fisheries and climate resilient fish varieties
  - Expand the fishing zones in both inland and coastal waters

The Updated NDC Technical Report proposes the following additional actions:

- Increase funding in research and commodity development and extension for adaptive crops/livestock/ fish value chains to enhance evidence-based decision-making and increases the economic effectiveness of research expenditure by 20%
- Conduct a risks and vulnerability assessment of the fisheries subsector
- Develop an adaptation capacity building plan for the fisheries sub-sector
- Improve adaptive aquaculture species to reduce the overall impact of abiotic and biotic stresses by 20% by 2030
- Increase the number of fishponds to 16,000
- Increase the number of climate-smart cages for fish farming from 3,450 to 8,000
- Carry out risk and impact analysis on marine fisheries and on communities whose livelihood depend on this sector
- Promote community participation in coastal and marine resources management
- Conduct blue carbon readiness among coastal communities
- Conduct climate change vulnerability/risk assessment of coastal areas
- Restore, protect and manage coastal and marine ecosystems, blue carbon and coral reefs to improve coastal resilience
- Develop marine spatial planning and outline sustainable management
- Promote nature-based enterprises including seaweed farming, and mangrove ecotourism

6.5.4 Forestry

The National Climate Change Action Plan (NCCAP) 2018-2022 sets the following goals relating to increasing forest/tree cover to 10% of total land area; rehabilitating degraded lands, including rangelands; increasing resilience of wildlife:

- Afforest and reforest degraded and deforested areas in Counties
- Reduce deforestation and forest degradation
- Restore degraded forest landscapes (ASALs and rangelands)
- Conserve land areas for wildlife

The National Adaptation Plan (2015-30) set out the following short and long-term actions:

- Short-term actions:
  - Undertake climate vulnerability and risk assessments on ecosystems and provide guidance on relevant adaptation actions
  - Strengthen current tree-planting and conservation initiatives
- Long-term actions:
  - Provide guidance and improve access to climate resilient tree species and cultivars

The Updated NDC Technical Report proposes the following actions on top of that under mainstreaming climate change adaptation in the environment sector:

- Protect and conserve an additional 100,000 hectares of community forests for ecosystem benefits
- Promote forest economic incentives/ subsidies
- Establish at least 2,000 hectares of nature based (non-wood forest products) enterprises across the country, to promote non-wood forest products and increase forest cover
- Establish150,000 ha commercial private forests plantations
- Establish 50,000 ha Bamboo plantations established
- Plant 350,000 agro-forestry trees in farmlands established
- Establish 70,000 woodlots, botanical gardens, boundary planting a
- Greening of 14,000 ha of infrastructure (Roads, a long railway lines, dams), schools, cooperates and MDAs to control flooding
- Continue conducting research and disseminating knowledge on climate resilient tree cultivars.

6.5.5 Tourism and Wildlife

The National Climate Change Action Plan (NCCAP) 2018-2022 sets the following actions to enhance the resilience of tourist attractions and tourism infrastructure:

- Develop and implement a climate change adaptation strategy for the tourism sector
  - Review and update (within the context of climate change adaptation) tourism sector policies, laws, regulations, and other quasi-regulatory guidelines and governance
  - Develop and implement climate-resilience action plans for the tourism sector and coordinate the response to climate change at all levels of tourism management
  - Enhance the diversification of climate-resilient tourism products
  - Safeguard tourist attraction sites by sensitising value chain actors on climate change.
- Support climate-proofing infrastructure in and/or leading to tourist attraction sites
- Identify and support climate-proofing of tourism infrastructure, with emphasis on:
  - Support for the improvement of drainage along roads in tourist attraction sites
  - Support for the construction of bridges that are better able to withstand flooding events
  - Putting in place early warning systems and communication structures that target value chain actors

The National Adaptation Plan (2015-30) set out the following short- medium- and long-term actions:

- Short term actions:
  - Conduct a climate risk and vulnerability assessment of the tourism sector
  - Build capacity and raise awareness on impacts of climate change on the tourism sector to relevant departments and partners
  - Develop climate resilient action plans for the sector
- Medium term actions:
  - Enhance the diversification of climate resilient tourism products
  - Design a pilot project that enhances resilience in the tourism sector
- Long term actions
  - Upscale successful pilot projects

The Updated NDC Technical Report proposes the following additional actions, emphasising the need to enhance the resilience of the tourism value chain

- Develop and adopt guidelines of how to integrate adaptation across the tourism sector
- Conduct a climate risk and vulnerability assessment of the tourism sector
- Develop climate resilient action plans for the sector

6.5.6 Health

The National Climate Change Action Plan (NCCAP) 2018-2022 sets the following actions to achieve the strategic objective of mainstreaming climate change adaptation into the health sector:

- Reduce incidences of climate sensitive diseases, as malaria and other vector and water-borne diseases. The current malaria incidence per 1,000 populations is 225
- Strengthen the capacity of health workers, including community health workers and volunteers on skills in, and awareness of, climate-related health risks
- Improve the surveillance, response, and monitoring of climate change related diseases
- Enhance the coordination mechanism within health and its collaborative sectors
- Development and tracking of indicators: Design appropriate measures for surveillance and monitoring of climate change related diseases, to enhance early warning. including enhancing existing databases on health sector indicators

The National Adaptation Plan (2015-30) set out the following short- medium- and long-term actions:

- Short term sub-actions:
  - Undertake a climate vulnerability and risk assessment of the impacts of climate change and variability on human health
  - Increase public awareness and social mobilisation on climate change and impacts on health
- Medium term sub-actions:
  - Design appropriate climate change related interventions for the health sector
  - Design appropriate measures for surveillance and monitoring of climate change related diseases in order to enhance early warning systems which includes enhancing existing databases on health sector indicators amongst others
- Long term sub-actions:
  - Upscale results of pilot projects in climate change adaptation in the health sector

The Updated NDC Technical Report proposes the following additional actions:

- Conduct a vulnerability and risk assessment of different climate risks on human health
- Develop a public awareness and social mobilisation strategy on climate change and health impacts
- Develop health protocols to manage new climate change related diseases such as dengue or diseases that can increase vulnerabilities to climate change such as the Corona virus
- Develop the LTS
- Reduce the incidence of malaria, other vector borne disease and other health conditions through:
- Scale up mass distribution of Insecticide Treated Net (ITNS)
- Malarial larval source management
- Scale up Indoor Residual Spray (IRS)
- Blanket supplemental feeding of vulnerable populations

6.5.7 Human Settlement, Urban Development and Housing

The National Climate Change Action Plan (NCCAP) - Adaptation Technical Analysis Report (ATAR) 2018-2022 includes the following actions for improving the resilience and adaptive capacities of urban areas by enforcing climate-proof standards for housing and other urban infrastructure.

- Strengthen the management of urban flooding in major urban centres, towns and cities
- Construct climate-proofed sanitary landfills in all major urban centres, towns, and cities

The National Adaptation Plan includes the following short-, medium- and long-term actions:

- Short term actions:
  - Conduct climate risk and vulnerability assessment of the sector
  - Increase awareness on impacts of climate change on population and housing
- Medium term actions:
  - Strengthen the enforcement of building codes by national and county governments.
  - Integrate adaptation into relevant building and urban planning policies and regulations
- Long term actions:
  - Enhance the adaptive capacity of the urban poor by increasing the number of affordable housing and related infrastructure

The Updated Nationally Determined Contribution (NDC) report adds:

- Conduct climate risk and vulnerability assessments of building/housing infrastructure specially to flooding, and sea level rise
- Develop a public awareness strategy on the impact of climate change and adaptation to relevant climate risks
- Introduce nature-based solutions in flood control specially around informal settlements and selected urban areas
- Strengthen the enforcement of green building codes by national and county governments

6.5.8 Manufacturing and Trade

The National Climate Change Action Plan (NCCAP) 2018-2022 sets the following actions in order to achieve the strategic objective of promoting energy and resource efficiency in the Manufacturing sector:

- Increase energy efficiency
- Promote industrial symbiosis in industrial zones
- Improve water use and resource efficiency

The National Adaptation Plan (2015-30) set out the follow short- medium and long-term actions:

- Short term sub-actions:
  - Build the capacity of the private sector (formal and informal) so as to enhance the resilience of their investments e.g., through identification of new products and services that are more resilient to climate change impacts
  - Demonstrate an operational business case for private sector investment in adaptation
- Medium term sub-actions:
  - Develop fiscal incentive measures to encourage businesses to undertake investment in adaptation and resilience building measures
- Long term sub-action:
  - Implement long term private sector investment in adaptation and resilience building measures

The Updated NDC 2020 Technical Report also proposed the inclusion of the following actions

- Implement the Green Business Agenda (2018-2022)
- Eco-label industrial products to promote green procurement especially by public procurement agencies
- Climate-proof waste management infrastructure for waste management facilities in SEZ (effluent treatment plants)
- Increase the number of companies participating in efficient water-use.

6.5.9 Energy

The National Climate Change Action Plan (NCCAP) 2018-2022 sets the goals of "Climate-proofed energy and transport infrastructure", with the following sub-goals:[241]

- Concrete poles replace wooden poles
- Existing hydropower plants optimised, and water management and conservation improved
- 1000 hectares of water catchment areas conserved and rehabilitated by protecting the areas feeding hydro-generation reservoirs

The National Adaptation Plan 2015-2030 sets out the following short- medium- and long-term actions:[242]

- Short term:
  - Conduct risk and vulnerability assessments of energy infrastructure
  - Increase the solar, wind and other renewable energy systems network to provide power to off-grid areas
- Medium-term:
  - Increase small hydropower and geothermal power generation plants to provide electricity to communities and businesses in the rural areas enabling job creation
  - Promote energy efficiency programmes
- Long-term actions:
  - Continue the rehabilitation of water catchment areas in order to provide sustainable ecosystem services, including energy production

The updated NDC sets out three priority adaptation programmes focusing on energy infrastructure.[243] The updated NDC, building on national policies, plans and legal frameworks,[244] aims to mainstream climate change adaptation into the Medium-Term Plans (MTPs) and County Integrated Development Plans (CIDPs) and implement adaptation actions. Increasing average temperatures will cause more transmission losses, but the amount of lost power is small compared with the large increases in electricity demand and hence in power generation and transmission over the next few decades. The Prioritized Adaptation Programmes include the following programmes focused on energy infrastructure:

- Develop and adopt guidelines on how to climate proof energy infrastructure that can withstand a changing climate (high temperatures, increased flooding events, sea level rise), using vulnerability risk assessments
- Enhance climate proofing of energy infrastructure along the renewable energy supply chain
- Increase the number of companies participating in energy efficient water-use initiatives by 40% from the baseline

[241] Kenya Ministry Of Environment And Forestry (2018), "National Climate Change Action Plan (NCCAP) 2018-2022, Volume I"

[242] Kenya Ministry of Environment and Forestry (2015), "Kenya National Adaptation Plan 2015-2030". Available at: https://www4.unfccc.int/sites/NAPC/Documents%20NAP/Kenya_NAP_Final.pdf. Last accessed 2021-12-02.

[243] Kenya's Updated Nationally Determined Contribution (NDC) (2020). Available at: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Kenya%20First/Kenya%27s%20First%20%20NDC%20(updated%20version).pdf. Last accessed 2021-12-02.

[244] Constitution of Kenya, 2010; Climate Change Act, 2016; National Climate Change Action Plan (NCCAP I) 2013-2017; National Climate Change Action Plan (NCCAP II) 2018-2022; Climate Finance Policy; Sector specific Policies and Legislation like the Water Act (2016), Disaster Risk Financial Strategy (2018-2022), Kenya Climate Smart Agriculture Strategy (2017-2026).

6.5.10 Transport and Other Infrastructure

The National Climate Change Action Plan (NCCAP) 2018-2022 sets the goal of establishing efficient, sustainable world-class transport systems and logistic services that can withstand the expected impacts of climate change, as well as the following sub goals:

- Target a reduction of emissions of 1.93 and 4.7 $MtCO_2e$ by 2022 and 2030, respectively
- Electrification of the Mombasa-Nairobi railway and transfer of freight from road to rail (target: 30%)
- Extend the standard gauge railway (SGR) from Nairobi to Naivasha
- Invest in a Bus Rapid Transit (BRT) system for the Nairobi metropolitan area
- Increase efficiency of light- and heavy-duty trucks by implementing infrastructure improvements, developing strict vehicle standards, promoting fuel-efficient driving
- Provide power infrastructure in ports, substituting the use of ship engines during landing
- Enable the use of sustainable aviation fuels and foster the deployment of solar photovoltaics and biodiesel for ground services.
- Account for climate information planning and construction to enhancing infrastructure's resilience
- 'Climate-proof' 4.500km of existing road infrastructure
- Support domestic research and development of renewable energy for all modes of goods and people transportation

The National Adaptation Plan 2015-2030 sets out the following short- medium- and long-term actions:

- Short term actions:
  - Conduct risk and vulnerability assessments of existing infrastructure
  - Conduct risk and vulnerability assessments of upcoming infrastructure (roads, railways, marine, aviation, buildings, ICT)
  - Conduct an assessment of whether existing and planned infrastructural assets are compatible with a low carbon climate resilient economy
  - Conduct capacity building on infrastructure climate proofing
- Medium term actions:
  - Climate proof buildings, roads, railway, marine, aviation and ICT infrastructure through use of appropriate designs and building materials
- Long term actions:
  - Re-assess infrastructure vulnerability and upgrade infrastructure to withstand climate impacts with the latest technology

The 2020 NDC update technical report promotes the following additional mitigation actions to be prioritised for the transport sector[245]:

- Develop an electric bus transit system connecting Nairobi and the capital's airport
- Upgrades to the Nairobi Commuter Rail service, comprising new stations and rolling stock
- Include passenger transportation in the planning for the electrification of the Mombasa-Nairobi railway
- Establish a new Air Navigation Control Centre to optimise air routes and reduce congestions
- A shift from truck-based transportation of oil to a pipeline-based system

[245]Nationally Determined Contribution – Updated Technical Report 2020 (Kenya)

6.5.11 Gender, Youth and Other Vulnerable Groups

The National Climate Change Action Plan (NCCAP) 2018-2022 sets the goal of empowering men, women, children, orphans, people with disabilities, the marginalised, minorities and people displaced as a result of Climate Change to reduce their vulnerability to climate change issues, and also the following sub goals:

- Strengthen the adaptive capacity of vulnerable groups
  - Support counties to domesticate national policies, strategies, plans and programmes
  - Support counties to implement prioritised actions in the domesticated county policies, strategies, plans and programmes
  - Review and mainstream climate change adaptation in, and implement, all policies, strategies, plans, and programmes at County level focused on gender, children, youths, and other vulnerable groups.
  - Expand Social Protection Safety Net Programmes, and insurance mechanisms, to cover all Counties, and to include all climate change risks as part of their inclusion criteria.
  - Facilitate access to climate change funds for vulnerable groups, to enable them tap opportunities for climate resilient livelihoods
- Support the strengthening of resilience in drought-prone areas
  - Ensure that all vulnerable groups have equal rights to economic resources, and access to basic services, ownership and control over land and property, inheritance, natural resources, appropriate technology and financial services, including finance, by June 2023
  - Strengthen local institutions, mechanisms and processes that build resilience to flood risks
  - Promote and support robust community-based institutions and organisations to strengthen flood and drought risk preparedness and response
  - Strengthen community-led management of water points
  - Strengthen the coordination of resilience-building institutions, including knowledge management and information flow
  - Support the strengthening of delivery of such critical social services as health, nutrition, water, sanitation, hygiene, and education in at least 23 drought prone Counties
- Support peace building in drought-prone counties
  - Strengthen peace infrastructure and, mainstream peacebuilding and community security in the development agenda in conflict-prone Counties to prevent and / or enhance responses to conflicts
  - Support the provision of information to facilitate concerted and timely action by relevant stakeholders at all levels

The National Adaptation Plan (2015-30) set out the following short-, medium- and long-term actions:

- Short term actions:
  - Enhance access to the youth and women enterprise funds
  - Strengthen and expand social protection and insurance mechanisms against main climate hazards
  - Establish affordable and accessible credit lines for the urban and rural poor, youth and other vulnerable groups
  - Create awareness for climate finance opportunities that women and youth can access
- Medium term actions:
  - Promote livelihood diversification for vulnerable groups in order to reduce rural-urban migration
- Long term actions:
  - Promote and support climate resilient sustainable livelihoods

The updated NDC technical report proposed including the following priority actions:

- Continue strengthening access of women, youth, other vulnerable groups to enterprise funds, climate finance and credit lines
- Continue promoting livelihood diversification activities to enhance the adaptive capacity of vulnerable groups
- Enhance knowledge dissemination on climate finance opportunities for women, youth and other vulnerable groups at national and county levels
- Develop social safety net structures for women, youth and other vulnerable groups within the CCCFs

The NCCAP also aims to increase the number of households benefiting from social protection systems and County Climate Change Funds (CCCFs), with emphasis on reaching the poor, and marginalised and minority groups:

- Number of beneficiaries of social protection mechanisms, and other safeguards (under the Hunger Safety Net Programme) increased from 100,000 to 150,000 for regular beneficiaries; and from 90,000 to 130,000 for scalability to beneficiaries
- Number of households better able to cope with climate change because of receiving benefits from CCCFs increased from 300,000 households in 2018 to 800,000 households
- CCCFs address local adaptation priorities that are identified and monitored by community committees comprised of women and men

- Number of beneficiaries under the National Safety Net Programme increased from 4 million beneficiaries in 2017 to 4.3 million. (Number of beneficiaries increases because the expanded scope of programmes means that more Kenyans are eligible for support)
- Number of beneficiaries of social protection mechanisms, and other safeguards (under the Hunger Safety Net Programme) increased from 100,000 to 150,000 for regular beneficiaries; and from 90,000 to 130,000 for scalability to beneficiaries
- Number of households better able to cope with climate change because of receiving benefits from CCCFs increased from 300,000 households in 2018 to 800,000 households

- CCCFs address local adaptation priorities that are identified and monitored by community committees comprised of men and women.

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