Ministry of Energy and Meteorology

Lesotho Meteorological Services

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Climate Change Mitigation Assessment

Final Report

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LIST OF ABBREVIATIONS

AFOLU:	Agriculture Forestry and Other Land Use
AU:	African Union
BAU:	Business As Usual
BOS:	Bureau of Statistics
CBDR-RC:	Common But Differentiated Responsibility and Respective Capabilities
CBL:	Central Bank of Lesotho
CH_4:	Methane
CO_2:	Carbon dioxide
DNA:	Designated National Authority
DoE:	Department of Energy
DOE:	Department of Environment
DWA:	Department of Water Affairs
GDP:	Gross Domestic Product
GEF:	Global Environmental Facility
GHG:	Greenhouse Gases
GWP:	Global Warming Potential
H_2O:	Water vapour
HFCs:	Hydro-Fluorocarbons
INC:	Initial National Communication
INDC:	Intended Nationally Determined Contributions
IPCC:	Intergovernmental Panel on Climate Change
IPPU:	Industrial Processes and Product Use
LEAP:	Long-range Energy Alternatives Planning
LEC:	Lesotho Electricity Company
LMS:	Lesotho Meteorological Services
MACC:	Marginal Abatement Cost Curve
MCA:	Multi Criteria Analysis
$MtCO_2e$:	Million tonnes of Carbon Dioxide Equivalent
N_2O:	Nitrous Oxide
NC:	National Communications

NCCC:	National Climate Change Committee
NCCP:	National Climate Change Policy
NCCPIS:	National Climate Change Policy Implementation Strategy
NDC:	Nationally Determined Contributions
NGOs:	Non-Governmental Organizations
NSDP:	National Strategic Development Plan
O_3:	Ozone
PFCs:	Per-Fluorocarbons
PRPS:	Poverty Reduction Strategy Paper
SDGs:	Sustainable Development Goals
SF_6:	Sulphur Hexafluoride
SNC:	Second National Communication
TNC:	Third National Communication
UNFCCC CGE:	United Nations Framework Convention on Climate Change Consultative Group of Expert
UNFCCC:	United Nations Framework Convention on Climate Change
V & A:	Vulnerability and Adaptation Assessment

Glossary of Terms

Term	Definition/ Description
Mitigation	Actions taken to reduce GHG emissions. A human intervention to reduce the sources or enhance the sinks of GHGs (IPCC 2014)
Abatement Pathway	An abatement pathway defines a set of emission reduction trajectories (pathways) which are technologically achievable over time. The pathway merely identifies what is technically possible without providing a detailed scenario-based description of how that outcome would be achieved.
Carbon Dioxide equivalent (CO_2e)	The universal unit of measurement used to indicate the global warming potential (GWP) of each of the six Kyoto greenhouse gases. It is used to evaluate the impacts of releasing (or avoiding the release of) different greenhouse gases.
Climate change	A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability over comparable time periods (Source: UNFCCC).
Emission Reduction Scenario	Scenario describing plausible future emission trajectories to reflect the likely quantity and trend of greenhouse gas emissions released for a given period, including variances related to levels of economic growth, the structural makeup of an economy, demographic development and the effect of emission reduction policies.
Global Warming Potential	An index, based on radiative properties of GHGs, measuring the radiative forcing following a pulse emission of a unit mass of given GHG in a present-day atmosphere integrated over a chosen time horizon, relative to that of carbon dioxide (IPCC 2014).
Greenhouse Gas	Greenhouse Gases (GHGs) are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorbs and emits radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere and clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. Besides carbon dioxide, nitrous oxide and methane, the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride (SF_6), Hydro-Fluorocarbons (HFCs) and Per-Fluorocarbons (PFCs) (IPCC, 2014).
Greenhouse Gas Sink/Emission Sink	A sink is defined as any process, activity or mechanism that removes a GHG, an aerosol or a precursor of a GHG or aerosol from the atmosphere (IPCC, 2014).
Greenhouse Gas Source/Emission Source	A source is defined as any process, activity or mechanism that releases a GHG, an aerosol or a precursor of a GHG or aerosol into the atmosphere (IPCC, 2014).
Indirect Emissions	Emissions that are a consequence of the activities of the reporting company but occur from sources owned or controlled by another organisation or individual. They include all outsourced power generation (for example, electricity, hot water), outsourced services (for example, waste disposal, business travel, transport of company-owned goods) and outsourced manufacturing processes. Indirect emissions also cover the activities of franchised companies and the emissions associated with downstream

Term	Definition/ Description
	and/or upstream manufacture, transport and disposal of products used by the organisation, referred to as product life cycle emissions.
Marginal Abatement Cost Curve (MACC)	A Marginal Abatement Cost Curve (MACC) shows the costs and potential for emissions reduction from different measures or technologies, ranking these from the cheapest to the most expensive to represent the costs of achieving incremental levels of emissions reduction.
Mitigation Measures	Typically, mitigation measures are technologies (that is, a piece of equipment or a technique for performing a particular activity), processes, and practices which, if employed, would reduce GHG emissions below anticipated future levels, when compared to the status quo or existing counterfactual techniques normally employed.
Mitigation Potential	The mitigation potential of a measure is the quantified amount of GHGs that can be reduced, measured against a baseline (or reference).The baseline (or reference) is any datum against which change is measured. Mitigation potential is represented in tonnes of carbon dioxide equivalent (tCO_2e).
Projection	In general usage, a projection can be regarded as any description of the future and the pathway leading to it.
Scenario	A scenario is a coherent, internally consistent and plausible description of a possible future state of the world. It is not a forecast; rather, each scenario is one alternative image of how the future may unfold. A projection may serve as the raw material for a scenario, but scenarios often require additional information (for example, about baseline conditions).

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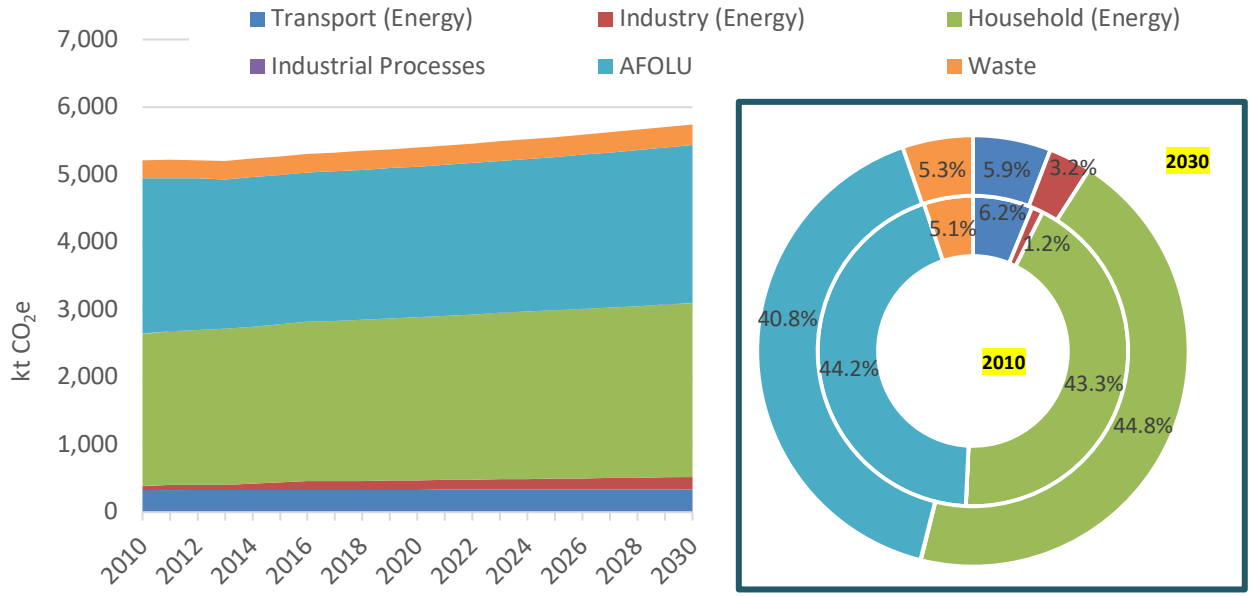
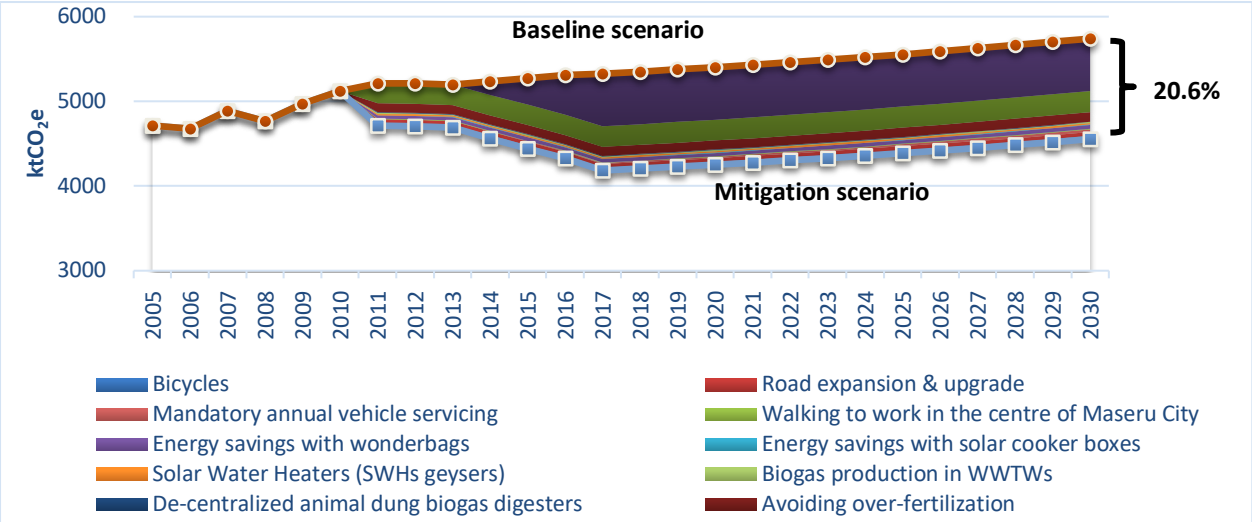
DASHBOARD EXECUTIVE SUMMARY

Lesotho's GHG emissions are projected to grow from 5,213.4 $ktCO_2e$ in 2010, reaching at 5,739.9 $ktCO_2e$ by 2030.



Projected 10.1% increase in National GHG emissions between 2010 and 2030



20.6% annual mitigation by 2030, through 10 mitigation actions

Lesotho's unconditional 10% NDC target can be achieved at a total saving of M5,889 million to the economy.

1 INTRODUCTION

1.1 Background

The Kingdom of Lesotho (referred to as Lesotho hereafter) is a Non-Annex-I country party to the United Nations Framework Convention on Climate Change (UNFCCC). The country is committed to contribute to the attainment of the ultimate objective of the Convention, "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogensjic interference with the climate system". Lesotho, therefore, continues strengthening actions to protect the climate system for the benefit of present and future generations of humankind on the basis of equity and in accordance with the principle of Common But Differentiated Responsibility and Respective Capabilities (CBDR-RC) in line with Article 3 and 4 of the Convention.

1.1.1 International Regulatory Arrangements and Frameworks

In synchrony with the international political response to climate change, and in line with the above, Lesotho signed and ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and 1995 respectively. Furthermore, in 2017, Lesotho ratified the Paris Agreement, a universal agreement with the global goal to strengthen response to the threat of climate change in the context of sustainable development and eradication of poverty, taking into account the principle of CBDR-RC. The Paris Agreement sets a long-term temperature goal well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels. Pursuant to Decision1/CP.21 of the Paris Agreement Lesotho communicated the Nationally Determined Contributions (NDC) to the UNFCCC.

1.1.2 National Regulatory Arrangements and Frameworks

1.1.2.1 Nationally Determined Contributions

The NDC presents Lesotho's two-fold strategy for climate change action. The country's primary focus is on activities which enhance the country's adaptive capacity and build the resilience to the impacts of climate change. Secondly, Lesotho focuses on transitioning to low-carbon and more climate resilient development pathways. Effectively, the NDC aims to put forth adaptation and mitigation actions that Lesotho will take to tackle its growing vulnerability to climate change and reduce the GHG emissions. This strategy is further echoed by the National Climate Change Policy 2017-2027.

1.1.2.2 National Climate Change Policy 2017-2027

The vision of National Climate Change Policy (NCCP) 2017-2027 is to build climate change resilience and a low-carbon society, including a prosperous economy and environment in Lesotho. The mission of the Policy is to increase climate change resilience and improve the well-being of Basotho through mainstreaming and implementing concrete measures for adaptation and climate risk reduction, mitigation and low-carbon development in the context of sustainable development. The Policy calls for active participation of all stakeholders in respective to social, environmental and economic sectors. The vision and the mission of the NCCP 2017-2027 are premised on government's commitment to poverty reduction and sustainable development as echoed in the Nation Vision 2020. The Policy, therefore,

articulates the national strategic response to climate change within the context of Lesotho's broader national development plans as outlined in the National Strategic Development Plan (NSDP I and II). Both of the national development plans encompass creation of high, shared, and employment generating economic growth and sustainable development, international economic competitiveness, improving human and environmental health, and poverty alleviation.

The policy also calls for prioritisation and implementation of adaptation and climate risk reduction measures as well as mitigation and low-carbon development pathways. It identifies water, agriculture, energy, mining, industrial manufacturing, tourism, forestry, rangelands, biophysical environment, health, transport, human settlements and infrastructure as key socio – economic sectors of focus.

1.1.2.3 National Climate Change Policy Implementation Strategy

The NCCP Implementation Strategy (NCCPIS) presents a five (5) year implementation strategy of the NCCP 2017-2027.. It identifies action guidelines to build a climate resilient society and promote green development pathways by mainstreaming and integrating climate change into key national socio – economic and environmental sectors. The following are strategic objectives of the NCCPIS:

i. To increase resilience of Lesotho to the impacts of climate change by reducing climate risks to people, ecosystems and built environment while restoring and ensuring the rational use and the protection of natural resources;
ii. To explore low-carbon development opportunities, nationally and internationally, in order to promote the sustainable use of resources and
iii. To strengthen the governance, institutional and human capacity enabling access to technological and financial resources for the implementation of the NCCPIS with the equal participation of women, men, youth, vulnerable groups, the civil society and the private sector.

While the strategy identifies adaptation and climate risk reduction as issues of national priority, it recognises Lesotho's niche, need and potential to mitigate climate change through low- carbon development pathways without prejudice to sustainable development.

1.1.2.4 The National Strategic Development Plan II - 2018/19-2022/23

The National Strategic Development II 2018/19-2022/23, (NSDP II), emphasizes extreme weather conditions caused by climate change as one of the major domestic threats which continue to undermine the country's ability to achieve long term development objectives and goals. Of particular focus are the impacts of climate change sustainable development and achievement of inclusive growth in the country to the poor and rural communities who are more vulnerable to the impacts of climate change due to lower adaptive capacities. Accordingly, the plan recognizes that sustainable development, inclusive economic growth and the improvement of the well-being of Basotho cannot be attained without careful consideration of climate change and its impacts to various social and economic sectors including such as Agriculture, Water resources, and Biodiversity.

Similarly, the plan acknowledges the need for careful consideration of synergies, opportunities and risks associated with respective sectoral adaptation and mitigation measures. For this account, the NSDP calls for various socio-economic sectors to mainstream climate change and environment into respective policies, plans and programmes. Integrating climate change and environment as cross-cutting issues in development plans is depicted a mechanism to safeguard hard-won as well as future developmental milestones and aspirations. This approach also ensures that climate action measures are effective and optimal in terms of their costs and benefits. The approach further ensures that such actions do not lead to unintended consequences.

Furthermore, the NSDP II narrates Lesotho's plans to fully explore prospects of Clean Energy and Green Technologies to sustainably advance national developmental aspirations enshrined in the NSDP II, Vision 2020, Sustainable Development Goals (SDGs) and SADC Regional Indicative Strategic Development Plan (RISDP) 2005-2020. Through both public and private investments, the Government will promote appropriate clean technologies to reduce biomass and fuel consumption in order to curb GHG emissions, reduce pollution while preventing loss of biodiversity and ecosystems. Moreover, the NSDP recognizes: i) the growing Energy demand in the SADC region as Lesotho niche to generate and export renewable power and supply renewable energy products and technologies, ii) the relevance of investments in green energy technologies in reversing deforestation and soil erosion, iii) adoption of green technologies as a strategic measure to rebuild Lesotho's natural capital as a critical economic asset and source of livelihoods. The NSDP II echoes objectives and interventions outline in Table 1 as key measures aimed to achieve environmental protection and climate change adaptation.

Table 1: Strategic Objective And Interventions Environmental Protection And Climate Change Adaptation.

Strategic Objectives	Interventions/Actions
Reverse Land Degradation	Enhance watershed management programmes (Integrated Catchment Management)
	Increase productive capacity of rangelands
	Extent indigenous forest cover
Promote Biodiversity Conservation	Improve management of protected areas
	Increase coverage of protected areas (i.e. establish national botanical garden)
	Establish national inventory for socio-economically important plants and animals including their valuation
	Promote sustainable Bio-trade
	Promote eco-projects initiatives
Improve National Resilience to Climate Change	Mainstream Climate Change in Government Policies and Programmes
	Strengthen climate services for climate resilient development
	Develop climate change awareness programme and raise awareness of stakeholders about climate change issues.
Improve Environment and	Strengthen Environment and Climate Change Coordination to enhance efficiency and policy implementation

Climate Change Governance	Establish dedicated Environment and Climate Change National Authority;
	Develop Climate Change Act;
	Review, Develop and Harmonize relevant Environment and Climate change Legislation (i.e. review Environment Act of 2008, Develop Climate Change Act and Bio-diversity Resource Management Act)
	Establish Climate Change and Environment Fund.
	Establish an Environment and Climate Change information hub (i.e. to keep record of GHG emissions, climate finance, Ecosystem status).
Improve enforcement and compliance with environmental regulations and standards	Enhance enforcement of Environmental Impact Assessments (EIAs) and other enforcement tools.
	Scale up environmental education programmes and awareness,
	Develop appropriate incentives to encourage environmental protection.
	Review and develop enforcement tools .
	Scale up monitoring and evaluation of environmental programmes.

1.1.2.5 Lesotho Energy Policy 2015-2025

In synchrony with the NSDP II, the Lesotho Energy Policy 2015-2025 envisions energy to be universally accessible and affordable in a sustainable manner, with minimal negative impact on the environment. It is premised on pillars of the United Nations initiative on Sustainable Energy for All (SE4ALL). In addition, the Policy is aligned with relevant international, regional and local environmental agreements, protocol and strategies. Governed by the Environmental Sustainability Framework, the main goals of the Energy Policy include sound protection of the environment, advancing economic growth through initiatives that emphasize on renewable sources of energy and energy efficiency, job creation as well as those which positioning the country as a private sector – led competitive player in the SADC region.

To effect the above, the Policy has established respective regulatory and strategic frameworks for operation, implementation and regulation of energy sector programmes and activities. It has also demarcated relevant institutions for operation, implementation and regulation. Furthermore, the Energy Policy has established a platform and interface for participation of different stakeholders for implementation of the policy.

The aforementioned paradigm shift aims to increase the share of cleaner fuels and decrease that of non-sustainable forms of energy in the energy supply mix thereby substantially reducing GHG emissions typical of unclean energy carriers.

1.1.2.6 The National Forestry Policy 2008

The main purpose of the National Forestry Policy, 2008 is to maximize the contribution of forestry development to socio-economic development, protection of the environment and reduction of poverty particularly in the rural communities. Anchored on the principles of community based participatory approach, the goal of the Policy is to attain sustainable management and forestry development through promoting people participation in forestry programmes and activities towards improving their social and economic well-being. The Policy identifies sustainable forest management, social and economic dimensions of forestry development as well as enhancing people participation in forestry development as key policy interventions to advance the attainment of the aforementioned aspirations. Table 2 presents respective policy issues and objectives of relevance to the national climate change agenda.

Table 2: The National Forestry Policy 2008 - Policy Issues and Objectives

SUSTAINABLE FOREST MANAGEMENT	
Policy Issue	Policy Objective
Combating land degradation through increased tree forest cover	Increase tree cover to ensure soil conservation and improvement of water catchment areas.
	Promote sustainable water management and conservation practices.
Conservation and management of indigenous forests and conserving biological diversity.	Encourage conservation and protection of endangered tree and shrub species (unique forest areas and forest biodiversity), including the re-introduction of extinct species and protection of threatened and endangered ones.
	Encourage sustainable management and utilization of patches or groves of natural indigenous forest by adjacent communities; who are also encouraged to take ownership of such forests through appropriate legal process.
	Conserve the existing flora and fauna for present and future generations.
	Improve management of the existing forest reserves.
Forestry development strategy.	Increase tree cover; from less than 1% to at least 5% by the year 2020.
	Prepare and implement a National Forest Programme that addresses forestry needs in the country which are in line with national strategies (like Vision 2020 and Poverty Reduction Strategy) and is aligned with forestry-related international treaties that Lesotho is a signatory to, including the Inter-governmental Panel of Forests (IPF), Inter-governmental Forum of Forests (IFF), and the United Nations Forum on Forests (UNFF), as well as other relevant environmental conventions such as Convention on Biological Diversity (CBD) United Nations Convention to Combat Desertification (UNCCD), United Nations Framework Convention on Climate Change (UNFCCC), and the Ramsar Convention on Wetlands.

	Identify, control/mange and – where appropriate - eliminate invasive and other undesirable tree species.
Protecting forests from all kinds of destructive agents.	To support the introduction of appropriate measures by communities and individuals to protect both natural and man-made forests from damage anthropogenic threats including climate change.
	To support the conservation of special ecosystems which harbour unusual and rare species of flora and fauna.
	To Promote cooperation and collaboration among local government authorities and communities to enhance management of forest reserves.
Types of Forest/Plantation	To support the establishment and management of different types of forests and plantations for specific purposes.
Seedling Production.	To support establishment of private nurseries by government.
	To support the production of high quality planting materials by both government and private nurseries.
	To specifically encourage the production of indigenous tree and shrub species to be used in forestry development programmes and projects.
SOCIAL AND ECONOMIC DIMENSIONS OF FORESTRY DEVELOPMENT	
Poverty Reduction	To use National policy documents such as the Vision 2020, Poverty Reduction Strategy, to support the improvement of people's livelihoods through participation in appropriate income generating forestry activities.
	To promote sustainable use of wood and non-wood forest products by local communities and private individual farmers.
	To promote agro-forestry practices through establishment of vineyards and fruit tree Orchards.
Forest industries and trade.	To maximize the special development advantages of small-scale forest-based industries.
	To promote (small-scale) forest industries to generate employment, income and reduce imports.
Urban Forestry.	To promote the establishment and maintenance of green belts/spaces in urban areas as part of urban land-use planning, with urban authorities.
	To promote the establishment and maintenance of green belts/spaces in urban areas as part of urban land-use planning, with urban authorities.
	To provide technical advice and guidelines on urban tree planting and management, including site selection criteria and appropriate tree species and sources of seed.
Non-Wood Forest Products	To encourage the sustainable management of forests
	Promote the planting of appropriate exotic (indigenous) trees and shrubs in order to curb biomass energy deficit. Encourage and give priority to the establishment of

Biomass energy development/supply and Energy-saving Devices	individual and communal woodlots for fuel-wood production
	Participate in the production of energy efficient technologies in rural households including energy efficient stoves, biogas and solar in order to conserve the remaining forests resources.
ENHANCING PEOPLE PARTICIPATION IN FORESTRY DEVELOPMENT	
Involvement of all stakeholders.	To enhance involvement of all stakeholders in decision making on forestry development programmes in the country.
	To enhance equitable access and participation of all stakeholders in the implementation of forestry programmes.
Capacity building of stakeholders, local communities, local government structures and individual farmers	Provide relevant education and training to stakeholders, local communities, and members of the public on forestry planning, management, and implementation of projects and programmes, through a well-planned and efficiently implemented forestry extension education programme.
	Sensitize and educate the public on values, purposes, and benefits of forests.
Ownership of forestry resources.	Existing mechanisms and instruments have to be put in place – and may have to be adapted – to allow legal ownership of forests/trees and access to forest products.
Awareness and training.	Advocate for inclusion of an expanded forestry education syllabus in both primary and secondary school curricula.
	Establishment of a national forest for educational value.
	Promote forestry education at all levels.

The Policy recognizes the importance of range resources as a major source of clean water, bio-resources and a life form support for humans and a variety of plant, animal species. The Policy further acknowledges that Lesotho's rangelands are, however, under severe stress and rapid loss due to myriad of factors including poor legal control, uncontrolled wildfires, poor grazing control. The Policy highlights climate change as one of the major threats to the sustainability of range resources. Particularly, rangelands are severely affected by prolonged drought, erratic rainfall as well as both early and late frost. They result in deterioration of the rangelands and thus poor condition. Additionally, they result in changes in distribution of species whereby more tolerant species such as re-sprouting Karoo bushes increase in abundance. The stressors have severely jeopardized the socio-economic, cultural as well as ecological services inherent of range resources.

The National Range Resources Management Policy 2014, therefore, aims to provide guidance for the development of strategies to curb land and vegetation degradation and motivate for improved legislation and implementation thereof. The main goal of the Policy is to attain sustainable development and management of rangeland resources for an enhanced biodiversity, optimum productivity and improved inter-generational livelihoods of Basotho.

To achieve the above, the Policy identifies sustainable management of rangeland resources, conservation and protection of biodiversity and maintenance of ecosystem, Rangeland monitoring and research, maintenance and protection of wetland area as well as socio-economic dimensions as key policy options to be pursued illustrated in Table 3.

Table 3: ***Sustainable Management of Rangeland Resources***

Sustainable Management of Rangeland Resources	
Goal	Strategies
To ensure sustainable management of range resources to curb land and vegetation degradation through development and implementation of appropriate strategies for rehabilitation of lost rangeland resources and also by ensuring equitable access and participation of stakeholders in the sustainable development of rangeland resources.	Develop and facilitate implementation of grazing management plans, which promote livestock grazing system that recognizes rest and rotation and variations of deferment of grazing areas.
	Promote fodder production and storage for stall feeding programmes.
	Restore degraded rangeland through ecologically sound methods by stakeholders including communities and herders.
	Explore options and benefits for provision of environment services on the rangelands.
Conservation and Protection of Biodiversity and Maintenance of Ecosystem	
To maintain healthy and balanced ecosystem to sustain the biodiversity through proper conservation of plant and animal species in the rangelands through Protection of water sources against destruction and negative exploitation for sustenance of rangeland and riverine habitats as well as Protection and conservation of threatened indigenous vegetation against overexploitation to maintain balanced ecosystem and maintenance of natural grasslands and other vegetation and management of invasive species.	Promote establishment of community gardens through collection and propagation of seeds for threatened and endangered species
	Develop guidelines for economic and sustainable utilization and harvesting of plant and animal species without compromising food chain and quality of biodiversity
	Support systematic reintroduction of lost valuable species of plants, birds and animals to appropriate habitats.
	Uphold designation of hot spots for conservation and protection of threatened and endangered species.
	Enforce the restoration of disturbed rangeland resources to near pristine or pre-development conditions
Maintenance And Protection Of Wetland	
To ensure that information on the location, status, extend, characteristics and function of the wetlands is provided to promote the understanding and conservation of this resources.	Identify degraded wetland and wetland areas and determine appropriate reclamation activities.
	Promote declaration of major wetland catchments as protected areas.
	Collaborate with key stakeholders to foster diversification of alternative livelihood coping strategies, to reduce pastoral communities' dependence on cattle posts and wetland areas thus enhancing resilience of rangeland resources.

	Collaborate with relevant stakeholders to improve livestock nutrition programmes and promote construction of water harvesting structures for livestock drinking to minimize direct use of wetlands.
Socio-Economic Dimensions	
To ensure proper management and control for harvesting of rangeland resources to meet social, cultural and economic requirements for improvement of the livelihoods of the rural communities and without compromising the status of biodiversity.	Review and develop guidelines in consultation with other relevant stakeholders for harvesting rangeland resources by various resource users.
	Improve participatory grazing management planning.
	Work in collaboration with relevant authorities to strengthen curriculum in tertiary institutions to integrate Climate Change and Range Science.
	Provide technical support for enhanced productivity of rangeland resources in selected areas and exploitation for income generation purposes.

1.2 Progress in Mitigation Analysis and Assessment

Despite the insignificant contribution of Lesotho's emissions to the global GHG emissions, Lesotho is willing to mitigate GHG emissions by leveraging on opportunities presented by low-carbon development pathways. In this regard, sectors including energy, transport, agriculture, forestry, waste management, land use and land use change are identified as catalytic in propelling the transition to low-carbon development pathways and green economy. The country considers mitigation in the context of sustainable development and seeks to balance the country's contribution to the global agenda paved out by the UNFCCC and Paris Agreement with the need to tackle socio-economic and development challenges that is faced with.

According to NDC, Lesotho has already undertaken several actions to support mitigation based on national circumstances. Such include extensive investment into hydro, solar and wind power potential, embarking on rural electrification and afforestation projects. However, for the country to realize her full potential in contributing to global mitigation efforts, substantial support from the international community is imperative. Lesotho promotes adaptation and intends to explore mitigation measures that will promote sustainable use of resources while contributing to the achievement of goals set out in the NCCP 2017-2027, NSDP II, Sustainable Development Goals (SDGs), African Union (AU) Agenda 2063 and other relevant national policies and plans.

Lesotho's NDC had set out the mitigation targets against a Business As Usual (BAU) projection considering emissions reductions in five (5) socio–economic sectors, namely: Energy, Industrial Processes, Agriculture Forestry and Other Land Use (AFOLU) and Waste. Respective plans to mitigate GHG emissions focus on the following interventions: improving crop and livestock production practices for food security while reducing emissions; Protecting and re-

establishing forests for their economic and ecosystem services, while sequestering CO_2; expanding electric power generation from renewable energy sources; improving access to modern and energy efficient technologies in transport, industry and building sectors.

1.3 Objectives of the Study

The overall objective of the exercise is to undertake mitigation analysis and assessment with the view to present a set of viable options to reduce sources of GHG emissions and/or enhance their sinks in key economic sectors in accordance with Lesotho's obligations under the UNFCCC. This exercise is specifically within the framework of the preparation of the National Communications (NCs) through which Lesotho is required to:

- Take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects" (Article 3);
- Have "common but differentiated responsibilities" based on the national circumstances;
- Gather and share information on GHG emissions, national policies, and best practices;
- Launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts.

2 OVERALL METHODOLOGY

Figure 1 illustrates a seven (7) step methodology and process followed to conduct mitigation analysis and assessment of options to reduce greenhouse gases emissions and/or enhance Lesotho's carbon sinks. The methodology is recommended by the UNFCCC Consultative Group of Experts (CGE) under the UNFCCC.

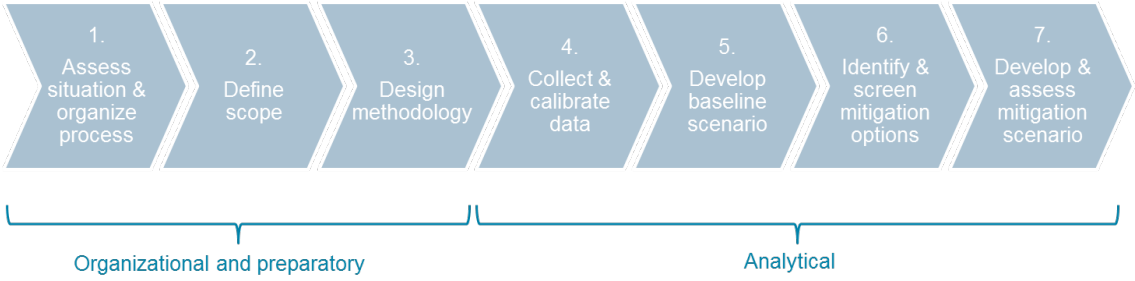


Figure 1: Mitigation assessment process recommended by CGE process

Step 1. Assess situation and organise process: The step consisted of three main phases, namely:

i. Determine and prioritise objectives of assessment. Objectives of the assessment were determined based on the contribution to national objectives effectiveness in reducing GHG emissions as outlined by NDC, NCCP 2017-2027, National Communications and the NSDP, effectiveness in reducing GHG emissions.

ii. Assess existing studies, current capacities, and data availability –This phase entailed reviewing and analysing available national reports relevant to mitigation studies and identifying strengths and gaps.

iii. Define key participants and stakeholders – The mapping of key participants and stakeholders, as well as the definition of their respective roles, was undertaken. Organizations with institutional responsibility for the analysis and for implementing results of the mitigation assessment were identified as key stakeholders. Stakeholders included policy and decision makers, the scientific community, Non-Governmental Organizations (NGOs), the private sector, and academia.

Step 2. Define the Scope of the assessment: The step entailed delineation of the extent of mitigation assessment and scoping of mitigation actions per sectors. The key socio-economic sectors such as energy supply and demand, agriculture, land-use, forestry, solid waste constituted the basis of the assessment. Scoping of mitigation options considered the technological scope, relevance to national priorities, timeframe and the base year.

Step 3. Design assessment methodology: The methodology was designed on the basis of economic outputs including cost and benefits (bottom-up approaches), macroeconomic impacts (top-down models) as well as integrated and/or sector-specific analysis (e.g. power supply or transportation modelling). Other criteria for methodology selection included consideration of GHG inventory as well as Vulnerability and Adaptation Assessment (V&A).

Step 4. Collect and calibrate data and assumptions: The national GHG inventories, the First and Second NCs, Energy statistics, and energy balances, national economic and demographic statistics and surveys, were the primary data sources. In cases where there were Data inconsistencies and gaps were bridged with international data and studies.

Step 5. Develop Baseline Scenario: This step involved collection of necessary macro-economic and demographic data required to set up the model, base year setup, as well as modelling of the baseline scenario. Projections of GHG emission were informed by macro-economic and demographic data, 2005 and 2010 GHG Inventory Report and stakeholder's consultation. The scenario was developed based on documented assumptions informed by the reports from the Central Bank of Lesotho (CBL) and Bureau of Statistics (BOS) about the expected economic in the key sectors as well as demographic changes. The baseline scenario assumed emissions trajectory without any mitigation from the year 2010 projecting to 2030.

Step 6: Identify and Screen mitigation options: Identification and analysis of mitigation opportunities in key sectors of the economy were undertaken in consultation with key stakeholders. Key emitting sectors were identified by the stakeholders guided by the 3rd GHG Inventory Report. Based on the sectors, stakeholders identified and screened mitigation options. The mitigation potential of each of the suggested options was assessed, quantified and appraised using Multi-Criteria Analysis (MCA) and Marginal Abatement Cost Curves (MACC).

Step 7: Develop Mitigation Scenario: This involved data gathering, scenario set up, scenario modelling, as well as comparison of the scenario with the baseline. The Mitigation scenario assumed emissions trajectory considering future policies and measures that could be adopted to reduce sources of GHG emissions or enhance the sinks from the year 2010 projecting to 2030.

The final results of the assessment determined the projected GHG mitigation is depicted in Figure 2, wherein the Baseline scenario represents events or conditions most likely to occur in the absence of the mitigation actions. It provides a plausible and consistent description of future developments in the absence of explicit new GHG mitigation policies. On the other hand the mitigation scenario represents events or conditions most likely to occur in the presence of the mitigation actions. It reflects a future in which explicit policies and measures are adopted to reduce the GHGs sources or enhance the sinks.

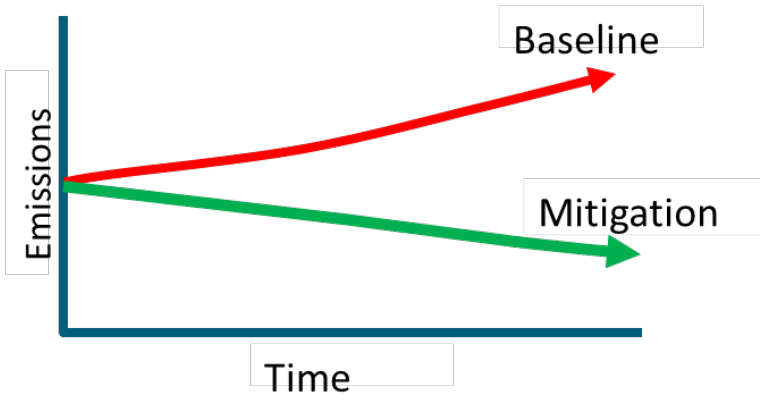


Figure 2: schematic representation of baseline and Mitigation scenarios

2.1 Data collection and Stakeholder Engagement Process for Mitigation Analysis and Assessment

To ensure active participation and engagement of all key socio-economic sectors, hence ownership of the mitigation analysis and assessment process, a multi-sectoral approach was deployed for data collection as well as identification and screening of mitigation options. The approach was also aimed at strengthening institutional capacity for respective sectors to drive mitigation measures and undertake future analysis and assessments within respective institutions. .

Stakeholders from various sectors Such as Energy, Agriculture, Trade, Environment, Range and Soil conservation, Transport and Public Works, Private Sector and Industry, Academia and others were organised into teams of Energy and Non-Energy sectors, and engaged through workshops and stakeholder consultations (Appendix D). These workshops provided a platform to generate and validate data. The workshops also capacitated stakeholders on Long-range Energy Alternatives Planning (LEAP), basic concepts of climate change mitigation and steps in mitigation assessment including base year determination, baseline scenario, Screening of mitigation actions, Mitigation scenario.

Follow – up stakeholder consultations were conducted to generate additional data. Subsequently, stakeholders collectively analysed data and prioritised possible mitigation options in key economic emitting sectors as identified by the third GHG Inventory Report. The mitigation potential of each of the suggested options was assessed, quantified and appraised using MCA and MACC.

Government Policies, development plans, strategies and reports of relevance to mitigation including the NCCP (2017-2027), Sustainable Energy Strategy, NDC, Forestry and Range Management Policies etc. served as primary data sources. Energy statistics, energy balances, micro-economic and demographic data were also used. In cases where there were inconsistencies and data gaps, relevant international data sources and studies were consulted.

2.2 Scope

The scope of the assessment was defined based on sectors, base year and projection period. Of substantial consideration were sectors that are drivers of economic growth and of greenhouse gas emissions. These sectors are consistent with IPCC 2006 categories, and include, Energy (transport, household demand, and industry), Agriculture, Forestry and Other Land Use (AFOLU)), Industrial Processes and Product Use (IPPU) and Waste. The scoping of mitigation options considered among other factors, the technological scope based on the cost and availability of the technology, the alignment with national priorities as well as cross-sectoral issues. The base year and time frame of the projections were other factors which influenced the scope of this assessment. The base year was selected based on the most recent GHG Inventory while the projection period to 2030 was selected to align with the time frames of Lesotho's submitted Nationally Determined Contributions (NDC).

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3 BASELINE SCENARIO

3.1 Key Assumptions and Drivers

The baseline scenario was developed for a single Business As Usual (BAU) scenario that aims to represent the most likely future of Lesotho to 2030 in the absence of actions and policies to reduce GHG emissions. Using the base year of 2010 from the Third National GHG Inventory Report, projections of emissions to 2030 were prepared by making assumptions of how activity related to specific sources of emissions changes over time. The main drivers of emissions are related to economic growth, changes in population growth as well as energy demand. The assumptions were based on the datasets extracted from the Third National GHG Inventory report, Energy Balance of 2010, Bureau of Statistics (BOS) Census reports and the Macroeconomic reports from the Central Bank of Lesotho (CBL). A consolidated table of assumptions can be found in Appendix A. While multiple baseline case scenarios could have been considered in the analysis, a single baseline scenario was selected to have a single starting point for the mitigation options analysis.

3.1.1 Population Growth and Household Size

The national population is a critical driver of GHG emissions and therefore a fundamental parameter in building the baseline scenario. Population and household size were based on the data available from 2006 and 2016 census reports from the BOS. To estimate the national population and household size, for the base year 2010, the data from 2006 and 2016 censuses were interpolated (Figure 3). The population was estimated to be 1,926,761 for 2010 and average household size estimated to be 4. Linear extrapolation model was then used to

estimate population and household size up to 2030. The number of households (481,690) which was also used as an assumption to model the baseline scenario was calculated using 2010 figures for population and household size.

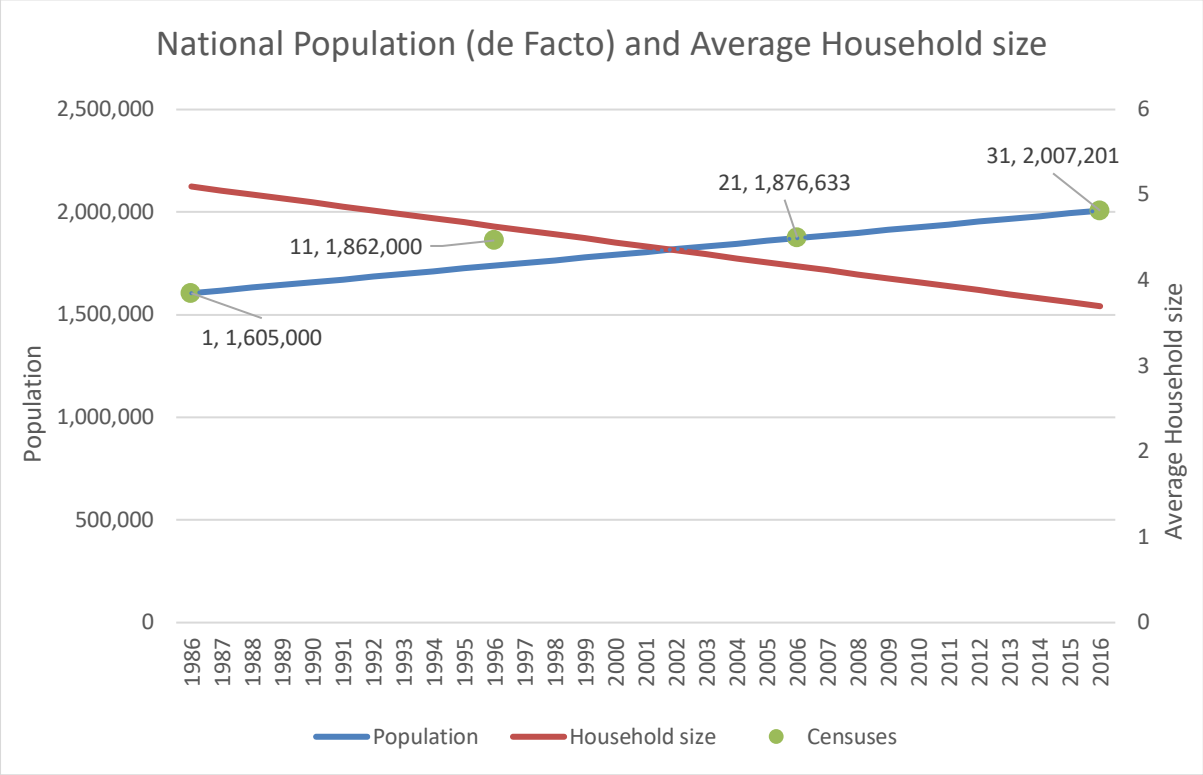

Figure 3: National Population and household sizes[1]

3.1.2 GDP Growth

The governing assumptions for the baseline scenario are based on growth rate for the Actual Gross Domestic Product (GDP) contribution of the key economic sectors as per Lesotho Economic Outlook reports by the Central Bank of Lesotho. Actual GDP growth rates from 2010 until 2016 from Lesotho Macroeconomic Outlook reports[2][3][4] were extracted and plotted for Manufacturing, Construction and mining and Quarrying. The real GDP observed during the period 2010- 2016 for Manufacturing, Construction and Mining and Quarrying respectively is shown in Figures 4. The average GDP growth rates observed for each of these industrial sectors between 2010 and 2016 were used to project the growth of the respective sectors from 2017 to 2030 as shown in Table 4 below.

[1] Bureau of Statistics 2009. 2006 Lesotho Population ANALYTICAL REPORT Volume IIIA Population Dynamics. Ministry of Finance and Development Planning Bureau of Statistics, Maseru
[2] Central Bank of Lesotho 2013, Lesotho Outlook Report- October 2013. Central Bank of Lesotho, Maseru
[3] Central Bank of Lesotho 2015, Lesotho Outlook Report- November 2015. Central Bank of Lesotho, Maseru
[4] Central Bank of Lesotho 2018, Lesotho Outlook Report- December 2018. Central Bank of Lesotho, Maseru

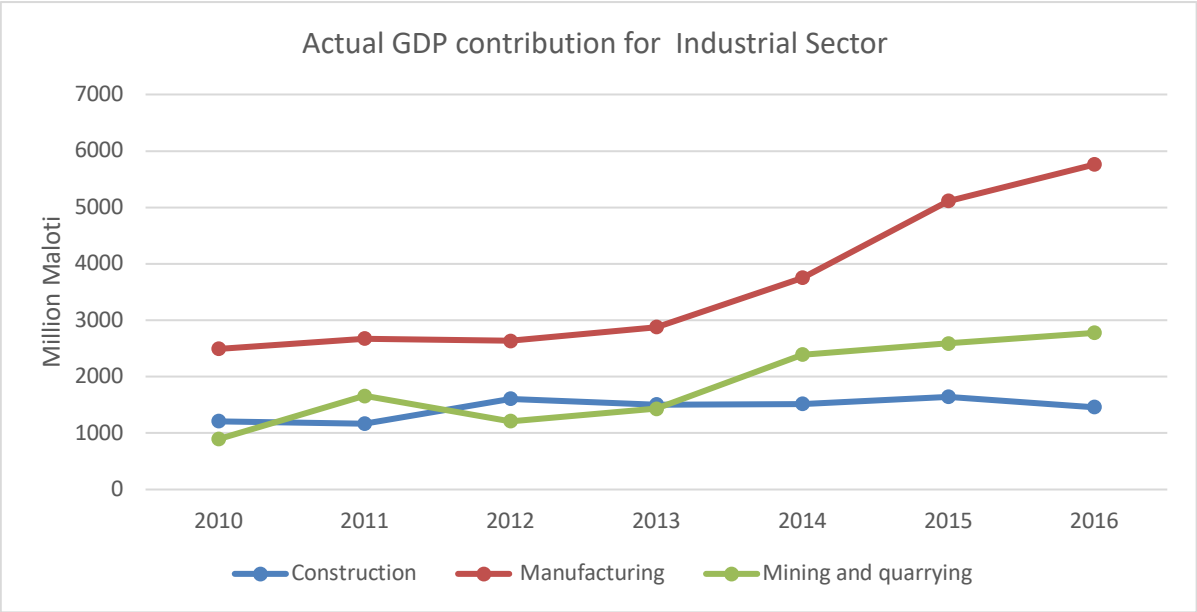

Figure 4: Actual GDP contribution for Industrial Sector

Table 4: Actual GDP Growth (2010-2016) and Projections for 2017-2030

Sector	2010 - 2016	Projected 2017 - 2030 growth rates (average of 2010 – 2016 growth rate)
Manufacturing Industries	Actual GDP split as per Lesotho Economic Outlook reports	1.07%
Construction industries only		3.73%
Mining & quarrying		4.83%

Assumptions for the baseline emissions projections for energy demand were based on all activities identified in the national Greenhouse Gas Inventory for 2010. Additionally, the reports from the BOS and the Department of Energy (DOE) are also used as a basis for the assumptions made in building the baseline scenario. The majority of households in Lesotho rely on using kerosene (lighting and cooking), biomass and other solid fuels for space heating and cooking. 2011 household survey was used to disaggregate household fuel use into space heating, cooking, water heating and lighting, and the rest allocated to others. Petrol and Diesel are mainly used for transportation. The demand for Liquid fuels such as Petrol, Diesel, Paraffin, LPG, and Aviation for all different sectors was based on 2010 energy balance. Assumptions under Third National Greenhouse Gas Inventory (GHGI) were used to disaggregate the liquid fuels demand. Table 5 shows the disaggregation of liquid fuels. Information on the solid fuel consumption and demand was extracted from consumption of Solid fuel quantities used during the compilation of the Third GHG Inventory compilation.

Table 5: Disaggregated Liquid Fuels Demand

	Sector	Petrol	Diesel	Paraffin	LPG	Aviation
2010 (%)	Industry		25.0%		24.2%	
	Transport	75.0%	75.0%			100.0%
	Households	25.0%		100.0%	75.8%	
	Commercial & public					
	Agric / Forestry		5.8%			
	Non-specified					

	Non-energy use						
2010 (TJ)							
	Industry	TJ		744		107	
	Transport	TJ	2 620	2 231			1.34
	Households	TJ	873		1 479	334	
	Commercial & public	TJ					
	Agric / Forestry	TJ		174			
	Non-specified	TJ					
	Non-energy use	TJ					

3.1.3 Vehicle statistics, Fuel Consumption Rates, Mileage and occupancy

Petrol and Diesel consumption for all different categories of vehicles has been assumed to increase at a constant rate of 0.5% annually. Due to lack of national data on number of vehicles, the assumptions made under the third GHG inventory report, and the study by Mphethe et al[5] were used as a basis for modelling the baseline scenario. The fuel used by vehicles made approximately 75% of total petrol and diesel consumption in Lesotho. Table 6 summarises the assumptions made regarding passenger vehicle occupancies, freight vehicle carrying capacities, annual change in vehicle fuel efficiencies, passenger-kms (pkm) and ton-kilometres (tkm).

Table 6: Vehicle Fuel Consumption Rates, Occupancy, Efficiency and Vehicle Distance

Vehicles	Occupancy & carrying capacity	Annual Increase in fuel efficiency	Pkm and tkm per person
Car	1.4	0.50%	284.898
Buses	25	0.50%	275.748
Minibuses	14	0.50%	919.068
Motorcycles	1.1	0.50%	1.448
Light Duty Vehicles (LDV)	1	0.50%	183.373
Heavy Duty Vehicles (HDV)	9	0.50%	361.726
MAF* & LDF** aircrafts	5	0.50%	

*MAF – Mission Aviation Fellowship
**LDF – Lesotho Defence Force

3.1.4 Growth in Animal Population

Livestock: Using base year of 2010, the livestock population from Lesotho livestock statistics report 2013/14 was used to estimate the growth rate for dairy cows, non-dairy cows, and poultry. The extrapolation methods were used to project the change in population for sheep, goats, horses, mules and swine. Projected changes in livestock population and their average growth rate were used to estimate GHG baseline projections associated with livestock. Projected livestock population can be found in Appendix B.

[5]Tongwane, M., Piketh, S., Stevens, L., Ramotubei, T, 2015: Greenhouse gas emissions from road transport in South Africa and Lesotho between 2000 and 2009, *Transportation Research Part D, 37:1-13*

3.2 Lesotho's Baseline Trajectory (2010 – 2030)

Projections of all GHGs for both Energy and Non-Energy sectors for baseline scenario are presented in Table 7 and Figure 5. The projections show that if no climate change mitigation measures are to be implemented, the emissions in 2030 will be 10% higher (at 5,739.9 $ktCO_2e$) than in 2010 (5,213.4 kt CO_2e).

Table 7: Projections of Greenhouse Gases under Baseline Scenario

Sectors	2010 (kt CO_2e)	2020 (kt CO_2e)	2030 ($ktCO_2e$)
Energy Sector Emissions	2 644.5	2 887.2	3 093.2
Non Energy Emissions	2 568.9	2 515.7	2 646.8
Total	**5 213.4**	**5 402.9**	**5 739.9**

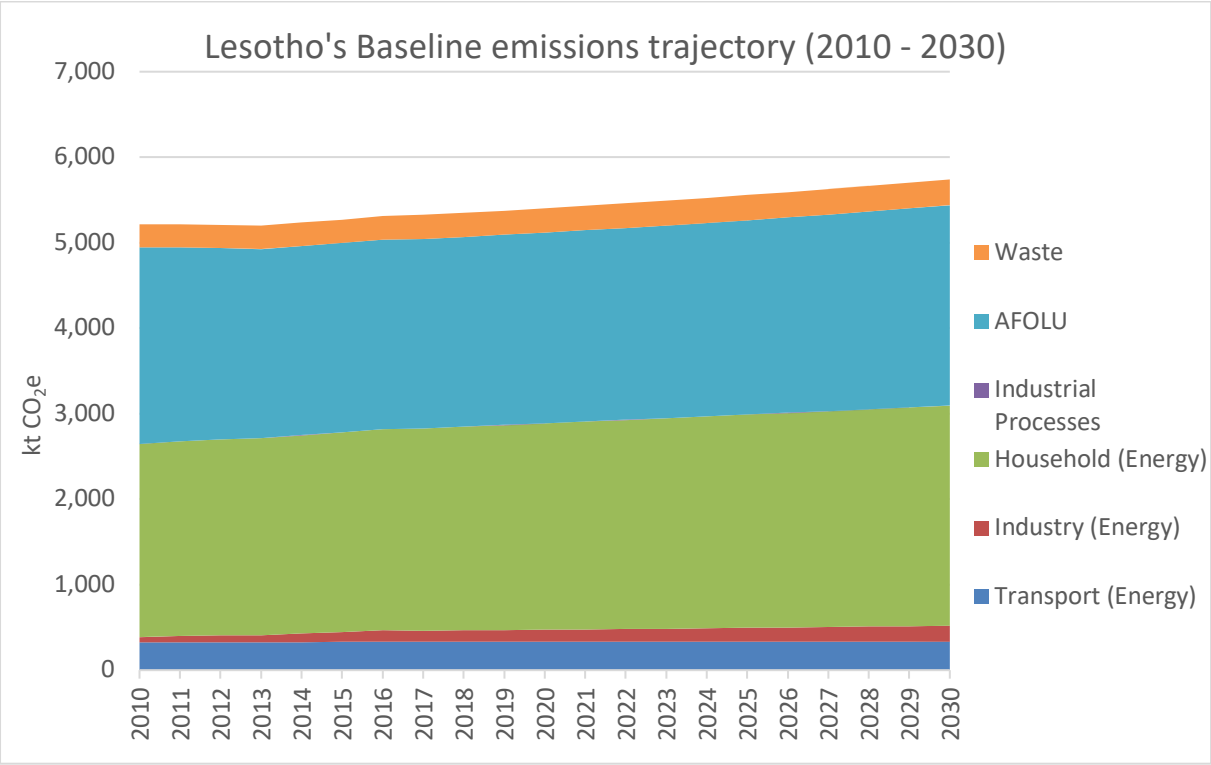

Figure 5: Projection of Greenhouses Gases for all Sectors under Baseline Scenario

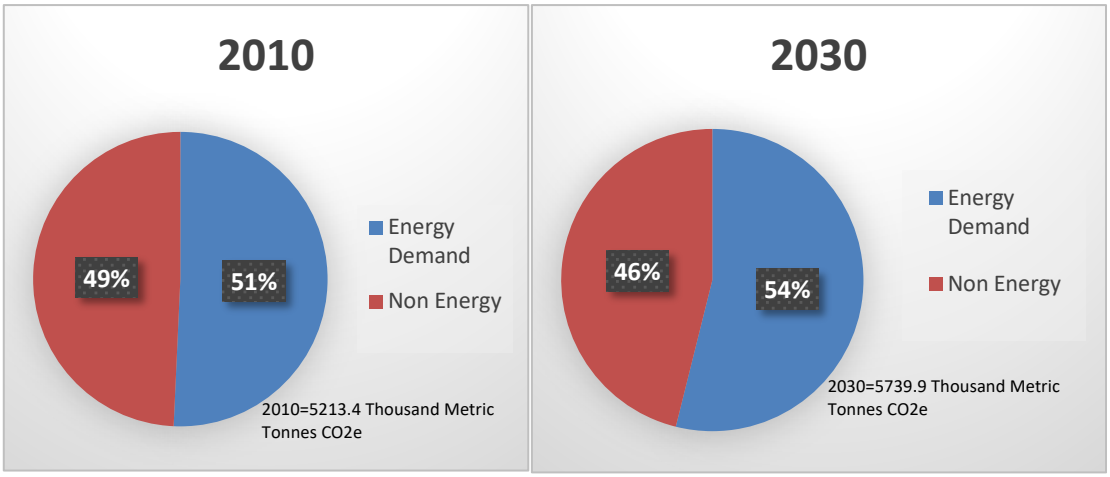

Figure 6: Contribution of Greenhouse Gases as per sector

3.2.1 Energy Sector Baseline Trajectory

The most significant contributor to the current and future emissions is energy demand. Energy contributed a total of 2,644.5 $ktCO_2e$ in 2010 and projected to increase by about 17% to 3,093.2 $ktCO_2e$ in 2030 if status quo continues. The baseline scenario projections depict that the largest share of emissions currently is from household demand and currently constitutes about 86 % of total Energy demand. The emissions associated with energy demand are projected to steadily increase by about 14% to 2,571.8 $ktCO_2e$ by 2030. Emissions due to future demand for energy in industry, including, construction, mining and quarry, and manufacturing, has been projected to rise from 62 $ktCO_2e$ in 2010 to 185.1 $ktCO_2e$ in 2030. The industries (construction, mining and quarry, and manufacturing) contribute just about 3% of the total energy demand, but their projected rate of increase is higher than of any other sector within energy demand (Figure 7 and Table 8).

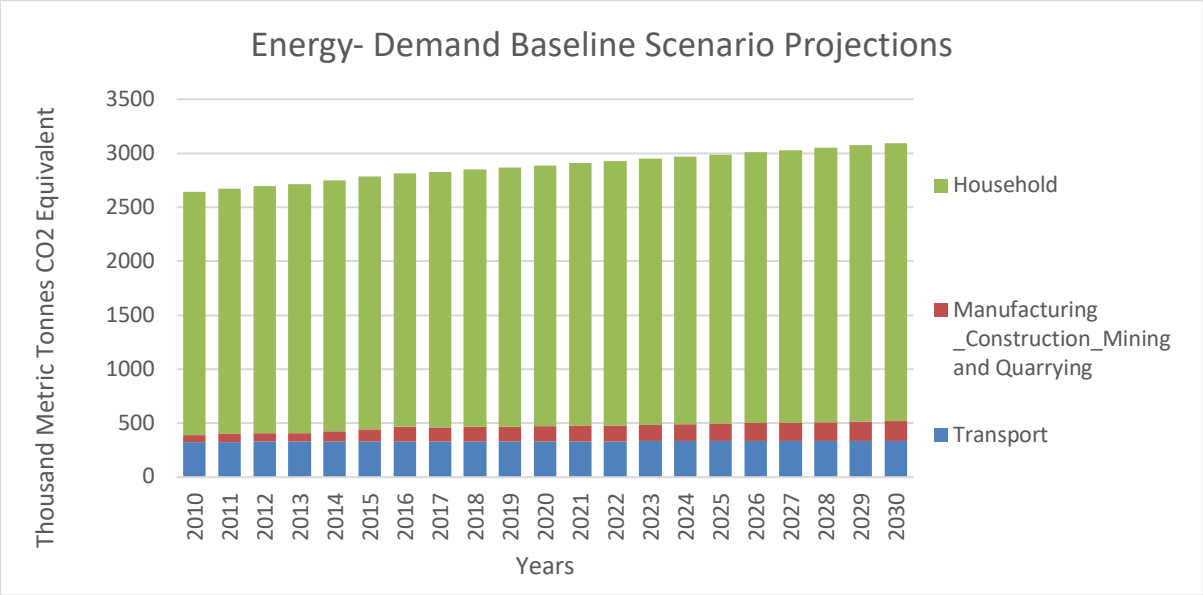

Figure 7: Energy Demand Baseline Scenario Projections Per Sector (2010-2030)

Table 8: Energy demand Baseline Scenario Projections per Sectors (2010-2030)

Energy demand sectors	2010 ($ktCO_2e$)	2020 ($ktCO_2e$)	2030 ($ktCO_2e$)
Transport	324.8	331.9	336.3
Industry: Manufacturing, Construction, Mining and Quarrying	62.0	140.6	185.1
Household	2 257.6	2 414.7	2 571.8
Total	2 644.5	2 887.2	3 093.2

3.2.1.1 Transportation

Figure 7 and Table 6 depict that transportation is the second largest contributor to the energy demand associated emissions and therefore is and will continue to be the most important

source of emissions. Between 2010 and 2030, emissions were projected to increase from 324.8 ktco2e to 336.3ktco2e which is about 4 % of the increase (Figure 8). However, due to lack of national data on number of vehicles as explained under key assumptions and drivers' Section *3.1.3*, there are uncertainties associated with transportation emissions projection. In 2030, passenger's transportation will account for about 51 % of the total emissions, while 48 % will be from freight and 1 % aviation. Private vehicles also referred to as Cars (Figure 9) will account for about 58 % of passenger's transportation emissions by 2030 under the baseline scenario.

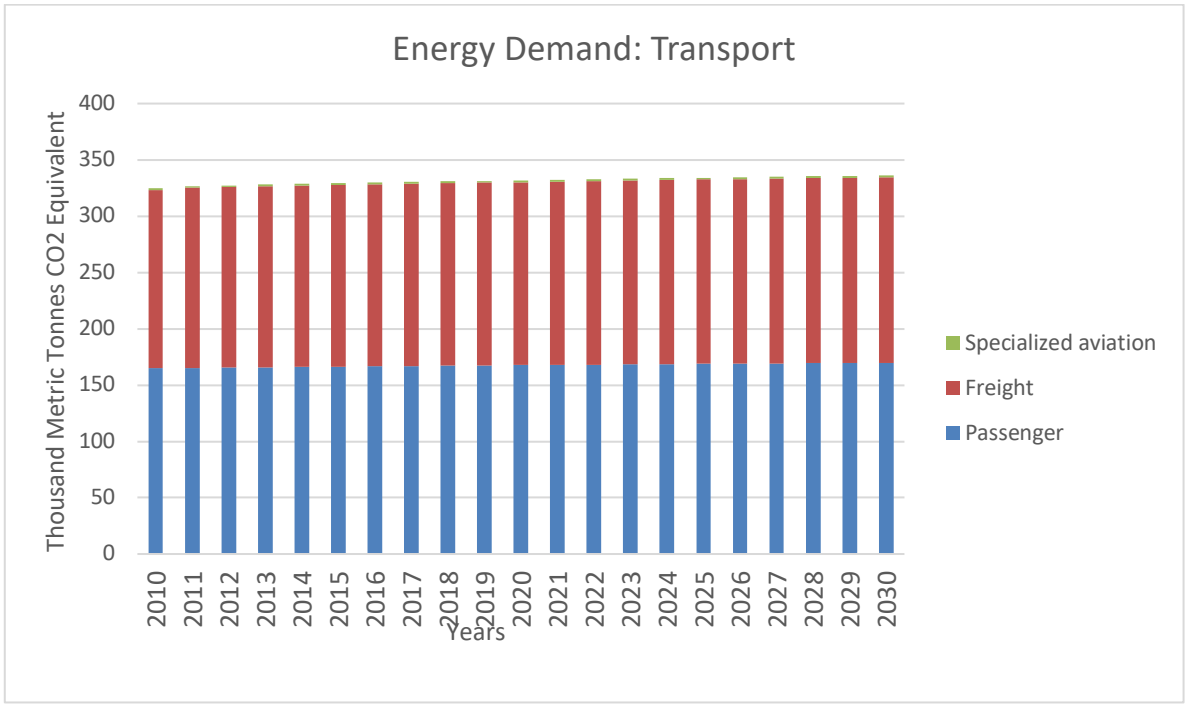

Figure 8: Transportation Baseline Scenario Emission Trajectory

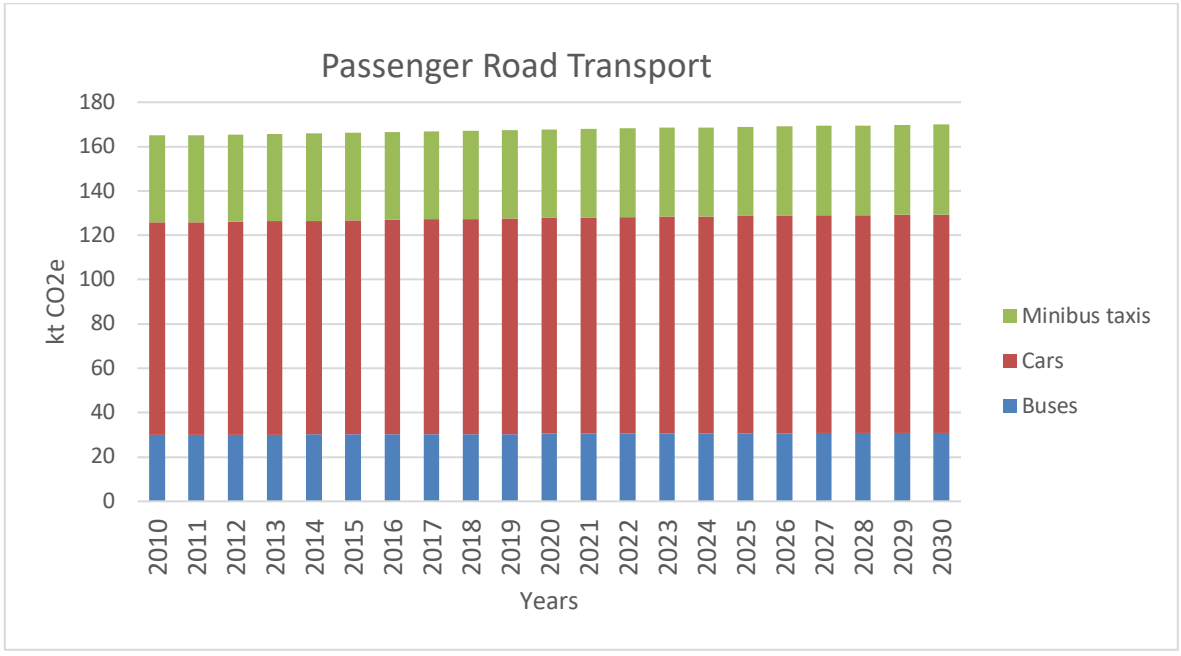

Figure 9: Road Road/ Passenger's Transportation

3.2.2 Non- Energy Baseline Trajectory

Emissions from non-energy sources accounted for 49% of Lesotho's emissions in 2010 and are expected to account for 46% of Lesotho's emissions in 2030 under the baseline scenario. About 3% decrease is projected during the projection period 2010- 2030. These emissions are from LULUCF, Biomass Burning, Agricultural Soils, Livestock, and Industrial Processes and Product Use (IPPU) (Figure 10, Table 9). IPPU emissions are only composed of emissions from brick manufacturing.

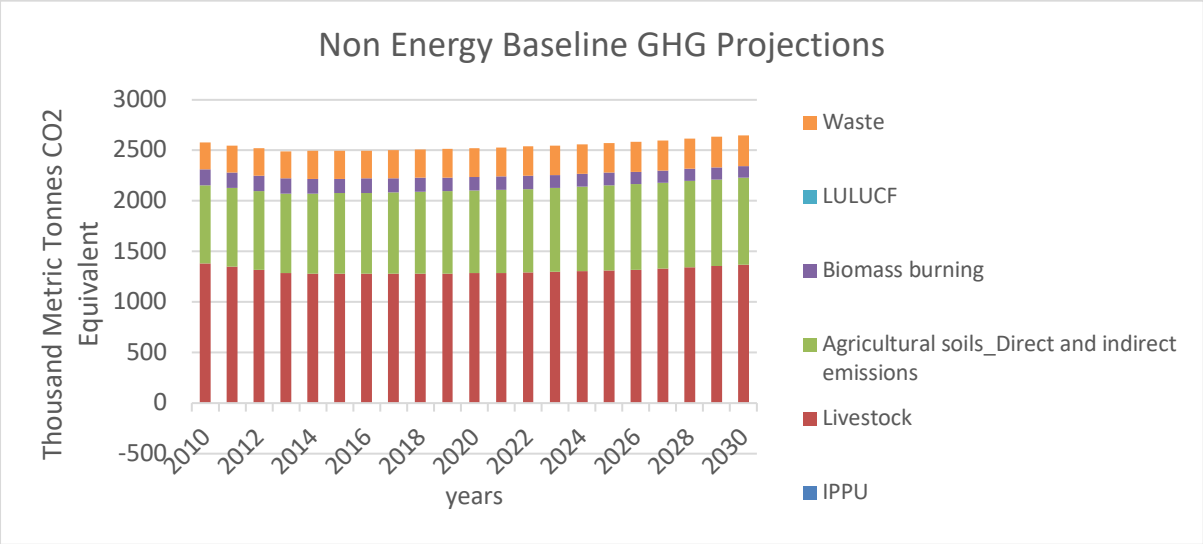

Figure 10: Non-Energy baseline greenhouse gas projections

Table 9: Non-Energy baseline greenhouse gas projections

Non- Energy Sectors		2010($ktCO_2e$)	2020 ($ktCO_2e$)	2030 ($ktCO_2e$
IPPU	Brick Manufacturing	0.8	1.3	1.8
AFOLU	Livestock	1 382.4	1 282.3	1 366.3
	Agricultural soils- Direct and indirect emissions	772.4	817.9	863.4
	Biomass burning	154.5	135.2	115.8
	LULUCF	- 7.5	- 5.7	-3.9
Waste		266.2	284.7	303.3
Total		2 568.9	2 515.7	2 646.8

3.2.2.1 Livestock Baseline Emissions

Livestock emissions make up to 54% (= 1382.42 $ktCO_2e$) of the non- energy baseline emissions for the base year 2010 and are expected to decrease by about 2% (=1366.28 $ktCO_2e$) by 2030 as indicated in Table 9. Livestock emissions are mostly made up of methane emissions from enteric fermentation and manure management, and nitrogen oxide emissions from manure management. 64% (889.0 $ktCO_2e$ in 2010) of livestock emissions are from enteric fermentation. These emissions are expected to decrease to 58.2 $ktCO_2e$ by 2030. Table 10 and Figure 12 depict a decline in enteric fermentation emissions from non-dairy cows, horses,

mules and asses by 2030. The enteric fermentation emission trends could be attributed to the decline in livestock population numbers especially non-dairy cows as they account for the largest share of the baseline emissions.

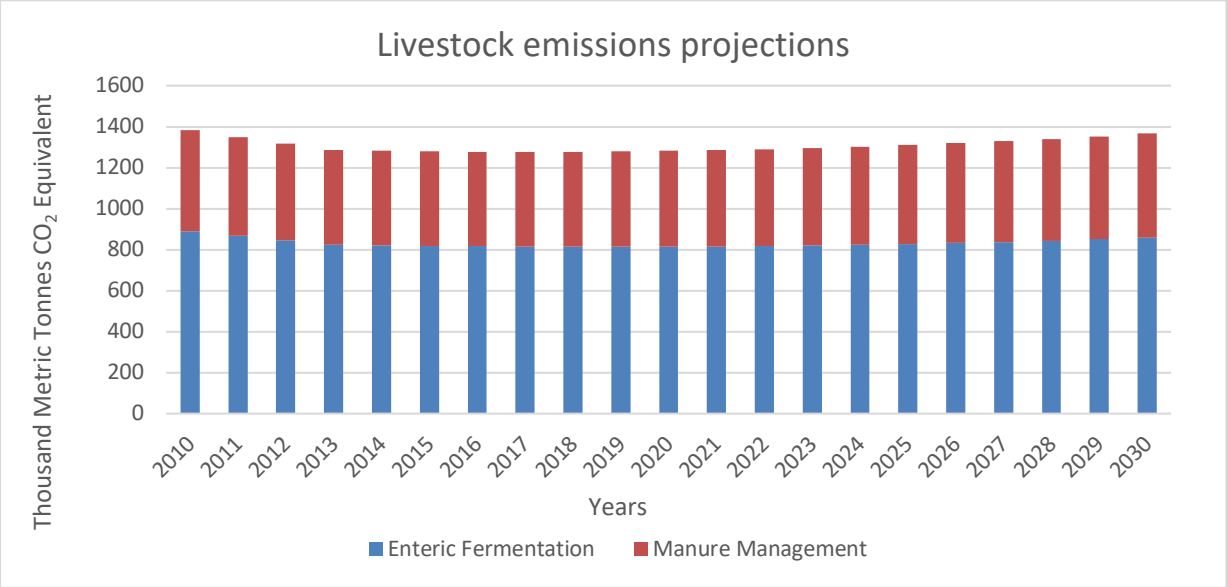

Figure 11: Livestock Baseline Emissions Projection

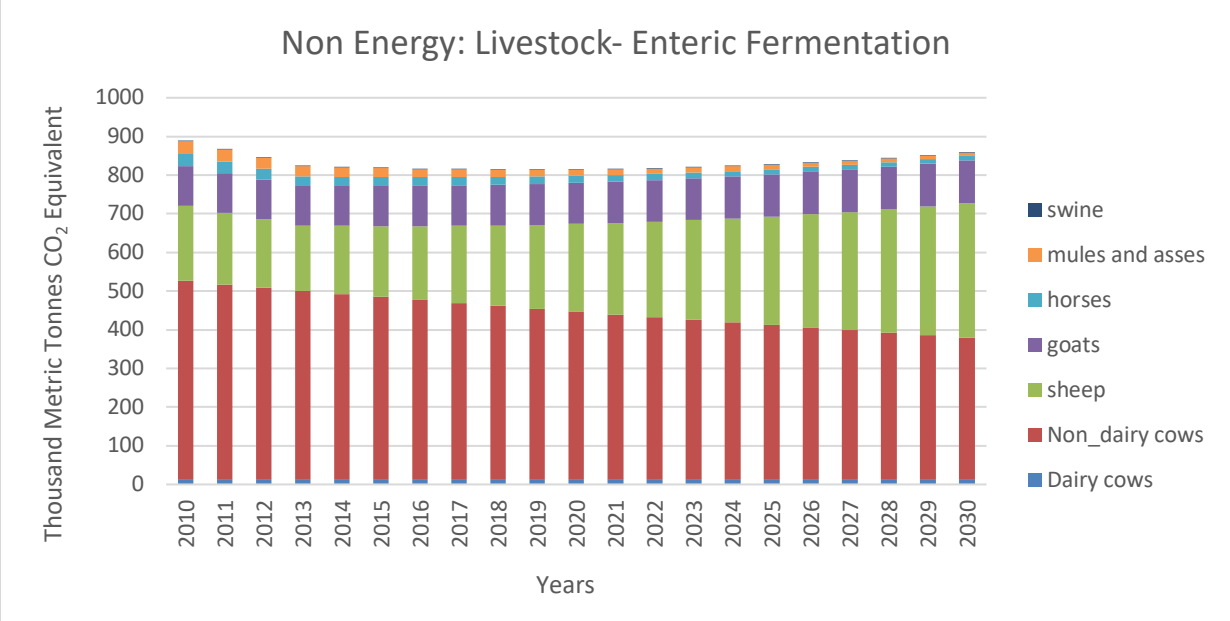

Figure 12: Enteric Fermentation Baseline Emissions

Table 10: Livestock Enteric Fermentation Baseline Projections

Livestock	2010($ktCO_2e$)	2020 ($ktCO_2e$)	2030 ($ktCO_2e$)
Dairy cows	12.2	12.4	12.5
Non-dairy cows	513.8	434.6	367.6
sheep	194.0	226.8	347.2
goats	102.6	106.5	111.5
horses	31.4	17.7	10.8
mules and asses	34.1	16.1	8.2

swine	0.9	0.6	0.5
Total	889.1	814.6	858.2

3.2.2.2 Waste Baseline Projections

Emissions from the waste sector are primarily from methane from wastewater treatment which accounts for about 90 % of total emissions for the base year 2010. Under the baseline scenario, these emissions are expected to increase from 266.20 $ktCO_2e$ in 2010 to 303.26 $ktCO_2e$ in 2030 (Figure 13) due to population increase. Table 11 presents the emissions under the baseline scenario for the waste sector.

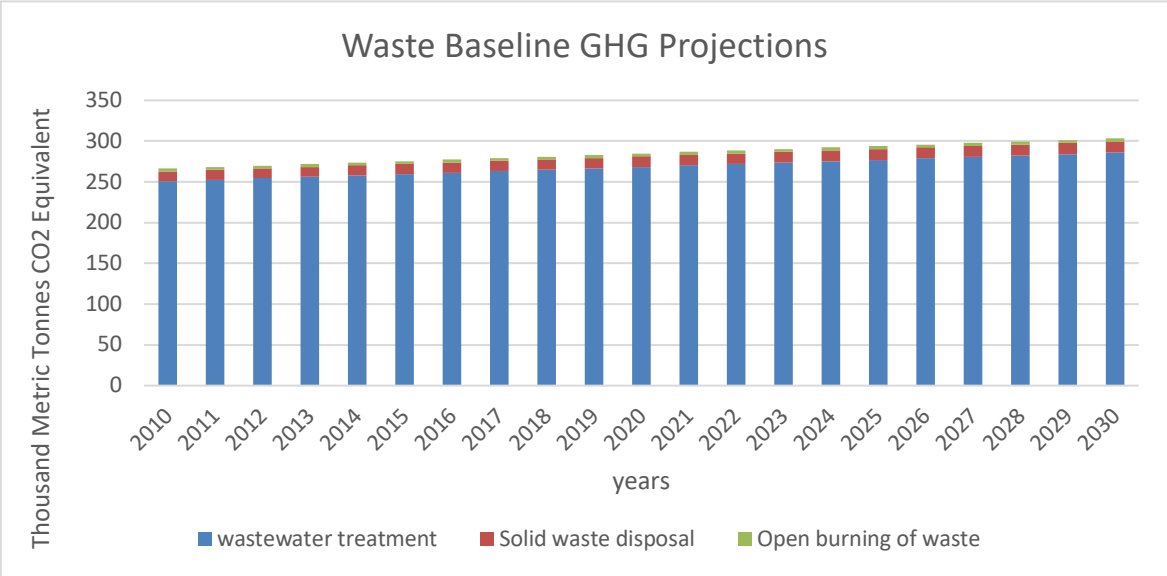

Figure 13: waste Sector Baseline Projection Emissions

Table 11: Waste Baseline Emissions

	2010 ($ktCO_2e$)	2020 ($ktCO_2e$)	2030 ($ktCO_2e$)
Solid waste disposal	12.1	12.9	13.8
Open burning of waste	3.3	3.5	3.7
wastewater treatment	250.9	268.3	285.8
Total	266.2	284.7	303.3

4 IDENTIFICATION, SCREENING AND SELECTION OF MITIGATION MEASURES

In order to develop a mitigation scenario, the individual potential mitigation measures were identified, assessed and screened before the final set of mitigation measures was selected. This chapter presents the steps taken in this selection process as well as the respective outcomes.

4.1 Individual Mitigation Options

A stakeholder workshop was convened for the identification and screening process, where stakeholders presented a list of mitigation measures per sector, based on existing climate-related policies and strategies, as well as the stakeholders' sectoral insights and expertise. An initial list was composed of 42 measures, only presented as titles with no detailed descriptions. The first step in the selection process was to screen and compile a consolidated list of mitigation measures to be assessed based on the following criteria:

i. Whether the proposed measures actually lead to a reduction of GHG emissions or an increase in carbon sinks;
ii. Whether the measures are not duplicates of others;
iii. Whether some measures cannot be better implemented in combination with others, and
iv. The feasibility of implementing the mitigation measures in Lesotho based on expert judgement.

This initial screening reduced the number of mitigation measures to be assessed to 28 as shown in Table 12 below. The Table presents the detailed descriptions of the mitigation measures as well as the key assumptions used in modelling of their mitigation potential and cost of implementation.

Table 12: Description and assumptions of individual mitigation measures

	No	Title	Description and assumptions
Aviation	1	**Efficient aircrafts**	Replacement of 4 old Mission Aviation Fellowship's (MAF) (1980 - 2982) Cessna 2016 G aircrafts with the new and more efficient Cessna 2016 H's.
	2	**Restrict aircraft age to 10 years**	Replacement of Mission Aviation Fellowship's (MAF) 4 old (1980 - 2982) Cessna 2016 G aircrafts with the new and more efficient Cessna 2016 H's every 10 years to ensure that the fleet is never older than 10 years old
Road Transport	3	**Restrict age of vehicle imports to 5 years**	All vehicle imports to be 5 years old or newer
	4	**Electric trains**	Construction and operation of a high-speed rail system similar to the Gautrain, from ha Foso Maseru, past the city centre to Roma (50km)
	5	**Bicycles**	20% of the country's population is supplied with bicycles once-off to use for their daily transport needs, instead of using motor vehicles (Only people using vehicles; No new bicycle lanes are constructed; cyclists share roads with motorists)

	No	Title	Description and assumptions
	6	**Bus Rapid Transit (BRT) system**	Construction and operation of a Bus Rapid Transit (BRT) System in Maseru, with infrastructure and operating conditions similar to those of Johannesburg's Rea Vaya Phases 1a & 1b BRT system.
	7	**Road expansion**	Expanding and upgrading 90% of the roads managed by the National Roads Directorate. It entails expanding the good roads, fixing the bad paved roads and paving the unpaved roads.
	8	**Motorcycles**	Incentivising the purchase and use of scooter motorcycles. Assumption: 20% of the population using private motor vehicles shift to scooters
	9	**Mandatory servicing of vehicles**	Mandatory vehicle servicing of all vehicles annually.
	10	**Each car restricted to one weekday per week**	With the exception of essential service vehicles (police, military, ambulances, etc.), each vehicle is allowed on the road only one weekday per week. All cars allowed on weekends
	11	**Walking to work**	20% of the Maseru City Central Business District (CBD) area is closed off to vehicles and converted to "Walking only" area to promote walking to work within the CBD
	12	**No vehicles on weekends**	With the exception of essential service vehicles (police, military, ambulances, etc.), no vehicles (passenger & freight) allowed on weekends at all
	13	**One car per household**	Households allowed to have a maximum of 1 private car. It is assumed that ALL the avoided car traffic is taken up by 5-seater cabs commonly referred to as "4+1s"
	14	**Drones to deliver small parcels**	Using electricity-charged drones for small parcel deliveries in the urban areas instead of Light Delivery Vehicles. NB: Drones have a maximum range of 3km & carrying capacity of 4kg. It is assumed that 5% of parcels are 4kg or under.
Household	15	**Wonderbags**	Introduction of wonderbags in households that use LPG, paraffin & wood for cooking & water heating
	16	**Solar cookers**	Introduction of bread solar cookers in households that use LPG for cooking
	17	**Solar Water Heaters (SWHs)**	introduction of Low-pressure Solar Water Heaters in households using LPG, paraffin and wood for water heating
AFOLU	18	**Ration formulation**	Ration formulation for ruminants and swine (feeding the animals with high quality feed) - 80% of ruminants grazing in public areas
	19	**Reduce number of non-productive animals**	Reduce number of non-productive animals (excl. poultry) - 15%
	20	**Grazing fees**	implement grazing fees (excl. chickens and swine) – Assumption: 80% grazing in public areas
	21	**Restricting grazing times to 4hrs**	Reduce grazing time of ruminants from 8 hours to 4 hours per day. This is achieved by restricting access to grazing areas (makhulo) to 4 hours
	22	**Decentralized manure biogas digestion**	Biogas digestion of animal dung / manure in decentralized constructed biogas digesters (Assumption: 25% of manure digested annually)

	No	Title	Description and assumptions
	23	**Composting**	Large-scale composting of animal manure (excl. chickens) & selling the compost. Using simple compost heaps and not composters
	24	**Cow dung for house construction**	Using dung from cows, horses & mules for building houses. Assumption: There is very little improvement in this area beyond what is currently happening since those who want to do that are already doing it; most people, especially in the cities do not want to do it.
	25	**Crop rotation & Conservation agriculture**	Implementing Crop rotation and Conservation Agriculture instead of traditional agriculture
	26	**Avoiding over-fertilization**	Avoid over-fertilisation of agricultural soils with synthetic fertilisers (Assumed 30% over-fertilisation currently)
	27	**Planting of indigenous trees**	To increase tree cover by 3.7% from 1.63% (49,478ha) to 5.4% of the total land area by 2017 (Forestry Strategic Plan 2014 -2017)
Waste	**28**	**Biogas production in Wastewater treatment Works (WWTWs)**	Centralised digestion of all wastewater that is treated in Wastewater Treatment Works, to produce biogas used for cooking in households. Assumption: the biogas replaces LPG.

4.2 Assessment and Selection

In order to determine the most appropriate mitigation measures to be included in the mitigation scenario, the measures were subjected to two types of assessments:

i) The Marginal Abatement Cost assessment, and
ii) The Multi-criteria assessment.

Each of these is presented in detail in the sections below.

The two common inputs of these assessments are the mitigation potential and the implementation costs of the identified mitigation measures, which were determined for the period 2011 – 2030, based on the assumptions outlined in Table 12 above. Figure 14 below presents the mitigation potentials of all the identified measures, arranged from highest to lowest potential.

The planting of indigenous trees and restriction of vehicles to one weekday per week on the road have the highest mitigation potential at 9,574 $ktCO_2e$ and 9,482 $ktCO_2e$ respectively. These are followed by restriction of grazing times to 4 hours and crop rotation coupled with conservation agriculture at 5,689 $ktCO_2e$ and 4,935 $ktCO_2e$ respectively. In descending order, the three mitigation measures with the least mitigation potential are restricting aircraft age to ten years (12.08 $ktCO_2e$), replacing old aircrafts with efficient ones (10.72 $ktCO_2e$) and using animal dung for construction of houses (3.45 $ktCO_2e$).

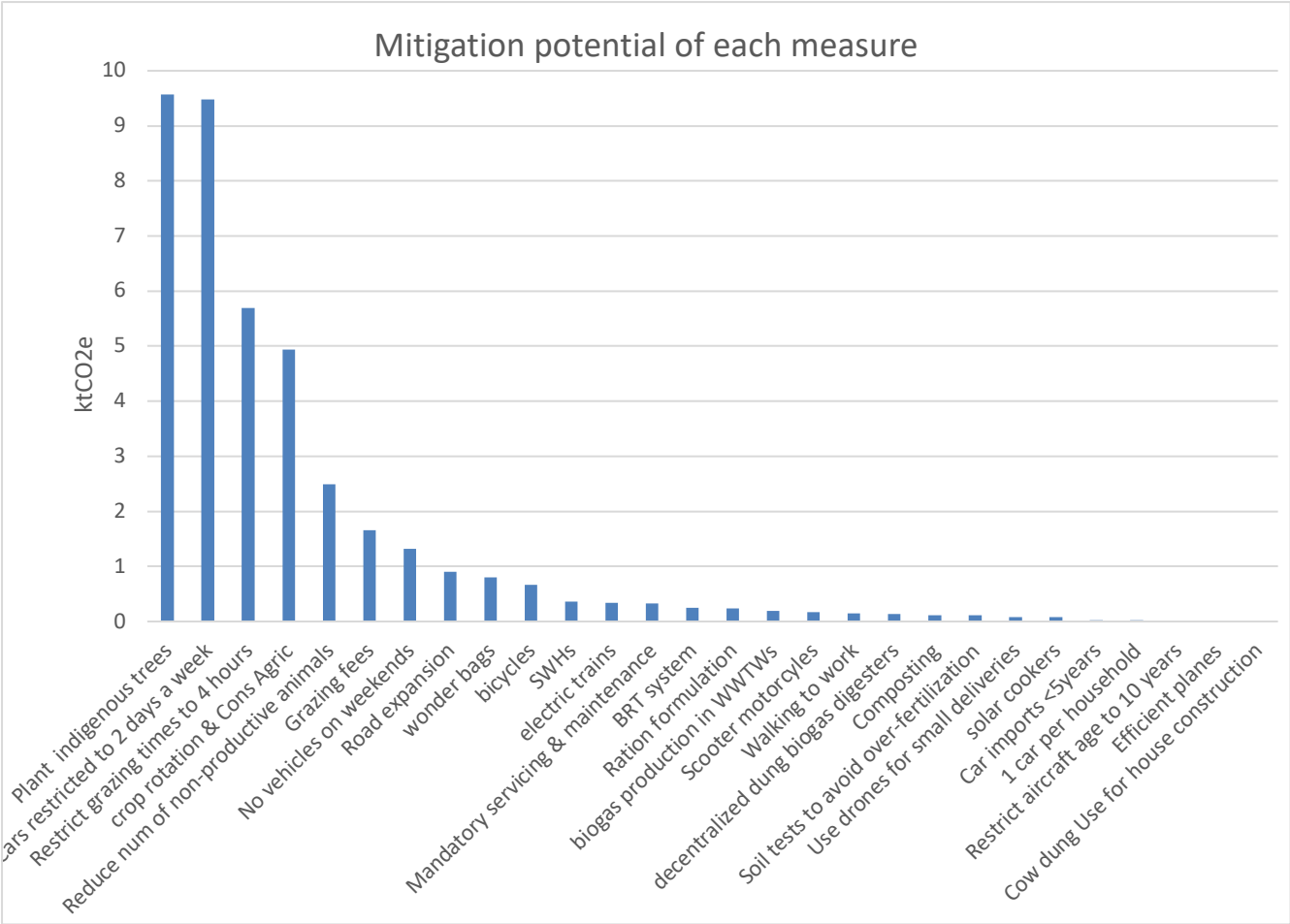

Figure 14: Mitigation potential of each measure

In terms of total implementation costs, road expansion and electric trains are the two most expensive individual mitigation actions at M 51.66 billion and M 12.5 billion respectively. These costs comprise both investment and operational costs. On the other hand, composting is the cheapest mitigation measure with the potential of saving the country a total of M 4.86 billion compared to the baseline scenario. This is followed by the use of bicycles and wonderbags with the potential of saving M 2.36 billion and M 2.22 billion respectively.

Mitigation potential and total implementation costs of mitigation measures on their own, however, are not good criteria for comparing the measures. Instead, a criteria of marginal abatement cost, combining mitigation potential and total implementation cost is usually used. This is presented in the next section.

4.2.1 Marginal Abatement Cost

Marginal Abatement Cost is a measure of the cost effectiveness of the mitigation measure. It depicts the cost of reducing one tonne of CO_2e emissions, and is calculated as per the equation below:

$$Marginal\ Abatement\ Cost = \frac{Net\ implementation\ cost\ in\ LSL\ (Mitigation\ cost - baseline\ cost)}{Total\ mitigation\ potential\ in\ tCO2e}.$$

Figure 15 below presents Lesotho's Marginal Abatement Cost Curve (MACC) based on the identified mitigation measures. It compares the mitigation measures on their cost-effectiveness of mitigating GHG emissions on the y-axis and their potential to mitigate on the x-axis. The mitigation measures are ordered from the most cost-effective on the left to the least cost-effective on the far right. Negative values mean net savings compared to baseline. The Figure shows that based on cost-effectiveness alone, it is advisable to implement composting first (since it saves M41 274 / tCO_2e), followed by walking to work (it saves M3 771 / tCO_2e), while restricting car imports to five years and below should be the last mitigation measure to be implemented, if at all necessary (it costs M81 861 / tCO_2e) . The measure with the highest mitigation potential, planting indigenous trees, comes at a marginal abatement cost of M2 / tCO_2e.

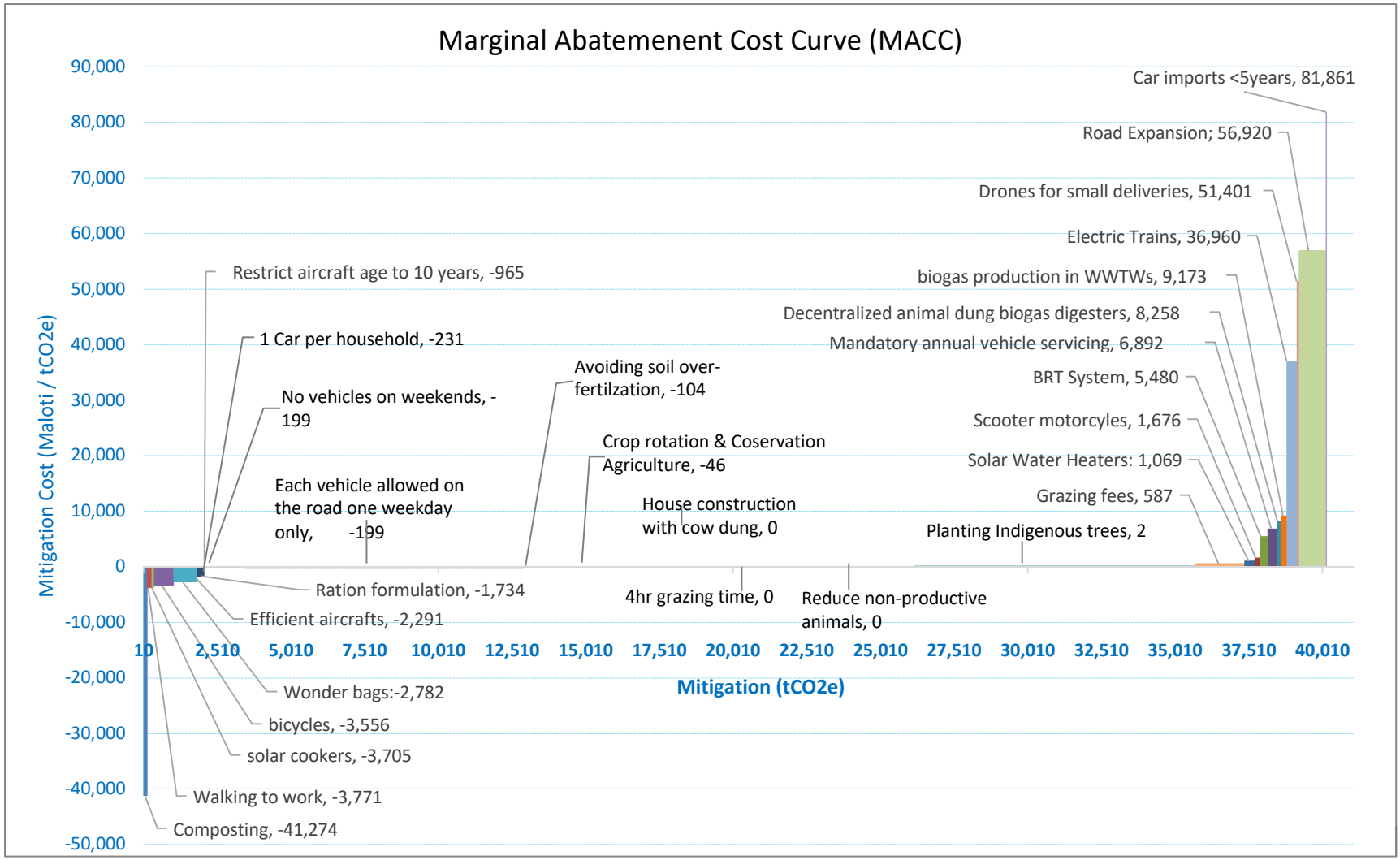

Figure 15: The Marginal Abatement Cost Curve (MACC)

4.2.2 Multi Criteria Assessment

Lesotho, like all other countries, is always weighing and balancing multiple objectives hence the cost-effectiveness and mitigation potential of mitigation measures cannot be the only factors that determine the appropriateness of mitigation measures for the country. As a result, the stakeholders identified six other criteria, in addition to cost and mitigation potential, which the mitigation measures need to be compared on. Table 13 below presents all the criteria used in the multi-criteria assessment as well as their allocated weights.

Table 13: Multiple criteria used for screening mitigation measures

CRITERIA	Allocated Weights (%)
1. Mitigation potential	20
2. Net implementation cost	15
3. Potential for poverty alleviation	30
4. Technical Feasibility	10
5. Potential for improving air quality	8
6. Political and social Popularity	7
7. Reliance on Domestic Energy Sources	6
8. Ability to boost other sectors	4
TOTAL	**100**

In this assessment, the stakeholders first allocated weightings to the various criteria, based on their relative importance for the country, after which they collectively scored each mitigation measure on the six criteria from zero to ten (0=bad, 10=good).

Among all the criteria, the potential for mitigation measures to alleviate poverty was considered the most important for the country and therefore allocated the highest weight of 30%, while the ability to boost other sectors was allocated the least weight of 4%. Mitigation potential and cost were automatically scored based on their calculated values from the preceding assessment, with the highest value designated ten, the smallest value designated zero and the rest of the values in between allocated weighted scores based on their relative proximity to the highest and lowest values. Mitigation potential and cost were allocated weightings of 20% and 15% respectively.

Figure 16 below and Appendix C present the results of the multi-criteria assessment. Planting of indigenous trees attained the highest overall score of 8.9, followed by Crop rotation and Conservation Agriculture at 6.7. Efficient planes and No vehicles on weekends scored lowest at 3.5. A total of 12 mitigation options made it above the desirability threshold score of five: Bicycles (5.5); Road Expansion (5.1); Mandatory servicing of vehicles (5.03); Walking to work (5.1); Wonderbags (5.3); Solar cookers (5.7); Solar Water Heaters (5.6); Biogas production in WWTWs (6.1); Decentralized animal dung biogas digesters (6.1); Crop rotation and conservation Agriculture (6.7); Avoiding over fertilization (5.8) and planting indigenous trees (8.9). These mitigation measures will form part the mitigation scenario.

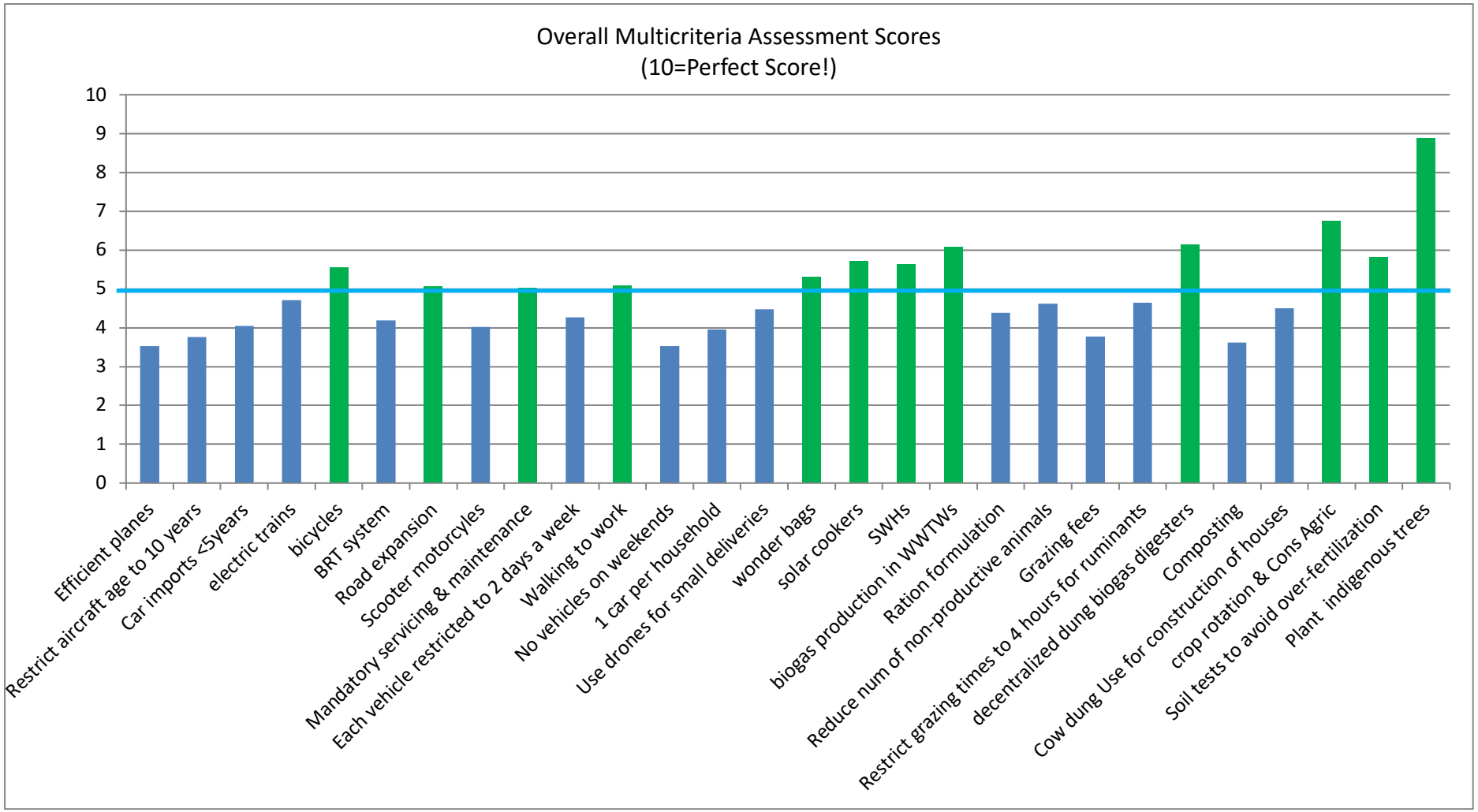

Figure 16: Results of the multi-criteria assessment

5 MITIGATION SCENARIO

While the assessment of mitigation measures in this project was based on mitigation potential in the various sectors for the period of 2011 to 2030, two alternative mitigation scenarios have been presented in this chapter, depending on the year in which implementation of mitigation measures is done:

i. Mitigation scenario assuming mitigation measures are implemented from 2011, and
ii. Mitigation scenario assuming mitigation measures are implemented from 2020. This assumes that no mitigation measures were implemented between 2011 and 2019.

5.1 2011 – 2030 Mitigation Scenario

Figure 17 presents the total annual mitigation potential of implementing the 12 most appropriate mitigation measures for the country between 2011 and 2030. The total mitigation potential starts off at 503 $ktCO_2e$ in the first year and increases to 1 142 $ktCO_2e$ in 2017 and finally to 1 183 $ktCO_2e$ by 2030.

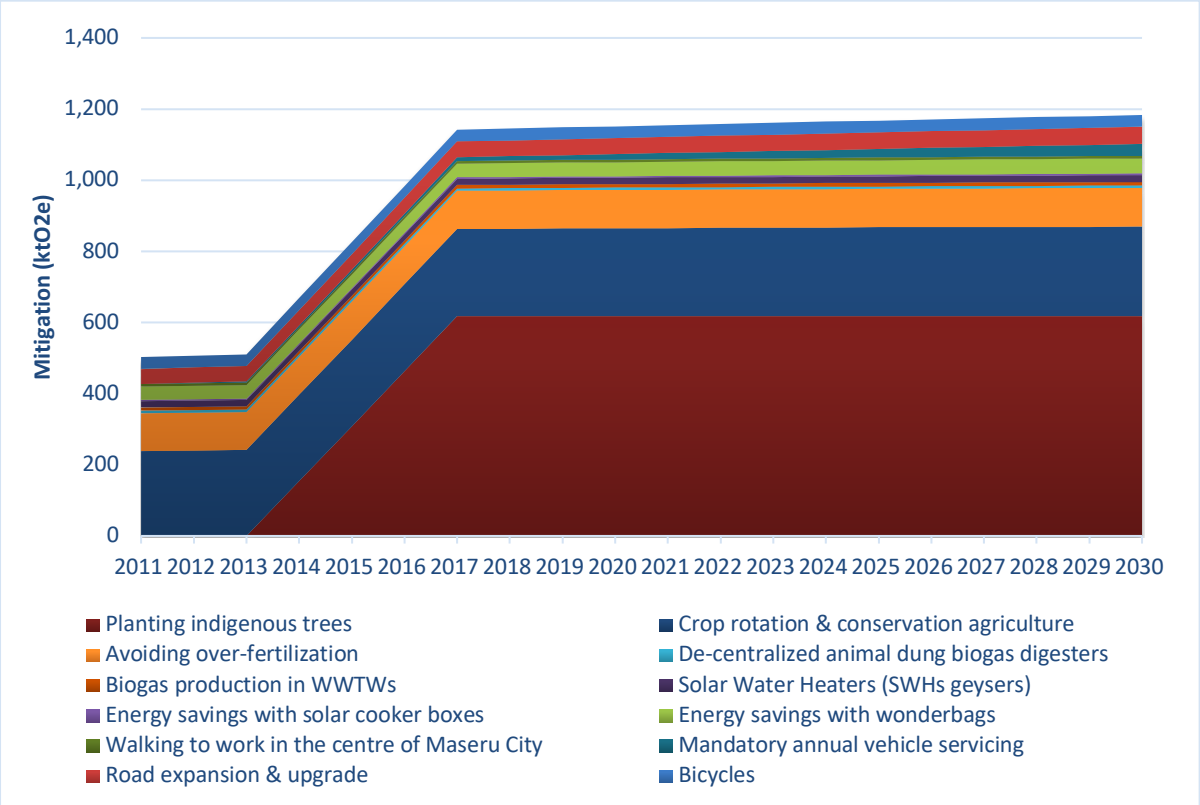

Figure 17: Mitigation potential of the 12 selected measures between 2011 and 2030

The total cumulative mitigation for the entire period amounts to 20 276 $ktCO_2e$. The planting of indigenous trees is the highest contributor at 47.22%, followed by crop rotation coupled with conservation agriculture at 24.34%. The least contributor is the introduction of solar cooker boxes at 0.41%. Of the twelve mitigation measures, four primarily mitigate emissions

in the AFOLU sector, four address the transport sector, three address household energy emissions while one focuses on the waste sector.

The difference between the baseline scenario and the total mitigation potential results in the mitigation scenario of the country as shown in Figure 18 below. Figure 19 compares mitigation scenario with the baseline emissions since the first GHG inventory in 1994. Under the mitigation scenario, the emissions are reduced to 4 712 $ktCO_2e$ in 2011 (from 5 215 $ktCO_2e$) and ultimately to 4 557 $ktCO_2e$ from 5 740 $ktCO_2e$ by 2030. This implies a 20.6% reduction from baseline. The net implementation cost of this mitigation scenario is estimated at M51.3 billion.

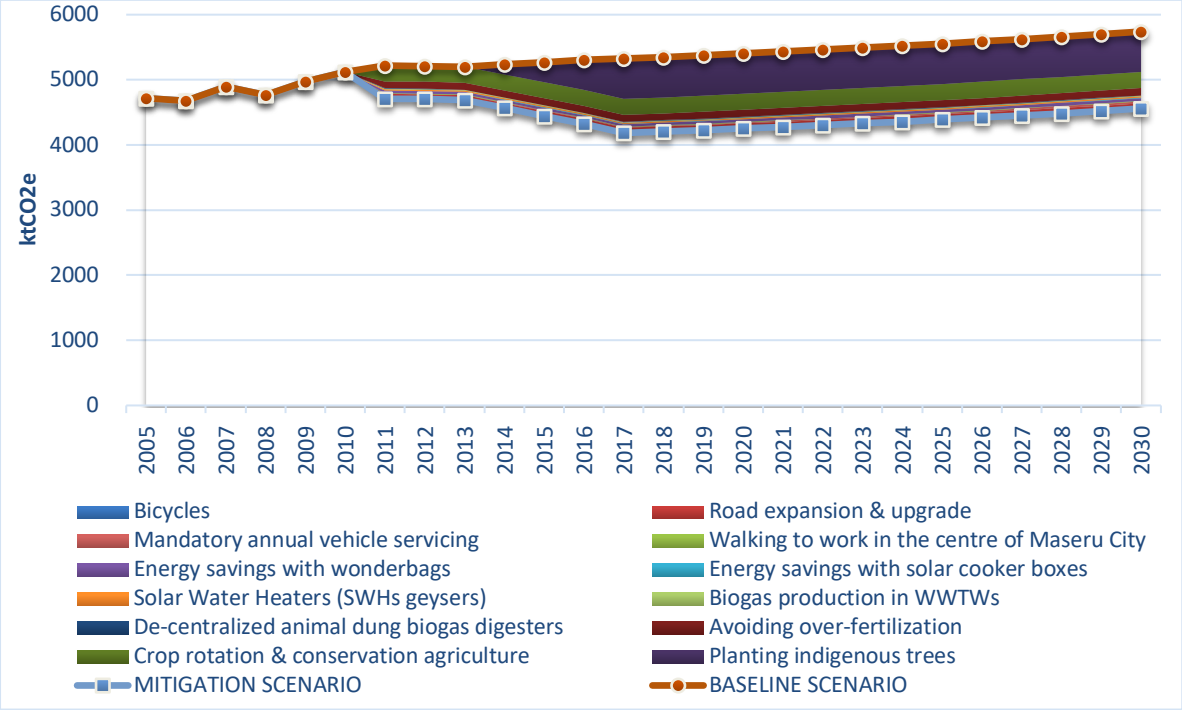

Figure 18: Development of the mitigation scenario

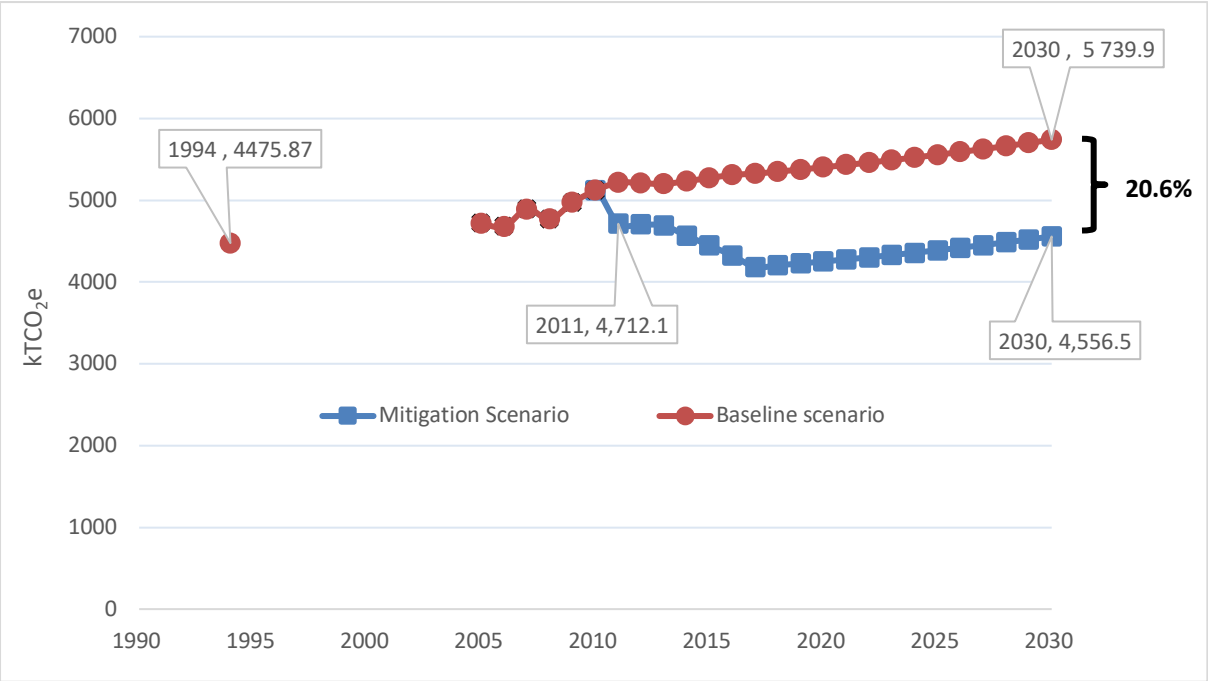

Figure 19: The 2011 – 2030 mitigation scenario compared with the baseline scenario

5.2 2020 – 2030 Mitigation Scenario

In this version of the mitigation scenario, implementation is assumed to only start in 2020 as shown in Figure 20.

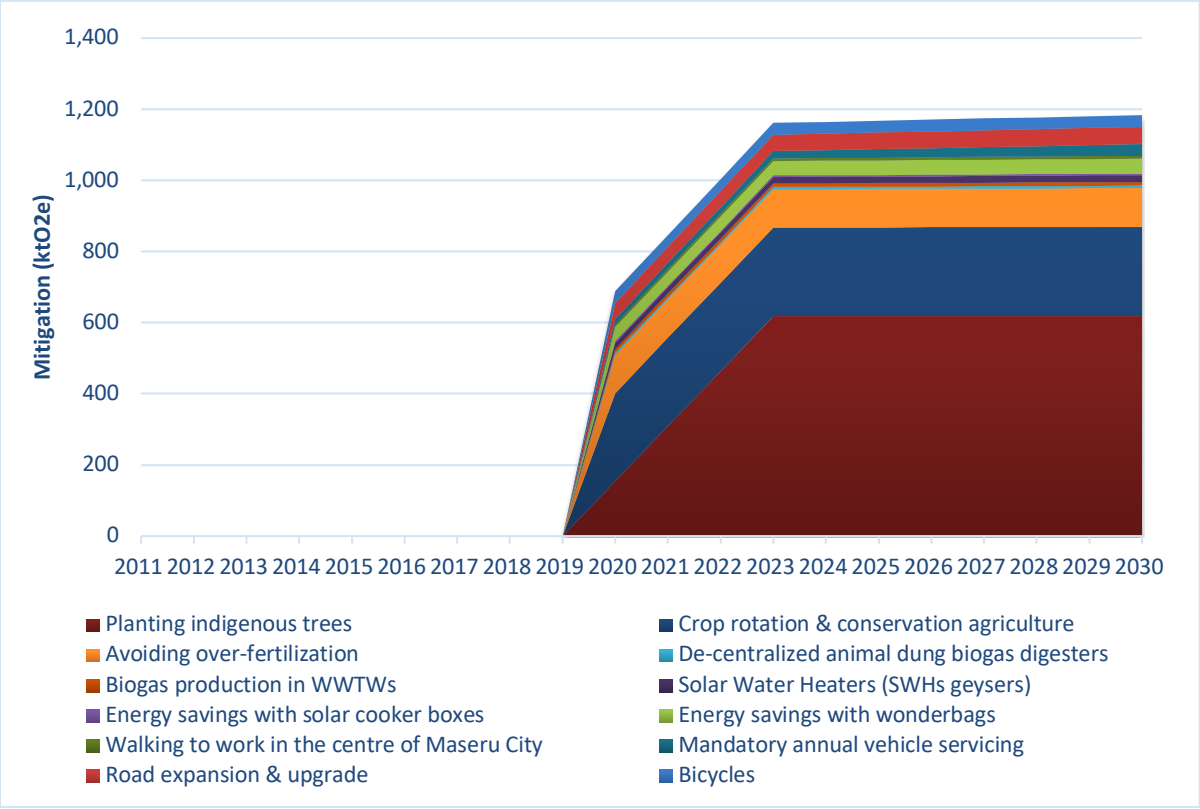

Figure 20: Mitigation potential of the selected mitigation measures implemented from 2020

The mitigation scenario is made up of the same 12 mitigation measures that make up the 2011 – 2030 mitigation scenario, but the mitigation potential starts off at 688 $ktCO_2e$ in 2020 and reaches a maximum of 1 183 $ktCO_2e$ by 2030. The total cumulative potential between 2020 and 2030 is 11 917 $ktCO_2e$.

Figure 21 below presents the 2020 – 2030 mitigation scenario, and compares it with the baseline scenario. Under this mitigation scenario emissions are reduced from 5 403 ktCO2e to 4 714 ktCO2e in 2020 and from 5 740 ktCO2e to 4 557 ktCO2e in 2030. This is also a 20.6% reduction from baseline.

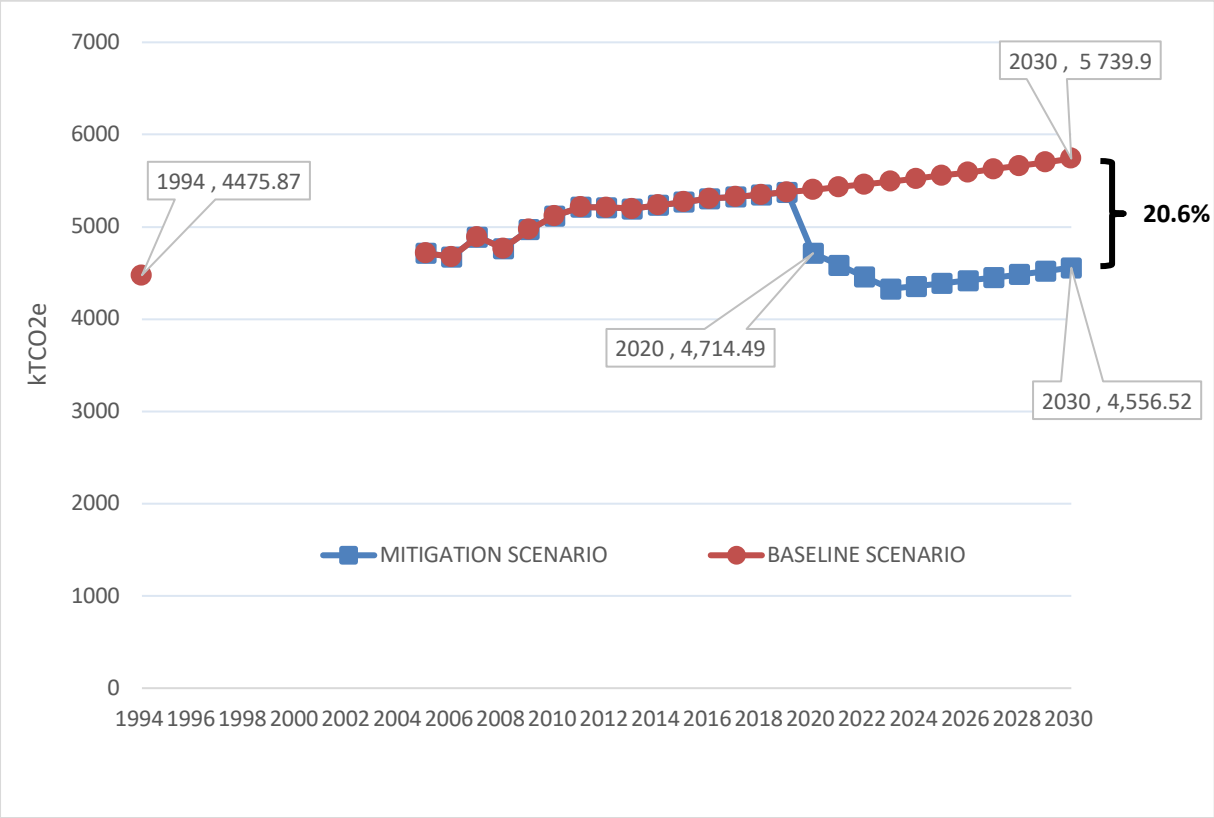

Figure 21: The 2020 – 2030 mitigation scenario compared with the baseline scenario

5.3 Benchmarking

The NDC submitted by Lesotho under the UNFCCC was used to benchmark the emission reduction potential determined in this study. Figure 22 is an extract from Lesotho's submitted NDC, showing the conditional and unconditional mitigation scenarios, while Figure 23 compares the reductions from those scenarios with the reduction of the mitigation scenarios in this study by 2030.

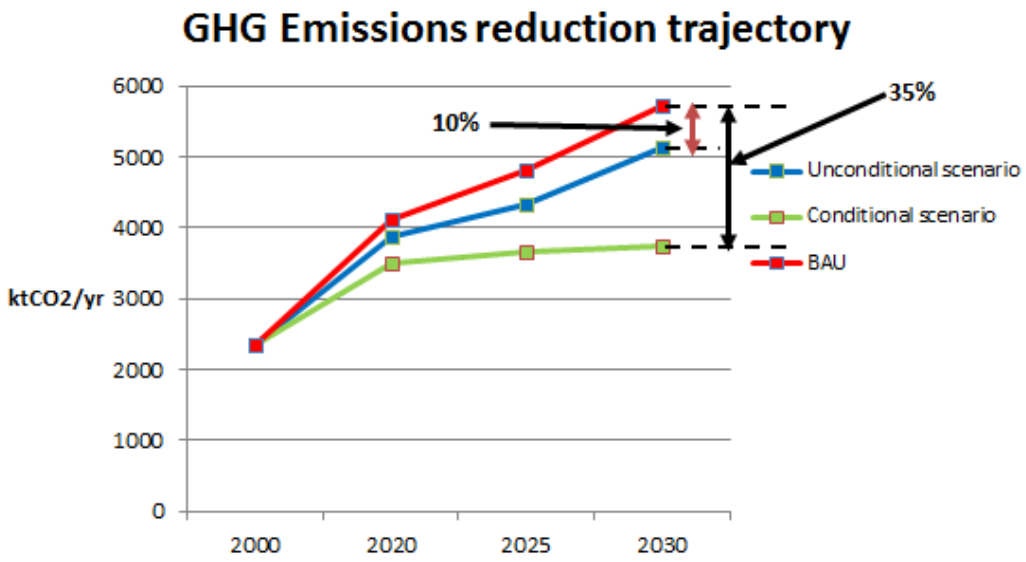

Figure 22: Lesotho's GHG emissions reduction trajectories in the NDC

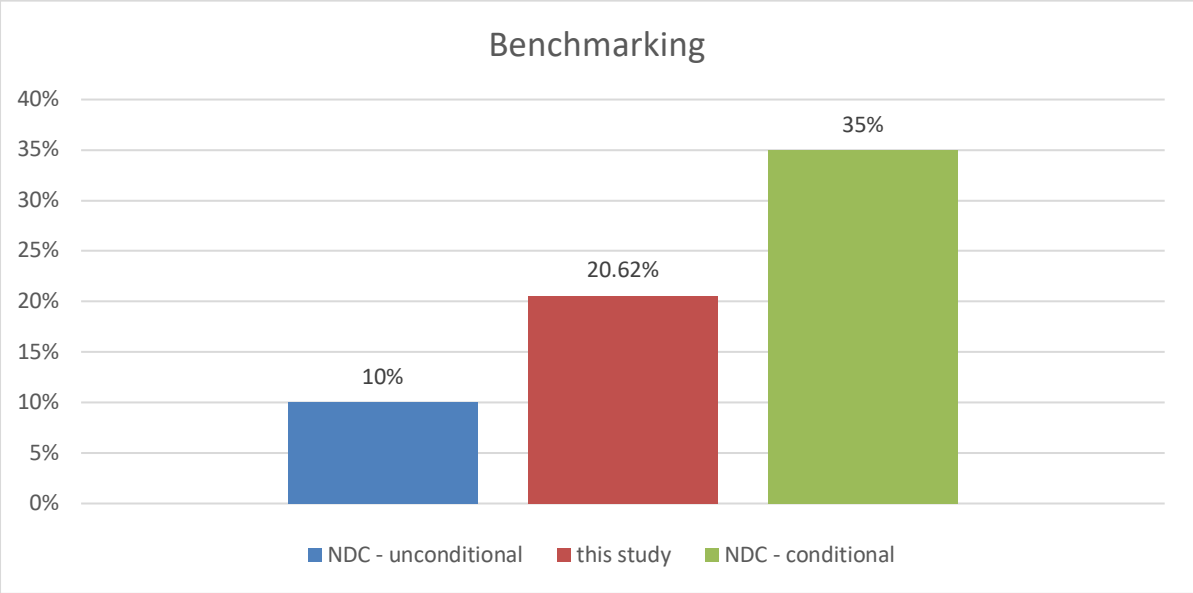

Figure 23: Comparison of the GHG reductions in this study and in the NDC

The benchmarking exercise shows that the mitigation scenario determined in this study is more than sufficient to achieve Lesotho's unconditional NDC target of 10%, but not sufficient to achieve its conditional target of 35%. The 10% unconditional target could be achieved at a net saving of M5.9 billion, through the mitigation measures shown in Table 14 below.

Table 14: The mitigation measures & costs that could be used to achieve Lesotho's unconditional NDC target

I	Mitigation Measure	**Net implementation cost (Million Maloti)** (Mitigation – baseline cost)
1	Bicycles	-2 361
2	Walking to work in the centre of Maseru City	-549
3	Energy savings with wonderbags	-2 221
4	Energy savings with solar cooker boxes	-312

5	Avoiding over-fertilization	-223
6	Crop rotation & conservation agriculture	-227
7	Planting indigenous trees	3.4
	TOTAL	- **5 889**

This is the most effective way of achieving the 10% unconditional target, based on the results of the multi-criteria analysis. Achievement of the unconditional target of 35% would require additional mitigation measures over and above the 12 selected through the multi-criteria analysis.

6 Constraints, Gaps and Recommendations

Data collection was affected by numerous challenges encountered. As it is the case with many other developing countries, Lesotho experiences challenges of weak and fragmented data base. In addition to the poor state of database are problems posed by the inconsistent, unsystematic and unstandardized presentation of data, lack of update and series data in many socio-economic sectors, low national data collection capabilities, and the general unreliability of methodologies used. The following specific constraints and challenges were encountered:

a. **Vehicle statistics**: Of much limitation was lack of national data on number, type, model of vehicles, for which assumptions that were made under the third GHG inventory report and other studies had to be used as the sole basis for modelling the baseline scenario. It is recommended that accurate vehicle statistics be obtained and used in the next modelling process.
b. **Disaggregated energy balances**: The unavailability of disaggregated national energy balances was also a key constraint to this project. Accurate disaggregated national energy balances show the type and amount of energy consumed by each sector of the economy, hence making it possible to accurately determine the impact that each individual mitigation intervention can have on each sector, and collectively on the national GHG emissions. It is recommended that annual disaggregated national energy balances be compiled to enable improved mitigation assessments in the future.
c. **Mitigation option in the power generation sector**: the national stakeholders that were involved in this mitigation assessment did not include mitigation options in the electricity sector. The inclusion of such options in future assessments my enhance the results, especially because the country's submitted NDC under the UNFCCC focused primarily on emission reduction through renewable electricity generation sources.
d. **GHG Inventory improvement**: The national GHG inventory plays a critical role in mitigation assessment, particularly in baseline development because it is the starting point for making baseline projections. Thus the more accurate, complete and consistent the GHG inventory is, the better the results of the mitigation assessment can be. While the 3rd National GHG inventory as a basis for this mitigation assessment was a significant improvement from the previous GHG inventories, there remained lots of areas where accuracy, completeness and consistency could be improved. It is thus recommended that a GHG improvement programme be developed to aid in the continuous improvement of national GHG inventories for the country.

APPENDICES

APPENDIX A: Key Assumption for Baseline Scenario Modelling

	2010	Projected Change up to 2030
population	1,926,761 people	2, 194,894 people (Linear extrapolation)
Household size	4 people	
Number of households	481,690 population per household size	
Private car occupancy	1.4	
Bus occupancy	25	
Minibus occupancy	14	
Motorcycle	1.1	
Light Duty Vehicles (LDV)	1	
Heavy Duty Vehicles (HDV)	9	
Bus petrol consumption	0.49	0.5% growth rate
Bus diesel consumption	0.45	0.5% growth rate
Car petrol consumption	0.10	0.5% growth rate
Car diesel consumption	0.08	0.5% growth rate
Motorcycle	0.04	0.5% growth rate
LDV petrol consumption	0.10	0.5% growth rate
LDV petrol consumption	0.08	0.5% growth rate
Truck petrol consumption	0.20	0.5% growth rate
Truck diesel consumption	0.36	0.5% growth rate
Manufacturing Industries	2491 (GDP Contribution Million Maloti)	1.07% - Growth Rate
Construction industries only	1211 (GDP Contribution Million Maloti)	3.73%- Growth Rate
Mining & quarrying	893 (GDP Contribution Million Maloti)	4.83%- Growth Rate

	2010	Projected Change up to 2030
Dairy cows	11,000	0.11% growth rate
Non-dairy cows	663,000	-1.6% growth rate
Sheep	1,552,000	2,777,000 (Linear extrapolation,)
Goats	821,000	892,000(Linear extrapolation)
Horses	70,000	24,000 (Linear extrapolation)
Mules and Asses	136,000	33,000 (Linear extrapolation)
Swine	36,000	19,000 (Linear extrapolation)
Poultry	55,000	55,000(Linear extrapolation)

APPENDIX B: Projected number of animals in the baseline scenario

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Dairy cows	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Non-dairy cows	663	652	641	631	620	610	600	590	580	570	561	552	542	533	524	516	507	499	491	482	474
Sheep	1 552	1 484	1 415	1 347	1 405	1 466	1 530	1 597	1 666	1 739	1 814	1 893	1 975	2 061	2 151	2 245	2 342	2 444	2 550	2 661	2 777
Goats	821	822	824	825	828	832	836	840	844	848	852	856	859	863	867	871	875	879	883	888	892
Horses	70	65	60	55	53	50	48	45	43	41	39	37	36	34	32	31	29	28	26	25	24
Mules and Asses	136	125	115	104	97	91	85	79	74	69	65	60	56	53	49	46	43	40	37	35	33
Swine	36	33	31	29	28	27	27	26	26	25	24	24	23	23	22	22	21	21	20	20	19
Poultry	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55

APPENDIX C: Multi-criteria Assessment Scores

SUB-SECTOR	TRANSPORT													
Group	Aviation		Road											
CRITERIA / MITIGATION ACTION	Efficient planes	Restrict aircraft age to 10 years	Car imports <5years	electric trains	bicycles	BRT system	Road expansion	Scooters	Mandatory servicing	Each vehicle restricted to 1 weekday a week	Walking to work	No vehicles on weekends	1 car per household	Use drones for small deliveries
Criteria Taken from Cost Curve														
Mitigation Potential (kilo tonnes CO2e)	11	12	27	338	664	243	908	173	324	9 482	146	1 317	27	85
Direct Total Costs (million M)	-25	-12	2 229	12 500	-2 361	1 334	51 656	290	2 232	-1 884	-549	-262	-6	4 345
Other Criteria														
Ability to boost other sectors	1	3	5	8	4	8	10	6	6	-	4	1	4	7
Reliance on Domestic Energy Sources	-	-	-	5	10	-	-	-	-	-	10	-	-	5
Potential for poverty alleviation	2	2	3	6	4	5	8	5	5	1	3	2	3	4
Potential for improving air quality	2	4	7	10	10	4	6	8	7	5	10	3	3	7
Technical Feasibility)	10	10	10	1	10	1	9	1	10	1	10	10	10	3
- Political/Social Popularity	5	5	1	4	3	8	10	2	5	1	3	-	4	8

Residential			Waste	AFOLU									
				Enteric Fermentation				Animal Waste management			Direct emissions from agricultural soils	Indirect emissions from agricultural soils	Forestry
wonder bags	solar cookers	SWHs	biogas production in WWTWs	Ration formulation	Reduce non productive animals	Grazing fees	Restrict grazing times to 4 hours for ruminants	decentralized dung biogas digesters	Composting	Cow dung Use to construct houses	crop rotation & Conservation Agriculture	Soil tests to avoid over-fertilization	Plant indigenous trees
798	84	363	192	232	2 486	1 656	5 689	134	118	3	4 935	2 154	9 575
-2 221	-312	388	1 762	-402	0	972	0	1 110	-4 857	0	-227	-223	17
3	3		5	3	7	6	6	5	5	3	6	4	8
-	10	10	10	-	-	-	-	10	-	-	-	-	-
6	6	6	6	3	5	2	2	6	2	5	8	6	9
6	6	6	6	3	3	3	3	6	1	2	-	4	10
9	9	9	10	10	5	10	10	10	10	10	10	10	10
6	6	6	9	10	3	-	-	10	3	5	10	10	10

APPENDIX D: Mitigation Assessment Stakeholders

Sector	Institution	Mitigation Assessment Team
Agriculture	Ministry of Agriculture and Food Security	Agriculture Research
		Crops
		Livestock Services
Energy	Ministry of Communication, Science and Technology (MCST)	Appropriate Technology Services (ATS)
	Ministry of Trade and Industry	Trade
	Ministry of Energy and Meteorology (MEM)	Energy
	Lesotho Electricity Company	Energy
	Ministry of Development Planning	Bureau of Statistics (BOS)
Waste	Tourism, Arts & Culture	Environment
	Local Government and Chieftainship Affairs (MOLG)	Urban Councils
		Maseru City Council
	Ministry of Water Affairs	Department of Water Affairs
		Rural Water Supply
	Ministry of Health	Environmental Health
	Ministry of Communication, Science and Technology	Information and Communication Technology
	Water and Sewage Company	
	Lesotho National Development Corporation (LNDC)	Trade
IPPU	Development Planning	Bureau of Statistics (BOS)
	Lesotho National Development Corporation (LNDC)	
	Lesotho Housing	Marketing
	Trade and Industry (MTI)	Bakeries, Brick, Breweries, Factories
		Basotho Enterprise Development Corporation (BEDCO)
	Civil Society Organizations (including NGOs)	Lesotho Environmental Justice and Advocacy Centre (LEJAC)
		Transformation Resource Centre (TRC)