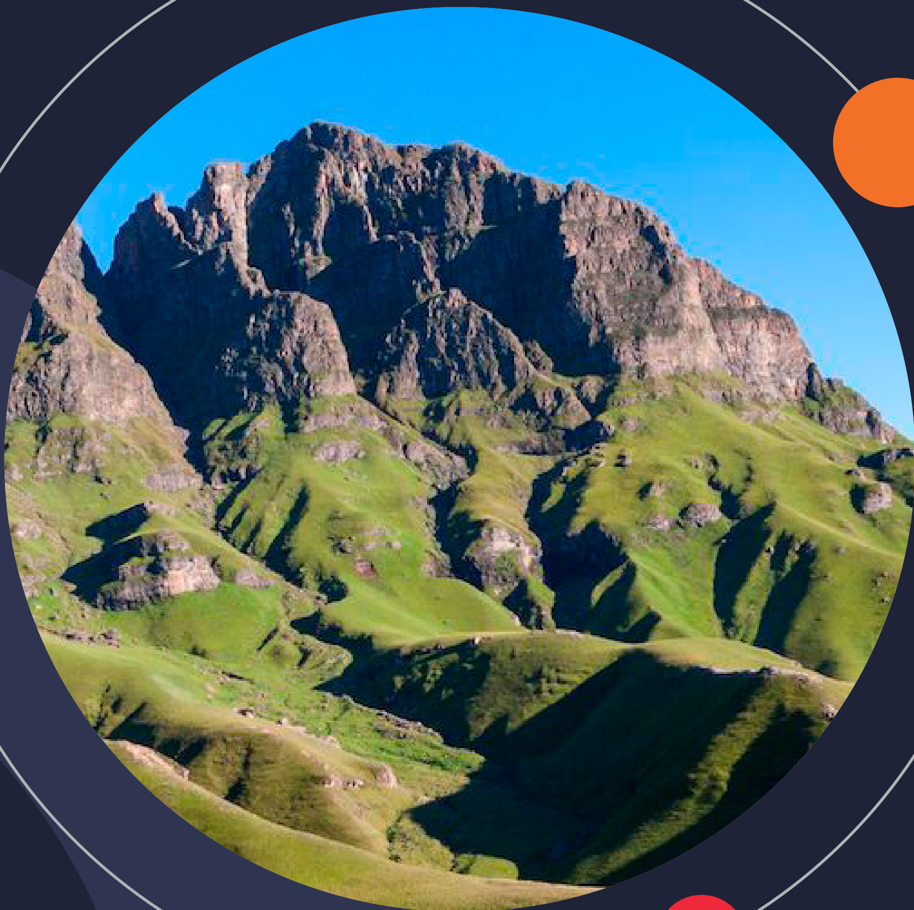
THE KINGDOM
OF LESOTHO'S

THIRD NATIONAL COMMUNICATION

to the United Nations Framework Convention on Climate Change

2021



UN environment
United Nations
Environment Programme

gef

Recommended Citation Format

LMS, 2021. The Kingdom of Lesotho's Third National Communication on Climate Change. Lesotho Metereological Services.

MINISTERAL FOREWORD

The Kingdom of Lesotho is a Party to the United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol, and its amendment (Doha Amendment), and the Paris Agreement[1], instruments which seek to curb climate change and promote sustainable development. Climate change destabilises the Earth's temperature equilibrium and has far-reaching effects on human beings and the environment.

Climate change is already affecting Lesotho and its challenges are being felt at every level; economically, socially, and culturally. Lesotho has formulated policies and strategies to address the country's current climate change challenges in respective vulnerable socio – economic sectors. Some key policy and strategic frameworks include: the National Strategic Development Plan (NSDP I and II), Lesotho's Nationally Determined Contributions (NDCs), Lesotho National Climate Change Policy (NCCP) 2017-2027 as well as the five-year National Climate Change Policy Implementation Strategy (NCCPIS) 2017. Furthermore, the country has taken strides for cross-sectoral institutional and systems capacity building to ensure continued focus on areas of climate change in the context of sustainable development in Lesotho.

This Third National Communication (TNC) report has been formulated in accordance with the guidelines adopted by the Parties to the United Nations Convention on Climate Change (UNFCCC). Lesotho considers the publication of this report not only as an effort to meet the national obligations under the Convention, but also to showcase the urgent need to achieve steep reductions in greenhouse gas emissions and measures needed to adapt to climate change. In line with the spirit of the Initial and the Second National Communications, the submission of the TNC is a confirmation of Lesotho's unreserved will and commitment to meeting international obligations under the UNFCCC.

This document, which is the product of collective efforts of all sectors in the country, will inform and guide both state and non-state actors in responding to climate change and its impacts, and foster the mainstreaming of evidence-based climate actions into national development planning.

On behalf of the Government of Lesotho, it is my greatest honour to present to you this Third National Communications (TNC) report.

Mohapi Mohapinyane
Minister of Energy and Meteorology

.

LESOTHO TNC
CONTRIBUTORS

Chapter 1: Introduction

This chapter was drafted by the following PKM Training and Consulting Services consultants: Dr. Njongenhle Nyoni and Mr. Michael Muvondori

Chapter 2: National Circumstances

This Chapter was drafted by B.T. Consults (Pty) : Mr. B.T. Sekoli
Chapter Reviewers: Motulu Molapo, Limpho Masilo-Motsamai, Mabafokeng Mahahabisa, Mokoena France, Charles Tseole, Tsekoa Maqhanolle, Mookho Monnapula, Theletsa Mpholle, Malehloa Jockey, Makoanye Maphutseng.

Chapter 3: National Greenhouse Gas Inventory 2005 and 2010

National GHG Task Team Members

INSTITUTION NAME	PARTICIPANT
AGRICLTURE, FORESTRY AND LAND USE	
Ministry of Agriculture and Food Security - Department of Agriculture Research	Mr. Mphasa Rampeta
Ministry of Forestry and Land Reclamation - Department of Forestry	Mr. Leduma Bereng
Ministry of Forestry and Land Reclamation - Department of Soil and Water Conservation	Ms. Mabongani Adoro
Land Survey and Physical Planning	Ms. Mamphaka Mabesa
Ministry of Agriculture and Food Security - Department of Crops	Mr. Mphasa Rampeta
Ministry of Energy and Meteorology - Lesotho Meteorological Services	Mr. Mosuoe Letuma Mr. Kabelo Lebohang Mr. Pheello Ralenkoane
ENERGY	
Ministry of Energy and Meteorology -Department of Energy	Ms. Liketso Seisa Mr. Bokang Shakhane
Department of Transport	Ms. Lineo Lerotholi-Mosoeunyane
Ministry of Energy and Meteorology - Lesotho Meteorological Services	Ms. Malehloa Jockey Mr. Maqhanolle Tsekoa
INDUSTRIAL PROCESSES AND PRODUCT USE	
Ministry of Trade and Industry -Department of Industry	Ms. Matseliso Makhele
WASTE	
Ministry of Tourism Environment and Culture - National Environment Secretariat	Mr. Thabiso Leballo
Ministry of Health - Department of Environmental Heath	Mr. Thekiso Mokitimi
Ministry of Water - Department of Water Affairs	Mr. Ntiea Letsapo
Maseru City Council	Mr. Thabo Mothebe

Chapter 4: Vulnerability and Adaptation Assessment

This Chapter was compiled by T-Squaredesigns : Mr. Thabang Tsehlo.

National Climate Change Scenarios: Mokoena France, Malehloa Jockey, Lebohang Kabelo, Mosuoe Letuma, Mookho Monnapula, Kuroane Ts'epo Phakoe, Pheello Victor Ralenkoane, Maqhanolle Tsekoa, **Mohau Jacob Mateyisi (Chapter Writer).**

Sector Contributors

Forestry (Malebajoa Anicia Maoela); **Health** (Mohau Jacob Mateyisi); **Livestock** (Puleng Matebesi), **Crops** (Botle Mapeshoane, Selebalo Ramakhanna & Arbitrage (Pty) Ltd), **Water Resources** (Dr. Liphapang Khaba, Thabang Tsehlo, Billy Makakole & Ngoanamathe Nthathakane), **Soils and Land Degradation** (Native Seed (Pty) Ltd), **Biodiversity and Environment** (Sebataolo Rahlao & Lisebo Motjotji). **Tourism** (Native Seed (Pty) Ltd), **Gender and Youth** (Ntlafalang Consultants), **Culture and Historical Heritage** (BT Consults).

Chapter Reviewer: Mrs. Mabafokeng Mahahabisa & Dr. Makoala Marake

Chapter 5: Climate Change Mitigation Assessment

This Chapter was compiled by Africa Clean Energy Services: Dr. Albert Butare, Mr. Thapelo Letete and Mrs. Keeena Malefane.

Chapter 6: Other Information Relevant to the Achievement of the Convention

This Chapter was drafted by Mr. Michael Mhlanga (**Capacity building, education, training and public awareness, and Information and Networking**); Mrs. Joalane Marunye (**Research and Systematic Observations**); South Pacific - Prof Molibeli Taele (**Technology Transfer**); Thabang Tsehlo (**Integration of Climate Change**).

Chapter 7: Constraints, Gaps and related Financial, Technical and Capacity Needs to the Third National Communication

This Chapter was compiled by Sustainably (PTY) Ltd: Ms. Relebohile Bulane.

COMPILATION OF THE LESOTHO TNC

This TNC was compiled by the following PKM Training and Consulting Services consultants: Dr. Njongenhle Nyoni and Mr. Michael Muvondori

TNC REVIEW TEAM

Lesotho Meteorological Services

PROJECT COORDINATION

Lesotho Meteorological Services - Ms. Malehloa Jockey

OVERALL RESPONSIBILITY

Ministry of Energy and Meteorology

ACKNOWLEDGEMENTS

The Ministry of Energy and Meteorology (MEM) would like to acknowledge and appreciate the input from all stakeholders who participated in the preparation of the TNC report. MEM would like to acknowledge the contributions of the following stakeholders:

GEF
for providing financial and technical support.

UNEP
for providing technical support.

UNFCCC Secretariat
for providing information and guidelines for preparing sectoral reports, thematic area reports, and for providing necessary trainings aimed at building institutional capacity.

The staff of Lesotho Meteorological Services

for steering the preparation process, managing, coordinating and reviewing the Lesotho's TNC

Government Ministries & Various national institutions including academics, private sector organizations, Non-Governmental Organizations and development partners
preparation process.
for providing expertise and data for the preparation of this document.

PKM Training and Consulting Services
for compiling the TNC.

List of Tables

List of Figures

ACRONYMS AND ABBREVIATIONS

AAP	Africa Adaptation Program
AFOLU	Agriculture Forestry and Other Land Use
AFDB	African Development Bank
AGOA	African Growth and Opportunity Act
AR4	Fourth Assessment Report of the IPCC
AG	Attorney General
ALU	Agriculture and Land Use
ATS	Appropriate Technology Section
AU	African Union
BAU	Business as Usual
BEDCO	Basotho Enterprises Development Corporation
BNR	Biological Nutrient Removal
BOS	Bureau of Statistics
BRT	Bus Rapid Transit
CBL	Central Bank of Lesotho
CBO	Community-Based Organizations
CCA	Climate Change Adaptation
CCAS	Climate Change Adaptation Strategy
CCD	Consecutive Dry Days
CH_4	Methane
CGE	Consultative Group of Experts
CMIP5	Coupled Model inter-comparison Project Phase 5
CO_2	Carbon dioxide
CO_2e	CO_2-equivalent
COP	Conference of the Parties
CORDEX	Coordinated Regional climate Downscaling Experiment
COMESA	Common Market for East and Southern Africa
CSDI	Cold spell duration index
CTCN	Climate Technology Centre and Network
CWD	Consecutive wet days
DJF	December, January, February
DoAR	Department of Agricultural Research
DoC	Department of Crops
DoE	Department of Energy
DOE	Department of Environment
DoF	Department of Forestry
DoSWC	Department of Soil and Water Conservation

DMA	Disaster Management Authority
DSSAT	Decision Support System for Agro- Technology Transfer
DWA	Department of Water Affairs
EAC	East African Community
EF	Emission factor
ESD	Education for Sustainable Development
ETCCDI	Expert Team on Climate Change Detection and Indices
ENEA	Energy and Sustainable Economic Development
EU	European Union
EWS	Early Warning System
FAO	Food and Agricultural Organisation of the United Nations
FAR	First Assessment Report
FBUR	First Biennial Update Report
GCMs	General Circulation Models
GBV	Gender-Based Violence
GCOS	Global Climate Observing Systems
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Greenhouse Gas
GIR	Gas Inventory and Research
GIS	Geographic Information System
GIZ	Gesellschaft Internationale Zusammenarbeit
GWP	Global Warming Potential
H_20	Water vapour
HDI	Human Development Index
HFCs	Hydro-Fluorocarbons
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome
HPC	high-performance computer
ICM	Integrated Catchment Management
ICT	Information and communication technologies
IDRS	Integrated Disease Surveillance and Response
IFAD	International Fund for Agricultural Development
INC	Initial National Communication
INDC	Intended Nationally Determined Contributions
IMELS	Ministry for the Environment, Land and Sea
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use

ITCZ	Inter Tropical Convergence Zone
JJA	June, July, August
LASAP	Lesotho Adaptation of Small-Scale Agriculture Production
LDCF	Least Development Countries Fund
LDCs	Least Developed Countries
LDNTSP	Land Degradation Neutrality Target Setting Programme
LHWP	Lesotho Highlands Water Project
LNHSP	Lesotho National Health Strategic Plan
LNDC	Lesotho National Development Corporation
LEAP	Long-range Energy Alternatives Planning
LEC	Lesotho Electricity Company
LePhIA	Lesotho Population-Based Impact Assessment
LESIS	Lesotho Soil Information Systems Project
LMS	Lesotho Meteorological Services
LLWSS	Lesotho Lowlands Water Supply Scheme
LNBSS	Lesotho National Broadcast Service
LNHSP	Lesotho National Health Strategic Plan
LULUCF	Land-Use, Land-Use Change and Forestry
LVAC	Lesotho Vulnerability Assessment Committee
LPG	Liquefied Petroleum Gas
MACC	Marginal Abatement Cost Curve
MEA	Multilateral Environmental Agreement
MAFS	Ministry of Agriculture and Food Security
MAM	March, April, May
MCA	Multi Criteria Analysis
MCDC	Matelile Community Development Centre
MCF	Methane conversion factor
MCST	Ministry of Communication, Science and Technology
MDGs	Millennium Development Goals
MEM	Ministry of Energy and Meteorology
MESA	Monitoring for Environment and Security in Africa
MFRSC	Ministry of Forestry, Range and Soil Conservation
MMS	Manure management system
MoET	Ministry of Education and Training
$MtCO_2e$	Million tonnes of Carbon Dioxide Equivalent
MWPT	Ministry of Works and Public Transport
N	Nitrogen
N_2O	Nitrous oxide
NAMA	National Appropriate Mitigation Actions

NAPA	National Adaptation Programme of Action
NCCC	National Climate Change Committee
NCCP	National Climate Change Policy
NCCPIS	National Climate Change Policy Implementation Strategy
NCDC	National Curriculum Development Centre
NDC	Nationally Determined Contributions
NDF	National Development Framework
NDE	National Designated Entities
NDP	National Development Plan
NEP	National Energy Policy
NEAP	National Environmental Action Plan
NEPAD	New Partnership for Africa's Development
Nex	Nitrogen Excretion Rate
NGO	Non-Governmental Organisations
NH3	Ammonia
NOX	Nitrogen oxides (nitric oxide (NO) and nitrogen dioxide (NO2))
NSDP	National Strategic Development Plan
NTFP	Non-Timber Forest Products
NSES	National Sustainability Energy Strategy
NUL	National University of Lesotho
O3	Ozone
OPBRC	Output and Performance-based Roads Contracting
PFCs	Per-Fluorocarbons
PPP	Public Private Partnership
PRPS	Poverty Reduction Strategy Paper
PRS	Poverty Reduction Strategy
QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
RCP	Representative Concentration Pathways
RSDA	Rural Self-Help Development Association
RE	Renewable Energy
RVCC	Reducing Vulnerability from Climate Change
RWS	Rural Water Supply
SACU	Southern African Customs Union
SADC	Southern African Development Community
SADC MES	Southern Africa Development Community – Monitoring for Environment And Security in Africa
SADP	Smallholder Agricultural Development Programme
SDGs	Sustainable Development Goals
SGP	Small Grants Program
SF6	Sulphur Hexafluoride

SNC	Second National Communication
SON	September, October, November
TCP	Technical Cooperation Programme
TDT	Technology Development Transfer
TICAP	Tokyo International Conference on African Development
TNA	Technology Needs Assessment
TNC	Third National Communication
UNCBD	United Nations Convention on Bio Diversity
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNFC-CC-CGE	United Nations Framework Convention on Climate Change Consultative Group of Expert
UNFPA	United Nations Population Fund
USAID	Unites States Agency for International Development
VAA	Vulnerability Adaptation Assessment
WAMPP	Wool and Mohair Promotion Project
WASCO	Water and Sewerage Company
WCRP	World Climate Research Program
WMO	World Meteorological Organisation
WUE	Water Use Efficiency

EXECUTIVE SUMMARY

Chapter 1: Introduction

This chapter introduces Lesotho's Third National Communication (TNC). The Government of Lesotho, through the Ministry of Energy and Meteorology under the Lesotho Meteorological Services (LMS), submitted the initial (2000) and the Second National Communication (2013) in accordance with Article 12 of the United Nations Framework Convention on Climate Change (UNFCCC). The chapter introduces the various reports which this TNC has been drawn from. These includes: (1) national circumstance; (2) anthropogenic greenhouse gas (GHG) inventories of emissions and removals by sinks; (3) vulnerability and adaptation assessments; (4) measures to mitigate GHG emissions by addressing emissions and removals; (5) other information drawn from research programmes, systematic observations, activities related to technology needs, and steps taken in the integration of climate change information in capacity building, education, training and networking; and, (6) constraints and gaps and related financial, technical and capacity needs.

Chapter 2: National Circumstances

Since the publication of the Second National Communication in 2013, Lesotho has made notable advances in transforming its national circumstances, and particularly its climate change policies and institutional arrangements, which included the establishment of the National Climate Change Committee (NCCC). LMS was restructured to accommodate the secretariat of the National Climate Change Committee as it pursues and implements the National Climate Change Policy (NCCP) and the Nationally Determined Contributions (NDC). These policies and institutional arrangements have helped to respond to climate change challenges in a more systemic manner.

Due to a combination of many factors, Lesotho's economic development faces serious challenges. Between 2015 and 2017, its economic growth averaged 1.4 percent. The country's Gross Domestic Product (GDP) of US$ 2.7 billion is made up of: agriculture contributing 5.3 percent, industry at 34.6 percent and services contributing 60.1 percent. The economic performance and development of Lesotho needs to take cognisance of the emerging climate change patterns which have demonstrated the capacity to severely compromise productivity of all sectors of the economy. The country is one of the most vulnerable countries to climate change with a climate primarily influenced by the country's location in the Karoo basin, and its altitude and latitudinal positions. Its climate is classified as continental temperate with the altitude giving it some alpine characteristics that distinguish it from the rest of the sub-continent. Winters are dry and cold while summers are hot and humid. Temperatures are highly variable, on diurnal, monthly and annual time scales, and are generally lower than those of other inland regions of similar latitudes in larger landmasses both in the northern and southern hemispheres. Annual precipitation ranges from as low as 500 mm in the Senqu River Valley area to as high as 1200 mm in a few localities in the northern and eastern escarpment, which form the border with the Republic of South Africa and are part of the Highlands region. The country experiences 85 percent of its precipitation between October and April and the peak rainfall period is from December to February.

The Government of Lesotho considers the response to climate change as an aspect that warrants as broad an intervention as possible, requiring participation of all tiers of government, non-governmental organisations, the private sector, development partners, youth, women, and cultural groups. Implementation of the climate change initiatives has been overly crucial in the country's capacity building for climate change resilience and adaptation. According to the country's NDCs, Lesotho is committed to the UNFCCC's mitigation objective through achieving sizable GHG emissions and improving sinks to carbon dioxide by adopting a clean energy development path. Emissions reductions targets have also been identified in other sectors, namely Industrial Processes and Product Use (IPPU), Agriculture (livestock and soil), Land-Use, Land-Use Change and Forestry (LULUCF), Transport and Waste. However, Lesotho's GHG emissions represent only 0.005 percent of global emission and a net per capita of 1.1 tCO2 equivalent in 2015.

Lesotho is also fully committed to the UN 2030 Development Agenda for Sustainable Development, and its Goals (SDGs). The government ensures that the national development plans are implemented together with other continental and regional programmes such as the AU Agenda 2063 and the SADC Regional Indicative Strategic Plan for the well-being of future generations of Lesotho. Furthermore, the government considers that broadly-based national participation is essential for the achievement of the SDGs according to set programmes.

In the report titled Kingdom of Lesotho Sustainable Development Goals Indicator Baseline Report 2016, the government acknowledges lack of success in the implementation of other targets/ goals, particularly the MDGs. This openness underscores the government's determination to successfully meet the targets of the SDGs, as well as to invite more assistance to the country in order to strengthen strategic sectors that would ensure that Lesotho progresses from being a least developed country. The report uses the base years of 2015 and 2016 to review progress on areas and indicators that are most critical to Lesotho.

Chapter 3: National Greenhouse Gas Inventory 2005 and 2010

This chapter presents national GHG inventory for Lesotho between 2005 and 2010 for the following sectors: Energy, Waste, Agriculture, Forestry and Other Land Use (AFOLU) and Industrial Processes and Product Use (IPPU). The institutional arrangement for the compilation of GHG inventory is comprised of Inventory coordinator, inventory reviewer, inventory compilers, and sectoral data collection. The national inventory coordinator responsible for compiling Lesotho's greenhouse gas inventory is also the LMS which is also the authority responsible for the coordination of the Quality Assurance/Quality Control (QA/QC) Plan.

The quality control (QC) procedures are performed by the experts at all levels during inventory calculation and compilation for the attainment of the quality objectives. The QC procedures is done in compliance with the IPCC good practice guidance and the 2006 IPCC Guidelines; using Tier 1 activity data together with the default emission factors. General inventory QC checks includes routine checks of the integrity, correctness and completeness of data, identification of errors and deficiencies and documentation and archiving of inventory data and quality control actions.

In addition to general QC checks, category-specific QC checks including technical reviews of the source categories, activity data, emission factors and methods are applied on a case-by-case basis focusing on key categories and on categories where significant methodological and data revisions have taken place. This is achieved through having various levels of QA/QC with each entity performing their specific QA/QC roles.

The assessment of GHG emissions from all the sectors were quantified using the 2006 IPCC guidelines. Results show that Energy and AFOLU sectors are the main sources of GHG emissions in the country (see Figure 1).

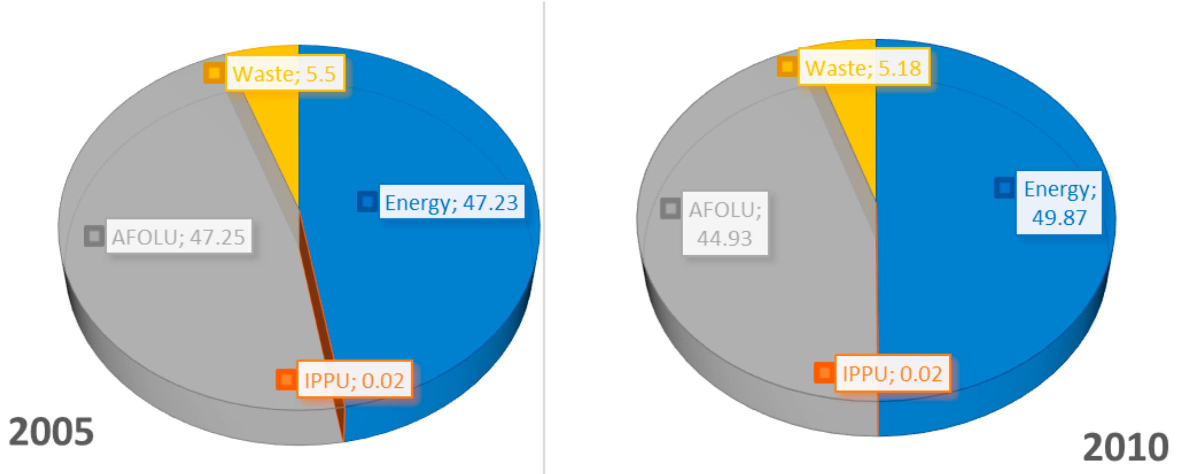


Figure 1: Summary of ratios (in %) of GHG emissions by source sector, 2005 and 2010

Energy sector has increased its dominance of primary sources. However, the quantification of GHG emissions needs to be improved. For the Energy Sector, there is need for collection and reporting of energy statistics in the country with an emphasis in areas such as annual reporting of number of vehicles by type and fuel economy. Also, surveys need to be conducted to determine kilometres travelled by each vehicle type. Furthermore, there is no complete national dataset of annual population of vehicles in the country. The national vehicle registration system has been manual for most districts (eight), while only two districts (Leribe and Maseru) had digitised systems. Since 2018, the country launched a digitised vehicle registration system country-wide.

There is limited activity data in the country for the IPPU sector. Appropriate GHG activity data from the industrial activities could not be obtained. Data for few years could only be obtained from the ceramic production activities, hence GHG emissions were estimated from these ceramic production activities only. There is a need to continually improve production processes by adopting appropriate technologies that increase energy use efficiency which leads to reduction in emission of GHG in the industry.

GHG emissions from the AFOLU sector are mainly from CH4 emissions from enteric fermentation and agricultural soils. Agriculture is the foundation of the economy in most African countries with mostly rain-fed agriculture constituting majority of agricultural activities that are mostly defined by dryland crop and extensive animal production. The AFOLU sector made a total of 2,236 Gg CO_2e and 2,307 Gg CO_2e in 2005 and 2010 respectively. Enteric fermentation and management of agricultural soils remain the largest sources of emissions in this sector. Land use change from forest-to-forest is the main cause of carbon stock change in Lesotho. Largest levels of uncertainty in the AFOLU sector are experienced in the Land Use Change. Emissions from enteric fermentation present lowest levels of uncertainty. Data collection to estimate GHG emissions in the AFOLU sector needs to be improved.

The most common wastes generated in Maseru include commercial waste, municipal waste and industrial waste, in that order. GHG emissions resulting from the waste sector are gradually increasing in Lesotho. Methane is the main GHG produced by in waste sector. Wastewater treatment and discharge are the main sources of CO_2e emissions from waste sector. However, it is noteworthy that estimations of GHG emissions from the waste sector are based on expert judgement and international reports. There is a need initiate routine national data collection process in waste sector.

Chapter 4: Vulnerability and Adaptation Assessment

This chapter focuses on the analysis of changes in the extreme climate indices, annual and seasonal precipitation, maximum and minimum temperatures using a methodology consistent with the multi-model ensemble climate change simulations under different emission scenarios. The climate projections analysis is based on a set of General Circulation Models (GCMs) under the Coupled Model Inter-comparison experiment, availed through the Coordinated Regional Downscaling Experiment (CORDEX). The chapter also assesses the vulnerability and impacts of climate change on gender and youth. This is followed by a summary of the adaptation options and strategies that each sector can adopt to offset the adverse impacts of climate change and challenges inherent to climate change adaptation in Lesotho.

The results indicate general warming trend of temperatures countrywide during the baseline period (1971-2000) and across all future periods (2011-2100). The models' outputs suggest that climate change has been happening over the past three (3) decades. The plausible increase in annual maximum and minimum temperatures simulated by the models is also reflected across all seasons. The increasing trends in temperature during the historic period are weak but statistically significant for all the seasons. Rainfall on the other hand, shows a high spatial variability which is also higher in magnitudes relative to the established inter-annual variability for the region. The highest total precipitation accumulation during the covered period is in the Mountains while the Lowlands have the lowest total precipitation accumulation.

Lesotho's extensive land degradation, geographic characteristics and the socio-economic conditions make it one of the countries that are most vulnerable to climate change-related impacts, especially for rural populations. Thus, it is important that there is a clear understanding of the possible impacts of climate change on land degradation and soil erodibility to be able to plan and implement adaptive measures and mitigation strategies that equip the nation to better deal with the impacts of climate change.

The country's current vulnerability also stems from the fact that its economic growth is dependent on climate-sensitive sectors which are subject to highly variable precipitation. In addition to variable climate and climate-sensitive economy, the majority of Lesotho's population is dependent on rain-fed subsistence agriculture coupled with the fact that these communities do not have sufficient resources to address the loss of soil fertility and climate variability. The country is expected to experience increased frequency and intensity of droughts, heavy rains and increased temperatures in all future periods. The temperature increases experienced in Lesotho have led to hydrological losses, which impact or change the quantity and quality of water resources. As such, there is need to optimize water resources development, equitable usage and management plans to sustain livelihoods of Basotho without comprising the sustainability of vital natural ecosystems.

Without adaptation, climate change could generally be detrimental to agriculture. There is evidence that climate change has already negatively affected crop yields in Lesotho. There has been a decrease in both the area planted and the yield of most important cereal crops due to recurring droughts in the last few years. Furthermore, the livestock sector, which also plays an important role in Lesotho's economy through wool and mohair production, has also been declining due to climate change. Climate change adaptation interventions and measures should therefore be developed to improve the resilience of both crops and livestock productivity to climate change which in turn will contribute to food security and poverty alleviation.

Biodiversity and ecosystems are under threat from several environmental changes in addition to climate change. It is therefore important to intensity investments towards quantifying the effects of climate change and other environmental changes across agro-ecological zones. Furthermore, given the potential impacts of climate change on forest resources, the forestry sector urgently has to develop and enforce adaptation measures, strategies and infrastructure that protect the country's various components (commercial, emerging, rain-fed, irrigated, etc.) in the immediate future. The rate of forest loss in Lesotho (just like in other SADC countries) can be attributed to a combination of many factors at local, national, and international levels.

Climate change has also negatively impacted the tourism sector (a sector with massive potential in boosting the country's economy). This is due to the fact that the tourism sector relies heavily on climate-sensitive resources and activities. Thus, in order to improve resilience, there is need for tourism diversification. One of the most effective measure for adapting to climate change through improved resilience of the most vulnerable population lies in the provision of basic health services. The level of health resilience is dependent on several socio-economic factors (which in Lesotho include (1) income levels, (2) housing standards, and (3) forms of labour) and biophysical factors (which include weather and climate conditions). The impacts associated with extreme climate events are likely to add more pressure on Lesotho's health system which is already burdened by communicable diseases. As a result, there is a need for enhanced disaster preparedness and disease outbreak responses at all levels of society and governance in the country.

According to the IPCC, by the year 2050, a child born in 2000 is likely to experience atmospheric concentrations of CO_2 of between 463 and 623 parts per million (ppm) by volume, compared with about 400 ppm in 2016. The impacts of these changes will be unevenly distributed, with the greatest risks experienced by the poor and marginalised, many of whose livelihoods are threatened by climate change. Thus, there is need for employing adaptation strategies to offset the adverse impacts of climate change on vulnerable communities.

While communities are generally becoming more innovative in coming up with response strategies, there is a need for research and development in collaboration with academia, communities, and government extension to look into the innovations and evaluate the extent they can be recommended for continued use.

Chapter 5: Climate Change Mitigation Assessment

This chapter focuses on mitigation analysis and assessment with the view of presenting a set of viable options to reduce sources of GHG emissions and/or enhance carbon sinks in key economic sectors in accordance with Lesotho's obligations under the UNFCCC. Projections of GHGs under baseline scenario for both energy and non-energy sectors show that, if no climate change mitigation measures are implemented, the emissions in 2030 will be 10 percent higher. The most significant contributor to the current and future emissions is energy demand with a total of 2,644.5 $ktCO_2e$ in 2010 and projected increase of about 17 percent (to 3,093.2 $ktCO_2e$) in 2030 if status quo continues. In 2010, GHG emissions from non-energy sources accounted for 49 percent of Lesotho's emissions. The emissions are expected to account for 46 percent in 2030 under the baseline scenario. Specifically, about 3 percent decrease in emissions is forecasted for the 2010-2030 projection period.

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

i. Mitigation scenario assuming mitigation measures are implemented from 2011 and
ii. Mitigation scenario assuming mitigation measures are implemented from 2020.

Under the first mitigation scenario (2011-2030), 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. Planting of indigenous trees, crop rotation and conservation agriculture and avoiding over-fertilization are the top three measures with the most significant mitigation potential in the country. This implies a 20.6 percent reduction from baseline. The net implementation cost of this mitigation scenario is estimated at M51.3 billion. This mitigation potential is more than sufficient to achieve Lesotho's unconditional NDC target of 10 percent (at a net saving of M5.9 billion) but not sufficient to achieve its conditional target of 35 percent. Additional mitigation measures elected through the multi-criteria analysis are required to achieve the unconditional target of 35 percent.

Similarly, the second mitigation scenario (2020-2030) shows that planting of indigenous trees, crop rotation and conservation agriculture and avoiding over-fertilization have the best significant mitigation potential in Lesotho. In this version of the mitigation scenario, 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.

Chapter 6: Other Information Relevant to the Achievement of the Convention

This chapter provides a synopsis on other information relevant to the achievement of the Convention which incorporates government policies, strategies and programmes. More specifically, this chapter presents information on research and systematic observations, information sharing and networks, information on technology transfer and the level of integration of climate change in development plans. The chapter also explores the capacity building, education, training, and public awareness initiatives focusing on strengthening communication, trainings, education, and awareness-raising at all levels, promoting south – south cooperation and stakeholder involvement among other things.

The chapter argues that for Lesotho to effectively integrate climate change into national policies and programmes, there should be a long-term strategy to strengthen institutional capacities across focal, sectoral and local level institutions. For integration of climate change education into school curricula to be effective, a conscious allocation of resources is necessary to cover the costs of reviewing the syllabi for schools and teacher training colleges, revision of textbooks and teacher refresher courses. It also requires awareness raising workshops for administrative and planning staff of Ministry of Education and Training (MoET).

To promote information sharing, Lesotho has embarked on several initiatives at national, regional and international levels, meeting obligations under the UNFCCC by preparing three National Communications to the COP, including the current one. Further, the process of identification, implementation and communication of the Nationally Determined Contributions (NDCs) provided a platform for in-country information sharing.

Technology transfer developments since the previous first and second national communication are also presented in this chapter together with identified needs that still exist in key economic sectors in Lesotho. A number of sector specific technology transfer projects, needs and limitations are discussed.

Chapter 7: Constraints, Gaps and related Financial, Technical and Capacity Needs to the Third National Communication

This chapter focuses on a number of constraints and/ gaps identified in the implementation of climate change initiatives. These include financial, technical and capacity needs, technology needs and transfer. The chapter acknowledges that Lesotho mainly relies on the donor financial support to meet national adaptation and mitigation costs. It argues that the level of support/ funding is insufficient for the country to meet its obligations and integrating climate change into national policies, plans and programs. Furthermore, possible funding for climate change research is limited. Lesotho's need to build local capacity to apply and/or develop various analytical models in order to acquire maximum benefits from a wide range of climate change mitigation options is also presented. This could best be taken by research institutions and universities though further support is needed in building technical and institutional capacities and efforts in integrating climate change into national policies, plans and programs.

The Chapter further exposes a huge gap between information provision and users demand of the information and the need for resources to translate information into action. Among several gaps identified for climate change implementation in Lesotho are those pertaining to legislative and regulatory frameworks, greenhouse gas data collection, collation, analysis and reporting; as well as vulnerability and adaptation assessments. Specific needs for various sectors in Lesotho are identified with the chapter concluding by providing a summary of the support on various projects on adaptation and mitigation which Lesotho has received.

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Climate change is transforming the planet's ecosystems and threatening the wellbeing of current and future generations[1]. The climate system is complex, and any enduring policy direction can only be based on long-term, high-quality observations and comprehensive assessments of the best available science. Given their poor adaptive capacity in terms of finances, resources, infrastructure and expertise, developing countries, such as the Kingdom of Lesotho, are the most adversely impacted by effects of climate change across various sectors of development[2].

Thus, efforts to combat climate change impacts are critical for promoting global development. There is augmenting evidence that emissions of greenhouse gases (GHGs – mainly carbon dioxide (CO_2)) are a major contributor to climate change[3]. Low GHG emissions development offers countries an opportunity to achieve economic gains, while responding to climate change.

The United Nations Framework Convention on Climate Change (UNFCCC) calls on country Parties to promote and cooperate in research and systematic observations (RSO) of the climate system, through exchange of information and support to international programmes and networks. The scientific understanding of climate change is based on a solid physical – theoretical foundation supported by long-term observations and research. The UNFCCC has been supporting the global response to the threat of climate change since it came into force in 1995. The Convention's principal focus is to address current and future climate change challenges and co-operatively attain aspirations of sustainable development which encapsulate improving the quality of life without increasing environmental degradation and compromising the resources needs of future generations.

The Kingdom of Lesotho, in its pursuit of sustainable socio-economic development, drives a continuing effort to promote the development of collaborative programmes in building resilience to climate change through research and systematic observations. Lesotho ratified the UNFCCC in 1994, Kyoto Protocol in 2000 and its amendment (Doha Amendment) in 2019, and the Paris Agreement in 20174, which builds upon the Convention to undertake ambitious efforts to combat climate change and adapt to its effects, demonstrating its commitment to seeking global solutions to climate change matters. This endeavour is supported by the Lesotho's National Climate Change Policy (2017-2027).

In accordance with Article 4, paragraph 1 and Article 12, paragraph 1 of the UNFCCC, the Government of Lesotho, through the Lesotho Meteorological Services, submitted the Initial National Communication (2000) and the Second National Communication (2013). This Lesotho's Third National Communication (TNC) was developed in line with the UNFCCC reporting guidelines for developing countries in reporting on national circumstances.

The TNC, funded by the Global Environment Facility (GEF), is a summary of the following reports: national circumstances; national inventories of anthropogenic GHG emissions and removals by sinks; vulnerability and adaptation assessments; measures to mitigate GHG emissions by addressing emissions and removals; other information related to research programmes, systematic observations, activities related to technology needs, steps taken to integrate climate change and information on capacity building, education, training and networking; and constraints and gaps and related financial, technical and capacity needs.

This report contributes to the enhancement of general awareness and knowledge on climate change related issues in Lesotho and strengthen the ability of the country to participate in different mechanisms directed to abate GHG emissions at the national level and to adapt to the impacts of climate change as well as to fulfil other UNFCCC obligations and commitments. It also addressed all constraints and gaps and makes necessary recommendations to inform and guide policy makers in: i) responding to climate change impacts; ii) understanding the cross-cutting nature of climate change; and, iii) the urgent need for mainstreaming climate change considerations into national development planning.

1.2 CHAPTER OUTLINE

Chapter 1 has provided a background and highlighted the focus of this TNC.

Chapter 2 provides an overview of the national circumstances in terms of describing the geography, climate, environmental and socio-economic profiles of Lesotho with emphasis on sensitivity to climate change and climate variability.

Chapter 3 presents the *National Greenhouse Gas Inventory* for the period 2005 to 2010. GHG estimates are made from the following sectors as per revised 1996 and 2006 IPCC Guidelines: i) Energy; ii) Industrial Processes and Product Use (IPPU); iii) Agriculture, Forestry and Other Land Use (AFOLU); and iv) Waste.

Chapter 4 outlines and reviews the *Programmes containing measures to facilitate adequate adaptation to climate change*

Chapter 5 focuses on the *Programmes containing measures to mitigate climate change in Lesotho.*

Chapter 6 explores *other information considered relevant to the achievement of the objective of the Convention.*

Finally, a general discussion on *Constraints and Gaps, and Related Financial, Technical and Capacity Needs* is provided in ***Chapter 7***.

References

1. Letsie, M., & Grab, S. (2015). Assessment of social vulnerability to natural hazards in the mountain Kingdom of Lesotho. Mountain Research and Development, 35(2),115-125.

2. Messerli, P., Murniningtyas, E., Eloundou-Enyegue, P., Foli, E., Furman, E., Glassman, A., Moatti, J. a. (2019). Global Sustainable Development Report 2019: The Future is Now–Science for Achieving Sustainable Development.

3. Pachauri, R., Allen, M., Barros, V., Broome, J., Cramer, W., Christ, R., Dasgupta, P. a. (2014). Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change (p. 151).

4. The Government of Lesotho. (2020, 06 12). https://www.lesmet.org.ls/home/open/Intended-Nationally-Determined-Contributions. Retrieved from www.lesmet.org.ls.

CHAPTER 2 NATIONAL CIRCUMSTANCES

2.1 INTRODUCTION

This chapter provides an overview on Lesotho's geographical, climatic, environmental, political, and socio-economic profiles. It also debunks on the developmental paradigms with an emphasis on sensitivity to climate change and climate variability. Just as highlighted in the first and second climate change national communications, the national circumstances are briefly described to serve as a basis for expositions and discussions elsewhere in the document.

2.2 GEOGRAPHICAL PROFILE

Lesotho lies between latitudes 28°S and 31°S, and longitude 27°E and 30°E. It occupies a land area of 30,555 square kilometres and is surrounded by the Republic of South Africa. Thabana–Ntlenyana at 3,482 m above mean sea level (amsl) is the highest peak. The lowest point in Lesotho is at 1,388 m amsl.[1]

The country is divided into four agro-ecological zones as shown on Figure 2.1 below:

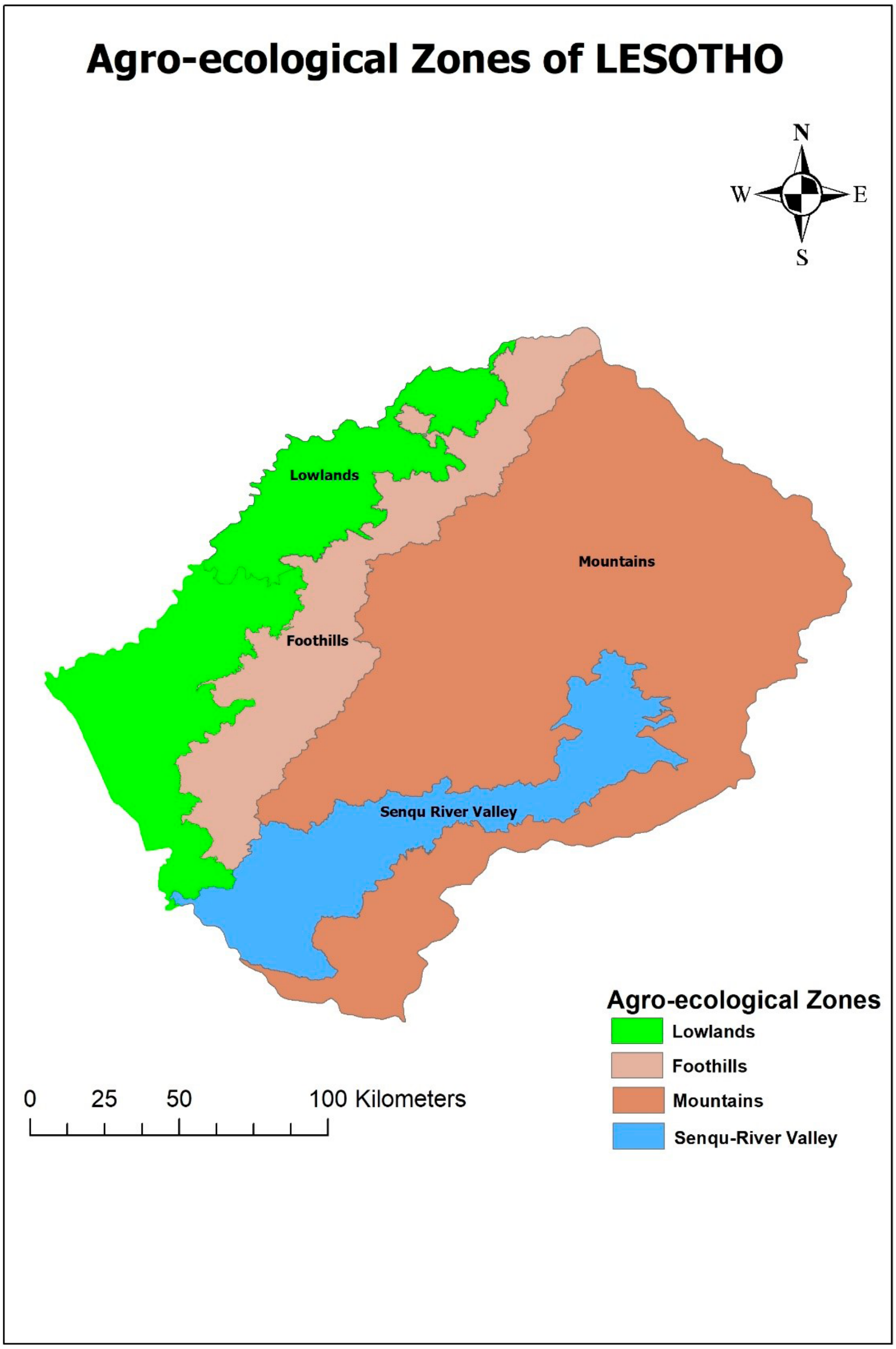


Figure 2.1: Agro-ecological zones of Lesotho (Lesotho Meteorological Services)

These are:

A. The Mountains with 59 percent of the land area, and the elevation beyond 2000 m above mean sea level. Deep valleys and rivers, clean water that supports some indigenous aquatic species run through there.

B. The Foothills occupy 15 percent of the land area and lie between 1800 and 2000 m above mean sea level. They host some microclimates that favour horticulture.

C. The Senqu River Valley lies between 1,388 and 2,000 m above mean sea level occupying 9 percent of the land area and is the driest region as it is in the rain-shadow of Maluti and Drakensberg Mountain ranges.

D. The Lowlands occupy the remaining 17 percent of the land and lies between 1400 and 1,800 m above mean sea level. The Southern region shows high vulnerability to climate change with poorer soils, the rampant damage to the ecosystem and geo-morphological conditions and the diminishing ability to support agriculture in general. The Northern lowlands possess fertile soils and thus are the main food producing region of the country.

2.3 ENVIRONMENTAL ISSUES

Land degradation in Lesotho, particularly in the last 40 years has been worsening. The state of physical environment has deteriorated as soon as the territory of Lesotho began experiencing marked increase in organized settlements and population. The topographic features with mountains and valleys that enclose steep slopes coupled with the highly variable rainfall and temperatures have always exposed Lesotho to environmental degradation (Figure 2.2). Soil erosion is further aggravated by the vulnerability of the country to drought and the setting in of desertification conditions[2].

Figure 2.2: Soil erosion in Berea district, Lesotho (Source: Ministry of Forestry, Rangelands and Soil Conservation)

2.4 GOVERNMENT AND ADMINISTRATION

2.4.1 Political Setup

Lesotho is a parliamentary constitutional monarchy, with the King as the Head of State. There are three arms of government, namely, the Legislature, the Executive, and the Judiciary. The Legislature has a bi-cameral parliament consisting of the Upper House or Senate, and the Lower House or National Assembly. The Senate comprises of 33 members (22 principal chiefs, who are members by heredity rights and 11 other members, nominated by the King). Its role is to examine and review draft legislation or bills which are initiated and passed by the National Assembly. The National Assembly with 120 elected members has a fixed term of 5 years. It consists of 80 directly elected Members (at constituency level), and 40 elected through proportional representation.

The Prime Minister is elected by Parliament and is a leader of the majority Party or Coalition of Parties in parliament. The Prime Minister heads the Executive arm of Government and Cabinet of Ministers. The Judiciary consists of the Court of Appeal, the High Court (whose Chief Justice is appointed by the Monarch,) Subordinate Courts and Courts-Martial, as well as tribunals exercising a judicial function. According to the Constitution, the judiciary is independent

and free from interference, subject only to the Constitution or any other law. The Attorney General (AG) is a legal advisor to the government. Other offices in support of the Judiciary include the

Directorate of Public Prosecutions and the Directorate of Criminal and Economic Office.

2.4.2 Administration

The country is divided into ten administrative districts shown on Figure 2.3. Government Ministries maintain presence at district administrative centres, for services such as registration of births and deaths, provision of identity documents, major medical services and others. The district headquarters are also the centres of commerce and provision of services such as law and order, health and education administration. The districts of Lesotho are further divided into 80 constituencies, which are in turn divided into 124 community councils.

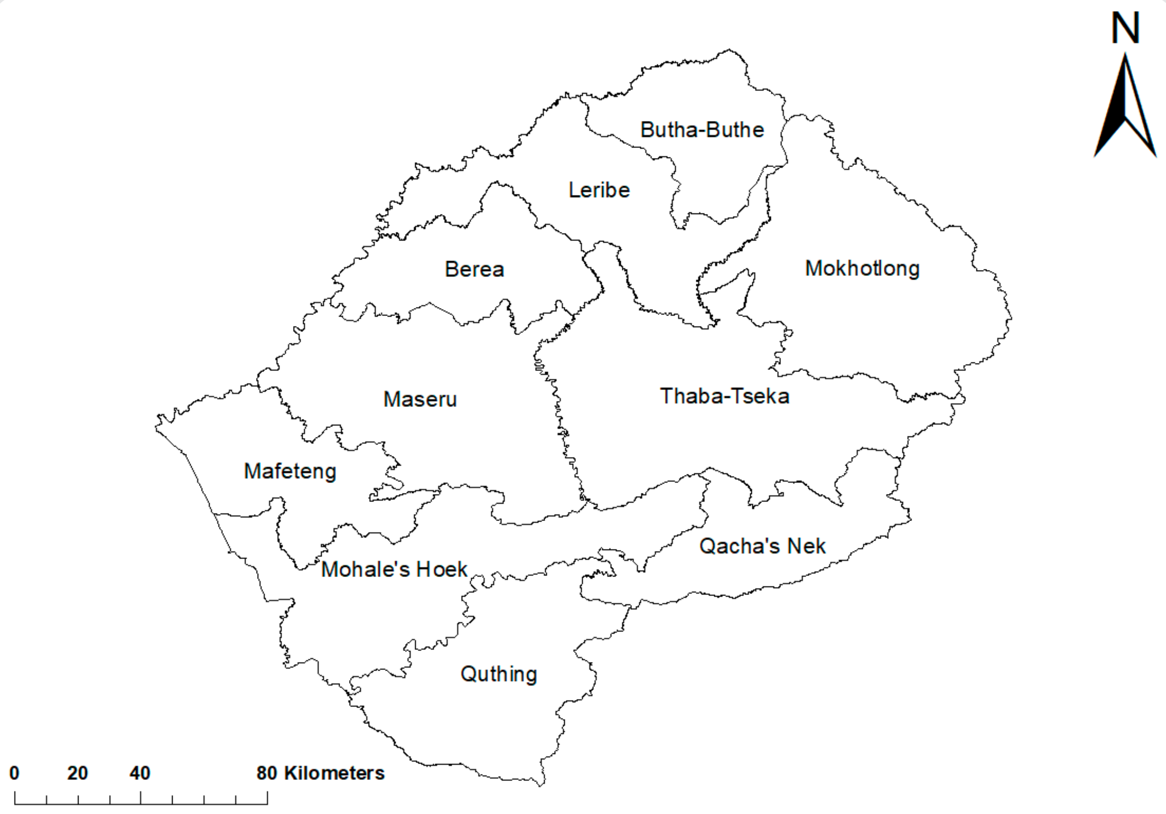


Figure 2.3: Political Map of Lesotho (Source: Lesotho Meteorological Services)

2.5 CLIMATE AND CLIMATE CHANGE

2.5.1 Climate of Lesotho

The climate of Lesotho is primarily influenced by the country's location in the Karoo basin, and its altitude. It is therefore under the influence of the sub-tropical high-pressure. It is classified as continental temperate with the altitude giving it some alpine characteristics that distinguish it from the rest of the sub-continent. The country has two distinct seasons (winter and Summer) and two transitional seasons (autumn and Spring). Winters are dry and cold. Winter (MAY, June and July) precipitation is mainly in the form of snow, which occurs annually over the Highlands, and occasionally over the Lowlands. Heaviest snowfalls occur either at the beginning or the end of the winter season. Summers (November, December and January) are hot and humid. The average annual precipitation of Lesotho is about 720 mm, of which 85 percent falls between October and April (peak rainfall period is from December to February). The peak rainfall period is from December to February when most parts of the country record over 100 mm per month. Precipitation is highly variable both temporally and spatially. Annual precipitation ranges from below 500 mm in the Senqu River Valley area to as high as 1,200 mm in a few localities in the northern and eastern escarpment, which form part of the Highlands region. (See Figure 2.4). The lowest rainfall occurs during July when the monthly totals of less than 15mm are recorded at most stations.

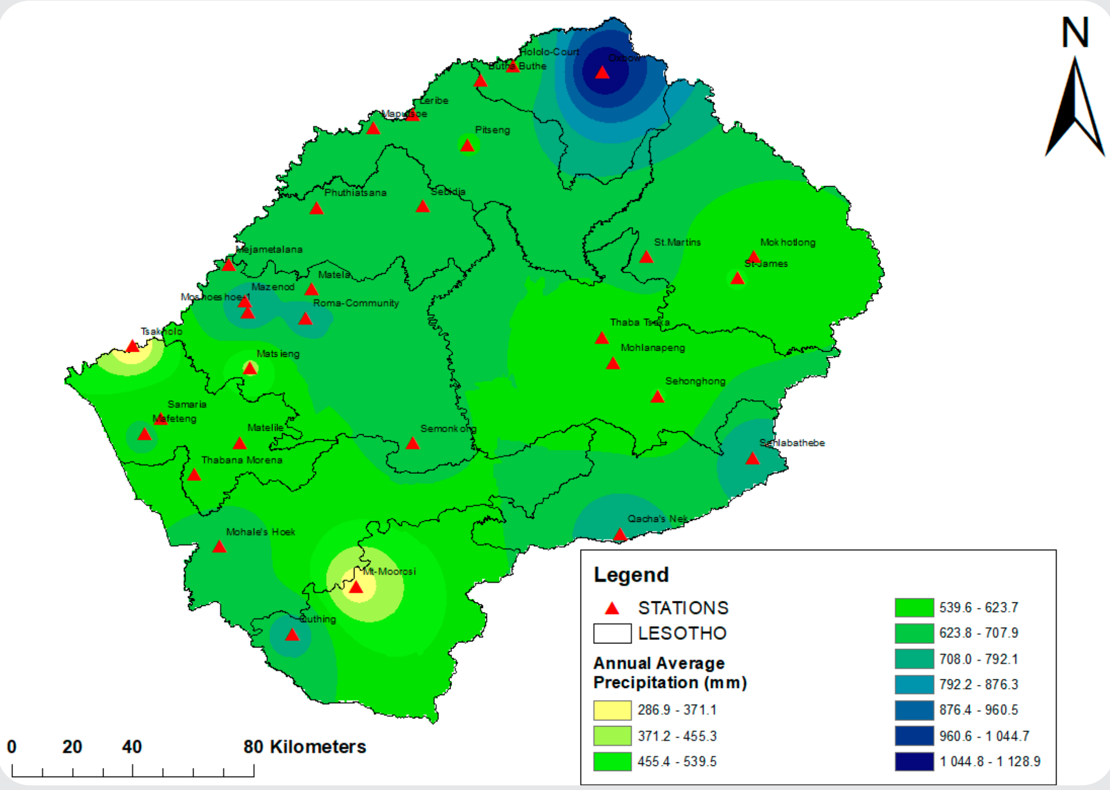


Figure 2.4: Mean Annual Precipitation (Source: Lesotho Meteorological Services)

Total monthly evaporation ranges from 60mm to 70mm during June – July period, to between 175 mm and 225 mm during December – January period. The annual mean evaporation for the whole country ranges from between 1,400 mm in the Highlands to 1,600 mm in the Lowlands. Evaporation is greater than rainfall, with the deficit greatest in summer. In general, Lesotho experiences relatively low humidity, and clean air. The country experiences annual average sunshine hours of around 3,211, over 300 days of sunshine. The annual total solar radiation over the country is estimated to be between 5,700 (Mega Joules per square metre) MJ/m² and 7,700 MJ/m².

Temperatures are also highly variable, on diurnal, monthly and annual time scales, and are generally lower than those of other inland regions of similar latitudes in larger landmasses of both northern and southern hemispheres. This is due to the tapering of the African sub-continent and overall altitude of the country. Mean annual temperature ranges from 15.2°C in the lowlands to 7°C in the Highlands (Figure 2.5). January records the highest mean maximum temperatures throughout the country, ranging from 20°C in Highlands to 32°C in the Lowlands. On the other hand, minimum temperatures of below 0°C are frequent in July, the coldest month, with the Lowlands recording the monthly mean temperatures ranging from -3°C to -1°C and -8.5°C to -6°C in the Highlands. Daily minimum temperature can drop as low as -21°C in winter, and highest daily temperature can reach 37 °C in summer.

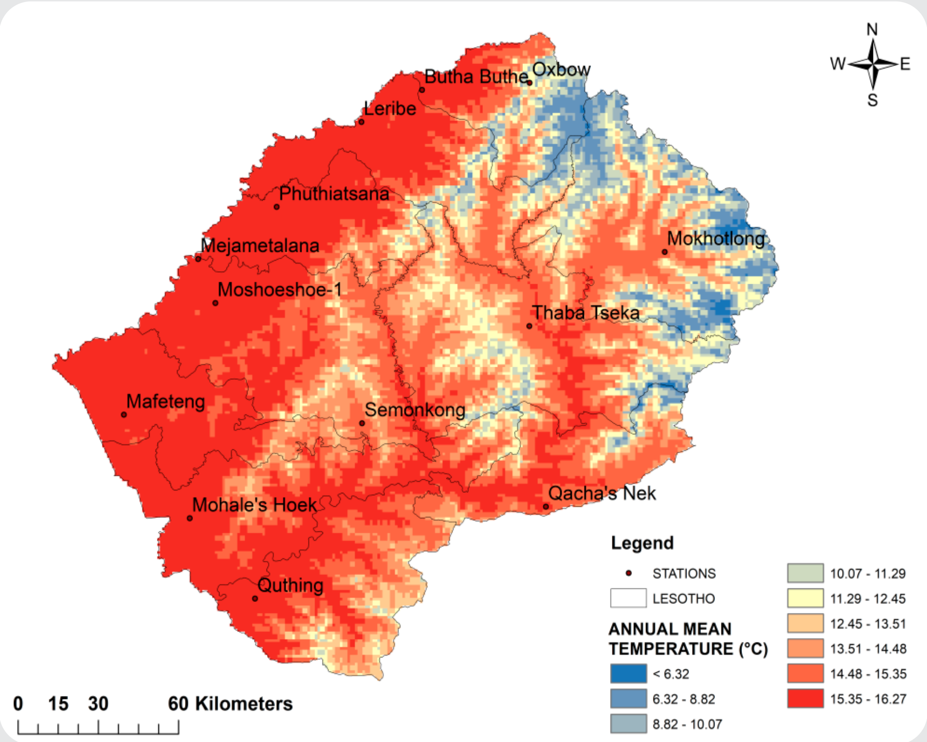


Figure 2.5: Mean Annual Temperatures of Lesotho (Source: Lesotho Meteorological Services)

On average, the first and last days of frost in the lowlands occur on 18 May and 6 September respectively. In the highlands they occur on 16 February and 19 November respectively. These give a frost risk of 111 days for the Lowlands and 276 days for the Highlands. Monthly mean wind speed varies from 1.4m/s in October to 8m/s in August and are generally westerly varying between south-westerly and north-westerly. High winds of up to 20m/s can sometimes be reached associated with summer thunderstorms. In addition, the wind and solar regimes possess tremendous potential for the development of related renewable energies.

2.5.2 **Climate change in Lesotho**

Earliest climate change reports by the IPCC and other documents have always identified Lesotho as one of the most vulnerable countries to climate change. There has been a notable increase in temperature as shown in Figure 2.6 that shows an increasing trend in average temperatures in representative districts for lowlands and highlands of Lesotho for the period 1967-2010.

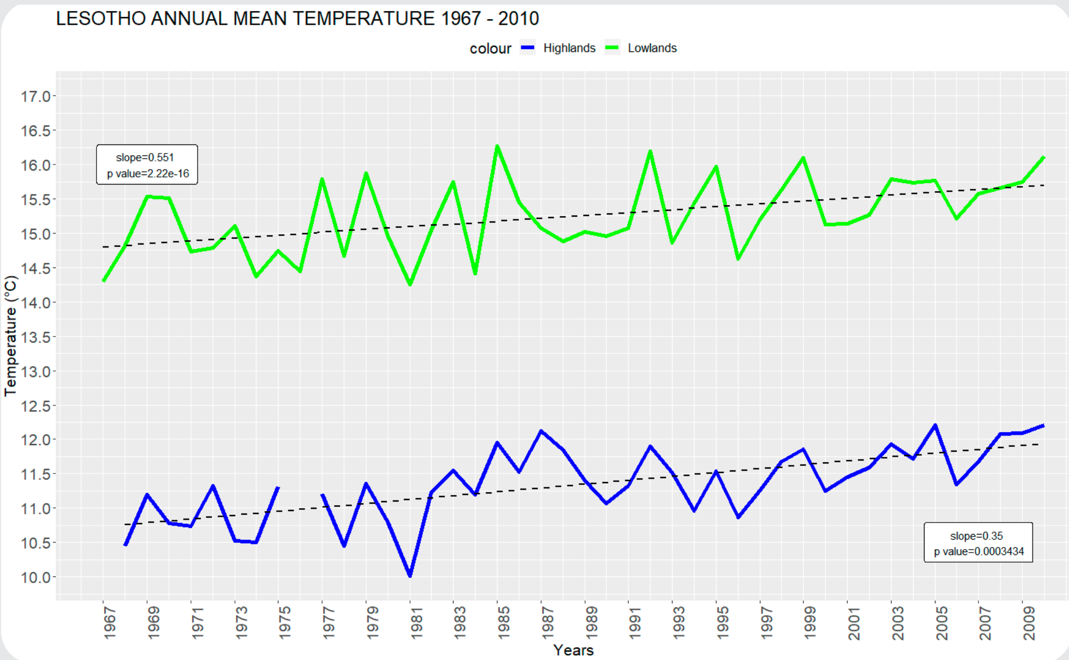


Figure 2.6: Annual mean temperature 1967-2010 (Source: Lesotho Meteorological Services)

2.5.2.1 *Vulnerability of Lesotho to climate change*

Lesotho has always been vulnerable to climate hazards.

The frequency and intensity of climate related hazards has increased. This has resulted in large number of the population particularly vulnerable to food insecurity as demonstrated in Figure 2.7.

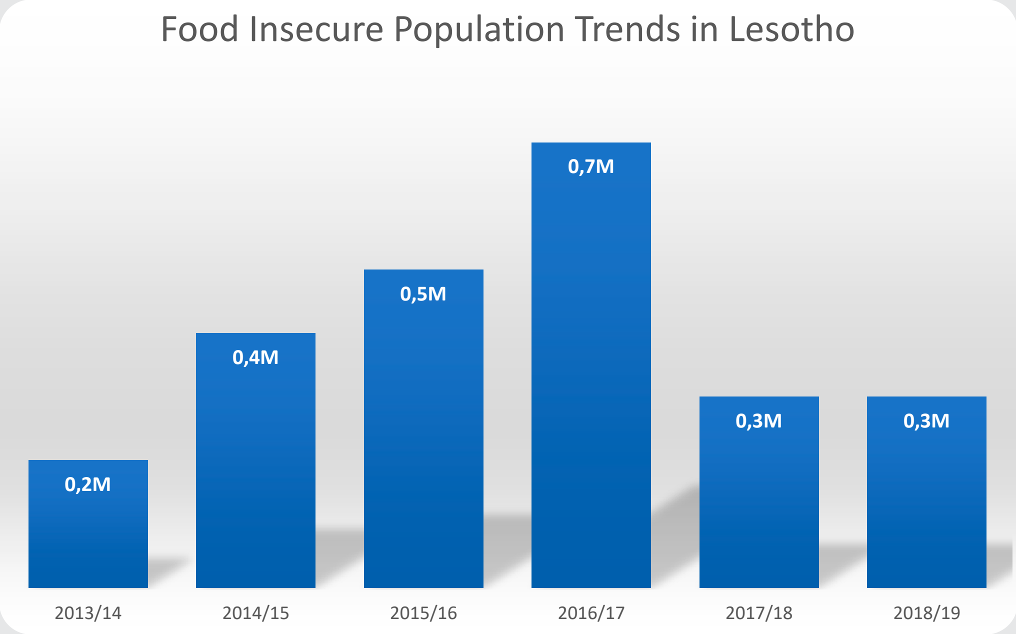


Figure 2.7: Food insecure population trends (Source: Lesotho Vulnerability Assessment Committee)

Moreover, even in a climatologically favourable year, a significant part of the population remains in need of support for food requirements because such a year would be preceded by a poor year where food reserves would have been depleted. In addition to this is the fact that Lesotho is a net importer of food. Thus, even in the year 2013/14 which experienced a normal rain season, the number of people regarded as vulnerable stood at 0.2 million. In 2014/15 agricultural season, Southern Africa experienced an unprecedented ***El Niño*** phenomenon in 2015/16 which resulted in drought and erratic rains and thus 2015 was regarded as one of the driest year on record over a century. This resulted in the doubling of vulnerable people and a state of drought emergency was declared. During 2015/16 season, unfavourable climatic conditions triggered a second year of heightened food insecurity, worse than preceding 2014/15 season. The number of food insecure people increased by 15.2 percent to 534,502 people from 463,936 people in July 2016[3].

Climate conditions were more favourable for food production in the 2016/17 season resulting in increased production of cereals. However, deficits accumulated in the 2014 to 2016 drought conditions rendered a record number of people (i.e., 0.7 million) remaining vulnerable to food insecurity. This illustrated the fact that recovery in terms of food security after prolonged disastrous climatic conditions can be a drawn-out process requiring sustained intervention.

In 2017/18, the rainfall season was delayed. Unseasonal snowfall, extreme cold temperatures and frost experienced in November 2017 damaged early planted crops. Other parts of the country received localised hailstorms and flash floods in March 2018, which also damaged crops4. As a result, 18 percent of rural population was exposed to starvation and in need of humanitarian assistance. A similar scenario repeated in the 2018/19 period.

Indeed, food insecurity caused by climate change is becoming more common. The vulnerability of Lesotho to climate change extends to all aspects of the economy, life and culture as has been confirmed in the Initial1 and Second5 National Communications to the Conference of the Parties (COP) to the UNFCCC.

2.5.2.2 *Responses to Climate Change*

Government of Lesotho considers the response to climate change as an issue that warrants as broad an intervention as possible, i.e., requiring participation of all tiers of government, traditional leaders, the non-governmental organisations, the private sector, development partners, women and youth. The National Adaptation Plan of Action (NAPA) prepared in 2007, helped launch the activities for the country to respond in a more systemic manner to climate change. The NAPA document considers energy, gender, infrastructure and policy reform to integrate climate into sectoral development plans as thematic areas in addition to the seven sectors addressed under the two Communications.

Following the adoption of the NAPA as a working document, the Government of Lesotho, through the support of various implementing agencies and the backing of Least Developed Countries Fund (LDCF) has successfully implemented the following projects since 2013:

- Improvement of early warning system to reduce impacts of climate change and capacity-building to integrate climate change into development plans;
- Lesotho Adaptation of Small-Scale Agriculture Production (LASAP);
- Reducing Vulnerability from Climate Change in the Foothills, Lowlands, and the Lower Senqu River Basin and
- Strengthening capacity for climate change adaptation (CCA) through support to integrated watershed management program in Lesotho.

Implementation of these projects has been overly critical in building the capacity of the country to adapt to Climate Change. Specifically, it has helped the LMS acquire valuable experience essential for effective leadership role on climate change. It has also helped develop a culture of networking and synergizing among the various Government departments and Non-Governmental Organizations. A prominent outcome of these projects has been the inclusion of climate change in the school curriculum.

Other completed and ongoing adaptation projects include the following:

- Increasing Capacity for CCA in the Agriculture Sector (2008-2019);
- Smallholder Agriculture Development Project – Cropping Systems (2011-2017);
- Lesotho Wool and Mohair Promotion Project (2015-2022);

- Smallholder Agriculture Development Project – Livestock (2011-2017);
- Mechanism to Implement the Forestry Initiative for Landscape and Livelihood Improvement Program (2015-2016);
- Improving Adaptive Capacity of Vulnerable and Food-insecure Populations in Lesotho (2020-2023); and
- Strengthening Climate Services in Lesotho for Climate Resilient Development and Adaptation to Climate Change (2020-2024).

Lesotho totally embraced the second focus of the UNFCCC objectives by acceding to the Paris Agreement and preparing its Nationally Determined Contribution (NDC)[6]. Through the NDC, the country is committed to the mitigation objective through achieving sizable GHG emissions and improving sinks to CO_2 by adopting a clean energy development path. Government accepts that the Mitigation effort must be achieved in all sectors. In 2000, Lesotho's GHG emissions were estimated at 3,512.89 Gg of CO_2 equivalent (CO_2e). The Land-Use, Land-Use Change and Forestry (LULUCF) provided a sink of 1,377.98 Gg of CO_2e emissions. This makes Lesotho a net emitter of GHGs. The Government policies aim at reducing the emissions and increasing the sinks. Thus, the National Energy Policy (2015-2025) has its vision "Energy shall be universally accessible and affordable in a sustainable manner with minimal negative impact on the environment".

The energy sector is regarded as having the highest potential for mitigation. Emissions reductions targets have also been identified in other sectors, namely Industrial Processes and Product Use, Agriculture (livestock and soil), LULUCF, Transport and Waste. The country has undertaken numerous studies that highlight and encourage integrated approach (Integrated Catchment Management - ICM) to preservation and improvement of biological and hydrological functions within the catchment areas.

Lesotho's GHG emissions represent only minute part of global emissions and a net per capita of 1.1 tCO_2 equivalent in 2015, but the country is still committed to the global efforts towards meeting the objectives of the UNFCCC and its Paris Agreement to limit average temperature rise to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.

2.6 DEMOGRAPHY: POPULATION AND HUMAN DEVELOPMENT INDICATORS: 2018

Lesotho's Bureau of Statistics puts the country's population in 2018 at 2.2 million. The population grew at a high rate in the 1950's, from around 700 000, where it peaked at around 2 million in 2000. It declined in 2005-2010 but rose again in 2015 due to a concerted effort by government, particularly through the implementation of Health Strategic Plan (2012-2015). However, for a decade, the population of Lesotho has hovered at approximately 2 million. The life expectancy is 56 years with 80 percent of the population residing in the rural areas.

Globally, Lesotho scores poorly on Human Development Index (HDI) with an index of 0.520. This puts Lesotho at 164 out of 189 countries[7]. The Human Development Index places Lesotho in the lower half of the SADC region, only ahead of some five countries out of sixteen countries. The country is aware of the situation and readily acknowledges and identifies areas of intervention as indicated by the country's report on progress towards implementation of Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs), vis-à-vis the shape and character of successive NDPs, Strategies and Policies. The government is also aware of the debilitating effects of climate change on the economy and health and thus accords high priority to climate change issues including operationalising the NCCP.

2.7 ECONOMIC OUTLOOK AND DEVELOPMENT

Lesotho has a small and open Economy that is closely linked with South Africa through revenue transfers from the Southern African Custom Union (SACU), workers' remittances and imports of essential goods and services. The performance of Lesotho's economy has been unstable in the past, with contraction in the last three years. Real GDP is estimated at M21,448 million in 2019 as the economy continues to contract, representing a 0.4 percent decline in GDP growth rate, and the lowest to be recorded in the past 10 years was 2017 with a decline of 3.2 percent. The average annual growth rate of GDP has been 2.2 percent for the last ten years, during which the highest was observed in 2012 with growth of 6.3 percent. The main positive contributors to the economy in 2019 were Financial and Insurance activities, Agriculture and Information & communication with 7.9 percent, 6.1 percent and 4.7 percent respectively[8].

Lesotho has been faced with development challenges such as persistent poverty and inequality (including gender as well as rural-urban inequalities). The unemployment remains high at 22.5 percent with the youth unemployment rate is especially high at above 29.1 percent9. Progress of health, education and service delivery outcomes has been slow. The private sector remains weak and is dominated by a few sectors (e.g., textile and apparel) and mostly micro, small and medium enterprises (MSMEs). The heavy dependence on the Southern Africa Customs Union (SACU) receipts, reliance on miners' remittances and textile exports to the United States continues make the country vulnerable to external shocks.

More than 80 percent of the population relies on natural-resource based industries such as agriculture, which exposed the economy of Lesotho to environmental shocks such as natural disasters and the negative impacts of Climate Change. the country has high risk of natural disasters and climate change.

Overall, the economic performance and development of Lesotho should take cognisance of the emerging climate change patterns as, which have demonstrated the capacity to severely compromise productivity of all arms of the economy.

2.8 KEY SECTORS OF THE ECONOMY

2.8.1 Water Sector

Water remains an incredibly significant contributor to the GDP at 1.25 billion (3.9 percent of the GDP) in 2019[8] with the Lesotho Highlands Water Project alone generating close to a billion Maloti from water and electricity sales. Water remains a key resource for the country, in support of the economy, environment and culture. Preservation of the wetlands is the prerogative of all tiers of governance. Chiefs and local government structures control grazing practices around the wetlands. At central government level, the Department of Environment (DOE), Department of Soil and Water Conservation (DoSCW) as well as some specific projects, all have components that aim at preservation and rational use of the wetlands.

The Metolong Dam was completed in 2016 as part of the Lowlands Water Supply Master Plan and already supplies water to the capital city Maseru and other neighbouring areas. The Lesotho Highlands Water Project was established to provide water to the Republic of South Africa, and to generate electricity. Under Phase I of the Project, completed in 2004, the Katse Dam and the Mohale Dam water transfer tunnels and the Muela Hydropower station were constructed. Phase 2 of the Project consists of Polihali Dam and transfer tunnel to Katse Dam. Polihali Dam will increase the yield of the system by another 437 million m3/a (the net yield is 151 million m3/a when the yield reduction of 286 million m3/a in the Orange River is accounted for). Transfers from Polihali Dam is expected to start in May 2019[10]. There will also be a water transfer tunnel, associated roads and bridges, accommodation and telecommunications infrastructure.

A scheme to transfer water to Botswana, from the Makhaleng River is also being negotiated. The water resource in Lesotho in general is under severe stress from the recurring droughts. This has called for government to introduce the whole aspects of water management.

2.8.2 Agriculture Sector

Agriculture remains an important sector through which Basotho derive their livelihoods, especially in the rural areas where 65.8 percent of the population resides[11]. The type of agriculture practiced is mainly subsistence with minimal commercial farming. Its contribution to GDP has declined over time, from a high of 15.2 percent in 1984 to a low of 4 percent in 2014, with a slight increase to 4.7 percent in 2019[8]. The sector is estimated to employ 8.5 percent of the urban population and 54.3 percent of the rural population. The declining productivity in the sector is due to low productive capacity of Basotho farmers, the negative impacts of climate change, the deterioration of the environment and poor land use practices. Efforts have been made by the Government to improve productivity through agricultural subsidies and modernisation of agricultural production. Value chain development and diversification in the sector is critical. It has been prioritised by government in order to build resilience in the sector that is currently dominated by the production phase of the value chain which is highly dependent on the environment and exposes the sector to climate change risk. Diversification is also promoted by government through initiatives such as establishment of a credit guarantee facility to promote access to finance and encourage investment in horticultural for Basotho farmers to move from the traditional grain production practices.

2.8.3 Mining and Quarrying

The mining and quarrying sector, which is dominated by diamond mining, contributed 5.6 percent to GDP in 2019[8]. It is projected to contribute more than 10% to the country's GDP in the coming years[12] which reflects a growing importance of the mining sector in the national economy. Lesotho has been known to produce quality diamonds which are known for fetching the highest dollar per carat price and are ranked in the top twenty globally. Diamond mining thus remains the main activity of this sector.

Lesotho's mineral resources potential is not limited to diamonds. For example, the significant occurrences of clays offer potential for a clay industry. Significant deposits of heavy clays, white-firing clays and stoneware clays have been identified. Formations of attractive sandstones for the construction industry have also been identified. The presence of fine-grained basalt and massive dolerites provide a good base for a dimension stones industry. Sporadic and small occurrences of a variety of semi-precious stones (agate, chert, rock crystal, amethyst, olivine, zircon and chrome diopside) are known to exist. There are possible occurrences of base metals, precious metals, rare earth minerals and hydrocarbons resources ascertained by the previous regional exploration programmes and the ongoing geochemical exploration which calls for further detailed exploration to confirm the viability of their commercial exploitation. Other identified minerals include galena, agate and uranium as well as coal, though their commercial viability still has to be assessed. Quarrying of sandstone and dolomite is a major activity, and clay deposits are abundant with the country producing some bricks, ceramics and tiles.

In general, low investor interests, inaccessibility of promising areas and inadequate geological information have inhibited the exploration for mineral resources needed to drive a vibrant and diversified mining industry. The government retains shareholding arrangements in mining ventures[12].

2.8.4 Energy Sector

The government is committed to promoting green energy development pathways and reducing traditional dependence on biomass utilization. However, deforestation hampers the government's efforts to preserve the environment. Efforts are made to implement energy policy to alter the energy balance towards environmentally friendly practices and securing energy for all.

Peak demand for electricity stands at 160 MW with locally generated hydropower accounting for 72 MW (Muela plant), Semonkong, 0.18 MW and 2 MW from mini hydro-power plant situated along the Mantsonyane river[13]. More hydropower is expected from the next phase of the LHWP. There are plans to establish multipurpose dams on Makhaleng, Hlotse and Senqu with a capacity to generate an additional 150 MW. The country enjoys on average 300 cloud free days a year and a favourable wind regime. Thus, the potential for development of wind and solar energies holds much hope for the future, and the government is actively inviting investment in these climate friendly energy sources. Feasibility of a 20 MW solar plant at Semonkong as well as a 50 MW wind power plant at Letseng-la-Terai have been completed. It is realistic to imagine Lesotho totally meeting all its domestic energy needs and even exporting some from the renewable energy sources.

2.8.5 Tourism Sector

The sector has great potential to make a significant contribution to the economy. The rugged, unspoiled mountains of Lesotho, with unpolluted air, malaria-free, snow caps, frozen waterfalls and meandering roads provide spectacular and breath-taking scenery. Places of interest to a tourist include Tsehlanyane National Park, the Katse Dam and Botanical Gardens, Major Bell's Tower and Fort, Kome Cave Dwellings, Thaba-Bosiu Mountains, Royal Villages with their archives and museums, Maletsunyane / Semonkong Falls, Bokong Nature Reserve, Liphofung Nature Reserve, Lesotho Highlands Water Project, Sehlabathebe National Park, Sani Pass, Ox-bow Skiing Resort, horse trails and trekking, and the casinos in Maseru.

The number of visitors to Lesotho in 2018 reached 1,172,648 with 1,056,433 visitors coming from neighbouring South Africa. Other visitors from the region included Zimbabwe (20,407); Botswana (6,016); Swaziland (4,897) and Malawi (3,331). International tourists came from Germany (9,477), the Netherlands (8,840), the USA (8,732), China (6,099), and the UK (4,880). The industry is supported by 23 hotels (946 rooms), 32 lodges (759 rooms), 29 Bed and Breakfast outlets (279 rooms), 75 Guest Houses (967 rooms) and 18 other facilities with 399 rooms. The hospitality industry has however over the last 5 years enjoyed very low occupancy rate, averaging about 20 percent. Notwithstanding this, it provides direct employment to 2663 people, with another 2000 engaged in supporting activities such as transport and equipment rental (112), air and road transport (122), heritage and culture (97), handicraft centres (94), leisure and sporting (65), tour operators and travel agents (58), restaurants (416), cafes and fast food (312), food and beverages (738), and public sector support (487)14. International tourists spent about 488 million Maloti in the country in 2018.

Forty (40) percent of the workforce engaged in the industry has received some formal training, which is significant in the effort to afford job opportunities to university graduates. Furthermore, 44 percent of the industry is directly family owned and managed. The sector also employs 30014 additional persons at peak demands. This is very crucial to social stability. To strengthen this industry, government has established a Tourist Board whose mandate includes international marketing, raising tourism awareness and providing guidance to new entrants to the industry. Contribution of tourism to the GDP is projected to increase.

2.8.6 Manufacturing Industry

Lesotho's manufacturing sector is based on textiles, garments, and footwear exports. In 2019, the sector contributed 16.5 percent to GDP which makes it one of the key economic activities in the country with a high potential for job creation and sustainable growth. It is dominated by female labour and large foreign firms with very limited linkages with the domestic private sector. In 2013, more than 45,000 people were employed in manufacturing, of whom over 40,000 were female[15]. Lesotho has access to regional and international markets such as AGOA, SACU, European Union, and SADC with an opportunity to explore new markets.

Participation of Basotho in the manufacturing sector is constrained by lack of financing and skills, which limits the country to exploit the full potential of the sector to contribute to an export led economy and enough performance in the available markets. Lesotho aims to promote the sector through diversification of products/markets and promote linkages to enable participation of Basotho private sector towards the aspired private sector led job creation. Through the Lesotho National Development Corporation (LNDC) government attracts investment and provides support in terms of infrastructure and logistics, e.g. provision of textile industrial estates where LNDC constructs structures to establish manufacturing factories. The Basotho Enterprise Development Corporation (BEDCO) on the other hand promotes local entrepreneurship through its centres.

2.9 HEALTH AND SOCIAL CONDITIONS

The health sector traditionally receives the highest budget allocation after education, underscoring the importance successive governments attach to this sector. The Ministry of Health, church organizations, and some donor-funded Non-Governmental Organizations operate major hospitals and satellite clinics throughout the country. The Flying Doctor's Service serves the remote mountain areas. Access to medical care is estimated at 60 percent.

Lesotho has a network of roads, fair distribution of educational facilities and fair access to drinking water. But due to pervasive poverty and the shrinking agricultural productivity, social conditions remain rather poor. The current droughts among others e have resulted in the population in rural areas being impoverished, thus migration to better living conditions in urban areas. On the other HIV/AIDS and rural poverty has deepened and the number of orphaned children has increased remarkably. Low employment amongst high school and tertiary institution graduates is apparent. However, government has introduced initiatives such as work for food, manual labour to maintain roads and other light civil works, and for those aged 70 years and over a pension scheme to alleviate poverty.

2.10 PROGRESS ON SUSTAINABLE DEVELOPMENT GOALS (SDGS)

The Government of Lesotho is fully committed to the UN 2030 Development Agenda for Sustainable Development Goals (SDGs). The government has domesticated and integrated the SDGs as well as other continental and regional development agendas such as the AU Agenda 2063 and the SADC RISDP, into its National Development Priorities.

In the report titled Kingdom of Lesotho Sustainable Development Goals Indicator Baseline Report 2016[16], the government acknowledges lack of success in the implementation of other Agendas, particularly the MDGs. This frankness underscores the government's determination to successfully meet the targets of the SDGs, as well as to invite more assistance to the country in order to strengthen strategic sectors that would ensure that Lesotho progresses from being a least developed country. The report uses the base years of 2015 and 2016 to review progress on areas and indicators that are most critical to Lesotho.

Objectives of SDG1 and SDG2 are to *End poverty in all its forms everywhere, and End hunger, achieve food security, improve nutrition and promote sustainable agriculture*, respectively. These objectives have been priority areas for the successive governments since independence in 1966. Lesotho is a Least Developed Country, and poverty in all its definitions is prevalent in the country. A number of short-term and long-term measures have been implemented to address this situation e.g., the old age pension for citizens at 70 years of age. There is also the child programme, public school feeding and support to orphaned and vulnerable children. One key intervention has been an effort to ensure security to stabilise home and land ownership through provision of leases to guarantee such ownership. This is key to promoting investment in the land for sustained use.

The Head of State, King Letsie III, is the African Union (AU) nutrition champion and the Food and Agriculture Organisation (FAO) Ambassador for nutrition. This affirms the importance the world attaches to eradication of hunger, poverty and attainment of all SDGs.

In line with SDG3, provision of adequate health infrastructure and services has been the primary goal pursued in earnest by Lesotho. The implementation of the Health Strategic Plan 2012-2016[17] is identified as one of the key moves by the government to improve health in the country. It included specific goals such as fighting HIV and AIDS, reducing maternal and new-born deaths and prevalence of some chronic diseases. However, the country continues to have a high mortality rate of 8.3 and a very high HIV/AIDS rate. The HIV prevalence is around 306, 000 (25.6 percent of the population). Furthermore, around 49.9 percent of women under the age of 40 (35-39) are infected with HIV. In 2017 there were 10,000 new infections. A total of 60 percent of adults living with HIV were on anti-retroviral treatment, with 90 percent for children. Condom use is estimated at 64.9 percent[18].

Trends indicate that during the period 2004-2014, maternal mortality increased from the 2004 level, peaked in 2009, but declined by 2014 (though still higher than in 2004). This is despite the significant increase of skilled Health Personnel from 2004 to 2014 (i.e., from 55 percent to 78 percent). There was an apparent success in the reduction of less than 5 years' mortality rate[19]. The tuberculosis incidence statistics show that the number of affected people declined steadily in the 2004-2014 period. Fatalities resulting from other diseases such as diarrhoea, gastroenteritis are relatively low, though alcohol abuse remains a major challenge.

Climate change remains a threat to health of the population to meet the objective of SDG3. The Ministry of Health is paying attention to the spread of tropical diseases as a result of increasing temperature. The Ministry of Education is traditionally allocated highest percent of the national budget. All development plans highlight education as a priority area. The quality of education and its appropriateness to meet the country's developmental needs,

is receiving increasing attention. Therefore, there has been a clear shift in policy towards improving quality and to align the educational system with the labour market needs. However, Lesotho's report on the progress of SDG 4 states that it "remains without a doubt that Lesotho has remained behind in ensuring that by 2030 it will have achieved the SDG 4 target to substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship". It is however to be appreciated that the curriculum at basic education level now includes introduction to climate change.

Lesotho has multiple laws and policies that promote, enforce and monitor equality and non-discrimination on the basis of gender. They can be clustered around the following:

a) Legal capacity including ownership of land and labour rights.
b) Civil and political – parliament and leader-ship roles.
c) Sexual offence including trafficking and child protection.

These set of policies and national laws have in the main not been antagonistic to the culture of Basotho and have generally received acceptance.

Lesotho's immigration laws remain very liberal to people even beyond SADC. Lesotho supports free movement of people among countries and believes relaxation of migration control can contribute to the attainment of SDG10. It accordingly supports initiatives and consultations on this subject, particularly for the SADC regions.

Since 2016 the country has undertaken a process of reform that will address all arms of governance, the parliamentary process, the public service and the judiciary. This Reform Process represents a most concerted effort to promote peace, inclusivity, justice and accountability in line with SDG16 objective. The country has never really achieved desired political stability. Vision 2020 foresaw Lesotho as a stable democracy where principles of good governance will be anchored on respect for human rights, the rule of law etc. The last ten years in particular have seen a number of political upheavals that slowed progress in meeting the targets of Goal 16. Since the year 2010, there have been three national elections (2012, 2015, and 2017) which have resulted in coalition governments as no party achieved outright majority. The country does not have a culture of coalition governments and political stability remains elusive.

Inequality has not been a feature of the Basotho history and culture. However, with the growing income disparities among individuals, families and even communities, inequality has in recent times been evident. Inequality within Lesotho and among Nations and countries will be better addressed through progress attained with other SDGs, particularly those that have a net result of reducing poverty and promoting equal access to economic opportunities.

Lesotho remains a patriarchal society to a considerable extent. Lineage and succession (royalty) devolve along the male. By 2017 Lesotho ranked 135th out of 160 countries in Gender Inequality with an index of 0.544[20]. To maintain momentum towards achievement of this SDG, Government has developed a document titled 'Lesotho Gender and Development Policy, 2018-2030' which sets out how the country will address many of the shortcomings hampering the achievement of SDG5.

In terms of GINI Coefficient, Lesotho fares poorly with an index of 47.8, scoring only better than 3 SADC countries.

To ensure sustainability of the water resource, the government pays particular attention to environmental protection to minimize soil erosion and other hazards in order to avoid sedimentation of the water ways and ensure ecological function of wetlands. Lesotho has one of the highest rates to clean water in the sub-Saharan Africa at 72 percent in urban areas and 63 percent in rural areas. Similar success has been achieved in sanitation. Thus, Lesotho seems well on the cause to meet the targets of SDG6 by 2030. However, climate change, particularly the frequent droughts have the most negative impact on this valuable resource and its exploitation warrants harmony with emerging and predicted climate scenarios.

By 2016, Lesotho's energy balance was still characterised by dependence on biomass, with resultant negative social, environmental and health impacts. The country has set for itself a target of 50 percent of electrification by 2020. While it may be difficult to totally satisfy the targets of this particular SDG by its end date, efforts to satisfy the energy needs through renewable energies beyond 2030 have commenced. Climate change mitigation in particular provides further impetus towards development of renewable energies, hydro, wind and solar.

Building of roads particularly to link the mountain areas with the lowlands, improvement of communication systems, and provision of power along with improvement of water and food security have always featured as key demands and indicators of development of the country in a broad sense and tie very well with the objective of SDG9. The country has registered improvement of rural roads such as the Maseru-Semonkong-Qacha's Nek Road, and infrastructure developments associated with the Lesotho Highlands Water Project.

Massive damage to rural road networks, following the 2013 floods has provided the policy developers to feature most prominently climate change realities as a means to climate-proof the infrastructure. This is in evidence in the drafts of the NSDP II[21] .

The role of innovation has not received a focus it deserves in the past policy documents and budget allocation. The creation of the Departments of Science and Technology, together with the Appropriate Technology Section within Government Ministries were the first initiatives at inculcating the culture of innovation. The National University of Lesotho (NUL) has also established an Innovation Hub to support effort towards promoting innovation.

Lesotho is basically a rural country. However, officially there are nine settlements that are designated as "urban". Maseru the capital enjoys the status of a "city". The urban population has rapidly increased in recent years due to availability of social amenities, services and a hope for job opportunities considering the declining agricultural productivity. It now stands at around 510, 000 constituting 27 percent of the country's population of 2,204,239 in 2016.

Most of the new inhabitants in the urban areas normally retain their rural homes, and although they resort to building or renting inferior houses, Lesotho does not have a serious problem of overcrowded slums, uncontrolled sewer and water discharges and refuse disposal. Furthermore, the successful enforcement of the ownership titles under SDG1 has helped improve provision of services, encourage investment and build the resilience of urban settlements. Urban life remains relatively safe in part because of the size and homogeneity of the culture of Basotho.

Both Lesotho's report on SDGs as well as the other policy documents appreciate that for Lesotho's economy to grow, there is need for macro-economic and political stability, higher savings and investments, economic diversification and a skilled and competitive labour force.

Past strategies have prioritised areas of potential growth as agriculture, mining and quarrying, manufacturing, technology and tourism.

The country has also seen establishment of many indigenous enterprises in areas such as dressmaking, leather works, mohair weaving and pottery that depend on the acquired innovative skills of the Basotho. Manufacturing has made good use of opportunities created by African Growth and Opportunity Act (AGOA), with textiles becoming the largest employer after agriculture. With an extremely low industrial base, Lesotho does not produce any toxic and harmful substances. Industrial discharges from the textile industries did attract attention. It is the maintenance of large herds of sheep, goat, cattle, and donkeys, together with the shrinking arable land that remain a concern. Government has recently launched a programme that emphasizes quality over quantity in as far as livestock production is concerned. The hope is that Lesotho will regain its reputation as a producer of quality wool and mohair.

Basic ingredients towards achievement of SDG8 still require sustained attention. Beginning in 1988 with the formulation of the National Environmental Action Plan (NEAP), Lesotho established the National Environment Policy in 1998 which laid the foundation for the Environmental Act of 2008. This Act also introduced the practice of Environmental Impacts Assessment. The country does have tools for the protection and management of the land base. The country also adopted the Forestry Policy (1997) and Forestry Act (1998) for the purpose of preserving indigenous shrubs and trees and for the expansion of land under trees. Thus, the forested area grew from 1.4 percent in 2004 to 1.63 percent of the total land area.

Desertification is increasing, particularly in the Senqu valley and southern lowlands. In pursuit of meeting the target of this goal and in pursuit of Lesotho's obligations under the United Nation Convention to Combat Desertification (UNCCD), and also to reduce poverty, efforts have been made to reclaim degraded lands and restore productivity of the affected areas. Success is however increasingly hard to achieve due to rainfall intensity and variation associated with climate change.

Lesotho has always been active at international fora to put across its views, solicit financial support and build partnerships. It advocates for international collaboration to maintain global peace, science and technology transfer and cultural exchanges. The country respects sovereignty of other countries and adherence to UN, the AU and regional charters. This is acknowledged to advance SDG17.

The National Strategic Development Plan (NSDP I: 2012-2017)[10] had as its goal to "reverse environmental degradation and to adapt to climate change" The country also plans to adopt green economic path there by contributing to the global climate mitigation effort. In addition to NSDP I development documents across all the sectors address the question of climate change and its impacts one way or the other. The development and adoption of the NCCP in 2017 emphasized the country's determination to mainstream climate change.

The country is on course to taking action on climate change in line with SDG13.

Achievement of Goal 15 coincides with the overall objective first focus is to eliminate barriers climate change impacts. The topographic features, rainfall characteristics, management techniques are the key areas to be considered in the pursuit to attain the objectives of this goal.

2.11 INSTITUTIONAL FRAMEWORK ON CLIMATE CHANGE

The Ministry of Energy and Meteorology (MEM) remains the focal point on climate change. Through the Department of Meteorology (LMS), the Ministry leads the efforts to implement the Lesotho's National Climate Change Policy (NCCP)22. Key functions of LMS are to monitor the weather and climate, climate change detection and protect the ozone (O_3) layer. It also assesses vulnerability and response measures to the same and coordinates activities emanating from Lesotho's obligations and related agreements.

The National Climate Change Committee (NCCC) was formally established in 2013. Its main function is to advise the MEM on effective implementation of the Lesotho's NCCP, acting as well as a link between the LMS and the various social and economic sectors. Climate change has an impact on all facets of life. As such the vision of the NCCP is to build a climate change resilient economy and environment. To achieve this, the Policy identifies some twenty-two policy statements that would promote adaptation by means of reducing climate risk and enhancing mitigation through a low carbon development path.

2.12 NEW POLICIES AND STRATEGIES THAT ADDRESSES CLIMATE CHANGE

Since 2013, the Government of Lesotho has been pursuing more aggressively policies and strategies to address climate change. In 2017, a new Ministry of Energy and Meteorology was created giving visibility to functions of LMS. LMS was restructured to accommodate the secretariat of the National Climate Change Coordinating Committee as it pursues and implements the NCCP.

The NCCP and the National Climate Change Implementation Strategy23 were both adopted in 2017. The document "Guidelines for the Integration of Climate Change in National Sectoral and Local Policies Strategies and Development Plans"[24] developed in 2018 provides further elaboration on institutional arrangements for successful implementation of NCCP and NCCPIS. It also recommends appointment of Officers to be designated as Climate Change Coordinators that will be placed at every line ministry and at the district level.

Another vital development has been the reshaping of school curriculum at basic education level to interpret issues of climate change. A toolkit was developed through collaboration between the LMS and the National Curriculum Development Centre (NCDC) in association with the implementation of the early warning systems under the NAPA Programme. Other initiatives include the approach of adopting a countrywide Integrated Catchment Management (ICM) and the concerted move towards developing renewable energies. All in all, the country appears poised for more action-oriented initiatives in the 2020 decade.

Government of Lesotho (GoL) has developed the NSDP II to provide an opportunity to improve performance towards achievement of SDGs and other regional and continental agendas and at the same time support the country to implement climate policies. A key feature of the NSDP II is the provision for continuous monitoring and evaluation during its implementation. It will also seek to reduce institutional fragmentation and strengthen coordination and encourage investment into priority areas. The overall target of the NSDP II is employment creation and achievement of the inclusive economic growth. Lessons learned from implantation of NSDP I, influenced the design of NSDP II. The NSDP II mainstreams climate change, environment protection, gender and social inclusion across all sectors. It notes that climate change has implication for employment creation and economic growth since it impacts on the various sectors of the economy such as agriculture, health, nutrition and tourism. Therefore, NSDP II strategy takes cognisance of CCA and mitigation. To date, NSDP implementation framework has been developed to speed up implementation of the NSDP II.

References

1. The Government of Lesotho. (2000). Initial National Communication to the Conference of the Parties to the United Nation Framework Convention on Climate Change. Maseru: Lesotho Meteorological Services.

2. Majara, N. (2005). Land Degradation in Lesotho: A synoptic Perspective. Cape Town.

3. The Government of Lesotho. (2016). Market Assessment. Maseru: Disaster Management Authority.

4. The Government of Lesotho. (2018). Lesotho's Vulnerability Assessment. Maseru: Lesotho Meteorological Services.

5. The Government of Lesotho. (2013). Second National Communication to the Conference of the Parties to the United Nations Framework Convention on Climate Change. Maseru: Lesotho Meteorological Services.

6. The Government of Lesotho. (2017). The Nationally Determined Contributions. Maseru: Lesotho Meteorological Services.

7. The Government of Lesotho (2019). Human Development Report. Maseru

8. Bureau of Statistics. (2019). Annual National Accounts of Lesotho 2010-2019. Maseru: BOS.

9. The Government of Lesotho. (2019). 2019 Labour Force Survey. Maseru: BOS.

10. The Government of Lesotho. (2012). National Strategic Development Plan I: 2012-2017. Maseru.

11. Bureau of Statistics. (2016). The 2016 Population and Housing Census. Maseru.

12. Government of Lesotho. (2015). The Minerals and Mining Policy 2015. Maseru.

13. The Government of Lesotho. (2012). 1st Annual State of Water Resources. Maseru.

14. The government of Lesotho. (2018). Annual Arrivals and Accommodation Statistics. Maseru: Lesotho Tourism Development Corporation.

15. Lesotho Tourism Development Corporation. (2014). Lesotho Review 2014. Maseru: Wade Publications CC.

16. The Government of Lesotho. (2016). Kingdom of Lesotho Sustainable Development Goals: Indicator Baseline Summary. Maseru.

17. The Government of Lesotho. (2013). Health Strategic Plan 2012-2016. Maseru.

18. The Government of Lesotho. (2019). LESOTHO POPULATION-BASED HIV IMPACT ASSESSMENT (LEPHIA) 2016-2017. Maseru.

19. The Government of Lesotho. (2017). Lesotho Country Analysis Working Document. Maseru.

20. UNDP. (2018). UNDP Human Development Indices and Indicator. Maseru.

21. The Government of Lesotho. (2019). National Strategic Development Plans II: 2019-2022. Maseru.

22. The Government of Lesotho. (2017). National Climate Change Policy: 2017-2027. Maseru: Lesotho Meteorological Services.

23. Lesotho, T. G. (2017). National Climate Change Implementation Strategy. Maseru: Lesotho Meteorological Services.

24. The Government of Lesotho. (2018). Lesotho Gender and Development Policy: 2018-2030. Maseru. Maseru.

CHAPTER 3

GREENHOUSE GAS INVENTORY 2005 AND 2010

3.1 INTRODUCTION

Globally, concentrations of greenhouse gases (GHGs) in the atmosphere are increasing (see Figure 3.1). According to the National Oceanic and Atmospheric Administration data,[1] Carbon Dioxide (CO_2) [Methane (CH_4) concentrations since 1960 [1984] are steadily increasing at an average of 1.54 parts per million (ppm) [4.92 parts per billion (ppb)] per year with the current levels standing at over 400 ppm [1,834 ppb]. Empirical evidence shows that the increase of GHG concentrations in the atmosphere is the cause of global warming. Each of the last three decades has been successively warmer at the earth's surface than any preceding decade since 1850.[2]

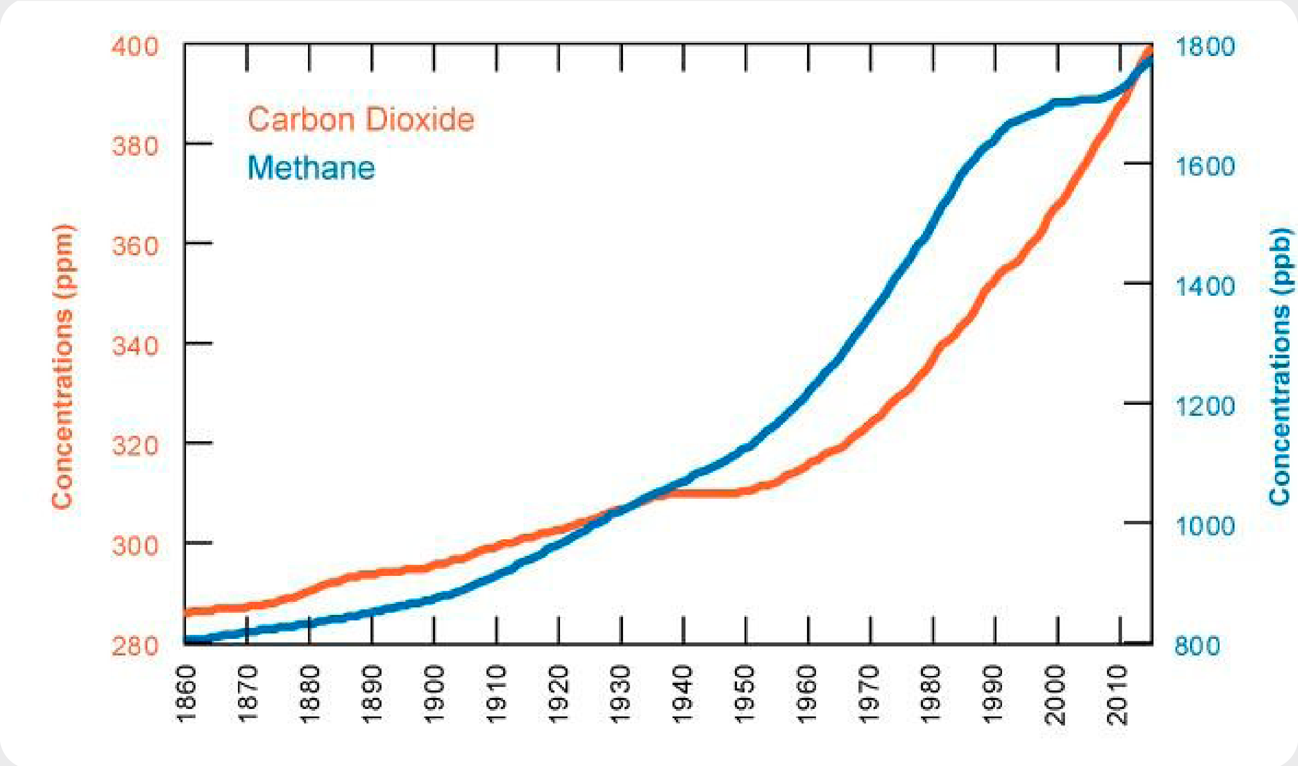


Figure 3.1: Global Historical Concentrations of CO_2 AND CH_4

Global warming has an effect on the earth's climate systems resulting in global climate change. Frequencies of drought and flood occurrences are anticipated to rise. Furthermore, high temperatures that will cause human discomfort and deaths are projected. Consequences of unmitigated climate change could be costly and unbearable. The World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in response to the appeal by the United Nations General Assembly, jointly formed the Intergovernmental Panel on Climate Change (IPCC) in 1988 to undertake assessments on all aspects of climate change and its impacts, based on available scientific information, with a view of formulating realistic response strategies. The IPCC provides technical information regarding the status of the global GHG concentrations and their impact on the climate. The First Assessment Report (FAR) of the IPCC that was released in 1990 provided initial consensus by the scientists that increasing global temperatures could be due to growing anthropogenic GHG emissions.

Lesotho, as one of the least developed countries, has low GHG emissions footprint. The country developed GHG inventories in 2000 for the base year 1994[3] and in 2013 for the base year 2000.[4] Both reports show that Lesotho is net emitter. In terms of carbon dioxide equivalent (CO_2e)

emissions, Agriculture, Forestry and Other Land Use (AFOLU) has been the main source of emissions in the country.

In this chapter, the Lesotho GHG emissions inventory is estimated for the years 2005 to 2010 using the 2006 IPCC guidelines.[5,6] The emissions from the following categories were made:

1. Energy Sector
2. Industrial Processes and Product Use (IPPU) Sector
3. Agriculture, Forestry and Other Land Use (AFOLU) Sector
4. Waste Sector

For comparison purposes, IPCC guidelines recommend that all the emissions be converted to CO_2e in accordance with the estimated effect on their warming influence (radiative forcing) on the global climate system due to their different radiative properties and lifetimes in the atmosphere.[7] The following 100-year global warming potential (GWP) for the three main GHGs were used i.e., CO_2 (potential = 1); CH_4 (potential = 25); and Nitrous oxide (N_2O) (potential = 298).[8]

3.2 GHG INVENTORY PREPARATION PROCESS

The GHG Inventory followed the six steps as illustrated in figure 3.2 below. Firstly, institutional arrangements were set-up followed by selection of methods and identifying key categories to be prioritised for the inventory. The third and fourth steps were data collection and GHG inventory calculation and compilation respectively. Quality Control checks were then carried out on the inventory followed by Quality Assurance step by an independent consultant. Issues raised during QA/QC process were referred back to the compilers to be addressed. The last step was to compile the Third GHG Inventory report.

Below is the breakdown of the GHG inventory compilation process.

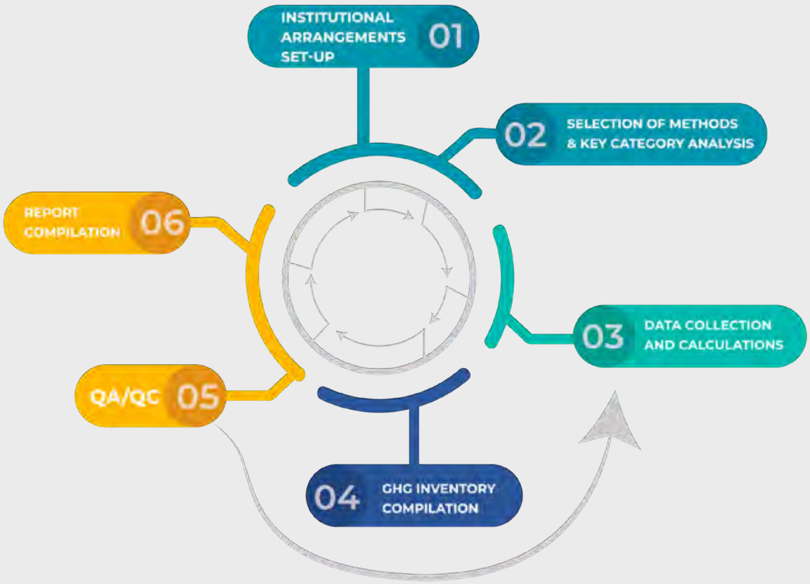


Figure 3. 2 Lesotho GHG Inventory Process

3.2.1 Institutional Arrangements

This step involved identification of a GHG Inventory Task Team including selection of sector leads and GHG Inventory Coordinator, understanding of roles and responsibilities by each task team member and training of task team members. Figure 3.3 illustrates further the roles played by different institutions in the development of the GHG Inventory.

The overall responsibility of the development and compilation of the GHG Inventory lies with the Lesotho Meteorological Services (LMS). The department also ensured that quality checks of the GHG inventory have been completed and that the report meets all international requirements. The responsibility of other government departments and institutions was to provide data and validate the data and information generated by the data they have provided.

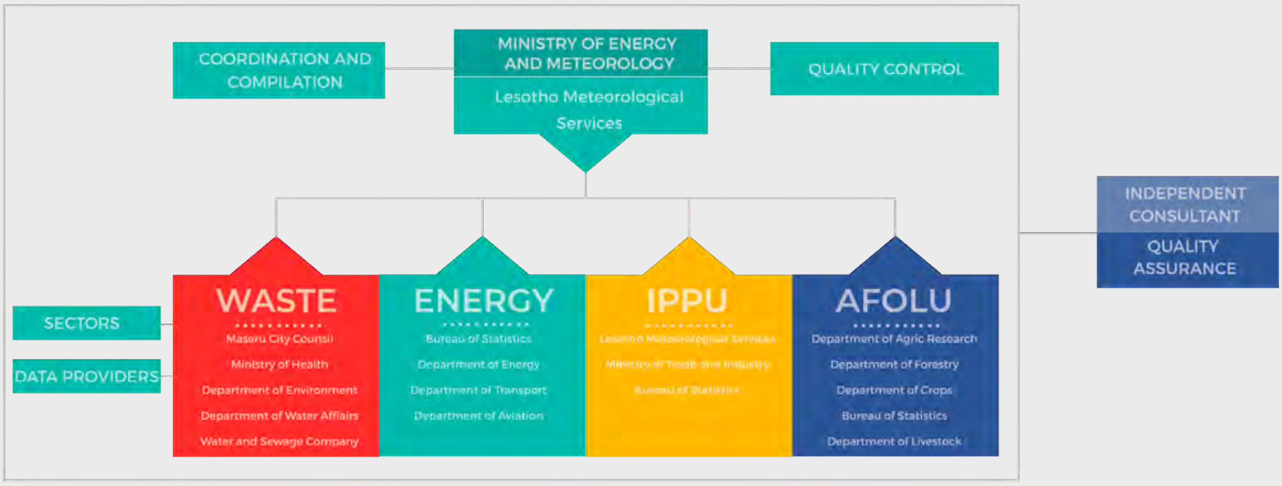


Figure 3. 3 TNC GHG Inventory Institutional Arrangements

3.2.2 Methods Selection and Key Category Analysis

The Key Category Analysis was done using tier 1 level methods for the second GHG inventory for the year 2000.

Level assessment

The contribution of each source category to the total national inventory level was calculated according to equation (3.1) level assessment:

Key category level assessment = |source category estimate|/ total contribution

$$L_{x,t} = E_{x,t} / \sum E_t \quad (1)$$

Where:

$L_{x,t}$ = level assessment for source x in latest inventory year (year ***t***)

$\boldsymbol{E}_{x,t}$ = value of emission estimate of source category x in year *t*

$\sum \boldsymbol{E}t$ = total contribution, which is the sum of the emissions in year *t*, calculated using the aggregation level chosen by the country for key category analysis

Key categories according to equation (1) are those that, when summed together in descending order of magnitude, add up to 95 percent of the sum of all $\boldsymbol{L}_{x,t}$. Results of the KCA are presented in table (3.1) below:

Table 3.1 - Key category analysis (KCA) based on contribution to total national emissions in 2000

IPCC Source Category	Sector	Source Categories to be Assessed in Key Source Category Analysis	GHG	Latest Year Estimate Ex,t (Gg CO_2eq)	Absolute Value of Latest Year Estimate Ex,t (Gg CO_2eq)	Level Assessment Lx,t	Cumulative Total
5.A.1	LULUCF	Removals from Forest Land remaining Forest Land	CO_2	-1,601.30	1601.3	16.309	16.309
5.A.2	LULUCF	Removals from Land converted to Forest Land	CO_2	-1,556.10	1556.1	15.849	32.158
5.B.1	LULUCF	Removals from Cropland remaining Cropland	CO_2	-1,556.10	1556.1	15.849	48.007
5.C.1	LULUCF	Removals from Grassland remaining Grassland	CO_2	-1,556.10	1556.1	15.849	63.856
4.D	Agriculture	(Direct and Indirect) Emissions from Agriculutural Soils	N_2O	1,184.90	1184.9	12.068	75.924
4.A	Agriculture	Emissions from Enteric Fermentation in Domestic Livestock	CH_4	665.4	665.4	6.777	82.701
1.A.4	Energy	Other Sectors: Residential	CO_2	327.8	327.8	3.339	86.039
1.A.3	Energy	Mobile Combustion: Road Vehicles	CO_2	252.6	252.6	2.573	88.612
1.A.1	Energy	Emissions from Stationary Combustion (Solid-A)	CO_2	240.1	240.1	2.445	91.058

5.B.2	LULUCF	Emissions from Land converted to Cropland	CO_2	167.7	167.7	1.708	92.766
1.A.4	Energy	Other Sectors: Residential	CH_4	159.9	159.9	1.629	94.394
1.A.1	Energy	Emissions from Stationary Combustion (Liquid-A)	CO_2	152.1	152.1	1.549	95.943
6.B	Waste	Emissions from Wastewater Handling	CH_4	137.8	137.8	1.403	97.347
5.C.2	LULUCF	Emissions from Land converted to Grassland	CO_2	45.2	45.2	0.460	97.807
6.A	Waste	Emissions from Solid Waste Disposal Sites	CH_4	31.9	31.9	0.325	98.132
1.A.4	Energy	Other Sectors: Residential	N_2O	31	31	0.316	98.448
1.A.2	Energy	Emissions from Manufacturing Industries and Construction	CO_2	30.4	30.4	0.310	98.757
4.B	Agriculture	Emissions from Manure Management	CH_4	27.6	27.6	0.281	99.039
1.A.4	Energy	Other Sectors: Agriculture/ Forestry/Fishing	CO_2	27.5	27.5	0.280	99.319
6.B	Waste	Emissions from Wastewater Handling	N_2O	26.8	26.8	0.273	99.592
4.B	Agriculture	Emissions from Manure Management	N_2O	19.9	19.9	0.203	99.794
1.A.4	Energy	Other Sectors: Commercial	CO_2	8.6	8.6	0.088	99.882

1.A.1	Energy	Emissions from Stationary Combustion (Liquid-B)	CO_2	6.5	6.5	0.066	99.948
1.A.3	Energy	Mobile Combustion: Aircraft	CO_2	2.8	2.8	0.029	99.977
1.A.3	Energy	Mobile Combustion: Road Vehicles	CH_4	1.1	1.1	0.011	99.988
1.A.3	Energy	Mobile Combustion: Road Vehicles	N_2O	0.7	0.7	0.007	99.995
1.A.4	Energy	Other Sectors: Commercial	CH_4	0.1	0.1	0.001	99.996
1.A.2	Energy	Emissions from Manufacturing Industries and Construction	N_2O	0.1	0.1	0.001	99.997
1.A.4	Energy	Other Sectors: Agriculture/ Forestry/Fishing	N_2O	0.1	0.1	0.001	99.998
1.A.4	Energy	Other Sectors: Commercial	N_2O	0.1	0.1	0.001	99.999
1.A.2	Energy	Emissions from Manufacturing Industries and Construction	CH_4	0.1	0.1	0.001	100.000
1.A.4	Energy	Other Sectors: Agriculture/ Forestry/Fishing	CH_4	0	0	0.000	100.000
1.A.3	Energy	Mobile Combustion: Aircraft	N_2O	0	0	0.000	100.000
1.A.3	Energy	Mobile Combustion: Aircraft	CH_4	0	0	0.000	100.000
Total					9,818.40		

The Table 3.2 below provides the summary of methods and types of emission factors used during the compilation of this inventory.

Table 3.2 Methods & Type of AD & EF

Category	Greenhouse Gases	Method Applied	Emission Factor
1 Energy			
1A Fuel Combustion Activities			
1A2 Manufacturing Industries and Construction			
1A3a Mining Quarrying	CO_2 CH_4 N_2O	T1	DF
1A3b Construction	CO_2 CH_4 N_2O	T1	DF
1A3 Transport			
1A3a Civil Aviation	CO_2 CH_4 N_2O	T1	DF
1A3b Road Transport	CO_2 CH_4 N_2O	T1	DF
1A4 Other Sectors			
1A4a Commercial / Institutional	CO_2 CH_4 N_2O	T1	DF
1A4b Residential	CO_2 CH_4 N_2O	T1	DF
1A4c Agriculture / Forestry / Fishing / Fish Farms	CO_2 CH_4 N_2O	T1	DF
2 IPPU			
2A Mineral Industry			
2A4 Other Process Uses of Carbonates			
2A4a Ceramics	CO_2	T1	DF
3 AFOLU			
3A Livestock			
3A1 Enteric Fermentation	CH_4	T1	DF
3A2 Manure Management	CH_4 N_2O	T1	DF
3B Land			
3B1 Forest Land	CO_2	T1	DF
3B2 Cropland	CO_2	T1	DF
3C Aggregate sources and non-CO_2 emissions sources on land			
3C1 Emissions from biomass burning	CH_4 N_2O	T1	DF
3C4 Direct N_2O emissions from managed soils	N_2O	T1	DF
3C5 Indirect N_2O emissions from managed soils	N_2O	T1	DF
4 Waste			
4A Solid Waste Disposal	CH_4	T1	DF

4C Incineration and open burning of waste			
4C Waste Incineration and Open Burning of Waste	CO_2 CH_4 N_2O	T1	DF
4D Waste water treatment and discharge	CH_4 N_2O	T1	DF

T1 = Tier 1, DF = Default Factor. Categories and sub-categories not listed in the above table were neither not occurring (NO) nor not estimated (NE) due to data unavailability.

3.2.3 Data Collection and calculations

LMS as the national inventory agency, set up an internal GHG inventory team with support from other stakeholders from relevant departments and institutions. The teams were formed based on the IPCC sectors for GHG Inventory. Each sector team coordinated and oversaw the collection of data, the GHG calculations, data documentation and quality control for their own sector. Relevant departments and institutions also aided in providing the necessary data, expert judgement and information to be used.

3.2.4 GHG Inventory Compilation

The GHG Inventory compilation was done by an independent consultant. The compilation was done using the IPCC Inventory software for most sectors and the ALU Software for the AFOLU Sectors.

3.2.5 Quality Control and Quality Assurance

Quality Control

The quality control (QC) was performed by the experts at all levels during inventory calculation and compilation for the attainment of the quality objectives was done in compliance with the IPCC good practice guidance and the 2006 IPCC Guidelines.

General inventory QC checks included routine checks of the integrity, correctness and completeness of data, identification of errors and deficiencies and documentation and archiving of inventory data and quality control actions. In addition to general QC checks, category-specific QC checks including technical reviews of the source categories, activity data, emission factors and methods.

Quality Assurance

Quality assurance was conducted by an independent third party that was not directly involved in the compilation of the inventory to verify that data quality objectives were met, and to reduce or eliminate any inherent bias in the inventory processes.

Report Compilation

The Report compilation was done by an independent consultant with support from the LMS team. The report was then shared with stakeholders for comments, validation and approval.

3.3 THE ENERGY SECTOR

Lesotho generates hydroelectricity which is often supplemented with imports from neighbouring countries during peak consumption periods.[9] The household electricity connection rate was 34 percent in 2014.[9] With mounting pressure on fuel requirements, the consumption of biomass fuel has far exceeded its manageable supply, and hence the population relies on supplementary energy sources, such as agricultural residues and cattle dung.[10]

Around 80 percent of residential energy demand in sub-Saharan Africa is for cooking.[11] In Lesotho, biomass is used by approximately 90 percent of rural households to meet both cooking and thermal energy needs.[12] A large fraction of the biomass used for energy may be part of the informal economy, and the trade in this type of fuel is frequently not registered in the national energy statistics and balances.[6] Data on biomass used for energy consumption is usually collected in Lesotho. However, biomass consumption by different sectors of the economy is not explicit, especially for firewood.

Generally, fuel imported into Lesotho is affected by market prices and may not be affordable to the majority of the population. However, demand for imported petrol and diesel has steadily increased in Lesotho.[3,12]

GHG emissions from the Energy sector were calculated using 2006 IPCC guidelines and software. Data on fuel consumption were obtained from BOS and the Department of Energy (DoE). Consumers of energy in the country range from various applications that include using kerosene for lighting and cooking by majority of households in the country, to the use of petroleum products by transport vehicles and machinery in industries. Energy balances do not show disaggregated consumption of petroleum products.

3.3.1 Methodology and Emission Factors

3.3.1.1 Electricity generation and heat production

Hydro-power electricity (72MW) is generated from 'Muela Dam (see Figure 3.2) in Lesotho for national consumption. As a result, this category is not a source of GHG emissions.

Figure 3.4: Hydro-power electricity generation in Lesotho. (Source: http://www.lhda.org.ls/lhdaweb/home/gallery)

3.3.1.2 Manufacturing Industries and Construction

Emissions from combustion of fuels in industry includes combustion for the generation of electricity and heat for own use by the same industries. In Lesotho, many activities of this category include operations of machinery and equipment, mining (excluding fuels) and quarrying, construction and, textile and leather. Fossil fuels are also used by both the formal and informal industries especially in towns to generate energy for preparing food etc. There is no activity data for this category. It was therefore assumed that manufacturing industries and construction used petrol and diesel equivalent to that of other sectors (Commercial/ Institutional).

3.3.1.3 Transport

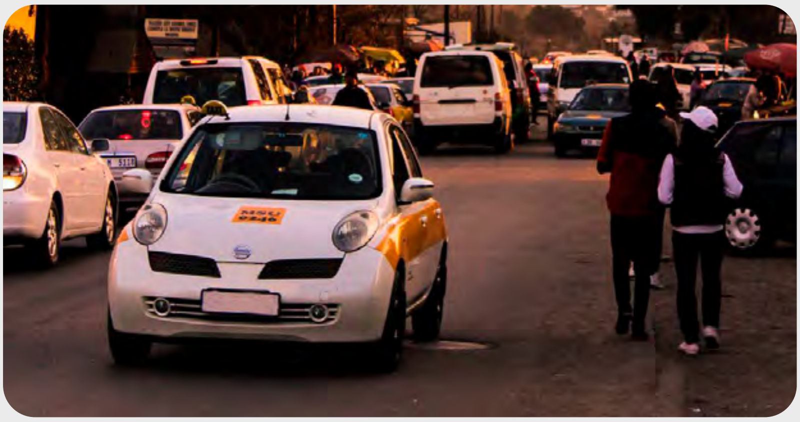


Figure 3.5: Road transport sector in Lesotho (Grato Designs)

This category includes all emissions from the combustion and evaporation of fuel for all transport activity (excluding military transport), regardless of the sector.[6] Transport sector in Lesotho comprises of road transport (see Figure 3.3) and civil aviation. Off-road consists mainly of tractors used for cultivating the land at the beginning of the planting season. Energy use in transport in sub-Saharan Africa is heavily concentrated on vehicles.[11] GHG emissions from road transport (Equation 1) include all combustion and evaporative emissions arising from fuel use in road vehicles, including the use of agricultural vehicles on paved roads.

[Equation 1]

$$GHG = \sum S_{a,b} \cdot D_{a,b} \cdot FE_{a,b} \cdot NCV_{a,b} \cdot EF_{a,b}$$

Where S is the number of vehicles; D is the distance (km) travelled; FE is the fuel efficiency rate (L/km); NCV is the net calorific value of the fuel (TJ/L); EF is the emission factor (kg/TJ); a is the fuel type; and b is the vehicle type.

There is no complete national dataset of annual population of vehicles in the country hence the total number of vehicles in the country was estimated using data from MWPT,[15] LMS,[3] Tongwane,[14] Tongwane et al.[16] and information on total number of registered vehicles (in the 2014/15 period) from the statistics office of the Department of Transport Table 3.3). Average distance travelled by modes of road transport was adapted from Tongwane et al.[16] (Table 3.4) The distances were capped at a point where the overall fuel used by vehicles made approximately 75 percent of total petrol and diesel based on Lesotho.[3] Data on the fractions of each mode of road transport using either petrol or diesel as a form of energy was assumed from Tongwane et al.[16] with slight adjustments on the fuel economies.

3.3.1.4 Civil aviation

Data on fuel consumed by civil aviation was obtained from the BOS and the DOE. Linear regression was used to extrapolate fuel consumed in 2010 based on BOS[17] and Tongwane.[14] None of this data was allocated to international bunkers as cross-border flights are not refuelled in Lesotho, but Johannesburg.[14]

3.3.1.5 Other sectors

GHG emissions from other sectors include emissions from fuel combustion in commercial and institutional buildings, households, agricultural activities, and off-road vehicles and other machinery.[6] It is assumed that almost all paraffin consumption is by residential sector. Annual consumption of LPG by residential purposes was estimated using 0.016279 MJ/capita rates obtained from BISIAS.[18] In various parts of the world depending on the soil characteristics and conditions, the average fuel consumption in the common plow depth of 0.2 to 0.25 m is close to 25 L/ha.[19-21] However, due to Lesotho's shallow soils which may reduce the plow depth, it was assumed in this inventory that fuel consumption by tractor was 10 L/ha. It was further assumed that conventional tillage was done on 90 percent of total area planted for maize, sorghum and wheat in the country. Draught power was used on the remaining land.

3.3.1.6 Conversions and emission factors

Table 3.5: shows the net calorific values of fuels used during energy conversions and calculations of GHG emissions from energy sector while Table 3.3 details the IPPC default GHG emission factors by combustion activity used in GHG emissions inventory in the energy sector.

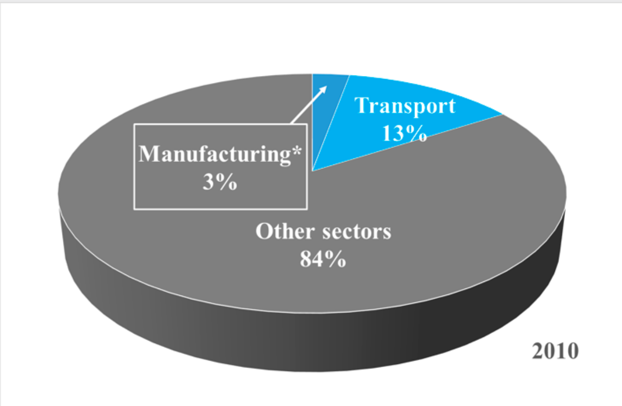
Table 3.3: Net calorific values of fuels used in Lesotho

	NCV	Source
Jet fuel	38.10 MJ/L	StatsSA[22]
Motor gasoline	33.90 MJ/L	StatsSA;[22] Tongwane et al.[16]
Gas/Diesel oil	41.60 MJ/L	StatsSA[22]
Other kerosene (paraffin)	34.30 MJ/L	StatsSA[22]
Coal	25.92 MJ/kg	Klein;23 StatsSA; 22 Pilusa et al.[24]
Fuelwood	19.32 MJ/kg	Klein; [23] Munalula and Meincken;[25] Mosiori et al.[26]
Shrubs	19.18 MJ/kg	Klein[23]
Crop residues	19.80 MJ/kg	Klein[23]
Cow dung*	14.00 MJ/kg	Gay and Khoboko;27 Klein[23]
LPG	34.20 MJ/L	StatsSA[22]
Furnace oil	20.10 MJ/L	StatsSA[22]

(*Average for lisu, mapharoa, khapane, bokuluba (local names of different cow dung fuels))

3.3.2 Greenhouse Gas Emissions: Energy

The Energy sector produced a total of 2,227 Gg and 2,553 Gg of CO_2e emissions in 2005 and 2010 respectively. This shows that the CO_2e emissions increased by 15 percent between the two years. The rate of increase of the emissions differed amongst other sectors, Transport and Manufacturing Industries and Construction, the three categories that are main consumers of energy in Lesotho. It is estimated that in 2005, 87 percent of these emissions were from other sectors and this fraction was reduced to 84 percent in 2010 (Figure 3.5). Emissions from Transport, Manufacturing Industries and Construction sectors increased in 2010.



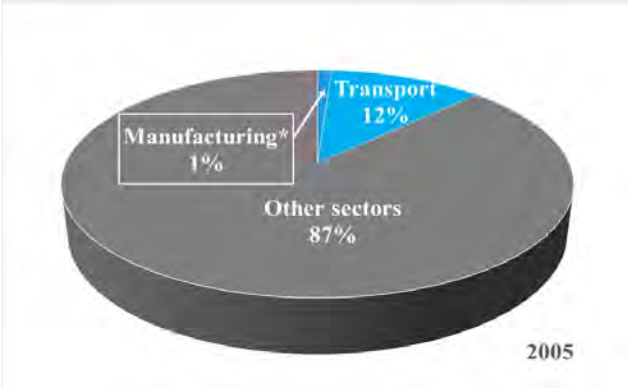


Figure 3-6: Proportions of GHG emissions from the energy sector for 2005 and 2010 in Lesotho
**Manufacturing = Manufacturing Industries and Construction*

3.3.2.1 Manufacturing Industries and Construction

Manufacturing industries and construction accounted for a total of 23.95 Gg of CO_2e emissions in 2005, and 72.59 Gg in 2010. This category emitted approximately 28 Gg and 31 Gg of CO_2e in 1994 and 2000 respectively.[3,4] Proper energy consumption profiles need to be established so that much more consistent emissions can be estimated in this category. Construction is the main source of emissions in this sector even though the rate of increase of emissions from the mining and quarrying is higher. Construction accounted for 74 percent and 54 percent of total emissions in this sector in 2005 and 2010 respectively while mining and quarrying accounted for 26 percent (2005) and 46 percent (2010). Mining and quarrying emissions from mining (excluding fuels) and quarrying are estimated to be increasing rapidly as a result of growing mining and quarrying operations in the country.

Table 3.4: Manufacturing Industries and Construction CO2e emissions (Gg) in Lesotho between 2005 and 2010

	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
	2005			2006			2007			2008			2009			2010		
Total CO_2e	23.96			20.69			30.23			46.82			52.16			72.59		
Manufacturing Ind and Con*	23.87	0.02	0.06	20.62	0.02	0.05	30.12	0.03	0.07	46.66	0.05	0.11	51.98	0.05	0.13	72.34	0.07	0.18
Machinery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining and Quarrying	6.12	0.01	0.01	5.97	0.01	0.01	11.78	0.01	0.03	20.07	0.02	0.05	21.26	0.02	0.05	33.35	0.03	0.08
Construction	17.75	0.02	0.04	14.65	0.02	0.04	18.34	0.02	0.05	26.59	0.03	0.07	30.72	0.03	0.08	38.99	0.04	0.10

*(*Manufacturing Ind and Con = Manufacturing Industries and Construction)*

3.3.2.2 Transport Emissions

Transport CO_2 emissions increased from approximately 257.61 Gg of CO_2e in 2005 to 332.52 Gg of CO_2e in 2010 (Table 3.9). These emissions are lower than estimations of LMS4 and Tongwane et al.[16] because of the shorter distance travelled when compared to the values in the latter. The rate of increase of emissions in the transport sector between 2005 and 2010 is approximately 29 percent which is higher than a growth rate of 5 percent between 2000 and 2005. GHG emissions (1.53 Gg) from civil aviation did not increase between 2005 and 2010. Since civil aviation is not a common mode of transport in Lesotho, road transport is generally the sole producer of transport-related GHG emissions in the country. Heavy duty trucks and buses are the main contributors of transport emissions with an average of 47 percent of total annual transport emissions. Two thirds of the total transport emissions in the country are produced by freight vehicles.[16] Petrol sales declined between 2006 and 2008 despite the estimated rapid increase of number of vehicles in the country during that period. This is reflected in the emissions of light duty vehicles and motorcars which are predominantly petrol powered. Decrease of petrol sales may have been caused by reduced mobility of these vehicles as a result of high fuel prices which started in 2004. Commuters would usually change their lifestyles by reducing their trips and changing their modes of transport from private vehicles to public transport because of expensive fuels. Figure 3.5 shows an example of the country's common meandering road network.

Table 3.5:Transport CO2e Emissions (Gg) in Lesotho between 2005 and 2010

	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
	2005			2006			2007			2008			2009			2010		
Total CO_2e	257.61			258.96			266.75			283.49			303.78			332.52		
Total Transport	252.15	1.78	3.68	253.52	1.72	3.72	261.14	1.78	3.83	277.54	1.89	4.06	297.37	2.06	4.35	325.46	2.30	4.75
Civil Aviation	1.52	0.00	0.01	0.96	0.00	0.01	1.11	0.00	0.01	1.56	0.00	0.01	1.20	0.00	0.01	1.52	0.00	0.01
Domestic Aviation	1.52	0.00	0.01	0.96	0.00	0.01	1.11	0.00	0.01	1.56	0.00	0.01	1.20	0.00	0.01	1.52	0.00	0.01
Road Transport	250.63	1.78	3.67	252.56	1.72	3.71	260.03	1.78	3.82	275.98	1.89	4.05	296.17	2.06	4.34	323.95	2.30	4.74
Cars	57.75	0.65	0.80	54.37	0.62	0.75	57.97	0.65	0.80	65.51	0.73	0.91	76.37	0.85	1.06	83.90	0.94	1.16
Light-duty trucks	77.40	0.64	1.12	74.39	0.62	1.07	73.96	0.62	1.07	76.02	0.62	1.10	77.90	0.63	1.13	89.95	0.73	1.30
HT&B*	115.48	0.49	1.75	123.80	0.49	1.88	128.10	0.51	1.95	134.45	0.53	2.04	141.90	0.57	2.16	150.09	0.62	2.28

Figure 3.7: Example of common road network in Lesotho (Adriaan Geldenhuys, Egan's Altitude Adventures 2013)

3.3.2.3 Other Sectors

Energy consumption from 'other sectors' is the main source of GHG emissions from the energy sector. The emissions in this sector increased from 1,946 Gg of CO_2e in 2005 to 2 148 Gg of CO_2e in 2010 (see Table 3.6). Generally, the emissions have more than doubled the 2000 (734 Gg CO_2e) emissions. The fuel burnt in residential areas is the largest producer of emissions in this category with approximately 70 percent of the 'other sectors' emissions. Residential sub-sector was responsible for 63 percent of total energy emissions in 2005 and 57 percent in 2010. The sub-sector accounted for half of total energy emissions in 2000.[4] An estimated 82 percent of total emissions from residential areas in 2010 were from the burning of coal, followed by 8 percent of energy obtained from other kerosene (paraffin). It is important to note that the emissions from residential areas do not include CO_2 released when burning biomass as these emissions are reported under 'information items' which are not included in the national total emissions.

Table 3.6: CO_2e emissions produced from consumption of energy by 'other sectors' in Lesotho, 2005 to 2010

	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
	2005			2006			2007			2008			2009			2010		
Total CO_2e	1,945.60			1,975.41			2,014.46			2,033.04			2,103.61			2,147.75		
Total Other Sectors	1,573.92	325.92	45.76	1,597.43	331.36	46.62	1,630.07	336.87	47.52	1,642.32	342.36	48.36	1,706.18	348.10	49.33	1,740.30	356.75	50.71
Commercial / Institutional	402.18	86.42	15.43	427.74	88.26	15.80	448.01	90.09	16.17	471.92	91.93	16.53	495.41	93.77	16.90	506.07	95.57	17.25
Residential	1,164.90	239.48	30.31	1,162.30	243.07	30.80	1,174.08	246.75	31.33	1,163.10	250.40	31.81	1,204.05	254.30	32.41	1,227.50	261.16	33.44
Agriculture/ Forestry/ Fishing/Fish Farms	6.84	0.02	0.02	7.39	0.02	0.02	7.97	0.03	0.02	7.30	0.02	0.02	6.72	0.02	0.02	6.72	0.02	0.02

3.3.3 Information Items

Biomass burning is the largest producer of CO_2 emissions in the country. However, these emissions are not included in the total national emissions because it is assumed that they are absorbed back into the plants system through photosynthesis. The gradual increase of these emissions is indicative of growing consumption of biomass fuels in the country (Table 3.7:).

Table 3.7: Information Items - CO2 emissions from Lesotho biomass burning

Year	2005	2006	2007	2008	2009	2010
Biomass CO_2 emitted	3 389.89	3 456.88	3 523.86	3 590.85	3 659.26	3 763.86

3.3.4 Quality assurance and quality control

Quality Control of GHG emissions from the energy sector was done using the total energy by type of fuel consumed in the country. Estimated disaggregated GHG emissions were checked against total energy consumed. This ensured that the emissions corresponded with the total energy. Disaggregation of energy statistics into different sub-sector consumers was done using previous GHG inventories, expert judgement, trends observed, available literature and data from DOE and BOS. Although emissions within the modes of road transport may have higher uncertainties, total emissions from this sub-sector were checked against historical profiles of energy consumed by vehicles relative to total fuel imported into the country.

3.3.5 Uncertainty analysis

The uncertainties were calculated using IPCC[6] inventory software and default IPCC uncertainties in activity data and emission factors (EFs) were assumed (see Table 3.8).

Table 3.8: Uncertainty analysis for Lesotho energy sector for base years 2005 and 2010

2006 IPCC Categories	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)
Manufacturing Industries and Construction	5.00 - 8.66	5.00 - 8.66	7.07 - 12.25
Transport	5.00 - 10.00	5.00 – 10.00	7.07 – 14.14
Other Sectors	7.07 - 8.66	7.07 - 8.66	10.00 - 12.25

3.3.6 Future improvements

Quantification of GHG emissions from energy sector needs future improvements. For energy emissions to be improved, collection and reporting of energy statistics in the country should enhance emphasis in these areas:

- Annual reporting of number of vehicles, by type and fuel economy in the country need to be made.
- Surveys needs to be conducted to determine kilometres travelled by each vehicle type. For other studies that may assist in formulating climate change strategies in the country, the studies may include vehicle occupancy, number of trips per time and all these data could be done at the district level.
- Current efforts by the DOE and the BOS regarding collection of energy consumption data as contained in the recent study "Energy Consumption Survey" need to be sustained. The survey contains crucial information on disaggregated use of energy in the country mainly in the huge industries. However, these studies need to be improved to include consumption of all forms of energy in the country by all sectors.
- Amount of coal and other forms of energy used for non-energy purposes needs to be quantified.

3.4 INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU) SECTOR

Lesotho has a small industrial base that is dominated by textile production. Figure 3.6 shows examples of industries in Lesotho. Textile industries do not produce GHG directly, but through waste management and energy consumption. Other active industries in the country include ceramic and beverage productions and use of chemicals mainly in health facilities and education centres. There are extensive clay deposits in Lesotho[26] and clays in Lesotho have long been used by local ceramic industries and small plaster brick individual producers as raw materials for bricks.[28] Between 14 000 m^3 and 15 000 m^3 of fire clay were used for ceramic production in Lesotho in 2010.[29,30] Compared to the estimates since 2,000, fire clay consumption in the country decreased by more than a half.

Figure 3.8: Examples of industries in Lesotho (Grato Designs)

3.4.1 Methodology and Emission Factors

Appropriate GHG activity data from these industrial activities mentioned in above was limited. Data for few years could only be obtained from the ceramic production activities. The F-gases were not included in the estimation of GHG emission due to limited data availability. As a result, GHG emissions were estimated from ceramic production activities only.

3.4.1.1 Ceramics

Process-related emissions from ceramics result from the calcination of carbonates in the clay, and the addition of additives. Ceramics in Lesotho are produced from fire clay and coal additives are used for colouring and to achieve the desired characteristics. Fire clay deposits may contain exclusively dolomites or calcites or both carbonates.[31] Production levels by the main fire clay consumers in the country (see Table 3.14) are reported to be nearly constant over the years from 2005 to 2010.[29,30] CO_2 emissions (Equation 2) result from the calcination of the raw material (particularly clay, shale, limestone, dolomite and witherite) and the use of limestone as a flux or slagging agent.

[Equation 2]

$$CO_2 Emissions = M_c \cdot (0.85EF_{ls} + 0.15EF_d)$$

Where, CO_2 Emissions = emissions of CO_2 from other process uses of carbonates, tonnes; Mc = mass of carbonate consumed, tonnes; EFls or EFd = emission factor for limestone (0.43971) or dolomite (0.47732) calcination, tonnes CO_2/tonne carbonate. For clays a default carbonate content of 10 percent can be assumed, if no other information is available.

3.4.2 Greenhouse Gas Emissions: IPPU

GHG emissions from this sector were estimated from ceramic production activities due to lack of data from other relevant industries. Ceramic production contributes small amounts of GHGs to the national total. It is estimated that ceramic production emitted less than 1.0 CO_2 per year between 2005 and 2010 (see Table 3.10).

Table 3.10: CO_2 emissions produced from the ceramic industries in Lesotho

	2005	2006	2007	2008	2009	2010
Mineral Industry	0.87	0.87	0.87	0.87	0.87	0.81
Other Process Uses of Carbonates	0.87	0.87	0.87	0.87	0.87	0.81
Ceramics	0.87	0.87	0.87	0.87	0.87	0.81

3.4.3 Quality Control and Quality Assurance

There is high confidence level on the data used for the ceramic production in Lesotho. Although data obtained from ceramic producers was outside the reporting period, it still showed similar consumption levels of fire clay.

3.4.4 Uncertainty analysis

It was the first time that emissions from this sector were estimated in Lesotho though the relevant activity data remains difficult to obtain. As a result, proper uncertainty analysis could not be made for this sector. Reflecting on the ceramic production data outside the reporting period obtained from producers, uncertainty levels are expected to be low.

3.4.5 Future improvements

For future estimation of emissions from IPPU, the following information is required:

- Annual volumes of wines and beverages consumed in the country. This annual information on volumes of wines and beverages, as well as quantities of bread and bakery products can form part of annual national economics bulletins and reported regularly.
- Annual amount of clay used to make ceramics' products in the country. Surveys may be conducted to determine amount of clay used by informal bricks' making industries in the country.
- Growing research activities especially from the National University of Lesotho can be improved to include annual consumption of fire clay in the country.

3.5 AGRICULTURE, FORESTRY AND OTHER LAND USE (AFOLU) SECTOR

GHG emissions from the AFOLU sector are mainly from CH_4 emissions from enteric fermentation and agricultural soils. Agriculture is the foundation of the economy in most African countries with mostly rainfed agriculture constituting majority of agricultural activities that are mostly defined by dryland crop and extensive animal production.9 The introduction of Smallholder Agricultural Development Programme (SADP) by the Government of Lesotho, that aimed at supporting smallholder farmers, has contributed significantly in increasing area planted which had been decreasing in recent years. According to BOS[33], crop production is practiced across all districts of Lesotho and covers four ecological zones with the lowlands constituting the highest area planted and the highlands having the lowest annual agricultural acreage. Lesotho's main crops grown by mostly subsistence farmers are maize, wheat, sorghum and dry bean with the harvested production of 90,072, 12,401, 9,844 and 2,400 million tonnes, respectively in 2014[33]. While arable output has decreased over the years in Lesotho, the livestock subsector has expanded substantially. Livestock farming in the country is mainly focused on extensive animal grazing, wool and mohair production, as well as a fast-growing aquaculture industry. Livestock production, particularly wool and mohair, is very important in Lesotho's farming systems, making up approximately 62 percent of agricultural GDP. [34] Forests in Lesotho account for very low percentage though indigenous trees and shrubs coverage is more significant and their contribution to socio-economic functions is intense.[35] These functions include providing fuel wood and other products, serving as fodder for animals and most importantly land conservation and protection.[35] The status of agriculture and forestry is highly dependent on varying climate, which in recent years has been marked by frequent drought occurrences.[36]

3.5.1 Methodology and Emission Factors

3.5.1.1 Livestock production

To estimate GHG emissions from the AFOLU sector, the 1996 and 2006 IPCC guidelines and Agriculture and Land Use National Greenhouse Gas Inventory Software (ALU) were used. Definitions of climate zones used in the ALU software for the AFOLU GHG emissions are given in Table 3.10. The ALU software requires that regions be divided into IPCC climate zones (see Figure 3.9: for Lesotho climate zones for estimating GHG emissions and land cover classes for 2000).

Table 3.10: Definitions of climate zones used in the ALU software for the AFOLU GHG emissions

Climate Name	Description	
Boreal Dry	BOD	Mean annual temperature of < 0 °C and annual precipitation < evapotranspiration.
Boreal Moist	BOM	Mean annual temperature of < 0 °C and annual precipitation >= evapotranspiration
Cool Temperate Dry	CTD	Mean annual temperature of < 10 °C and annual precipitation less than evapotranspiration.
Cool Temperate Moist	CTM	Mean annual temperature of < 10 °C and annual precipitation similar to or higher than evapotranspiration.
Polar Dry	POD	Polar Regions, little precipitation
Polar Moist	POM	Polar Regions, significant precipitation
Tropical Dry	TRD	Tropical Region, elevation < 1000 m, Precipitation < 1000 mm
Tropical Moist, Long Dry Season	TMLD	Tropical Region, elevation < 1000 m, Annual precipitation >= 1000 mm and Annual precipitation < 2000 mm, dry season > 5 months
Tropical Moist, Short Dry Season	TMSD	Tropical Region, elevation < 1000 m, Annual precipitation >= 1000 mm and Annual precipitation < 2000 mm, dry season <= 5 months
Tropical Montane Dry	TRMD	Tropical Region, elevation >= 1000 m, Annual precipitation < 1000 mm
Tropical Montane Moist	TRMM	Tropical Region, elevation >= 1000 m, annual precipitation >= 1000 mm
Tropical Wet	TRW	Tropical Region, elevation < 1000 m, annual precipitation >= 2000 mm
Warm Temperate Dry	WTD	Mean annual growing season temperatures in this zone usually range from 10 to 20 °C and annual precipitation less than evapotranspiration.
Warm Temperate Moist	WTM	Mean annual growing season temperatures range from 10 to 20 °C and with annual precipitation >= potential evapotranspiration.

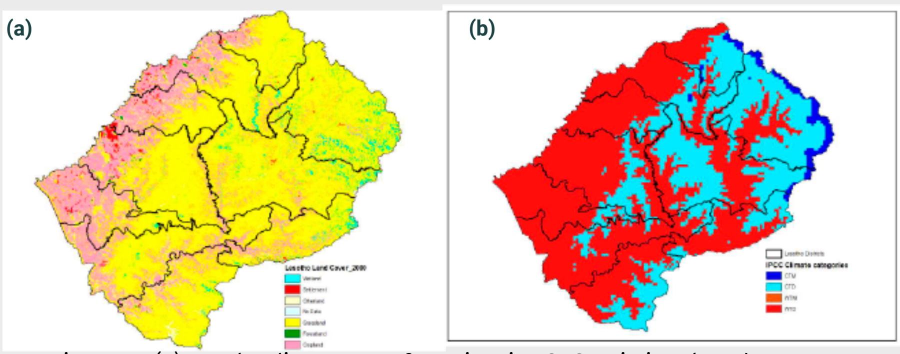


Figure 3.9: (a) Lesotho climate zones for estimating GHG emissions based on IPCC methodology, (b) Lesotho Land cover classes for 2000

Data used in this sector included climate, soil, burned-area scars maps, livestock information and crop management practices, and land use information. Climatology data from 1970 to 2010 sourced from the Lesotho Meteorological Services and Geographic Information System software, were used to generate Lesotho's climate zones. Land use map obtained from Southern Africa Development Community – Monitoring for Environment and Security in Africa (SADC MESA) for the year 2000 was used to make estimations of the land cover areas of Lesotho. Lesotho soil map was obtained from the Lesotho's Department of Agricultural Research (DoAR), Department of Forestry (DoF) and Department of Crops (DoC).

The important activity data for estimating emissions from livestock is annual livestock population.[6] Livestock numbers were obtained from the BOS.[37] A 2004/05 livestock survey report was used for the 2005 inventory year while 2010/2011 livestock survey report was utilized for the 2010 inventory year. Figure 3.8 shows a key livestock produced in Lesotho while Table 3.8 presents the total number of animals in Lesotho between 2005 and 2010.

Some animals like chickens (40 days for broilers) and pigs (165 days for market pigs) mostly have a lifecycle less than 365 days and thus the numbers were adjusted using the IPCC Equation 3:

[Equation 3]

$$AAP = days\ alive \times \left(\frac{NAPA}{365}\right)$$

Where AAP is the Annual Average Population of animals; NAPA is the total amount of animals produced annually

Figure 3.10: Livestock Production in Lesotho (Grato Designs, 2021)

Emission factors (Table 3.10) for N_2O for all manure management activities were 0.02 kg N_2O-N/kg N[6]

Table 3.11: Revised 1996 IPCC Guidelines Emission factors used for livestock GHG emissions[5]

Livestock Type	CH_4 Emissions Factor (Kg/head/yr)	
	Enteric fermentation	Manure management
Dairy Cows	46	1
Non-Dairy Cattle	31	1
Sheep	5	0.118
Goats	5	0.146
Horses	18	1.538
Mules & Asses	10	0.863
Swine	1	0.638
Poultry	-	0.017

3.5.1.2 Soil management

This section includes estimation of direct N_2O emissions from managed soils, indirect N_2O emissions from the application of Nitrogen into managed soils and estimations of CO_2 emissions from application of lime.[5,6]
Nitrous oxide emissions in soils are mainly due to the microbial process of nitrification [aerobic oxidation of ammonium] and denitrification [anaerobic reduction of nitrate to nitrogen].6 Emissions of N_2O are a result of anthropogenic inputs of N through application of either inorganic fertilisers, organic amendments, crop residues or sewage sludge.[5,6]
The default emission factor of 0.01 was used to estimate N_2O emissions from inorganic fertilisers, organic fertilisers and crop residues.[6]

Application of lime to the soil is normally practiced improving the soil PH in cases of acidic soils. This is done through application of carbonates which produces CO_2. The default EFs of 0.13 and 0.12 were used for dolomite and limestone respectively[6]

3.5.1.3 Other Land Use Change

The IPCC software and Agriculture and Land Use (ALU) software were used to estimate GHG emissions from the AFOLU sector. The software requires that regions be divided into IPCC climate zones. Climatology data from 1970 to 2010 was sourced from the Lesotho Meteorological Services and Geographic Information System software were used to generate Lesotho IPCC climate zones. Land use map obtained from SADC MESA for the year 2000 was used to make estimations of the land cover areas of Lesotho. Lesotho soil map was obtained from the Lesotho Department of Agricultural Research.

3.5.1.4 Prescribed biomass burning

Non-CO_2 emissions from prescribed biomass burning are mainly from the following sources: 1) forest land, 2) cropland, 3) grassland and 4) wetlands.[6] The amount of emissions was estimated as the product of the total amount of biomass and EFs of N_2O or CH_4.

3.5.2 Greenhouse Gas Emissions: AFOLU

The AFOLU sector made a total of 2,236 Gg CO_2e and 2,307 Gg CO_2e in 2005 and 2010 respectively. Enteric fermentation and management of agricultural soils remain the largest sources of emissions in this sector (Figure 3.10). There is no change in the fractions of GHG emissions contributed by each category in the sector's total, indicating that the emissions increased proportionally. The total emissions in this sector increased by approximately 0.64 percent per annum.

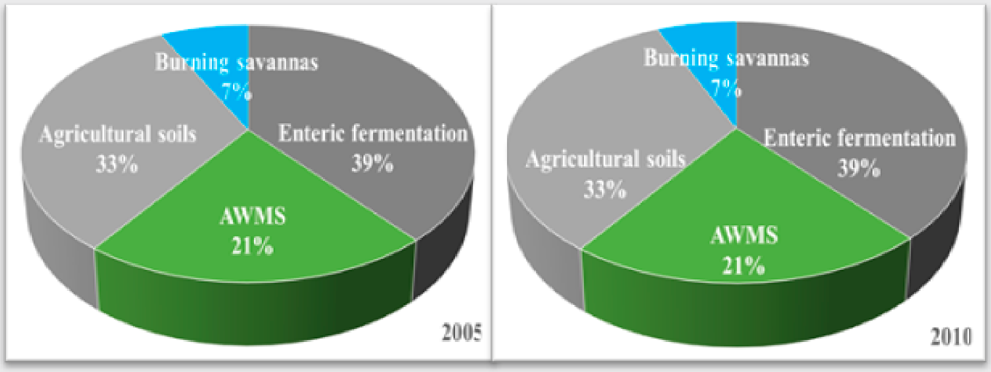


Figure 3.11: Proportions of GHG emissions from AFOLU for 2005 and 2010

3.5.2.1 Livestock GHG emissions

Livestock emissions are mostly made up of CH_4 emissions from enteric fermentation and manure management, and N_2O emissions from manure management.
Emissions from enteric fermentation for Lesotho in 2005 and 2010 is 34.73 Gg CH_4 [868.25 Gg CO_2e] and 35.57 Gg [889.25 Gg CO_2e] respectively (Table 3.12). Over 57 percent of the enteric fermentation is from non-dairy cattle farming. Horses, donkeys, pigs and dairy cows are the least contributing animal types with less than 5 percent individual contribution.

Table 3.12:CH_4 [CO_2e] from enteric fermentation, 2005 and 2010

Livestock Type	Emissions (Gg)					
	2005	2006	2007	2008	2009	2010
Dairy Cows	0.50	0.46	0.46	0.41	0.41	0.49
Non-Dairy Cattle	22.61	21.00	21.00	18.82	18.83	20.55
Sheep	5.21	4.52	4.52	6.38	7.01	7.76
Goats	4.11	4.40	4.40	4.58	5.05	4.11
Horses	1.39	1.24	1.24	1.40	1.35	1.26
Mules & Asses	0.85	1.73	1.74	1.37	1.46	1.36
Swine	0.06	0.09	0.09	0.04	0.04	0.04
Totals	34.73 [868.25]	33.45 [836.25]	33.47 [836.75]	33.01 [825.25]	34.15 [853.75]	35.57 [889.25]

3.5.2.2 Emissions from manure management

Methane emissions from animal waste management systems for 2005 and 2010 were 1.305 Gg [33 Gg CO_2e] and 1.225 Gg [31 Gg CO_2e] respectively (see Table 3.13). Non-dairy cattle are the highest contributors with over 40 percent while a non-significant contribution from the poultry farming was noted due to low emission factor coupled with low population.

Table 3.13: CH_4 from animal waste management system, 2005 and 2010

Livestock Type	Emissions (Gg)					
	2005	2006	2007	2008	2009	2010
Dairy Cows	0.011	0.010	0.010	0.009	0.009	0.011
Non-Dairy Cattle	0.729	0.678	0.678	0.607	0.607	0.663
Sheep	0.167	0.145	0.145	0.204	0.165	0.183
Goats	0.140	0.149	0.149	0.156	0.147	0.120
Horses	0.124	0.110	0.110	0.124	0.115	0.107
Mules & Asses	0.076	0.156	0.157	0.124	0.126	0.118
Swine	0.058	0.095	0.095	0.042	0.023	0.023
Poultry	0.001	0.003	0.002	0.001	0.001	0.001
Totals [CO_2e]	1.305 [32.63]	1.346 [33.65]	1.350 [33.75]	1.270 [31.75]	1.195 [29.88]	1.225 [30.63]

Table 3.21 shows nitrogen excretion (N_{ex}) from animal waste management system in 2005 and 2010. Animal production in Lesotho emitted a total of 1.47 Gg and 1.55 Gg of N_2O in 2005 and 2010 respectively from the manure management (Table 3.22). These emissions are mainly from solid storage and dry-lot of domestic animal's dung from kraals where livestock is kept at night.

Table 3.14: N_2O emissions from animal waste management system, 2005 and 2010

Animal waste management system	Emissions (Gg) [Gg CO_2e]					
	2005	2006	2007	2008	2009	2010
Solid storage & dry lot	0.957	1.092	1.091	1.120	1.210	1.08
Other	0.517	0.503	0.489	0.437	0.438	0.471
Totals [CO_2e]	1.474 [439]	1.596 [476]	1.581 [471]	1.557 [464]	1.648 [491]	1.551 [462]

3.5.2.3 Emission from agricultural soils

Direct N_2O emissions from agricultural soils is made up of three components: 1) Fertilizer application; 2) application of animal manure; and 3) decomposition of crop residues. Total estimated direct N_2O emissions for 2005 is 1.90 Gg [565.60 Gg CO_2e] and 2.017 Gg [601.07 Gg CO_2e] in 2010 (Table 3.13). Indirect N_2O emissions from agricultural soils are slightly less than the direct emissions.

Table 3.15: Total N_2O emissions from management of agricultural soils

Soil emissions categories	N_2O emissions (Gg) [CO_2e]					
	2005	2006	2007	2008	2009	2010
Direct emissions from application of synthetic fertilizer	0.041	0.046	0.044	0.032	0.048	0.045
Direct emissions from manure amendments	0.738	0.810	0.798	0.783	0.828	0.776
Direct N_2O emissions from grazing animals - Pasture, Range and Paddock	1.119	1.151	1.152	1.179	1.255	1.196
Total Direct N_2O emissions from agricultural soils	1.898	2.007	1.994	1.994	2.131	2.017
Indirect N_2O emissions from deposition of atmospheric NH3 and NOx (synthetic fertiliser)	0.004	0.005	0.004	0.003	0.005	0.004
Indirect N_2O emissions from deposition of atmospheric NH3 and NOx (manure amendments)	0.148	0.162	0.160	0.157	0.166	0.155
Indirect N_2O emissions from deposition of atmospheric NH3 and NOx (manure deposited on Pasture, Range and Paddock)	0.112	0.115	0.115	0.118	0.126	0.120
Indirect N_2O emissions from leaching (synthetic fertiliser)	0.009	0.010	0.009	0.007	0.010	0.009
Indirect N_2O emissions from leaching (manure amendments)	0.155	0.170	0.168	0.164	0.174	0.163

Indirect N_2O emissions from leaching (manure deposited on Pasture, Range and Paddock)	0.118	0.121	0.121	0.124	0.132	0.126
Total Indirect N_2O emissions from agricultural Soils	0.546	0.583	0.577	0.573	0.613	0.577
Total N_2O emissions from agricultural soils	2.444	2.59	2.571	2.567	2.744	2.594 [773.01]

3.5.2.4 Emissions from biomass burning

Prescribed burning of savannas in 2005 and 2010 resulted in a total of 3.01 Gg and 2.68 Gg of CH_4 respectively (see Table 3.14). Prescribed burning of biomass produced CO_2e amounts of N_2O that are similar to those of CH_4 (see Table 3.25). Field burning of agricultural residues is not a common practice in Lesotho. Crop residues are either grazed after crop harvests or they are collected and used as a source of households' energy. As a result, small amount of CH_4 and N_2O emissions were produced in the country from this activity in 2005. The emissions from this category doubled in 2010.

Table 3.16: Total CH_4 emissions from biomass burning

Soil emissions categories	CH_4 emissions (Gg) [CO_2e]					
	2005	2006	2007	2008	2009	2010
Savannas	3.0089	0.5449	3.8558	0.8796	0.9073	2.6830
Agricultural residues	0.3238	0.4801	0.3438	0.3870	0.3940	0.3964
Total	3.33 [83.33]	1.03 [25.63]	4.20 [105]	1.27 [31.68]	1.30 [32.53]	3.08 [76.98]

Table 3.17: Total N_2O emissions from biomass burning

Soil emissions categories	N_2O emissions (Gg) [CO_2e]					
	2005	2006	2007	2008	2009	2010
Savannas	0.2750	0.0497	0.3521	0.0803	0.0828	0.2450
Agricultural residues	0.0084	0.0124	0.0089	0.0100	0.0102	0.0103
Total	0.28 [84,33]	0.06 [18.48]	0.36 [107.6]	0.09 [26.82]	0.09 [27.71]	0.26 [75.99]

3.5.3 GHG removal from Land Use and Change

Land use change from forest-to-forest is the main cause of carbon stock change in Lesotho (Table 3.16). As a result, GHG removals from forest-to-forest change were larger than in other land use change (see Table 3.18).

Table 3.18: Estimated CO_2 removals/emissions between 2005 and 2010 for Land Use change

Land Categories	CO_2 removals/emissions (Gg)					
	2005	2006	2007	2008	2009	2010
Forest - Forest	5.448	5148	4.931	4.605	4.436	4.869
Cropland – Cropland	2.669	2.658	2.658	2.643	2.614	2.621
Grassland - Grassland	ns	ns	ns	ns	ns	ns
Settlement – Settlement	ns	ns	ns	ns	ns	ns
Wetland – Wetland	ns	ns	ns	ns	ns	ns
Total	8.118	7.806	7.59	7.249	7.051	7.491

(ns = not significant)

3.5.4 Quality Assurance and Quality Control

Much of quality control (QC) was undertaken while populating the raw data into the ALU software. The main QC measures were centred around the activity data and EFs obtained. Activity data checks included:

- Animal population data was discussed by the responsible person and the checks that the data was entered correctly was performed by a second person;
- All activity data was quality controlled through the utilization of ALU QA/QC functionality.
- The determination of annual population data was difficult in some of the animal sub-categories like broilers whose life span was around 40 days. Proper adherence to the IPCC guidelines were ensured in such cases.

Emissions QC included the following activities:

- EFs were obtained from the IPCC default EFs with over 50 percent uncertainty.
- The utilization of updated GWPs from the fifth assessment report for different GHG emissions was performed outside ALU software.

3.5.5 Uncertainty analysis

Largest levels of uncertainty in the AFOLU sector are experienced in the Land Use Change (see Table 3.19). Emissions from enteric fermentation present lowest levels of uncertainty.

Table 3.19:Uncertainty analysis for AFOLU sector

Categories	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)
Enteric fermentation	7.5	20	21.36
Manure management	21	23	31.14
Agricultural soils	5	30	30.41
Biomass burning	8	30	31.04
Land Use Change	30	32	43.86

3.5.6 Future improvements

Major adjustments needed to improve GHG estimates in the AFOLU sector in Lesotho are as follows:

- Accurate mapping of land-use according to the IPCC categories.
- Improving the estimation of enteric fermentation of major livestock categories like cattle, sheep and goats from Tier 1 to Tier 2. This exercise would require a further breakdown of livestock population data per production type, sex and age. There will also have to be intensive activity data acquisition per livestock sub-categories.
- Department of Crops would have to provide estimates of fertilizer and lime imported as per their records for all the agricultural season.
- Improvement in the accuracy of the crop harvest data and areas.
  Reproduction of a Lesotho soil map to suit the IPCC soil categories.
  Access to land use maps is crucial.
  Improvement on forest cover data through undertakings of periodic forest assessments.

3.6 WASTE SECTOR

Globalization, industrialization and urbanization worldwide has accelerated the usage of solid materials that give rise to accumulation of waste[2,38]. Even though Africa's industrialization rate is at a slower pace than that of developed countries, waste accumulation is a great concern to many nations because of poor infrastructure to handle the economic growth.[38] Waste has the potential to impact negatively on human health or the environment when improperly treated, stored, transported, disposed of or managed.[36] There are different kinds of wastes i.e. municipal solid wastes, industrial waste, agricultural waste, health waste and many more from several sectors. The most common wastes are commercial waste, municipal waste and industrial waste contributing 40 percent, 34 percent and 19 percent of total waste generated in Maseru, respectively. Figure 3.12 shows how some of the waste is managed in some parts of Lesotho.

Figure 3.12: Waste management sites in Lesotho (Grato Designs)

3.6.1 Methodology and emission factors

Emissions from waste were mostly estimated through the use of population and IPCC default factors due to lack of country-specific data on wastewater, municipal solid waste, industrial, commercial and health care waste. The emissions were estimated based on the national population and linear regression was used to interpolate in between the census data. Basic assumptions based on expert judgement were made on factors such as the percent of burning across the country (i.e., it was assumed that 60 percent of solid waste was burnt).

3.6.2 Greenhouse Gas Emissions: Waste

Methane is the main GHG produced by the Waste sector. Wastewater treatment and discharge are the main sources of CO_2e emissions from Waste sector. The emissions are gradually increasing with time. GHG emissions from waste management do not vary much from year to year due to stable waste management systems and low rate of population increase. Total emissions range from 221 Gg CO_2e in 2005 to 228 Gg CO_2e in 2010 (see Table 3.19). Most of the emissions are from the wastewater management with over 90 percent of the total.

Table 3.20: GHG emissions (Gg) from waste management in Lesotho

Categories	2005	2006	2007	2008	2009	2010
Waste Total CO_2e	**259.53**	**267.18**	**266.88**	**265.75**	**265.10**	
CO_2 emissions						
Open Burning of waste	0.326	0.326	0.326	0.327	0.327	0.328
CH_4 emissions						
Solid waste disposal	0.304	0.593	0.563	0.535	0.509	0.483
Open Burning of waste	0.105	0.105	0.105	0.106	0.106	0.106
Wastewater treatment and discharge	9.363	9.380	9.398	9.380	9.380	9.450
Sub-Total CO_2e	244.30	251.95	251.65	250.53	249.88	
N_2O emissions						
Open Burning of waste	0.001	0.001	0.001	0.001	0.001	0.001
Wastewater treatment and discharge	0.049	0.049	0.049	0.049	0.049	0.049
Sub-Total CO_2e	**14.90**	**14.90**	**14.90**	**14.90**	**14.90**	**14.90**

3.6.3 Quality Assurance and Quality Control

Quality control was undertaken while populating the raw data into the IPCC software. The main quality control measures were mostly in relation to activity data and EFs. Activity data checks included:

- Double-checking of population data obtained from the BOS reports. A linear interpolation of population data in between the census was checked by personnel not involved in data punching.

Emissions quality control included the following activities:

- The choice of default values was re-checked to ensure that values are in line with southern Africa practices.
- The utilisation of updated GWPs from the fifth assessment report for different GHG emissions was undertaken.

3.6.4 Uncertainty analysis

The data requirements of the waste sector are immense and there was limited information stored by different government sectors. This led to relatively high uncertainty values exceeding 30 percent (see Table 3.30:) for all estimated waste categories.

Table 3.21: Uncertainty values for different waste management categories

Categories	Activity Data Uncertainty (%)	Emission Factor Uncertainty (%)	Combined Uncertainty (%)
Solid waste disposal	22	30	37.20
Open Burning of waste	25	28	37.54
Wastewater treatment and discharge	20	30	30.41

3.6.5 Future improvements

GHG estimations from the Waste sector purely utilise expert judgement data as well as data from international reports. The first step would be to engage with government departments and agencies to initiate a routine national data collection process on the following basic information:

a) Daily, monthly and annual wastewater flow at major cities treatment centres.
b) Industrial waste.
c) Dispensation of sewage sludge.

3.7 OVERALL NATIONAL GHG EMISSIONS IN 2005 AND 2010

Table 3.21 presents a summary of actual GHG emissions and CO_2e in 2005 and 2010 for Lesotho. The general analysis of the GHG emissions shows an increase from 2005 to 2010, with highest emissions coming from Energy sector followed by AFOLU, Waste and IPPU. In the energy sector, most emissions emanate from residential under sub-category of other sectors followed by Road under transport sub-category. For AFOLU, enteric fermentation has the highest emission followed by direct emissions from agricultural soils. There was also a decline of carbon sequestration in Forestry and land use sub-category. In the Waste sector, most emissions come from waste water treatment and discharge, although solid waste has a significant increase from 2005 to 2010. There was an improvement in the IPPU sector from the previous GHG inventories because there were some emissions reported, although there is a decline from 2005 to 2010.

Table 3.22: Summary of GHG emissions in Lesotho, 2005 and 2010

	ACTUAL GHG EMISSIONS						CO_2-EQUIVALENT EMISSIONS (Gg)						TOTAL (Gg)	
	CO_2		CH_4		N_2O		CO_2		CH_4		N_2O			
	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010
NET GHG EMISSIONS	1,842.98	2,131.75	62.25	64.27	4.41	4.64	1,842.98	2,131.75	1,556.17	1,606.72	1,316.30	1,381.44	4,715.56	5,119.13
ENERGY	1,849.94	2,138.10	13.11	14.37	0.17	0.19	1,849.94	2,138.10	327.72	359.13	49.47	55.64	2,227.22	2,552.86
Manufacturing Industries and Construction	**23.87**	**72.34**	**0.00**	**0.00**	**0.00**	**0.00**	**23.87**	**72.34**	**0.02**	**0.07**	**0.06**	**0.18**	**23.95**	**72.59**
Transport	**252.15**	**325.47**	**0.07**	**0.09**	**0.01**	**0.02**	**252.15**	**3,25.47**	**1.78**	**2.3**	**3.68**	**4.75**	**257.61**	**332.52**
Domestic aviation	1.52	1.52	0.00	0.00	0.00	0.00	1.52	1.52	0.00	0.00	0.01	0.01	1.53	1.53
Road	250.63	323.95	0.07	0.09	0.01	0.02	250.63	323.95	1.78	2.30	3.67	4.74	256.08	330.99
Other Sectors		**1,740.3**	**13.04**	**14.27**	**0.15**	**0.17**	**1,573.92**	**1,740.3**	**325.92**	**356.75**	**45.76**	**50.71**	**1,945.66**	**2,147.79**
Commercial / Institutional	402.18	506.07	3.46	3.82	0.05	0.06	402.18	506.07	86.42	95.58	15.43	17.25	504.09	618.93
Residential	1,164.90	1,227.51	9.58	10.45	0.10	0.11	1,164.90	1,227.51	239.48	261.15	30.31	33.44	1,434.69	1,522.10
Off-road vehicles and machinery	6.84	6.72	0.00	0.00	0.00	0.00	6.84	6.72	0.02	0.02	0.02	0.02	6.88	6.76
AGRICULTURE, FORESTRY AND LAND USE	-8.16	-7.49	39.37	39.88	4.20	4.31	-8.16	-7.49	984.21	996.85	1,251.89	1,310.91	2227.94	2300.28
Agriculture			**39.37**	**39.88**	**4.20**	**4.31**			**984.21**	**996.85**	**1,251.89**	**1,310.91**	**2,236.10**	**2,307.75**
Enteric fermentation			34.73	35.57					868.25	889.25			868.25	889.25
Animal Waste Management Systems			1.31	1.23	1.47	1.55			32.63	30.63	439.25	461.90	471.88	492.53

Direct emissions from agricultural soils			0.00	0.00	1.90	2.02			0.00	0.00	565.60	601.07	565.60	601.07
Indirect emissions from agricultural soils			0.00	0.00	0.55	0.58			0.00	0.00	162.71	171.95	162.71	171.95
Prescribed burning of savannas			3.33	3.08	0.28	0.26			83.33	76.98	84.33	75.99	167.66	152.97
Forestry and Land Use	**-8.16**	**-7.49**					**-8.16**	**-7.49**					**-8.16**	**-7.49**
Forest – Forest	-5.49	-4.87					-5.49	-4.87					-5.49	-4.87
Cropland – Cropland	-2.67	-2.62					-2.67	-2.62					-2.67	-2.62
WASTE	0.33	0.33	9.77	10.04	0.05	0.05	0.33	0.33	244.25	250.75	14.90	14.90	259.53	265.20
Solid waste disposal			0.30	0.48					7.60	12.00			7.50	12.00
Open burning of waste	0.33	0.33	0.11	0.11			0.33	0.33	2.75	2.75	0.30	0.30	3.38	3.38
Waste water treatment and discharge			9.36	9.45	0.05	0.05			234.00	236.00	14.60	14.60	248.60	250.60
INDUSTRIAL PROCESSES AND PRODUCT USE	0.87	0.81					0.87	0.81					0.87	0.81
Mineral industry	0.87	0.81					0.87	0.81					0.87	0.81

3.8 CONCLUSION

This chapter has assessed the country's contribution to global GHG emissions and/or removals and includes all the GHGs dealt with in the INC and SNC. Specifically, it reflected on the four categories of emissions in Lesotho i.e., the Energy, AFOLU, Waste and the IPPU sector. It concludes that the rate of increase of the emissions differed with sectors.

The energy sector produced the highest emissions with a total of 2,227 Gg and 2,553 Gg of CO_2e emissions in 2005 and 2010, respectively. This shows that energy related CO_2e emissions increased by 15 percent between the two years. The AFOLU sector was the second highest emitter, making a total of 2,236 Gg CO_2e and 2,307 Gg CO_2e in 2005 and 2010, respectively. Enteric fermentation and management of agricultural soils were the largest sources of emissions under the AFOLU sector. The Waste sector was the third highest producer of emissions, with a range from 221 Gg CO_2e in 2005 to 228 Gg CO_2e in 2010, mostly from the wastewater management with over 90 percent of the total. The IPPU sector was the least Gg CO_2e, with less than 1.0 CO_2 per year between 2005 and 2010.

The quantification of GHG emissions needs future improvements. For the energy sector, there is need for collection and reporting of energy statistics in the country with an emphasis in areas such as (1) annual reporting of number, type and fuel economy of vehicles in the country, and (2) accurate determination of distances (kilometres) travelled by each vehicle type. Furthermore, for the AFOLU sector, there is need for a complete national dataset of annual population of vehicles in the country.

In a nutshell, for the waste sector, CH_4 is the main GHG produced, and wastewater treatment and discharge are the main sources of CO_2e emissions. Although, emissions in this sector are projected to be gradually increasing with time, there are relatively high uncertainty values exceeding 30 percent for all the waste categories estimated. GHG estimations from this sector purely utilise expert judgement data as well as data from international reports. There is need to engage with government departments and agencies to initiate a routine national data collection process.

Research has also revealed that there is no activity data in the IPPU Sector. Appropriate GHG activity data from the industrial activities could not be obtained. Data for few years could only be obtained from the ceramic production activities. As a result, GHG emissions were estimated from ceramic production activities only. Furthermore, there is a need to continually improve production processes by adopting appropriate technologies that increase energy use efficiency which leads to reduction in emission of GHG in industry.

3.9 REFERENCES

1. National Oceanic and Atmospheric Administration, 2017. Global Greenhouse Gas Reference Network – Trends in atmospheric carbon dioxide. Earth System Research Laboratory, Global Monitoring Division. Boulder, Colorado, USA.
2. Hartmann et al., 2013 Hartmann, D.L., Klein Tank, A.M.G., Rusticucci, M., Alexander, L.V., Brönnimann, S., Charabi, Y., Dentener, F.J., Dlugokencky, E.J., Easterling, D.R., Kaplan, A., Soden, B.J., Thorne, P.W., Wild, M. and Zhai, P.M. 2013: Observations: atmosphere and surface. In: Climate Change 2013: The physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
3. Lesotho Meteorological Services, 2000. Initial National Communication to the Conference of the Parties to the United Nations Framework Convention on Climate Change. Ministry of Natural Resources. Maseru, Lesotho.
4. Lesotho Meteorological Services, 2013. Second national Communication to the Conference of the Parties to the United Nations Framework Convention on Climate Change. Ministry of Energy, Meteorology and Water affairs. Maseru, Lesotho.
5. Intergovernmental Panel on Climate Change, 1996. Greenhouse gas inventory reporting instructions. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Bracknell: UNEP, WMO, OECD and IEA.
6. Intergovernmental Panel on Climate Change, 2006. IPCC 2006 guidelines for national greenhouse gas inventories. Eggleston H.S., Buendia L., Miwa K., Ngara T., Tanabe K. (eds.). Japan: Institute for Global Environmental Strategies.
7. Intergovernmental Panel on Climate Change, 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.
8. Forster, P., Ramaswamy, V., Artaxo, P., Berntsen, T., Betts, R., Fahey, D., Haywood, J., Lean, J., Lowe, D., Myhre, G., Nganga, J., Prinn, R., Raga, G., Schulz, M. and Van Dorland, R., 2007. Changes in atmospheric constituents and in radiative forcing. In: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K., Tignor, M., Miller, H. (Eds.), Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
9. Lesotho, 2015. Lesotho Energy Policy 2015-2025. Ministry of Energy, Meteorology and Water Affairs. Maseru, Lesotho.

10. Taele, B.M., Mokhutsoane, L. and Hapazari, I., 2012. An overview of small hydropower development in Lesotho: Challenges and prospects, Renewable Energy, 44:448-452.

11. International Energy Agency, 2014. Africa energy outlook. A focus on energy prospects in sub-Saharan Africa. International Energy Agency. Paris, France.

12. Tsehlo, T.B., 2012. Assessment of energy for rural development in Lesotho. Report for United Nations Economic Commission for Africa. Maseru, Lesotho.

13. Bureau of Statistics, 2012. Lesotho agricultural production survey crops 2010/2011. Statistical report No 07 of 2012. Bureau of Statistics. Maseru, Lesotho.

14. Tongwane, M., 2010. The greenhouse gas inventory for the transport sector in Lesotho for the base year 2006. BSc Hons project. University of the Witwatersrand. Johannesburg. South Africa.

15. Ministry of Works and Public Transport, 2006. Transport Sector Policy. Ministry of Works and Public Transport. Maseru, Lesotho.

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

17. Bureau of Statistics, 2015a. 2014 Energy, air and climate change. Statistical report No 13 of 2015. Bureau of Statistics. Maseru, Lesotho.

18. Bureau of Statistics, 2010. Statistical yearbook 2010. Statistical reports No. 12: 2009. Bureau of Statistics. Maseru, Lesotho.

19. Fathollahzadeh, H., Mobli H., Rajabipour, A., Minaee, S., Jafari A., Tabatabaio, S.M.H., 2010: Average and instantaneous fuel consumption of Iranian conventional tractor with moldboard plow in tillage, ARPN Journal of Enginnering and Applied Sciences, 5:2, 30-35.

20. Adewoyin, A.O. and Ajav E.A., 2013. Fuel consumption of some tractor models for ploughing operations in the sandy-loam soil of Nigeria at various speeds and ploughing depths, Agricultural Engineering International, 15:3, 67-74.

21. Oduma O., Igwe J.E. and Ntunde D.I., 2015. Performance evaluation of field efficiencies of some tractor drawn implements in Ebonyi State, International Journal of Engineering & Technology, 5:4, 199-204.

22. StatsSA, 2008. South Africa Energy Statistics. Statistics South Africa. Pretoria, South Africa.

23. Klein, G., 1986. Research development and dissemination of cooking technologies by the Lesotho renewable energy technology project. Department of Energy, Maseru, Lesotho.

24. Pilusa, T.J., Huberts, R. and Muzenda, E., 2013. Emissions analysis from combustion of eco-fuel briquettes for domestic applications, Journal of Energy in Southern Africa, 24:4

25. 24 Munalula, F. and Meincken, M., 2009. An evaluation of South African fuelwood with regards

to calorific value and environmental impact, Biomass and Bioenergy, 33:415-420.

26. Mosiori, G.O., Onindo, C.O., Mugabi, P., Tumwebaze, S.B., Bagabo, S., Johnson, R.B., 2015. Characteristics of potential gasifier fuels in selected regions of the Lake Victoria Basin, South African Journal of Science, 111(5/6).
27. Gay, J. and Khoboko, M., 1982. Lesotho village energy survey report. Department of Energy, Maseru, Lesotho.
28. Masheane, M., Nthunya L., Mubiayi M., Thamae, T. and Mhlanga, S., 2016. Physico-chemical characteristics of some Lesotho's clays and their assessment for suitability in ceramics production, Particulate Science and Technology, DOI:10.1080/02726351.2016.1226226.
29. Yager, T.R., 2007: The mineral industry of Lesotho. 2005 Minerals Year Book. United States Geological Survey. USA.
30. Mobb, P.M., 2015. The mineral industry of Lesotho. 2013 Minerals Yearbook. United States Geological Survey. USA.
31. Trindade, M.J., Dias, M.I., Coroado, J. and Rocha, F., 2009. Mineralogical transformations of calcareous rich clays with firing: A comparative study between Calcite and dolomite rich clays from Algarve, Portugal, Applied Clay Science, 42, 345-355.
32. Newman, H.R., 2013. The mineral industries of Lesotho and Swaziland. 2011 Minerals Yearbook. United States Geological Survey. USA.
33. Bureau of Statistics, 2015b. 2013/2014 agricultural production survey crops. Statistical report No 6 of 2015. Bureau of Statistics. Maseru, Lesotho.
34. Lesotho Review, 2018. Agriculture.
35. Department of Forestry, 2004. National Report to the Fifth Session of the United Nations Forum on Forests. Ministry of Forestry and Land Reclamation, Maseru.
36. Tongwane, M.I. and Moeletsi, M.E., 2015. Intra-seasonal rainfall variability during the maize growing season in the northern lowlands of Lesotho, Theor Appl Climatol, 120:575–585
37. Bureau of Statistics, 2014. 2013 Energy, air and climate change report. Statistical report No 12 of 2014. Bureau of Statistics. Maseru, Lesotho.
38. Bello, I.A, Ismail, M.N. and Kabbashi, N.A., 2016. Solid Waste Management in Africa: A review. International Journal of Waste Resources 6(2): 1-4.

CHAPTER 4
VULNERABILITY AND ADAPTATION ASSESSMENT

4.1 INTRODUCTION

There is a general consensus within the scientific community that climate change has its roots in anthropogenic effects.[1] It is also understood that increasing global average temperatures are associated with increased frequency and intensity of extreme weather events such as storms, floods, and droughts.[2] The fact that increased weather and extreme climate events pose major threats to human health and well-being calls for proactive measures towards creating a satisfactory level of resilience among communities.

The VAA chapter of the SNC (2013) states that the country is prone to the adverse effects of climate variability and change. The geographical features of the country and the present-day socio-economic development renders Lesotho socially vulnerable, thus any shift in present-day climate patterns is likely to exacerbate the situation leading to adverse implications on the infrastructure, economy, ecology, and culture (LMS, 2000, 2013).[3,4] To advise the present to long-term policy development programs, the country must have sound quantitative and qualitative information about possible shifts in climate and extreme climate events. Ensemble climate models provide valuable information that addresses the issue of uncertainties in climate models. With Ensemble Models, a range of possibilities for future is provided which informs adaptation planning.

Documented in this chapter are changes in the extreme climate indices, annual and seasonal precipitation, maximum and minimum temperatures calculated in a methodology consistent with the multi-model ensemble climate change simulations using different emission scenarios. The simulations were done within the framework of the Coupled Model inter-comparison Project Phase 5 (CMIP5).[5] The analysis in the study is based on the data downscaled from CMIP5 dataset by a project known as the Coordinated Regional Downscaling Experiment (CORDEX) from which data was downloaded. Only the model results of historical and projected extreme climate indices are discussed in this study. Following on the discussions of historical trends in climate and projections of future climate change in Lesotho, a review of the potential climate change impacts and vulnerabilities for the sectors of agriculture, forestry, water resources, soil and land degradation, tourism, environment, biodiversity and ecosystems, health, culture, and heritage is presented in this chapter. Furthermore, vulnerability and impacts of climate change on gender and youth are also discussed in this chapter. This is followed by a summary of the adaptation options and strategies each sector could adopt to offset the adverse impacts of climate change and challenges pertaining to CCA in Lesotho.

4.2 METHODOLOGY

4.2.1 Climate change Scenarios

The climate change projections were developed using a set of scenarios called Representative Concentration Pathways (RCPs) which were used by CMIP5 for the IPCC 5th Assessment Report. A distinctive feature of these scenarios is to provide time-dependent projections of atmospheric GHG concentrations. The RCPs are constructed in such a way that not only the long-term concentration or radiative forcing outcome is of interest but also the trajectory that is followed over time, hence the name “pathway”. There are four pathways under the RCPs namely: RCP8.5, RCP6, RCP4.5, and RCP2.6 (the numbers in the names refer to the respective radiative forcings) (refer to Appendix 4A for further details). Note that these scenarios include time paths for emissions and a database of concentrations of reactive gas emissions, GHG, O3, and Aerosol concentration fields. In each of the pathways, it is possible to experiment by varying socio-economic measures while keeping inbuilt fixed rates of warming. This makes it possible to establish the most productive combination (i.e., leads to a return on investment) on a timely basis and leads to cost-effective responses.

4.2.2 Downscaled model data and Global Circulation Models

The climate projections analysis in this report is based on a set of GCMs under the Coupled Model Inter-comparison Project phase 5 (CMIP5), availed through the CORDEX1 (Table 4.1).[6] Climate elements downloaded for this study are daily temperatures (Maximum and Minimum) and precipitation. Data downloaded was from 1951 to 2005 for the historical period, while that of the future projections was from 2006 to 2100. During the analysis, these data was divided into three future climate periods (2011-2040, 2041-2070 and 2071-2100).

`Table 4.1: The CMIP5 GCMs whose downscaled data is used in this study

CMIP5_id	Institution	Resolution (Atmospheric Grid)	
		Latitude	Longitude
CCCma-CanESM2	Canadian Centre for Climate Modelling and Analysis, Victoria, Canada	2.7906	2.8125
CNRM-CERFACS-CNRM-CM5	Centre National de Recherches Meteorologiques, Toulouse, France	1.4008	1.40625
ICHEC-EC-EARTH	Irish Centre for High-End Computing	1.1215	1.125
MIROC-MIROC5	Centre for Climate System Research, Tokyo, Japan/National Institute for Environmental Studies, Ibaraki, Japan/ Frontier Research Centre for Global Change, Kanagawa, Japan	1.4008	1.40625
MOHC-HadGEM2-ES	Met Office Hadley Centre	1.25	1.875
MPI-M-MPIESM-LR	Max Planck Institute for Meteorology	1.8653	1.875
NCC-NorESM1-M	Norwegian Climate Centre	1.8947	2.5
NOAA-GFDL-GFDL-ESM2M	Geophysical Fluid Dynamics Laboratory	2.0225	2.5

(*Model details available at (i) http://cmip-pcmdi.llnl.gov/cmip5/ (ii) https://portal.enes.org/data/enes-model-data/cmip5/resolution)

4.2.3 Climate Extreme Indices

A total of 27 indices (see Table 4.2) recommended by the WMO Expert Team on Climate Change Detection and Indices (ETCCDI) were calculated for Lesotho. Of the twenty-seven, sixteen indices are for analysis of extremes in temperature, and eleven indices are related to precipitation (PR). The magnitudes of trends and the test of their significance are computed as outlined by Zhang et al.[7] A trend is considered statistically significant if it is significant at the 5% level or lower. The climate indices associated with temperature and precipitation are often grouped into five categories namely the absolute indices, threshold indices, duration, percentile-based indices, and other (See Table 4.1 for a summary of the 27 indices). Several authoritative sources in the literature mathematically define the indices.[8]

Note that for precipitation-based indices, unlike temperature-based indices, have a lot of variability in the relative change per index across the time periods and scenarios. Thus, the extreme climate indices, are analysed in conjunction with the underlying near-surface observables (i.e., precipitation and temperature) to come up with plausible implications of the change in indices on future climate for the region.

Table 4.2: Climate Change extreme indices and their explanation (grey fill for temperature-related indices and blue fill for precipitation)

Category	ID	Indicator Name	Explanation	Units
Absolute indices	TXx	Hottest day	The monthly maximum value of daily max temperature	°C
	TNx	Warmest night	The monthly maximum value of daily min temperature	°C
	TXn	Coldest day	The monthly minimum value of daily max temperature	°C
	TNn	Coldest night	The monthly minimum value of daily min temperature	°C
	Rx1day	Max 1 day precipitation amount	Monthly maximum of 1-day precipitation	mm
	Rx5day	Max 5-day precipitation amount	Monthly maximum of consecutive 5-day precipitation	mm
Percentile-based indices	TN10p	Cool nights	Count of days when daily min temperature < 10th percentile	days
	TX10p	Cool days	Count of days of the time when daily max temperature < 10th percentile	days
	TN90p	Warm nights	Count of days when daily min temperature > 90th percentile	days
	TX90p	Warm days	Count days when daily max temperature > 90th percentile	days
	R95p	Very wet days	Annual total precipitation from days > 95th percentile	mm
	R99p	Extremely wet days	Annual total precipitation from days > 99th percentile	mm
Threshold indices	ID	Ice days	The annual count of days when daily maximum temperature < 0°C	days
	FD	Frost days	The annual count of days when daily minimum temperature < 0°C	days

	SU	Summer days	Annual count when daily max temperature > 25°C	days
	TR	Tropical nights	Annual count when daily min temperature > 20°C	days
	R10mm	Number of heavy precipitation days	Annual count when precipitation ≥10mm	days
	R20mm	<number of very heavy precipitation days	Annual count when precipitation ≥ 20mm	days
	Rnnmm	Count of days where precipitation is greater than 1 mm.	Let PRij be the daily precipitation amount on a day i in period j. Then count the number of days when PRij >1mm.	days
Duration indices	GSL	Growing season length	Annual (1st Jan to 31st Dec in NH, 1st July to 30th June in SH) count between the first span of at least 6 days with TG > 5C and first span after July 1 (January 1 in SH) of 6 days with TG < 5C (where TG is daily mean temperature)	days
	WSDI	Warm spell duration index	Annual count when at least six consecutive days of max temperature > 90th percentile	days
	CSDI	Cold spell duration index	Annual count when at least six consecutive days of min temperature < 10th percentile	days
	CDD	Consecutive dry days	Maximum number of consecutive days when precipitation < 1mm	days
	CWD	Consecutive wet days	Maximum number of consecutive days when precipitation ≥ 1mm	days
Others	DTR	Diurnal temperature range	The monthly mean difference between daily max and min temperature	°C
	PRCPTOT	Annual total wet day precipitation	Annual total precipitation from days ≥ 1mm	mm
	ETR	Extreme temperature range	TXx – TNn	°C
	SDII	Simple daily intensity index	The ratio of annual total precipitation to the number of wet days (≥ 1 mm)	mm/day
	R95pTOT	Contribution from very wet days	100 * R95p / PRCPTOT	days
	R99pTOT	Contribution from extremely wet days	100 * R99p / PRCPTOT	days

Figure 4.1 shows the map of Lesotho covering grid-boxes of co-ordinates analysed across the country's four agro-ecological zones.

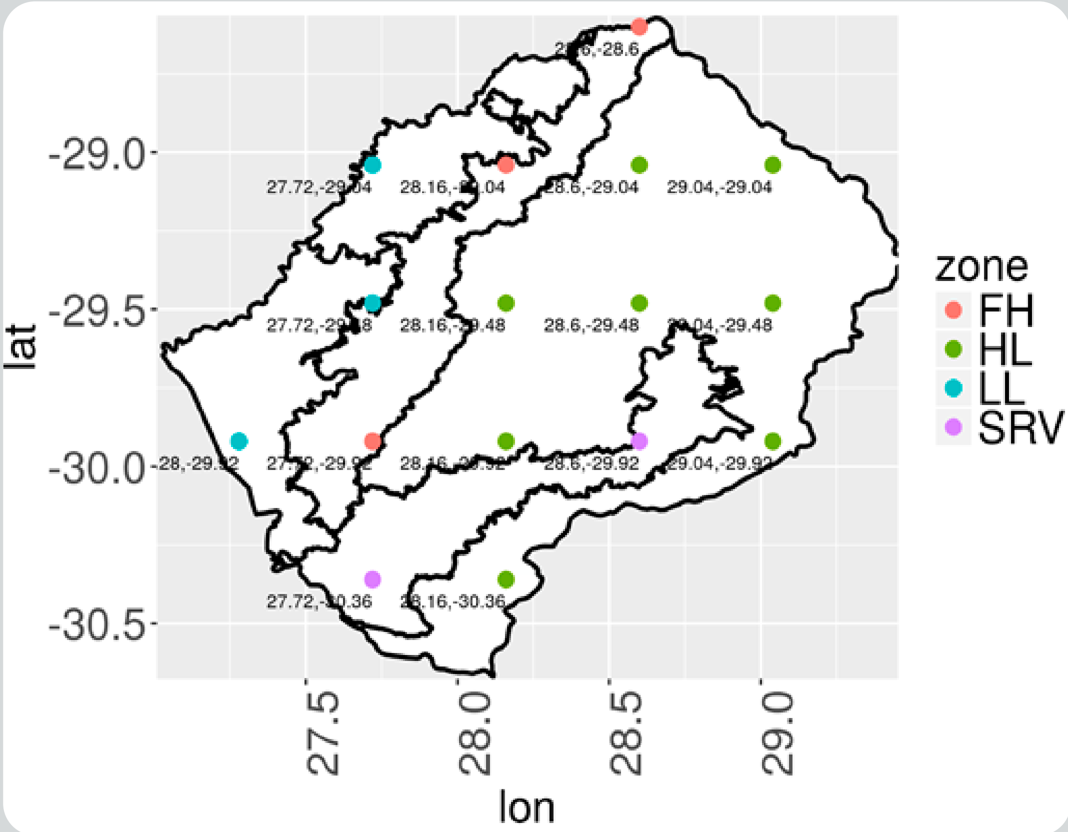


Figure 4.1: Map of Lesotho covering grid-boxes of co-ordinates analysed. Colours of stipplings indicate grid points belonging to the same ecological zones (HL, LL, FH and SRV).

4.3 HISTORICAL ANNUAL AND SEASONAL CLIMATE PATTERNS

There is generally warming trend of temperatures countrywide during the historical period (1951-2005). Most of the ensemble members (about 6 in 8) show the increasing trend in the annual hottest day (TXx) in the Mountains, extending to the lower Senqu River Valley and almost all of Lowlands as statistically significant. The increase in temperature is evident in all temperature indices that are based on the daily maximum temperatures such as the hottest day (TXx), warm days (TX90p) and coldest day indices (TXn) as well as the minimum temperature indices and coldest night indices (TNn). The indices reflect an increasing trend over historical period. The increasing trend in maximum temperature indices combined with decreasing trend in minimum temperature indices reflects plausible warming of day-time and night-time temperatures.

Most of the historical trends for daily minimum temperature-based indices are statistically significant. The exceptions are the cold spell duration index (CSDI) and coldest night index (TNn). In the case of TNn the statistical significance reflected by the ensemble members is variable across the agro-ecological zones hence, rendering the signal of change to be inconclusive. In summary, the indices reflect both night-time and day-time temperatures getting warmer with an increasing frequency of both warm days and nights.

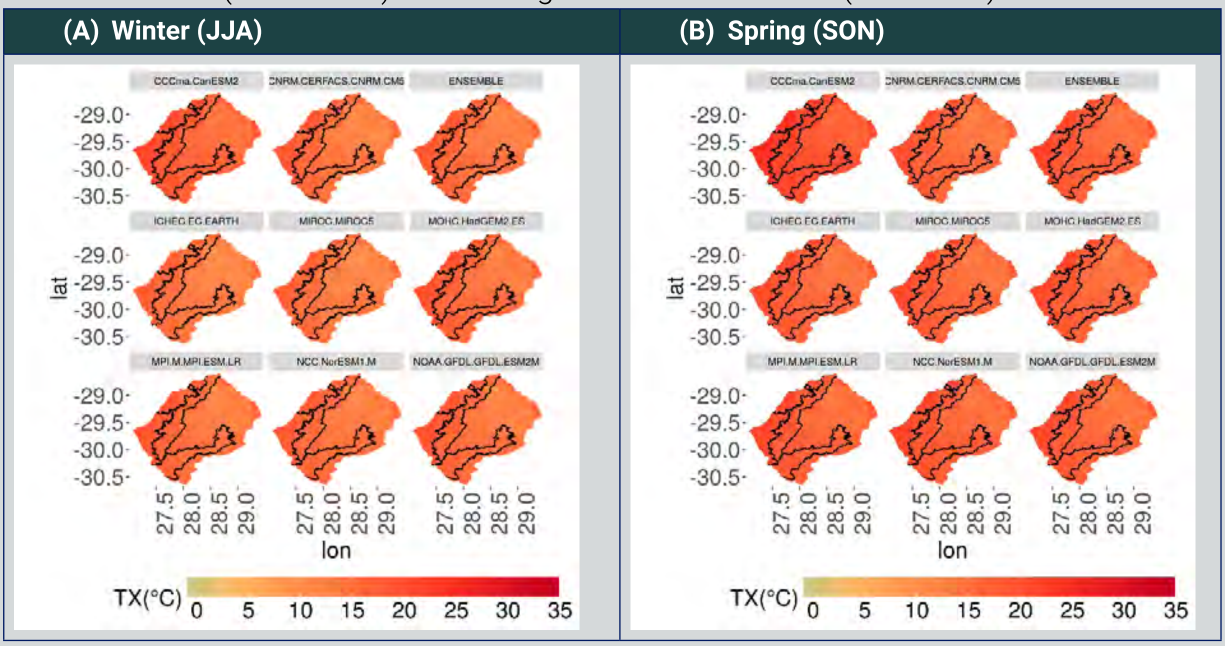
The spatial pattern of magnitudes of almost all the extreme climate indices, that are derived from daily precipitation (i.e., Rx1day, Rx5day, PRCPTOT, R95p, R99pToT, R10mm, R20mm, SDII and Rnnmm except the consecutive dry days index (CDD)), is the same for Lesotho during the baseline period (see Section 4.5). Based on the spatial variation of the magnitudes of the indices, the ensemble members reflect a consistent sensitivity to the precipitation variability.

The majority of the ensemble members portray the Mountains as predominantly wet relative to the rest of the agro-ecological zones. The Lowlands and Senqu River Valley are the least wet during the baseline period with the Foothills having precipitation conditions that are spatially variable similar to those seen in the Lowlands and the Mountains sub-regions. Contrary to the striking agreement in the spatial pattern of most of the indices among the ensemble members, when it comes to the trend, there is notable intermodal variability in sign/direction as well as in the magnitude of change. In fact, during the historical period, most places have an almost zero trend. In cases where there is a strong trend, multi-model disagreements in the sign of the trend is often the case.

4.3.1 A spatial analysis of historical temperature changes over Lesotho

4.3.1.1 Maximum temperature

The winter (June-July-August (JJA)), spring (September-October-November (SON)), summer (December-January-February (DJF)), and autumn (March-April-May (MAM)) average historical daily maximum temperature from the eight general circulation models (GCMs) including the ensemble mean are shown in Figure 4.2. Historical data reflect the lowest average daily maximum temperature range of all seasons to occur in JJA with the lowest value of 5.5°C (Mountains). In SON, the ensemble reflects that the average daily max temperatures, during the historical period, are slightly higher than those of winter for the whole country with the lowest value of 12.6°C (Mountains) and the highest value of 24.4°C (Lowlands).



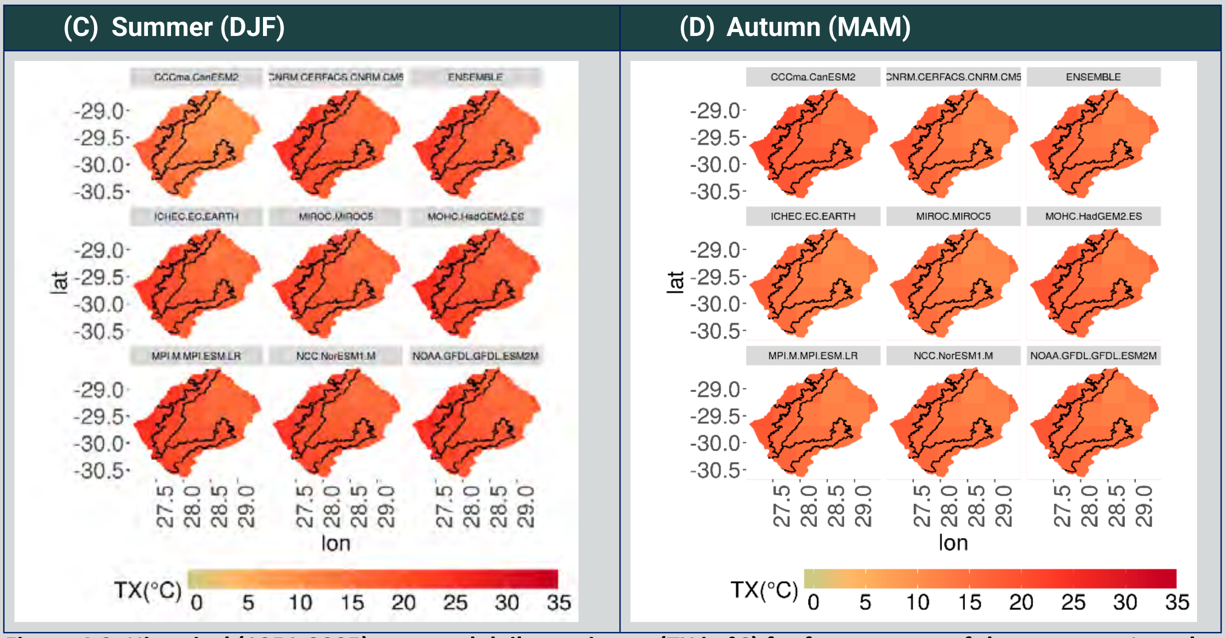


Figure 4.2: Historical (1951-2005) averaged daily maximum (TX in °C) for four seasons of the year over Lesotho.

The ensemble members indicate that the highest average daily maximum temperature (TX) for the whole country, during the historical period, is in summer (DJF). The summer season historical ensemble median values of the average daily maximum temperatures range from 16.3°C (Mountains) to 22.5°C (Lowlands). In autumn (MAM), the ensemble members' median values are less elevated compared to that of summer where values fall within the range 13.4 (Highlands) to 18.1°C (Lowlands).

Among the four agro-ecological zones, the Lowlands are shown to have the highest TX ensemble median, for all seasons, while the Highlands have the lowest. The seasonal TX ensemble members' median values for the Lowlands are 12.5, 20.8, 22.5, and 18.1°C for JJA, SON, DJF, and MAM respectively while for the mountains, the respective seasonal ensemble members' TN median values are 8.7, 12.3, 16.3 and 13.3°C.

There is variability in the spatial pattern of the strength of TX trend among the models. In general, most of the ensemble members reflect a weak but statistically significant positive TX trend during the historic period especially during the winter and spring seasons. In these two respective seasons, the majority of the models (at least 6 in 8) indicate the changes to be significant almost countrywide

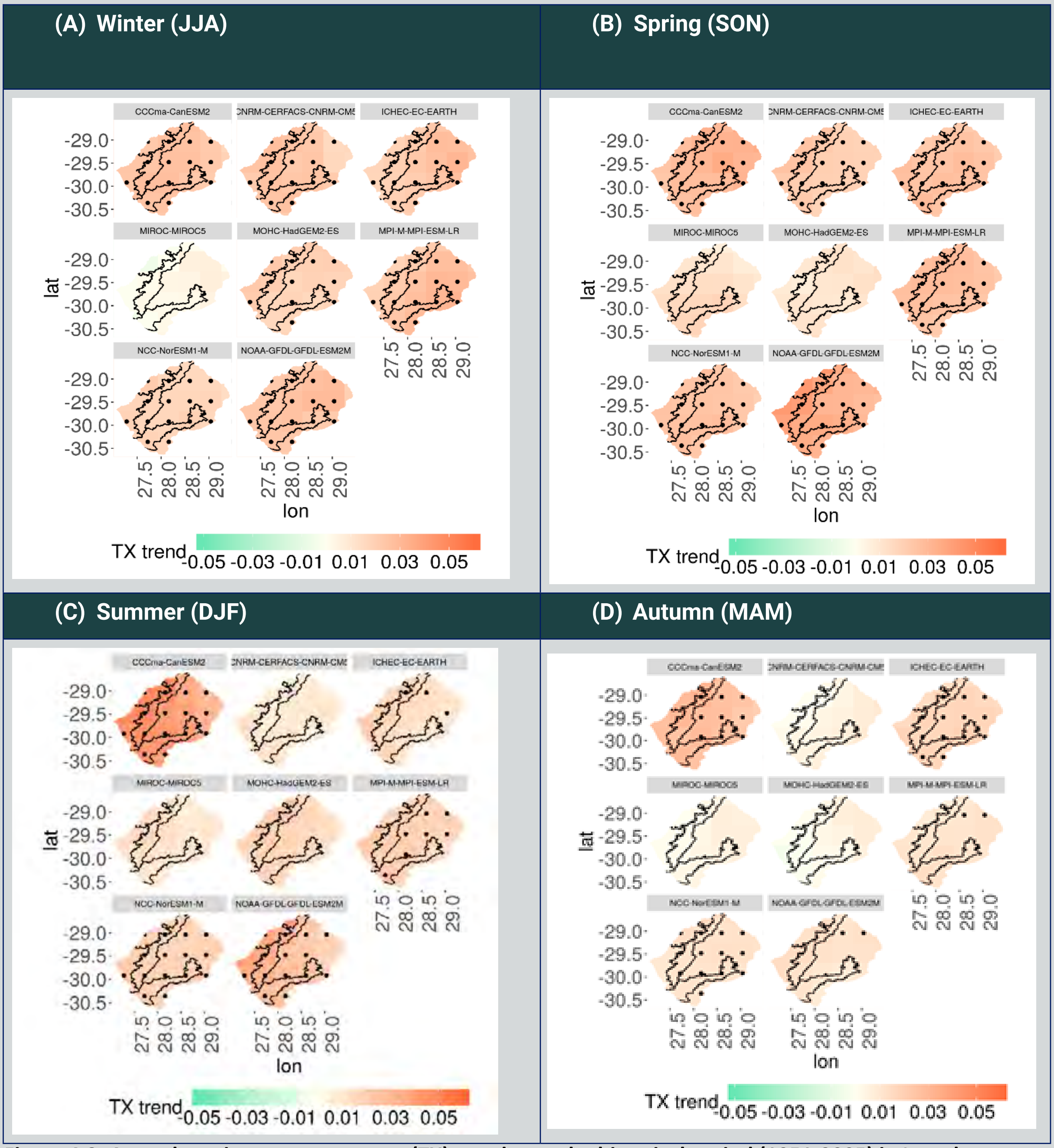
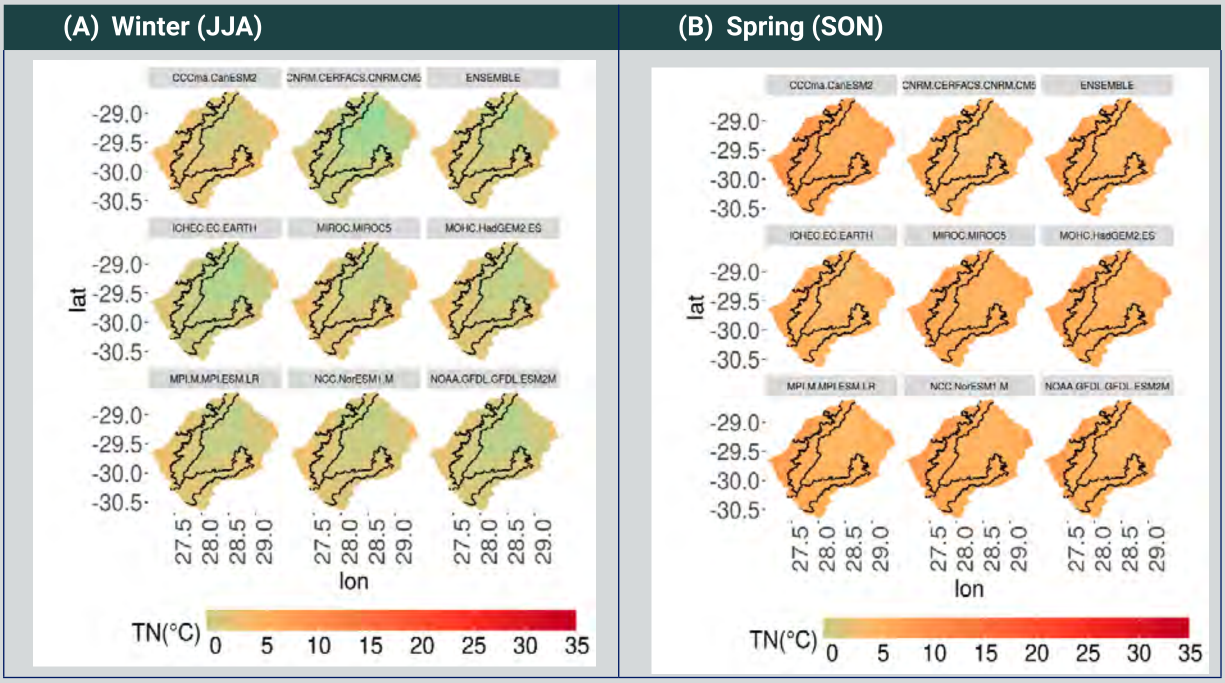


Figure 4.3: Annual maximum temperature (TX) trend over the historical period (1951-2005) in Lesotho

4.3.1.2 *Minimum temperatures*

Winter (JJA), spring (SON), summer (DJF), and autumn (MAM) long terms averages of the daily minimum temperature (TN) from the eight GCMs and their ensemble mean is shown in Figure 4.4. On comparing the agro-ecological zones, the Mountain area have the lowest seasonal ensemble median values of the average daily minimum temperatures (TN) while the Lowlands have the highest. For the Lowlands, the TN ensemble values during the reference period fall within the ranges (-0.1 to 2.7°C, 4.7 to 9.2°C, 9.4 to 12.8°C, and 5.1 to 8.9°C) during the respective JJA, SON, DJF and MAM months. TN falls within the ranges -2.5 to 2.1°C, 2.3 to 6.9°C, 6.3 to 10.2°C, and 2.9 to 7°C in Mountains during the respective seasons. Notably, the ensemble members agree on the temperatures getting highest in summer (DJF) and lowest in winter (JJA) countrywide. The Foothills and Senqu River Valley seasonal TN values are almost the same and their magnitudes for the respective seasons fall between the extreme ranges of the Lowlands and Mountains. The Foothills seasonal TN ensemble median values fall within the ranges -0.92 to 1.11°C, 3.87 to 7.15°C, 8.8 to 10.7°C and 4.1 to 6.5°C while for the Senqu River Valley the TN ensemble median values fall within the ranges -0.3 to 1.7°C, 8.9 to 6.8°C, 7.6 to 10°C and 4.1 to 6.9°C in the respective seasons.

The seasonal spatial pattern of maximum and minimum temperatures is consistent with the reported climatological temperature variations for the country (e.g., New et al.;[9] Gbode et al.;[10] Soltani et al.[11]).



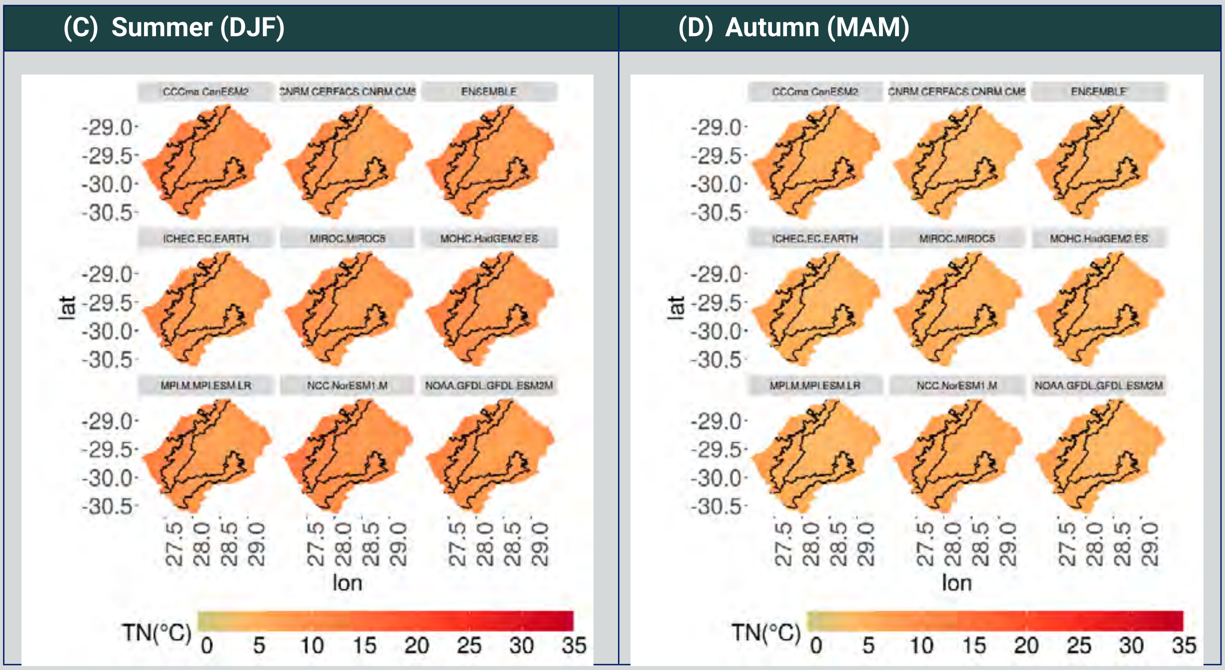
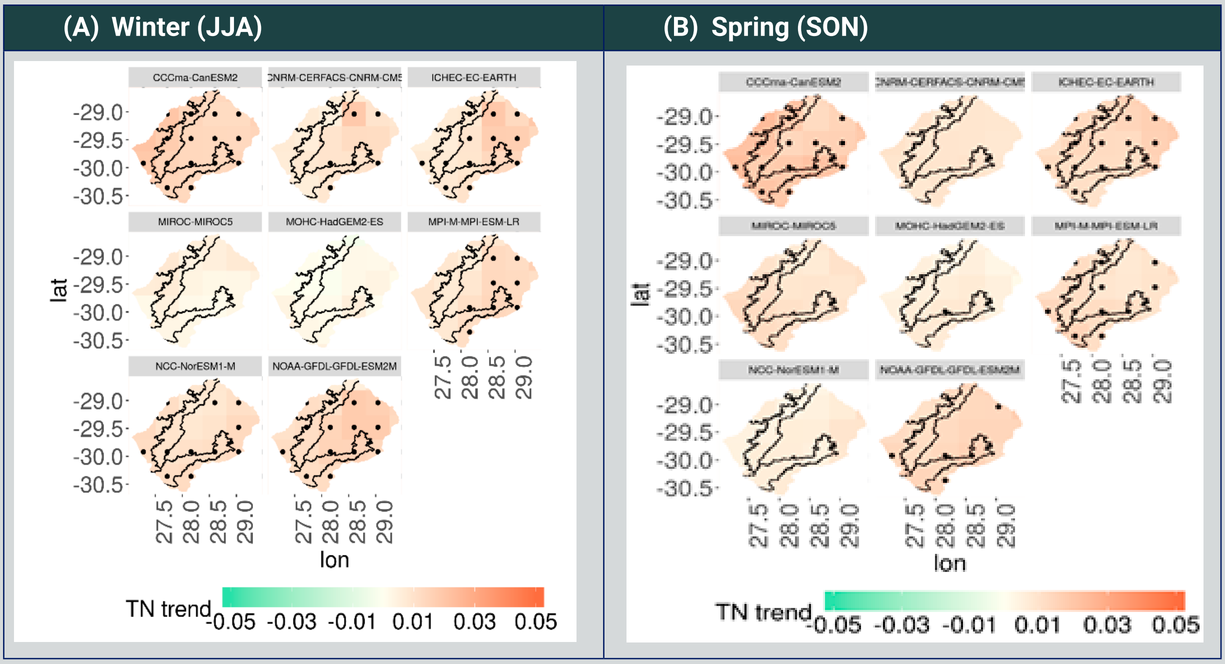


Figure 4.4: Historical (1951 - 2005) averaged daily minimum TN in °Cover Lesotho.

The ensemble members agree on the positive trend of the seasonal minimum temperature trend in the historical period as it is the case with TX. The models reflect weak changes in TN as statistically significant for majority of grid boxes (see Figure 4.5). Albeit the trend being weak with the models largely disagreeing on the spatial pattern of its strength, most of the models reflect the changes as significant.



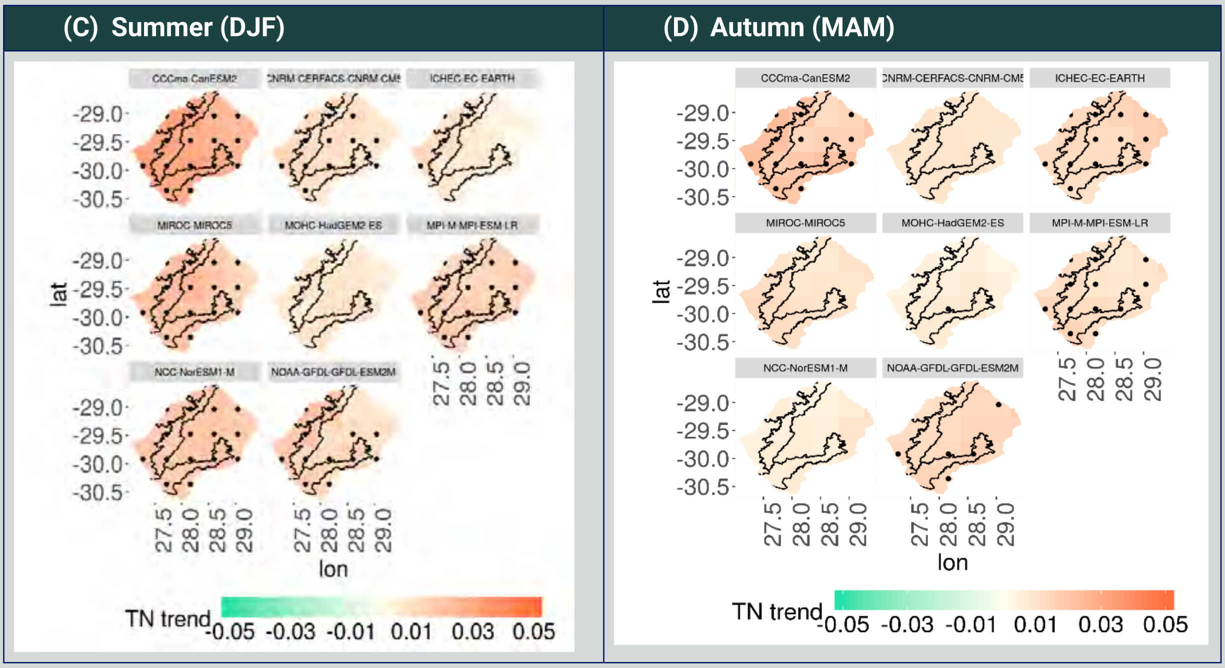
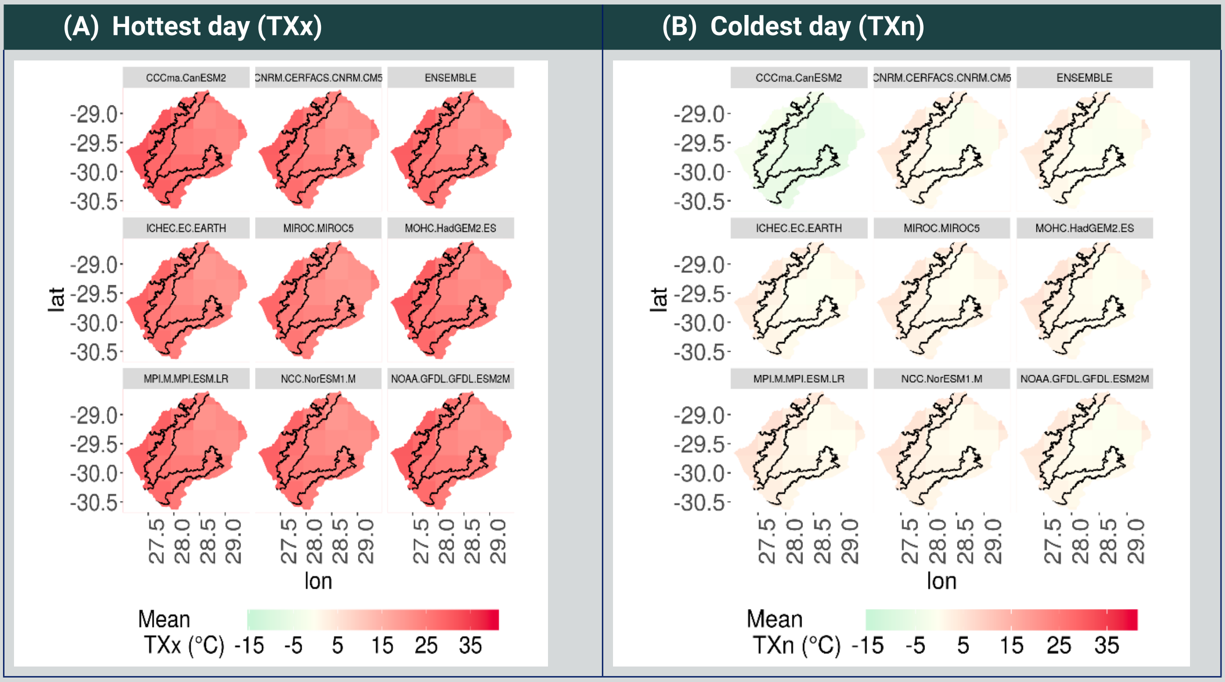


Figure 4.5: Lesotho annual Minimum temperature (TN) trend over the period (1951-2005). The stipplings show grid boxes whose trend is statistically significant within 95% confidence.

4.3.1.3 *Hottest days and coldest nights*

On comparing the spatial pattern of the hottest days (TXx) and coldest nights (TNn), there is an interesting spatial contrast (Figure 4.6). The ensemble members reflect that the hottest days occurred in the Lowlands region with the multi-model values ranging from 25.6 to 31.6°C while coldest night occurred in the Mountains. The multi-model values for TNn in the mountains range between -12.8°C and -2.77°C. This is consistent with the spatial pattern of TX and TN discussed in sections 4.3.1.1 and 4.3.1.2.



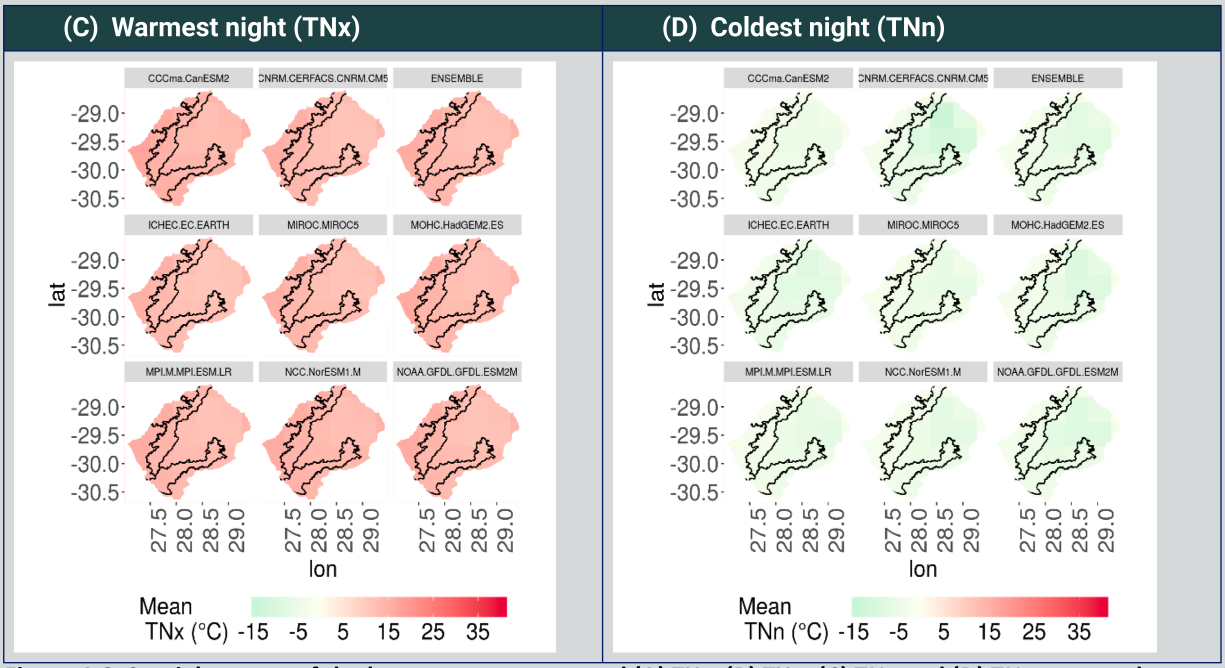
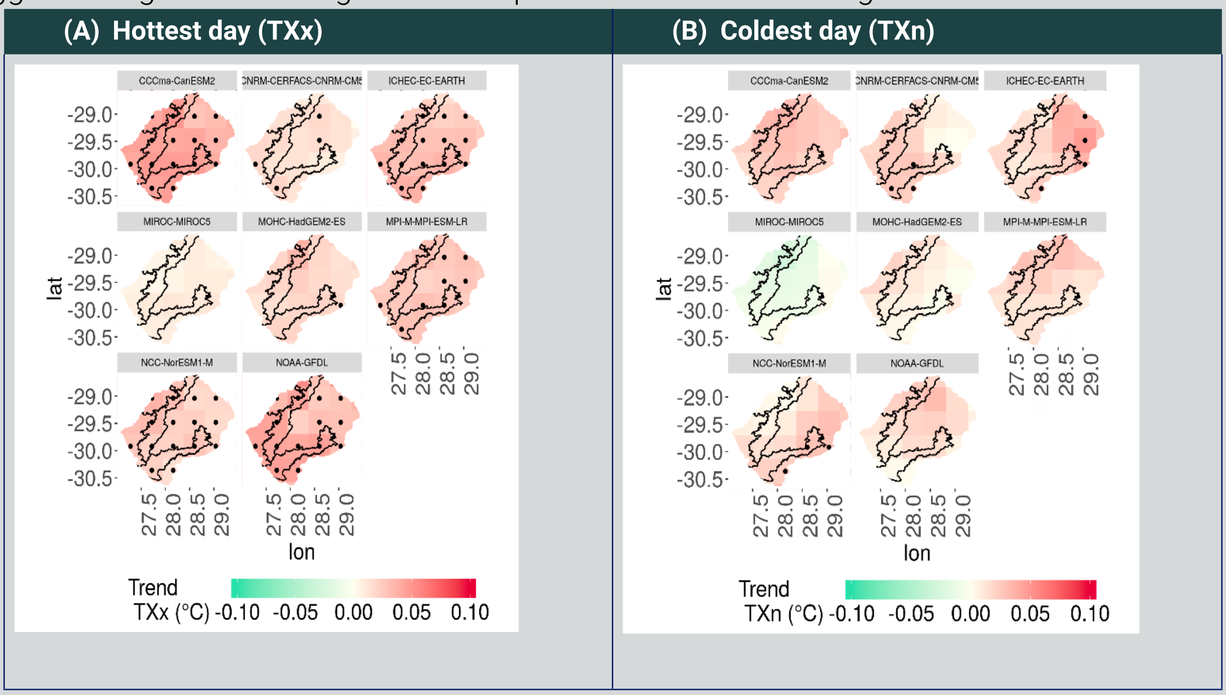


Figure 4.6: Spatial pattern of the long-term mean annual (A) TXx, (B) TXn, (C) TNx and (D) TNn averaged over a baseline period of 1971-2000.

All the models portray that the temperatures of the warmest day (TXx) and warmest night (TNx) are increasing in trend with most of the models suggesting the changes in the temperature of warmest days to be statistically significant ($p \leq 0.05$). Projected changes in temperatures of coldest nights (TNn), despite having an apparent increasing trend, appear to be variable across different models and agro-climatic regions (Figure 4.7). About 37% of the models indicate the change as statistically significant in the lower and northern Senqu River Valley. Only one model suggests a significant change in the temperature of the coldest night in the northern mountains.



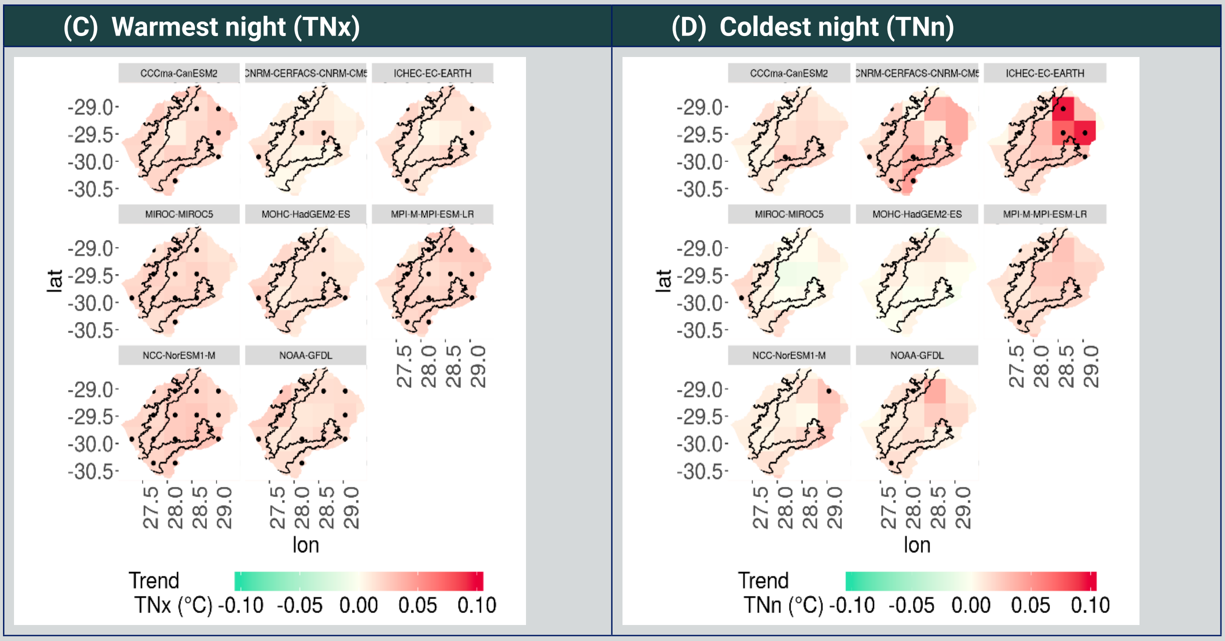


Figure 4.7: Spatial pattern of trends of annual (A) TXx, (B) TXn, (C) TNx and (D) TNn averaged over a baseline period of 1971-2000

In summary, the models reflect an increase in both TXx and TNn over the historical period (1951-2005) with almost all models suggesting that the strength of the increase in TXx is predominantly greater than that of the increase in TNn countrywide.

4.3.1.4 *Warm- and cold- days and nights*

Changes in percentile indices are reflected in absolute terms as opposed to differences relative to the baseline period. This is since, by design, percentiles indices portray exceedance rates (in days) relative to the historical period 1951-2005. Figure 4.8 shows the spatial pattern of warm days (TX90p) and cold nights (TN10p) during the historical period. It is noteworthy that both warm days and cold nights range around 10 - 11 (days) for the country. This is also the case for the cold days (TX10p) and warm nights (TN90p) indices as reflected in Figure 4.8 (c) and (d) during the same period.

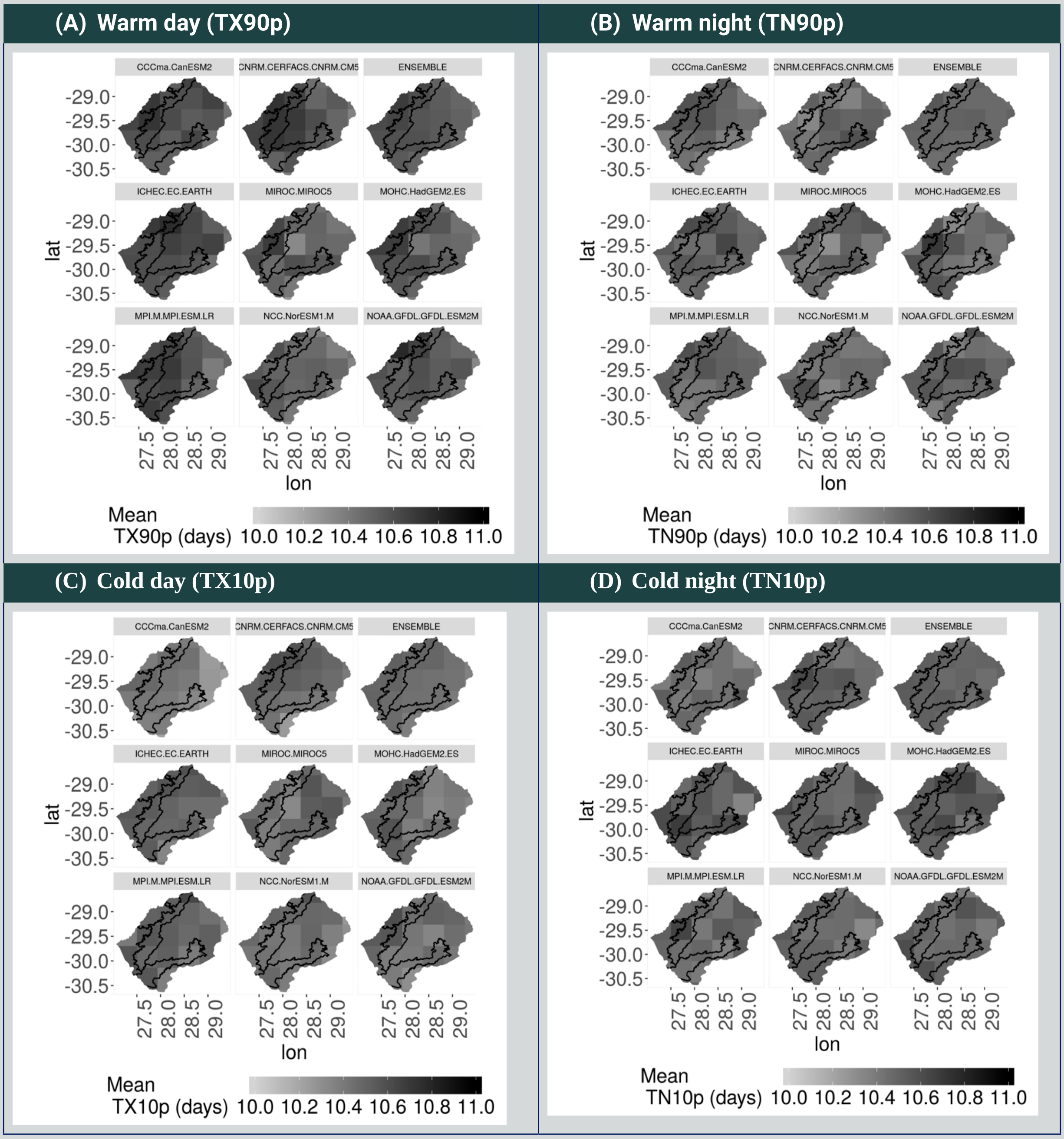


Figure 4.8: Spatial pattern of the long-term mean of annual (A) warms days -TX90p, (B) Warm nights -TN90p, (C) cold days - TX10p, (D) cold nights- TN10p averaged over a historical period of 1951-2005 in Lesotho.

Looking at the trend of the four respective indices, in **Error! Reference source not found.**, there is a decline in cold nights (TN10p) as well as in cold days (TX10p) indices while there is an increase in the number of warm days (TX90p) and nights (TN90p) indices during the period 1951 - 2005. These changes have high statistical significance ($p < 0.05$) as reflected by almost all ensemble members and this is consistent across all livelihood zones.

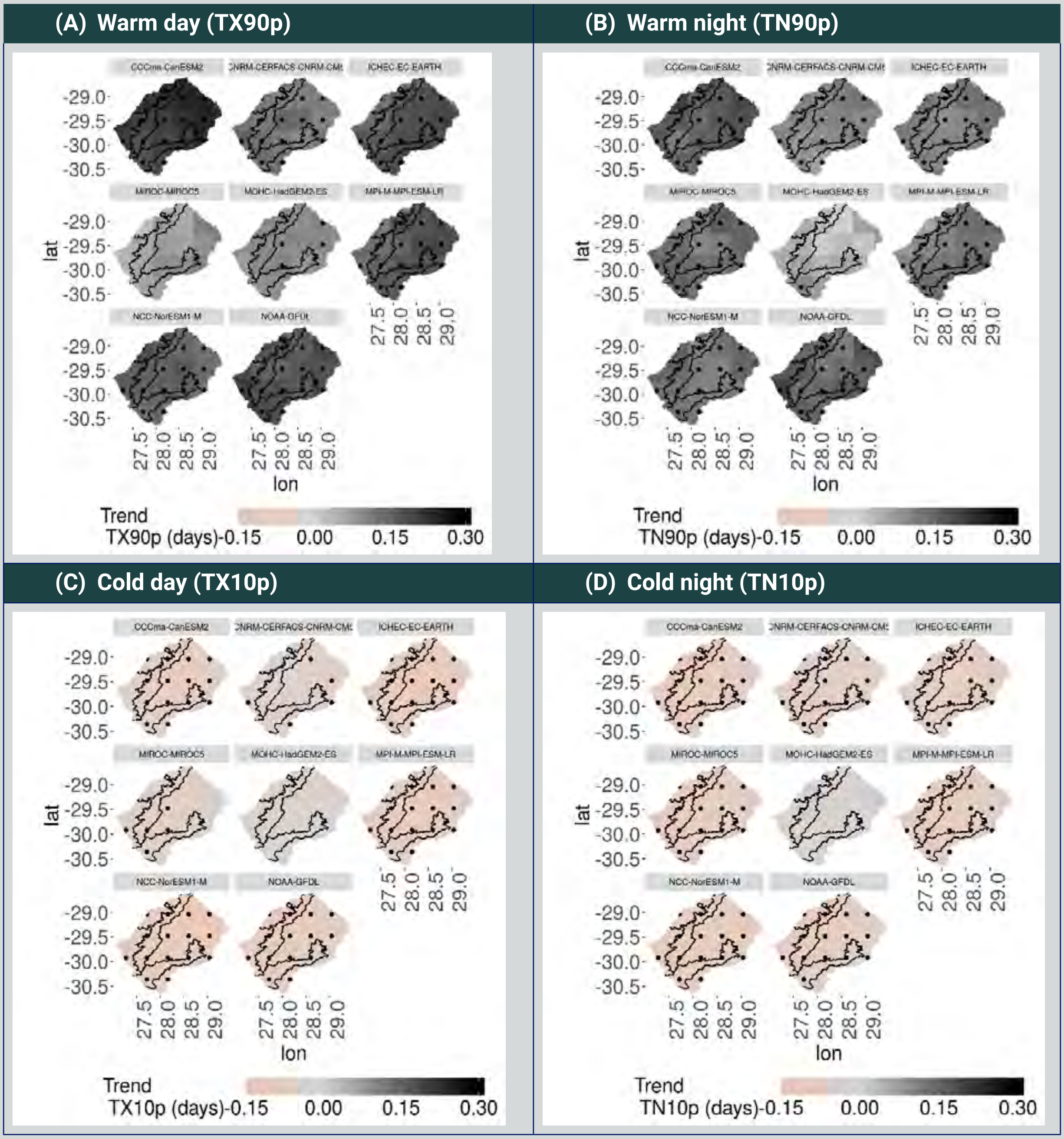


Figure 4.9: Spatial pattern of trends of annual (A) warms days -TX90p, (B) Warm nights -TN90p, (C) cold days - TX10p, (D) cold nights-TN10p averaged over a historical period of 1951 – 2005 in Lesotho

4.3.2 A spatial analysis of historical precipitation changes over Lesotho

The ensemble members overestimate the average precipitation volume for Lesotho though they equivalently capture the spatial distribution of precipitation during the historical period in a manner consistent with the observed seasonal and climatological variation. For all agro-ecological zones, precipitation is most amplified in volume in summer (DJF) and least in winter (JJA). The Autumn (MAM) and spring (SON) seasons have comparable precipitation which is much higher than winter precipitation but lower than that of summer. The North-Eastern Mountains receive the highest precipitation while the Lowlands and Senqu River Valley have the least. The ensemble members indicate that precipitation in the Foothills has relatively high spatial variability with some sub-regions being as wet as the Lowlands while others are nearly as wet as the southern Mountains or central Mountains (see Figure 4.10). The changes in historical precipitation are weak and mostly not statistically significant (see Figure 4.11).

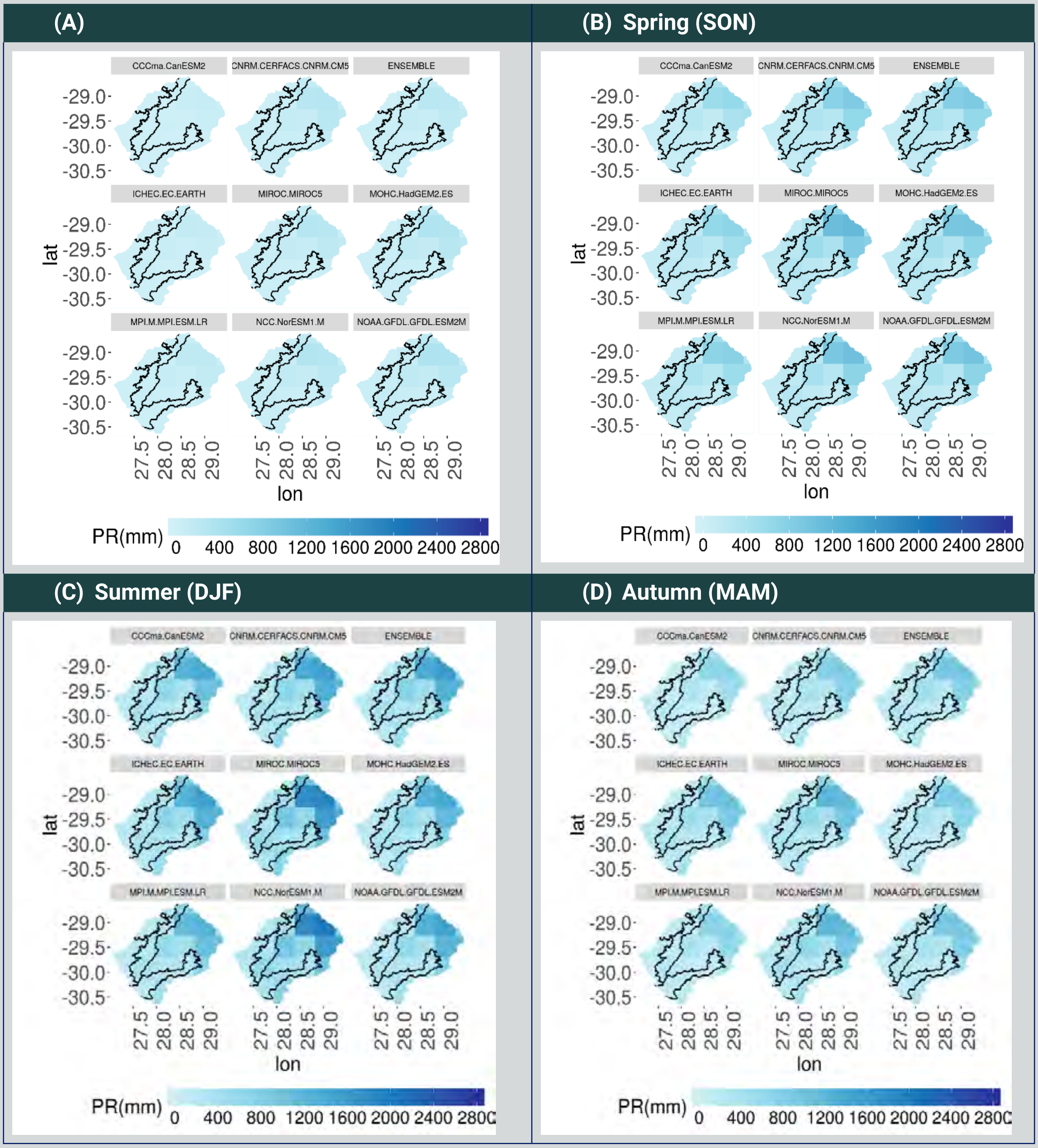


Figure 4.10: Historical (1951-2005) average daily maximum precipitation (PR in mm) in Lesotho.

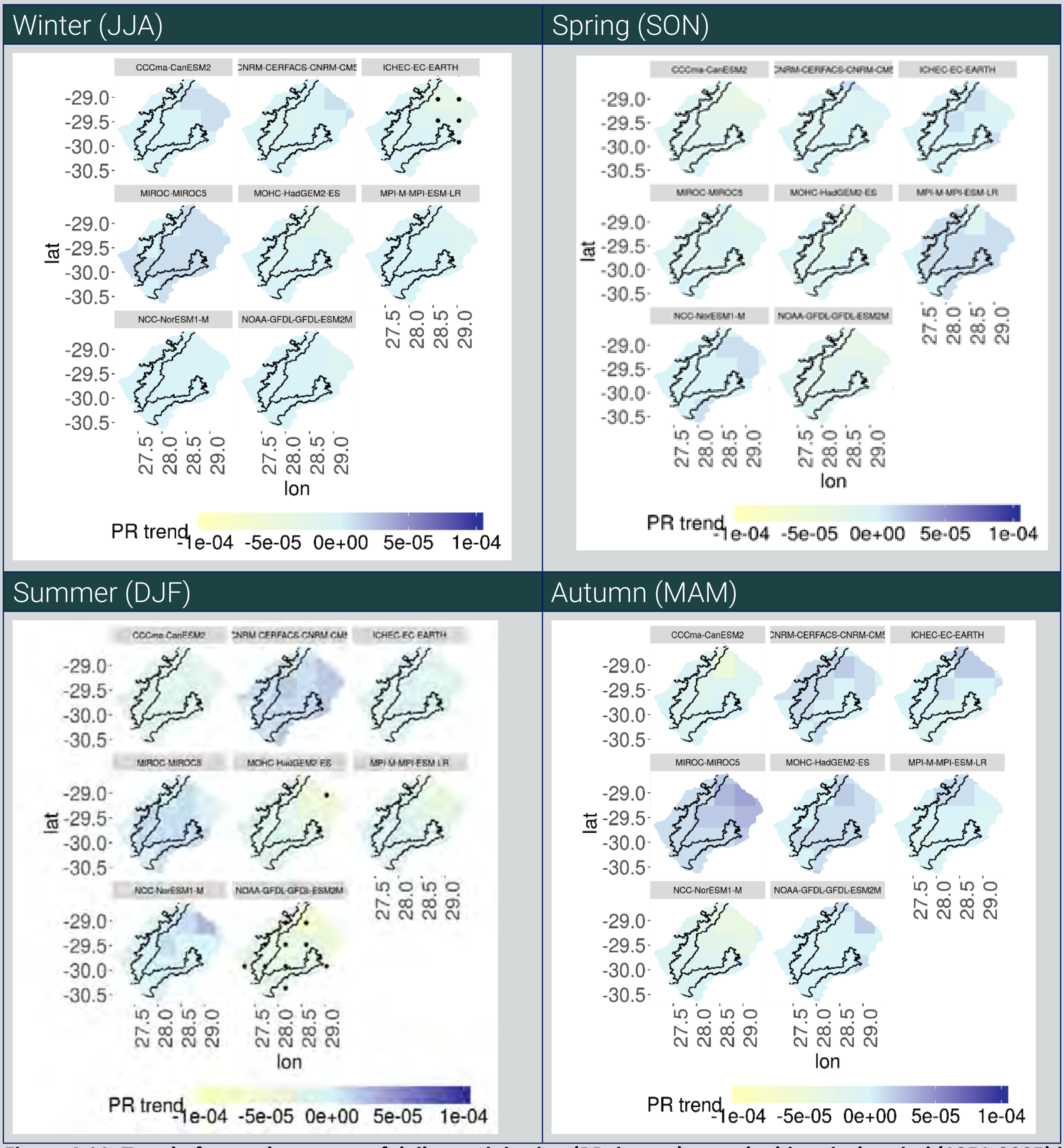
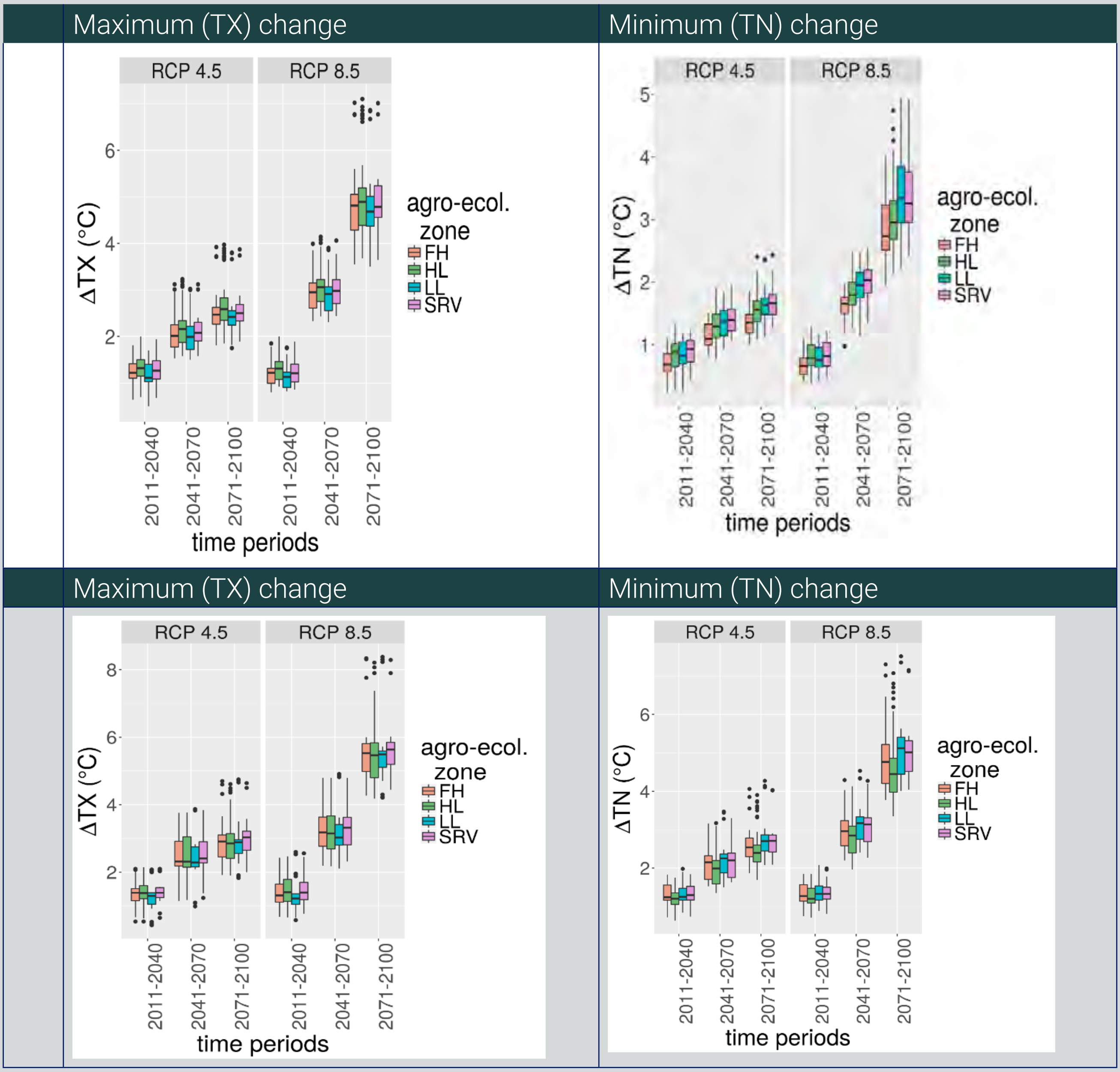


Figure 4.11: Trend of annual averages of daily precipitation (PR, in mm) over the historical period (1951-2005) in Lesotho. The stipplings show grid boxes whose trend is statistically significant within 95% confidence.

4.4 PROJECTED TEMPERATURES FOR LESOTHO

4.4.1 Average Minimum and Maximum Temperatures

In all four seasons, the ensemble members under both RCP4.5 and RCP8.5 scenarios project a gradual increase in both average maximum (TX) and minimum (TN) temperatures, relative to the baseline period, during the 21[st] century (Figure 4.12) Interestingly, the ensemble projections for the relative changes in TX and TN patterns are similar to climatological variation across the agro-ecological zones. This is best portrayed by the magnitudes of the median increases in almost all the seasons for both TX and TN. The relative median increase in TX is more pronounced in the Mountains and least in the Lowlands for all periods under both emission scenarios RCP4.5 and RCP8.5.



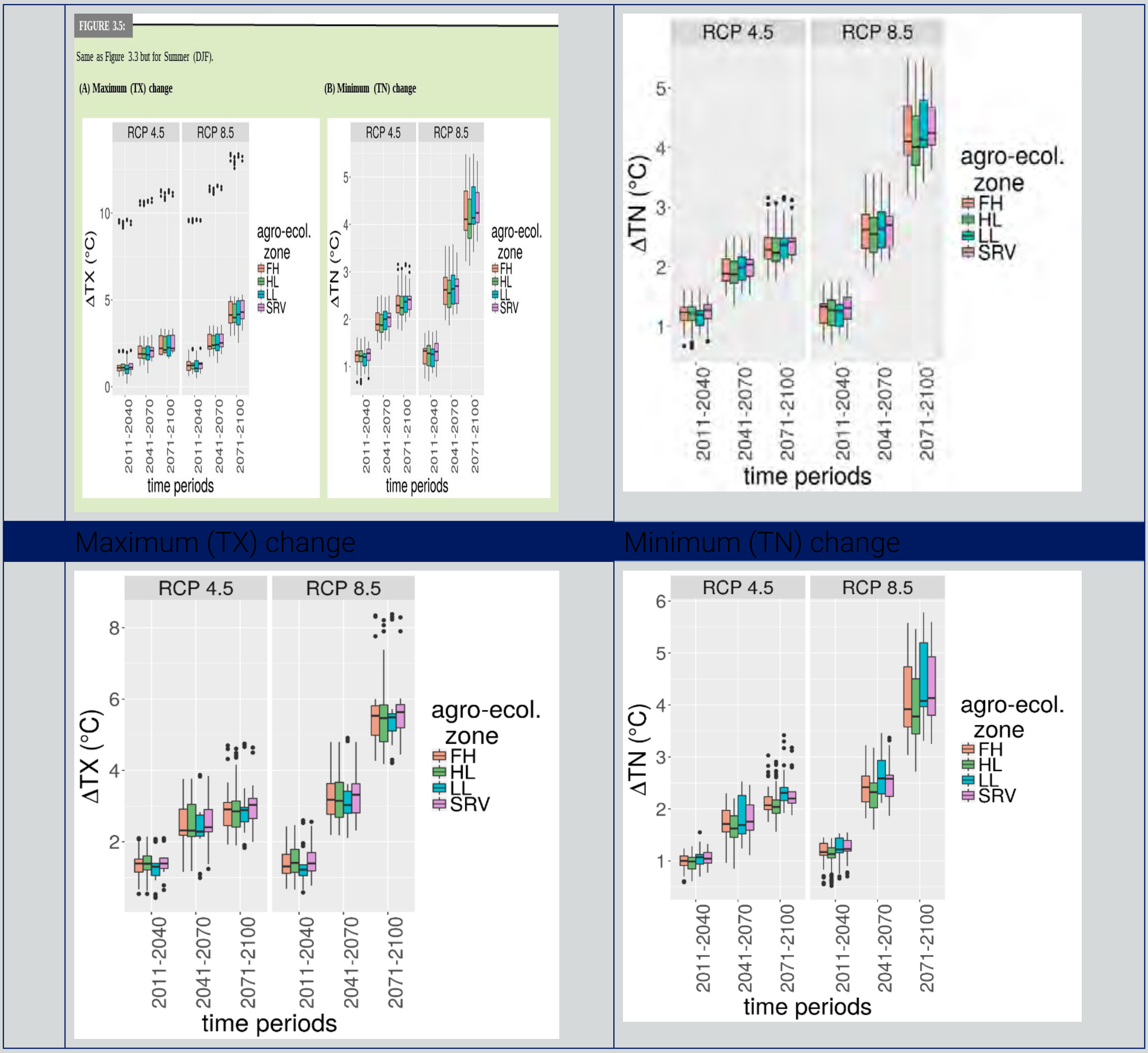


Figure 4.12: Summary of multi-model projections of change in TX and TX for the four seasons

Under RCP4.5, the summer (DJF), autumn (MAM) and winter (JJA) projected ensemble increase in average daily maximum temperature (TX) are above 0.9°C during the near future. The projected temperature increase is more in spring. For the agro-ecological zones, the average daily minimum temperature (TN) ensemble median increase ranges from 1.2°C, during the near-future, to 3.04°C (along Senqu River Valley), during the far-future period. The spring median temperature increase is the highest of all seasons under the scenario RCP4.5. This change indicates a possibility of early onset of summer period or equivalently a narrowing of the transition period (spring season) into summer season. For all the seasons but winter, the zonal range of projected increase in TN overlap with the corresponding range for TX. This indicates that night temperatures are warming as much as day temperatures in Lesotho. The night-time winter temperatures warming, as represented by the ensemble median, is less in magnitude than of the other seasons which go above 0.68°C in the near-future period while remaining below 1.7°C during the distant-future term.

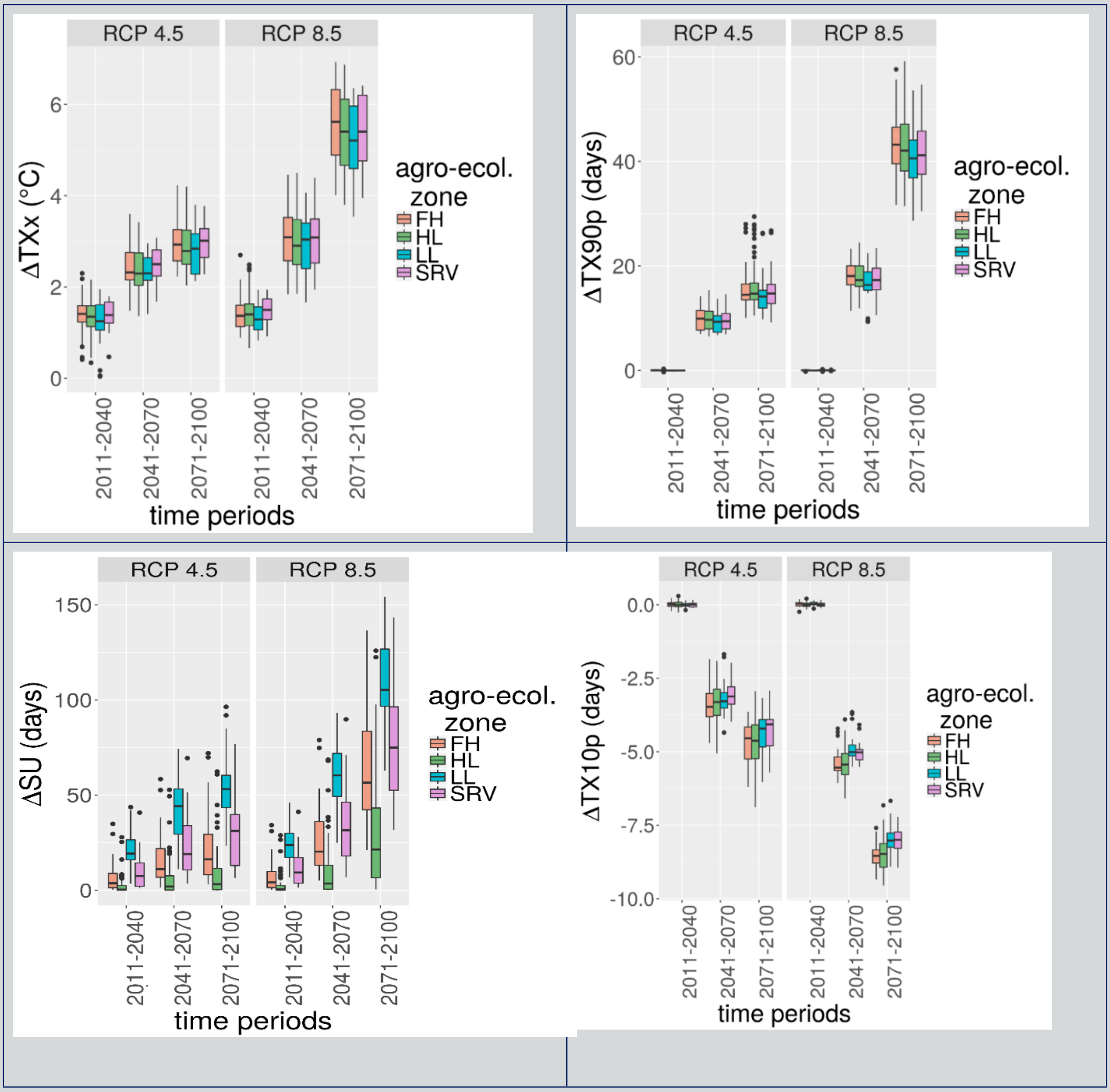
Under RCP8.5 the projected ensemble median increase in maximum (TX) and minimum (TN) temperatures are almost the same, corresponding agro-ecological ranges, in the near-future period. During the mid- and far-future periods, the increases are more in spring. The spring median increase is above 1.9°C and 2.4°C, during the mid- and far-future periods, respectively, reaching the highest values of 3.3°C and 5.6°C, during the respective periods. This corroborates a possibility of the early onset of the summer season. For the agro-ecological zones, the projected ensemble median increase for the summer and autumn is above 2.3°C, during the mid-future period, and above 3.9°C, during the far-future, remains below 2.8 and 4.4°C during the respective periods. In winter, the projected zonal TN median increase is far less in magnitude compared to that of corresponding TX. The TN median increase is above 1.0°C during the mid-future and more but less than 3.3°C during the far-future period.

In summary, the ensemble members project a plausible gradual increase in the average daily maximum (TX) and minimum (TN) temperatures within the 30-year time periods 2011-2040, 2041-2070 and 2071-2100 of the 21st century. The increases in TN and TX are close in magnitude for a majority of seasons particularly the winter season in the near future period. Furthermore, the projected increase gets significant during the mid and far future periods, especially under the emission scenario RCP8.5.

4.4.2 Temperature based extreme climate indices projection

In the near-future period, 2011-2040, the ensemble members project no change in the daily maximum temperature-based extreme indices with the exemption of the hottest days (TXx) and summer days (SU) indices which are projected to increase (see Figure 4.13). This is consistent under both emission scenarios (RCP4.5 and RCP8.5) across the agro-ecological zones.

During the mid-future period (2041 – 2070) and far-future period (2071 – 2100), all the ensemble members agree on an increase in all the daily maximum temperature-based indices except for cold days (TX10p) which is anticipated to decrease. The projected change is consistent in both RCP4.5 and RCP8.5 emission scenarios and across the agro-ecological zones. These scenarios show that daytime temperature extreme conditions are likely to get warmer under the two scenarios.


RCP 4.5
RCP 8.5
ΔTXx (°C)
0
2
4
6
2011-2040
2041-2070
2071-2100
time periods
agro-ecol. zone
FH
HL
LL
SRV
ΔTX90p (days)
0
20
40
60
ΔSU (days)
0
50
100
150
ΔTX10p (days)
0.0
-2.5
-5.0
-7.5
-10.0

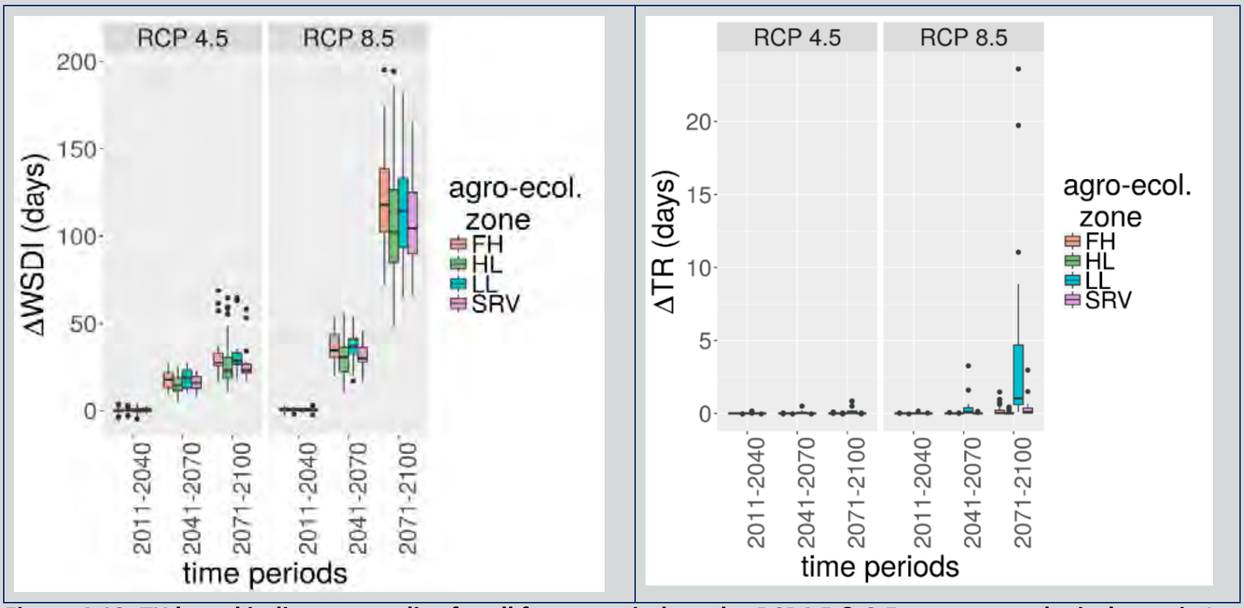


Figure 4.13: TX-based indices anomalies for all future periods under RCP4.5 & 8.5 per agro-ecological zone in Lesotho.

For the minimum temperature indices, only TN10p and TN90p are projected not to change during the near-future period under both scenarios (Figure 4.14). The projected change towards warming, for the two respective indices, are consistent among all the agro-ecological zones under the two scenarios. During the mid- and far-future periods all the ensemble members agree on a decrease in all the daily minimum temperature-based indices except the temperature of the coldest night (TNn) and the number of warm nights (TN90p) which are anticipated to increase. The projected change during the two temperature future periods is consistent under both scenarios RCP4.5 and RCP8.5 and across the agro-ecological zones. These scenarios show that night time extreme cold conditions are likely to get warmer/better under the two scenarios.

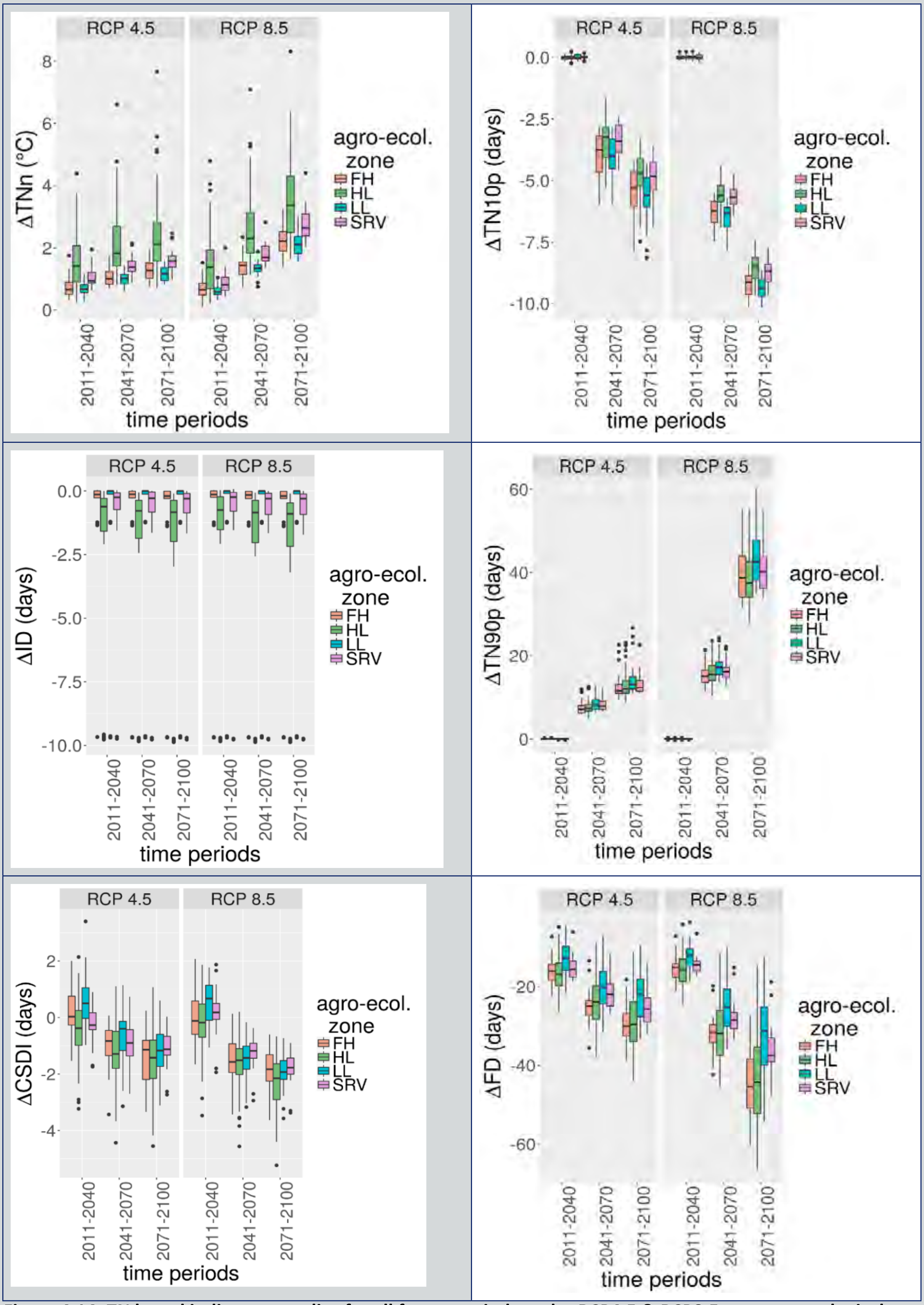


Figure 4.14: TN based indices anomalies for all future periods under RCP4.5 & RCP8.5 per agro-ecological zone in Lesotho.

On comparing the magnitudes of the projected change between maximum- and minimum temperature-based indices, there is a stronger warming in night time extreme temperature conditions as opposed to day time extreme temperatures conditions except for changes in the mid-future, where the hottest day (TX90p) is much more than the change in the number of warm nights (TN90p). Note that the magnitude of the projected change in the warm spell duration index (WSDI) is also much higher than that of the cold spell duration indices (CSDI) under both scenarios.

During the two time periods, the magnitude of change in warm days index (TX90p) is generally greater than the magnitude of change in cold days index (TX10p) and the magnitude of warm nights index (TN90p) is greater than that of cold nights index (TN10p). This indicates that the warm days are expected to increase faster than cold days, and warm nights are expected to increase faster than cold nights. The warming of night and day temperatures also leads to slight increase to the growing season length (GSL), as reflected in Figure 4.15.

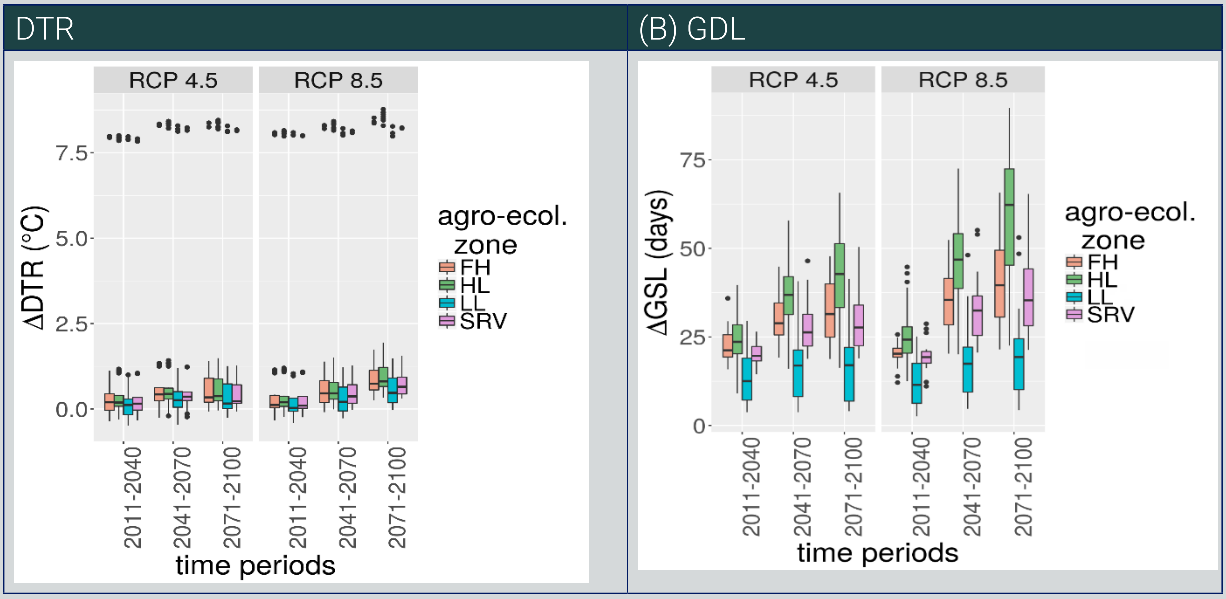


Figure 4.15: Diurnal temperature range and growing season length anomalies for all future periods under RCP4.5 & RCP8.5 per agro-ecological zone.

4.5 PROJECTED PRECIPITATION FUTURES FOR LESOTHO

4.5.1 Precipitation totals

The Mountains, Foothills, and Senqu River Valley are projected to get drier in the autumn season relative to the baseline period (see Figure 4.16). The signal of change is inconclusive for the other seasons but winter. In winter, dry conditions are projected by all ensemble members towards the end of the 21st century. Slightly different conditions to those of the rest of the agro-ecological zones are projected for the Lowlands with all ensemble members suggesting wetter conditions relative to the reference period during the summer months. The signal of average precipitation change suggested by the ensemble members, in the Lowlands, is mixed. This is true for all the seasons, during all periods, except for winter in the far-future in which case the Lowlands are anticipated to get drier relative to the reference period.

Despite the signal being inconclusive in spring and autumn, for the Lowlands, the model spread is relatively narrow during most of the periods. The ensemble medians change during most of the periods are almost at the overlap with the origin in which case the mixed signal could be interpreted as suggestive of no change in precipitation relative to the baseline period.

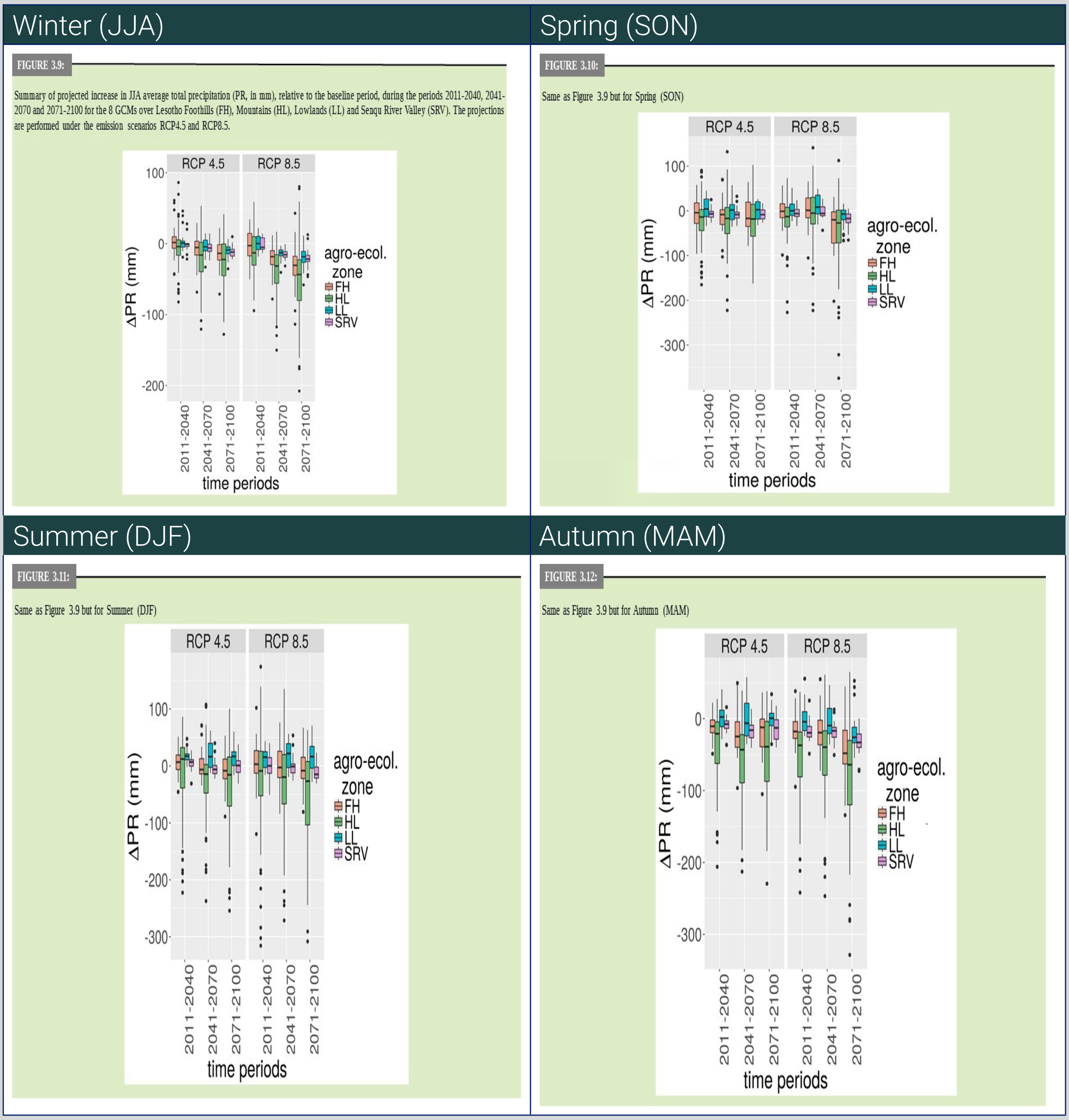


Figure 4.16: Summary of the projected increase in total precipitation (PR, in mm) for all four seasons relative to the historical period over Lesotho.

Majority of the ensemble members project dryer summer conditions relative to the baseline period. For winter and spring months, the multi-models project a mixed signal of change, in the near future, with the ensemble median overlapping with the origin suggesting a possibility of similar precipitation conditions to that of the reference period. However, during winter months of the mid- and far future periods, relatively dry conditions are projected by all models. Precipitation conditions that are drier than that of the historical period are projected by all models towards the end of the century particularly during summer and autumn months. The signal of change for these two seasons during the rest of future periods is inconclusive. In summer and spring, the projections are inconclusive apart from spring in the far-future period which is anticipated to experience plausible dry conditions relative to the baseline period under the emission scenario RCP8.5.

4.5.2 Precipitation-based extreme climate indices projection

The indices R10mm, R20mm, and Rnnmm as depicted in Figure 4.17 represent the number of heavy rain days, the number of very heavy rain days, and annual wet day precipitation respectively. These indices have a similar spatial pattern to that of PRCPTOT in Figure 4.17. The spatial pattern is typified by

- A pronounced magnitude of the median increase in the extreme North-Western and Western Mountains in the near-future with little to no median change towards the mid-future,
- A little decrease in the magnitude of ensemble median change in the Mountains during the far-future under both RCP4.5 and RCP8.5,
- An ensemble median decrease in the North-Eastern Mountains which becomes more intense and spatially pronounced towards end of the 21st century under both scenarios, and
- An increase in the ensemble median which gets weak towards the end of the 21st century in the central Mountains, or lower Maluti range, extending to the south-western part of the Foothills.

The general spatial pattern of the four indices is consistent under RCP4.5 and RCP8.5 albeit being stronger and a lot more pronounced in future projection periods under RCP8.5 in comparison to RCP4.5.

The second category can be exemplified by the spatial pattern of the ensemble median change for the index (R95pTOT, Figure 4.17(B)) which represents very wet days. Effectively, this pattern is shared between the indices R95pTOT, R99pTOT, Rx5day, Rx1day, and SDII. The respective sign and magnitude of the ensemble median change reflect a decreasing pattern in the Eastern Mountains. The change gradually intensifies towards the end of the 21st century. On the contrary, a pronounced ensemble median increase, which gradually gets stronger with time, is projected along the Maluti range extending to the Senqu River Valley under both RCP4.5 and RCP8.5. In the Lowlands, there is little to no relative change in the projected ensemble median especially during the near and mid-future while there is a decrease during the far-future. As is the case with the first category of indices, the pattern is much stronger under RCP8.5 in comparison with RCP4.5. In most cases, the pattern gets stronger towards the far-future periods.

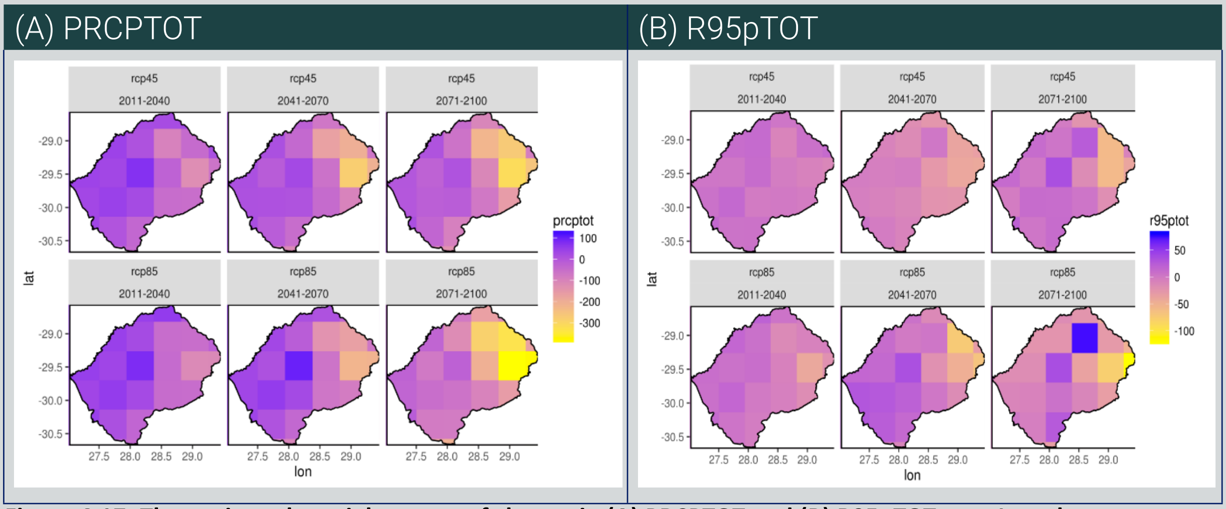


Figure 4.17: The projected spatial pattern of change in (A) PRCPTOT and (B) R95pTOT over Lesotho

4.6 PRECIPITATION-BASED INDICES PROJECTIONS ACCORDING TO AGRO-ECOLOGICAL ZONES

In the subsequent section, the projected changes in extreme precipitation according to agro-ecological zones are discussed. Each box-and-whisker plot reflects a distribution of anomalies per region, relative to the baseline, for the multi-model ensemble for a specific period. The change is described by looking at the median of the respective indices across the period. The spatial and ensemble uncertainty is reflected by the spread of the anomalies within the interquartile range of each box-and-whisker plot. The projected change in precipitation indices is considered inconclusive in the case where there is disagreement in the sign of change across the agro-ecological zone for a given period. The analysis does not delineate spatial uncertainty from the multi-model projection uncertainty for the region.

4.6.1 Mountains

For the Mountains, all the indices projections under the emission scenario RCP4.5 and RCP8.5 during the near-future period, 2011-2040, leads to inconclusive signals as there is a high uncertainty in the direction of change among the indices.

During the mid-future period, 2041-2070, there is a projected decrease in the annual total wet days precipitation index (PRCPTOT) as well as in the number of very heavy precipitation days index (R20mm), and an increase in consecutive dry days index (CDD) under both RCP4.5 and RCP8.5. The model projections for the rest of the indices are inconclusive. A decrease in

PRCPTOT, R20mm, and a simultaneous increase in CDD are suggestive of an intensification of meteorological drought conditions in the Mountains under both scenarios. During the far-future, the indices PRCPTOT and R10mm are also projected to decrease as well as the index R20mm. This is anticipated to happen simultaneously with an increase in CDD while the projected changes in the rest of the indices are inconclusive, as is the case during the mid-future period. In comparison with the mid-future period, the anticipated changes are much more pronounced in the far-future period particularly under RCP8.5. This signals a possibility of a much more intensified meteorological drought conditions in the mountains during the mid-future period, specifically under RCP 4.5 (see Figure 4.18).

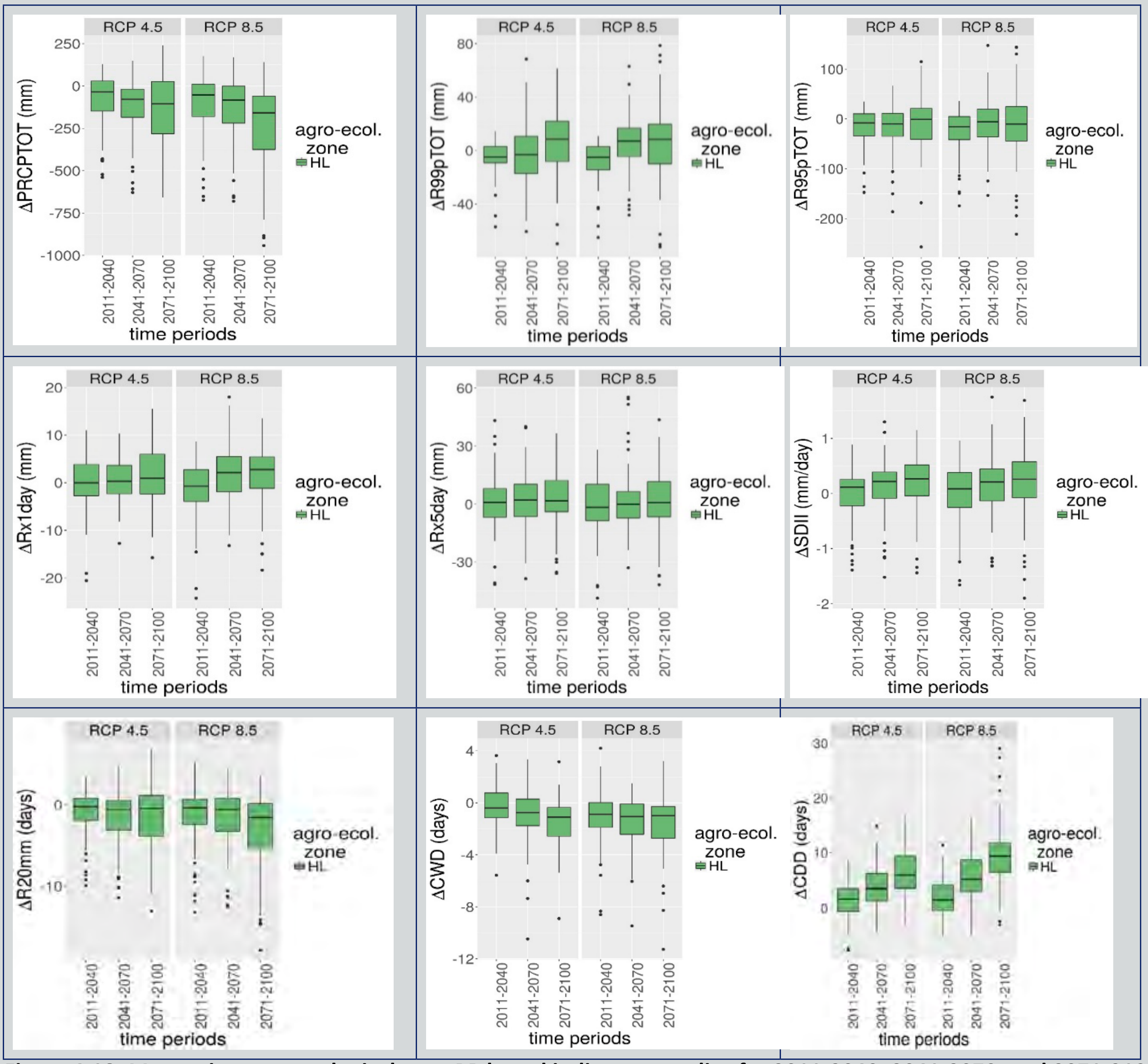
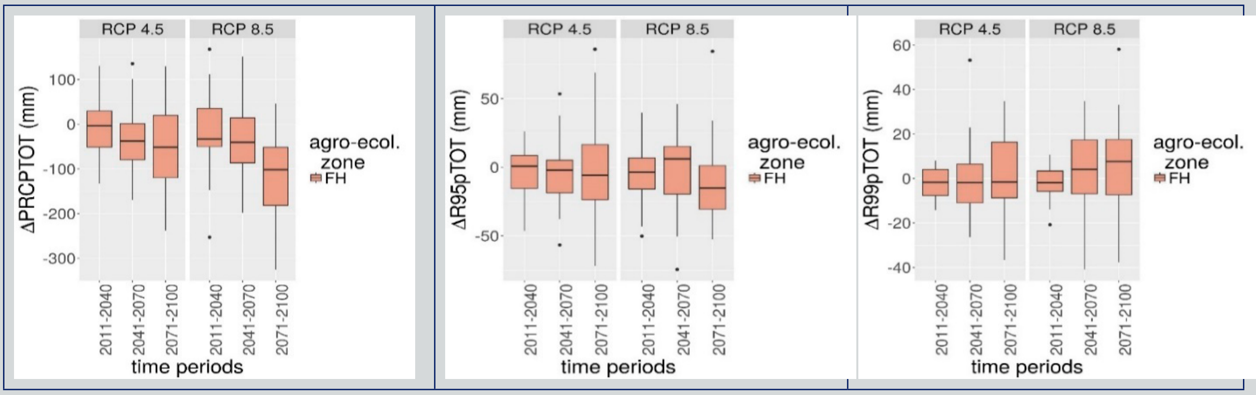


Figure 4.18: Mountains agro-ecological zone PR based indices anomalies for 2011-2040, 2041-2070, and 2071-2100 under RCP4.5 and RCP8.5

4.6.2 Foothills

For the Foothills, the ensemble members project no change in PRCPTOT, CWD, R95pTOT, and Rx1day during the near-future period, under RCP4.5, while projections for the rest of the members are inconclusive. During the same period, under RCP8.5, only the indices R20mm, R95pTOT, and CDD are projected to experience no change. Projections of change for the rest of the indices are inconclusive. Most indices indicate no change in extreme precipitation conditions along the Foothills under both scenarios during the near-future period. During the mid-future period, the contribution from very wet days index (PRCPTOT) is reflected as likely to decrease by all models while consecutive dry days index (CDD) is projected to increase with most of the models also suggesting a decrease in the number of heavy precipitation days (R10mm). The projected decrease in the indices PRCPTOT and R10mm and increase in the index CDD points to a possibility of intensified meteorological drought during the period. Note that the projected changes for the rest of the indices are largely inconclusive under RCP4.5. Under RCP8.5, during the mid-future, the models suggest no change in R95pTOT and CDD while the projections of change in the rest of the indices are all inconclusive (see Figure 4.19).

During the far-future period, the Foothills are anticipated to get an increase in Consecutive Dry Days (CDD) and there is almost no projected change in R20mm while the projected change in the rest of the indices is inconclusive under RCP4.5. Under this scenario, there is no clear derivable signal of change in the extreme precipitation index for the Foothills. Under RCP8.5 there is a projected decrease in PRCPTOT, R95pTOT, and a simultaneous increase in CDD. This indicates a possibility of amplified meteorological drought toward the end of the 21st century (see Figure 4.19).



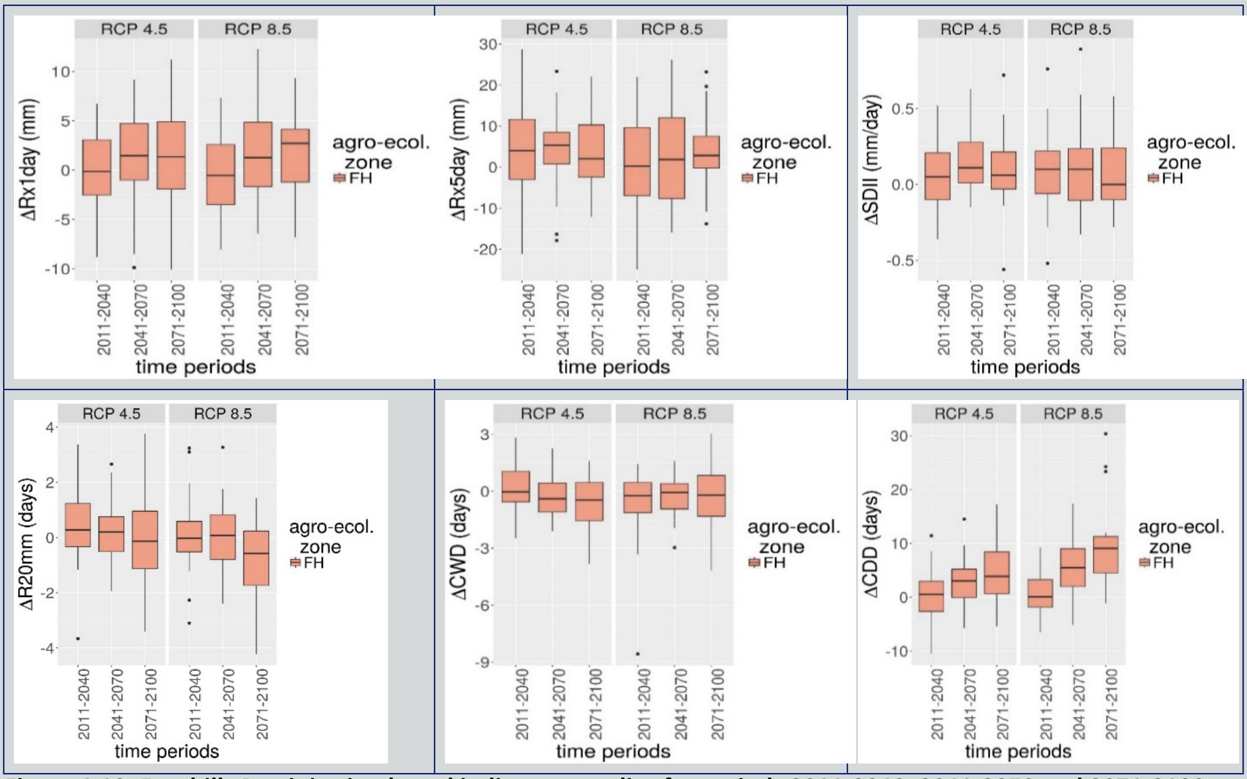


Figure 4.19: Foothills Precipitation based indices anomalies for periods 2011-2040, 2041-2070 and 2071-2100 under RCP4.5 and RCP8.5

4.6.3 Senqu River Valley

For the Senqu River Valley, in the near-future period the multi-model projections suggest no change in the indices Rx1day and Rx5day while there is an increase in R10mm and a decrease in Rnnmm under RCP4.5. The projected change in the rest of the indices is inconclusive. The contrast in the sign of change in R10mm and Rnnmm suggest that future precipitation in this zone, may come in large amounts for fewer days than before. Considering projections under RCP8.5, all models project a decrease in PR, CWD, and Rnnmm while the rest of the indices are inconclusive. The projected concurrent decrease in annual precipitation and the consecutive wet days signal the likelihood of the Senqu River Valley to get generally dry under RCP8.5 in the near-future period (see Figure 4.20).

During the mid-future period, all the models project a decrease in PR, PRCPTOT, Rnnmm, and CWD together with an increase in CDD under RCP4.5. The indices R20mm, R5day, R99pTOT are projected to remain almost unchanged during the mid-future period. The rest of the indices are inconclusive under RCP4.5. Similarly, under RCP8.5 the indices PR, PRCPTOT, and CWD are also projected to decrease while R99pTOT, CDD, and Rx1day are projected to increase. Still, under RCP8.5, Rx5day and R20mm are projected to remain unchanged. The decline in PR, PRCPTOT, and CWD reflect the Senqu River Valley as likely to experience dry conditions under both RCP4.5 and RCP8.5. The projected increase in Rx1day signals a possibility of an increased risk of occasional flooding along the Senqu River catchment while the region remains generally dry under RCP8.5 during the mid-future period (see Figure 4.20).

In the far-future period all models project a decrease in the indices R95pTOT, PR, PRCPTOT, Rnnmm, and CDW while CDD is anticipated to increase under both RCP4.5 and RCP8.5. This reflects that Senqu River Valley is likely to get relatively dry under both emission scenarios. The number of very heavy precipitation days (R20mm), under RCP8.5, is projected to decrease. The decrease is simultaneous with the projected increase of Rx1day and extremely wet days. These indicate a possibility of an amplified occasional precipitation, leading to an elevated risk of heavy flooding along the Senqu River catchment while the region remains generally dry during most of the year possibly including during historically wet seasons. Apart from PRCPTOT, a similar approach could also be taken using simple daily precipitation index (SDII) or annual precipitation (PR) (refer to Figure 4.20).

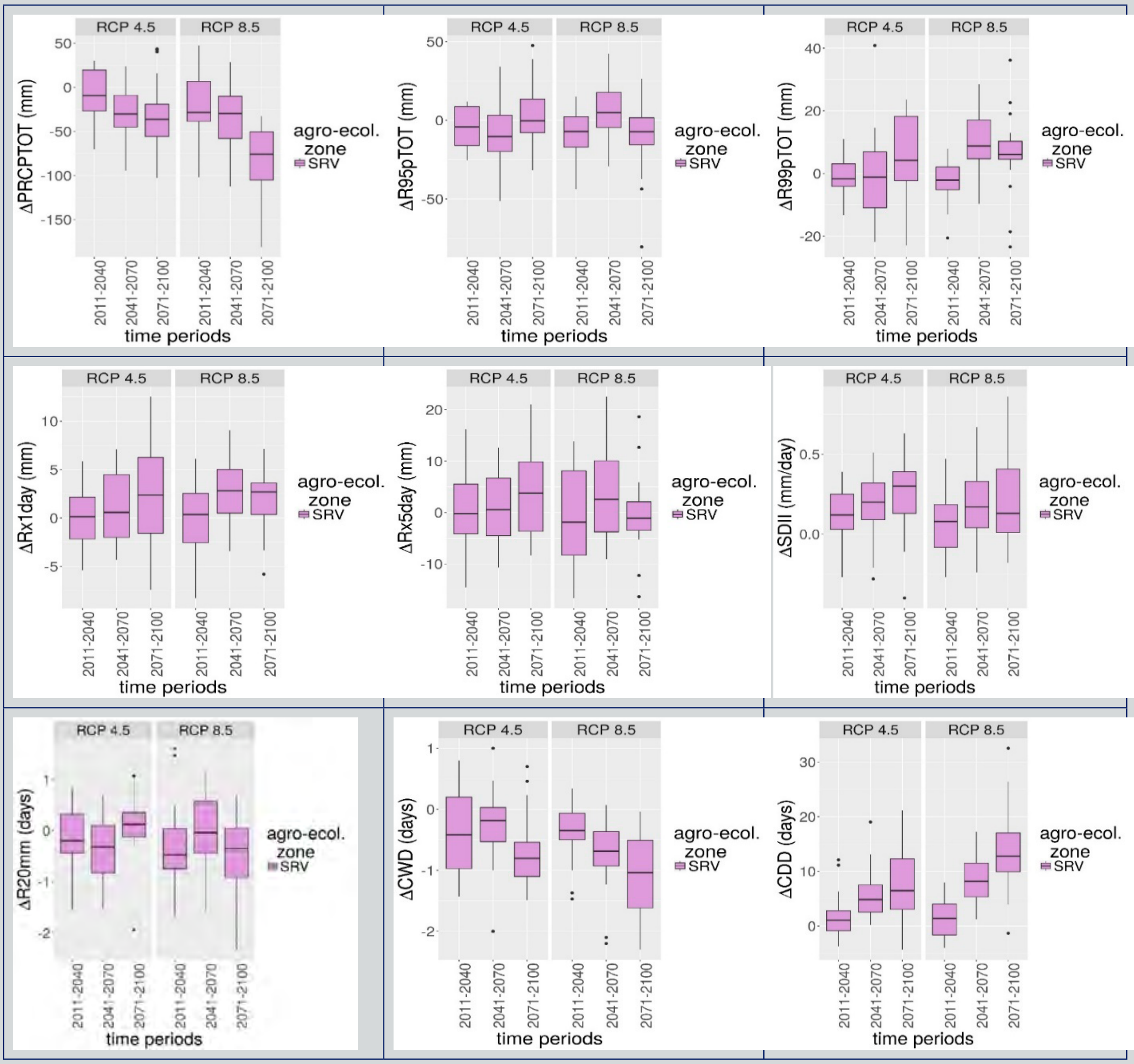


Figure 4.20: Senqu River Valley (SRV) Precipitation based indices anomalies for periods 2011-2040, 2041-2070, and 2071-2100 under RCP4.5 and RCP8.5.

4.6.4 Lowlands

In the near-future period, there is almost no change projected for the indices R99pTOT, Rx1day while the indices R10mm and CWD are anticipated to increase under the emission scenario RCP4.5. The increase in the number of heavy precipitation days and consecutive wet days suggests a possibility of the Lowlands being relatively wet in comparison to the reference period with a likelihood of wet seasons getter wetter under RCP4.5. Under RCP8.5, all models suggest no change in CWD an increase in R10mm and inclusive for the rest of the indices during the period. Under the emission scenario RCP8.5, the projected change in the two indices support the possibility of the Lowlands having wetter seasons relative to the baseline period during the near-future projection term (see Figure 4.21).

During the mid-future period, the index PRCPTOT is projected to remain the same by all ensemble members, while CWD and R99pTOT are expected to increase under RCP4.5. The rest of the indices are inconclusive under the scenario. A possibility of no change in the annual total wet day precipitation with an increase in extremely wet days is indicative of a possibility of a shift in the seasonal rainfall distribution under the scenarios. The indices R99pTOT, R95pTOT, CDD, CWD, and Rx1day are projected to increase under the emission scenario RCP8.5 during the mid-future period. The multi-model projections of change in the rest of the indices are inconclusive. The concurrent increase in the respective indices related to extremely wet days, the contribution from very wet days, consecutive wet days, consecutive dry days and maximum 1-day precipitation amount also indicates an increased likelihood of a shift in the distribution of precipitation under the emission scenario RCP8.5. For the wet seasons of the year, a simultaneous increase in CDD and CWD and Rx1day indicates a possibility of an aggravated risk of flood in the Lowlands under RCP8.5 (refer to Figure 4.21).

In the far-future period, only the index CDD is projected to increase with the multi-model projected change for the rest of the indices being inconclusive under the emission scenario RCP4.5. Under the emission scenario RCP8.5 the indices PRCPTOT, Rnnmm and R10mm are projected to decrease for the Lowlands while CWD is projected to increase. The decrease of PRCPTOT and R10mm with an increase in the number of consecutive dry days (CDD) during the period signals a possibility of intensification of meteorological drought under RCP 8.5 for the Lowlands in the far future term (shown in Figure 4.21).

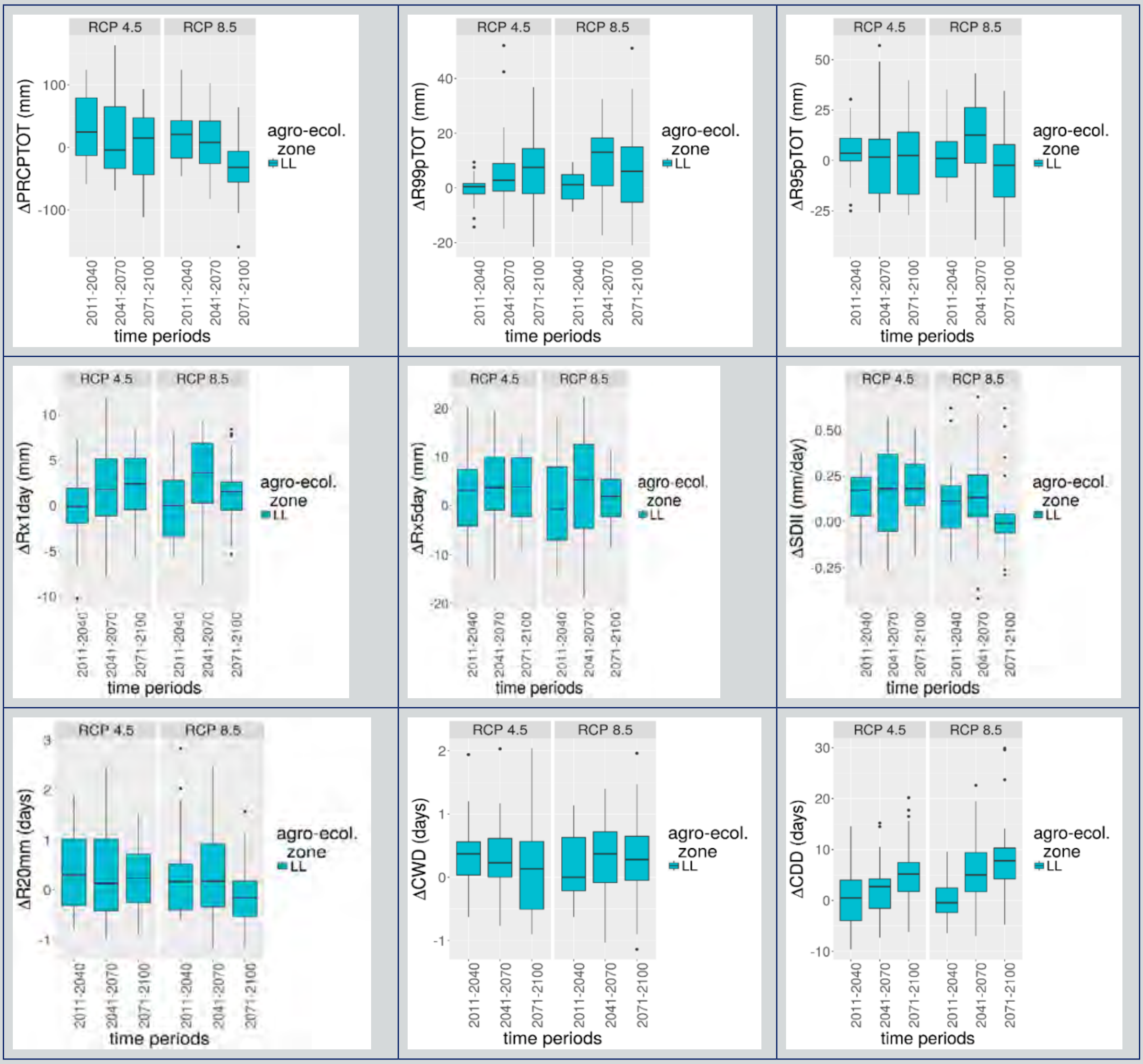


Figure 4.21: Lowlands (LL) Precipitation based indices anomalies for periods 2011-2040, 2041-2070 and 2071-2100 under CP4.5 and RCP8.5.

4.7 NARRATIVES OF CLIMATE CHANGE FOR LESOTHO AND ITS AGRO-ECOLOGICAL ZONES

A plausible gradual increase in both minimum and maximum temperatures is anticipated to happen during the 21st century with a peak happening in the last period (2071-2100) under both scenarios. The highest increase is expected under the worst-case scenario, RCP8.5. The increase is evident in, but not limited to, increase in mean minimum and maximum temperatures, increase in the number of hot days and nights, increase in growing season length, decrease in the number of cold days and nights and decrease in frost days. The day and night temperature increase are reflected for all agro-ecological zones under all scenarios.

Looking at the seasonal patterns of the projected changes, the Austral summer precipitation is indicative of a possibility of wet conditions in the Lowlands under both emission scenarios across all projection periods. However, there is no projected change in the Senqu River Valley under the RCP4.5 while drier conditions are expected under the worst-case scenario. The signal of change is inconclusive for the other agro-ecological zones under the two scenarios during the far future period. In austral autumn, the near-future projections indicate dry conditions along the Foothills, Senqu River Valley and Mountains, although the signal of change for the Lowlands is inconclusive. Winter projections indicate a high possibility of no change in precipitation relative to the baseline period in the Lowlands although the changes along the Foothills and Mountains reflect a possibility of relatively wet conditions under RCP4.5 and intense dry conditions under the worst-case scenario. For spring projections reflect the near-future (2011-2040), precipitation is likely to decline under both scenarios relative to the baseline for all agro-ecological zones. However, in the far-future (2071-2100), models project dry conditions in spring under the worst-case scenario.

In summary, in the Lowlands, wet spells are reflected as likely to increase during the near- and mid-future (2011-2040 and 2041-2070) while increased occurrences of drought are likely in the far-future (2071-2100) in both scenarios (RCP4.5 and RCP8.5). In the Foothills, during near-future, there is no change projected in the rainfall. However, the occurrence of drought conditions in mid- and far-future, which amplifies further into the future, is shown as plausible. In the Mountains, longer wet spells are likely in the near-future under both scenarios (RCP4.5 and RCP8.5). However intense droughts are likely in the mid-future which amplify in the long term. In the Senqu River Valley, drought spells and heavy rainfall are likely throughout the future periods, intensifying towards the end of the century.

4.8 VULNERABILITY AND ADAPTATION ASSESSMENTS OF KEY SOCIO-ECONOMIC SECTORS

Building on the work conducted in the SNC, this section reviews and prioritises the most significant climate change impacts and vulnerabilities for the following sectors: Soil and land degradation, Agriculture (Crops and Livestock), Forestry, Tourism, Health, Biodiversity and Environment, Youth and Gender, Culture and Heritage. A review of the barriers to adaptation, the available information and data gaps, as well as the adaptation priorities are presented for each sector. The vulnerability and adaptation assessments presented in this section are focused on the national scale and, where possible, agro-ecological zone-level details are presented to demonstrate the spatial distributions of vulnerability potentials across Lesotho. Each assessment is based on the climate change projections provided in Sections 4.3 to 4.6 of this chapter.

4.8.1 Soils and land degradation

Land degradation is a global problem facing land systems in all countries.1[2] IPBES12 describes land degradation as “the many human-caused processes that drive the decline and loss of biodiversity, ecosystem functions or ecosystem services in any terrestrial and associated aquatic ecosystems." Land degradation is, therefore, a major threat to biodiversity and the ecosystem, which mostly affects the livelihoods of rural populations, who are dependent on ecosystem services. Lesotho is a prime example of a country facing extensive land degradation. The country's extensive land degradation, its geographic characteristics, and the socio-economic conditions make it one of the countries that are most vulnerable to climate change-related impacts, especially for rural populations. It is thus important that there is a clear understanding of the possible impacts of climate change (Figure 4.22) on land degradation and soil erodibility (Figure 4.23) to be able to plan and implement adaptive measures and mitigation strategies that equip the nation to better deal with the impacts of climate change.

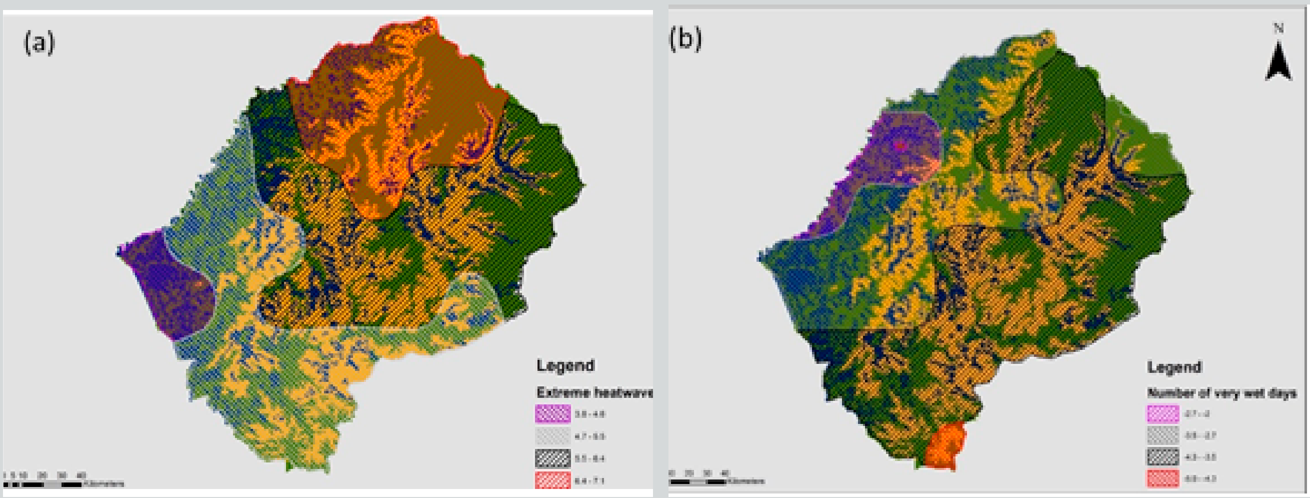


Figure 4.22:(a) The spatial distribution of extreme heatwaves relative to the erodibility of Lesotho's soils, (b) Spatial distribution of the number of very wet days relative to Lesotho's soil types13

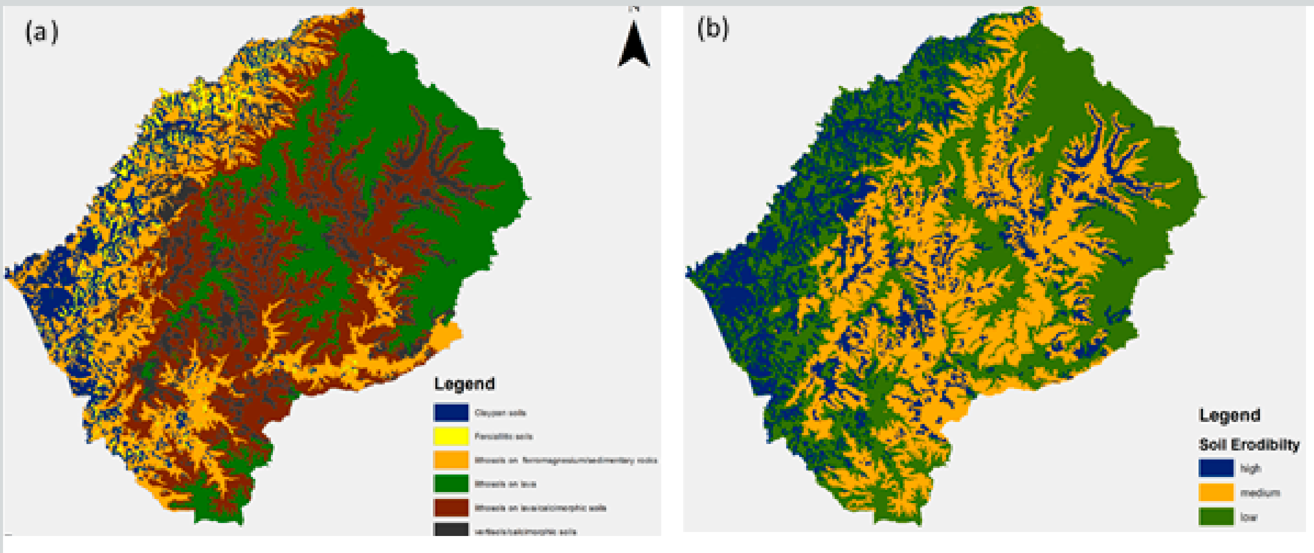


Figure 4.23: (a) Lesotho's soil types, (b) Spatial distribution of the erodibility of Lesotho's soils14

Lesotho's current vulnerability also stems from the fact that its economic growth is dependent on climate-sensitive sectors i.e. water, manufacturing, agriculture, biodiversity and mining which are subject to highly variable precipitation.[15] In addition to its variable climate and climate-sensitive economy, the majority of Lesotho's population is dependent on rain-fed subsistence agriculture and these communities do not have sufficient resources to address the associated loss of soil fertility and climate variability.16 The inherent nature of Lesotho's topography, soils (shown in Figure 4.24), vegetation cover, and rainfall patterns makes it particularly susceptible to soil and land degradation. This review will focus primarily on the soil erosion component of soil degradation.

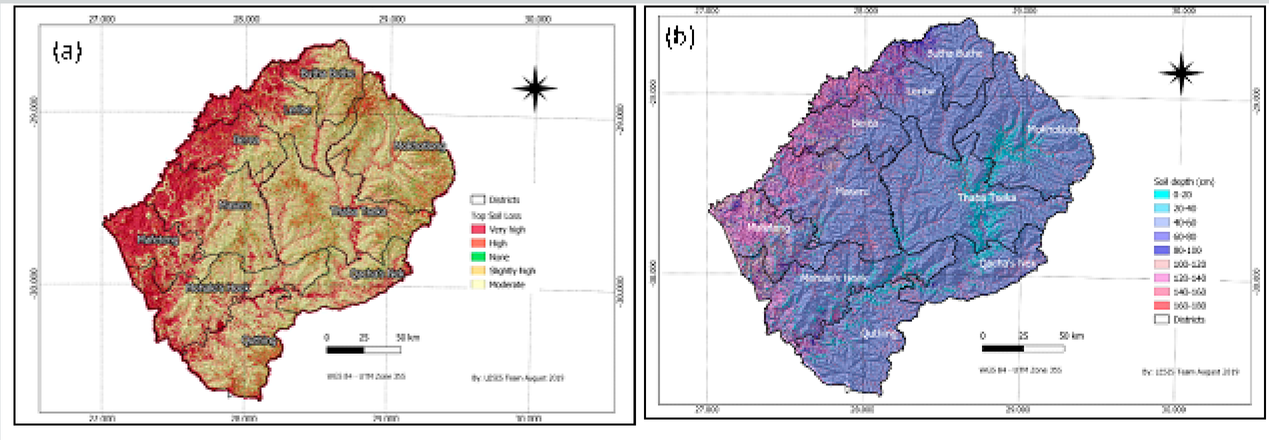


Figure 4.24: (a) Spatial distribution of the loss of topsoil in Lesotho; (b) Soil Depth Map of Lesotho. Source: MFRSC: Lesotho Soils Information System (LESIS), 2019.17

4.8.1.1 Climate change impacts and vulnerabilities

Lesotho is vulnerable to several climatic, environmental and economic factors with land degradation in the form of soil erosion, soil compaction, loss of soil organic carbon and resultant soil biodiversity loss. [4] The country's current vulnerability also stems from the fact that its economic growth is dependent on climate-sensitive sectors i.e., water, manufacturing, agriculture, and mining which are subject to its highly variable precipitation.[15] Increased temperatures, higher rainfall variability, and other extreme climatic events have been projected to occur in the advent of climate change. The impacts of climate change (Table 4.3) on land degradation impose far-reaching consequences including land and ecosystem degradation, human suffering, and threats to the survival of biological organisms.[18]

Table 4.3: Climate change impacts on soils of Lesotho

	Impacts of climate change
Land degradation	• Adding more to the countries' topography and the common agricultural practices done under subsistence farming, the projected increase in the number of heavy precipitation days and consecutive wet days suggests a possibility of the Lowlands being relatively wet. Thus, the high-intensity rainfall events in the absence of a protective surface cover have the potential to accelerate soil erosion and increase river sediment loads.[15] • During autumn and winter, the near-future projections indicate dry conditions along the Foothills, Senqu River Valley and Mountains, although the signal of change for the Lowlands is inconclusive. A reduction in soil moisture levels reduces the cohesive forces between soil particles, and the fact that there is little vegetation cover during those periods, makes the soil more susceptible to erosion by wind and water.[19] • Altered precipitation patterns, temperatures, and atmospheric CO_2 levels modify the soil-plant system, which influences decomposition rates. Consequently, this has a direct influence on soil organic matter levels.20 The decomposition of organic matter as a result of increased soil temperatures has the potential to reduce aggregate stability and lower infiltration rates making the soil more prone to erosion. • During the mid-future period, 2041-2070, there is a projected decrease in the annual total wet days precipitation index (PRCPTOT) as well as an increase in consecutive dry days index (CDD) under both RCP4.5 and RCP8.5. These changes are pronounced more in the Mountains, Foothills and Senqu-river valley and it signals an intensification of meteorological drought conditions, which will lead to agricultural, hydrological and socio-economic droughts. Intense drying of the soil as a result of prolonged drought events has a direct influence on vegetation growth and patterns which play a significant role in providing a protective cover.[21]
Ecosystem services	a. In the Lowlands, wet spells are reflected as likely to increase during the near- and mid-future (2011-2040 and 2041-2070) and in the Senqu River Valley, heavy rainfall are likely throughout the future periods, intensifying towards the end of the century. The increased frequency and intensity of rainfall events increase the likelihood of intense runoff events thus leading to the loss of vital ecosystem services through a decline in the diversity of soil organisms, a reduction in plant diversity UNCCD;[22] Brevik[23]

Brevik (2013)[23] and Karmakar et al. (2016) [21] present a comprehensive review the impacts of climate change on soil properties while Box 4.1 summarises the climatic changes most relevant to Lesotho.

Box 4.1: Influence of climate change on selected soil properties (Source: Brevik;23 Karmakar et al.;21 Musa et al.19)

Soil moisture:

- Floods and droughts have a direct impact on soil moisture levels.
- Low soil moisture levels reduce cohesion between soil particles making them susceptible to erosion.

Soil Organic Matter:

- Changes in temperature, precipitation and atmospheric carbon dioxide (CO_2) alter decomposition rates thus soil organic matter levels.
- Organic matter decomposition reduces aggregate stability making the soils more susceptible to erosion.

Vegetation Cover:

- A change in rainfall patterns influences vegetation growth/cover thus the erosion susceptibility of the soil.

4.8.1.1 Adaptation options and strategies

Lesotho has developed several sector-specific policies and regulatory frameworks to facilitate the implementation of appropriate measures to combat soil and land degradation and conserve the integrity of healthy ecosystems that support life on earth.

- Improving ecosystem management, protection and conservation.
- Improving technical capacity at national and community levels on land management practices.
- Research and development on appropriate technologies for land rehabilitation and management.
- There should be an investment in water harvesting through systematic earth dams constructed by communities in gullies and dongas around arable lands.
- Dams should be designed and constructed in accordance with engineering specification under the guidance and supervision of appropriate expertise from the Ministry of Forestry and Land Reclamation. These dams or reservoirs will serve multiple purposes such as for irrigation, drinking water for livestock and sediment control.
- Conservation efforts will have to be strengthened. Conservation farming methods such as minimum tillage / pit farming should be encouraged.
- It will be necessary to introduce an incentive for livestock improvement. Only improved breeds of livestock that are adapted to the climatic conditions and are economically viable should be maintained. Appropriate numbers of stocking rates should be maintained.

Policies and frameworks implemented in Lesotho include;

- Land Degradation Neutrality Target Setting Programme (LDNTSP): LDNTSP is a tool designed by UNCCD to assist countries to implement their National Action Plans. LDNTSP helped MFRSC from 2015 onwards, to identify which targets to report under e.g., MDG 15.3 (land cover, land productivity, and organic matter).
- Wool and Mohair Promotion Project (WAMPP): The seven-year project (2016 to 2022), with funding from the International Fund for Agricultural Development (IFAD), has a strong focus on land use and land management systems to combat land degradation and improve the wellbeing of livestock farming communities. The goal of WAMPP is to boost the economic and climate resilience of poor, smallholder wool and mohair producers to the adverse effects of climate change in the Mountain and Foothill regions of Lesotho.
- Integrated Catchment Management: With funding from the European Union and implemented through the Ministry of Water is intended to use a holistic multi-stakeholder approach that employs a catchment approach (the entire country delineated into specific catchments and sub-catchments), to implement successful and proven land and water management activities.
- Land rehabilitation programme: Nationwide implementation of land rehabilitation programmes through catchment management activities (known as fato-fato model). Several key interventions, mostly preventive measures, are implemented on lands that are not yet degraded or those that are slightly degraded. Community-based partnership approaches are commonly used by the Ministry of Forestry, Range, and Soil Conservation (MFRSC) to achieve its land rehabilitation objectives (Figure 4.25)2. Afforestation programme- Sustainable afforestation programme and tree planting in Lesotho becomes highly imperative to meet the forest products. The importance of trees is not limited to their provision of fuelwood only. Trees play a vital role in an environmental protection. stabilising soil, preventing soil erosion, controlling water run-off in catchment areas, providing shelter from wind and the sun's scorching heat are some of the important purposes for which trees are widely planed and need in Lesotho. A sustainable afforestation has a potential benefit to human life, although the establishment phase may however be riddled with a lot of challenges such as conflicts with local people, animal damages due to inadequate protection

Figure 4.25: Infiltration pits and trenches to promote groundwater recharge and rehabilitate degraded landscapes – Mafeteng district

[c] *Images in Figure 4.25 are used with permission from the Ministry of Forestry, Range and Soil Conservation – Department of Soil and Water Conservation.*

4.8.2 Crops

The majority of rural population in Lesotho is vulnerable to climate change due to its heavy dependence on rain-fed agriculture and other climate-sensitive resources, widespread poverty, and limited coping capacity.[24,25] Extreme weather events, notably drought, heavy rains, and hailstorms, also threaten development gains across agricultural related sectors. Agriculture's sensitivity to climate-induced water stress is likely to intensify the existing problems of decreasing agricultural outputs, declining economic productivity, poverty, and food insecurity, with smallholder farmers in Lesotho particularly affected. The spatial and temporal changes in the frequency of temperature and precipitation may be linked to a decline in crop production.

The projected annual maximum temperature changes in the near future (2011-2040) for the Highlands, Foothills, Lowlands and Senqu River Valley respectively include a temperature mean increase by at least (1.95, 1.83, 1.66 and 1.95 times) under the medium emission scenario (RCP4.5). Under the high emission scenarios (RCP8.5), the mean increases relative to the global average increase by a factor of (1.92, 1.86, 1.73 and 2.00) for the respective ago-ecological zones. During the mid (2041-2070) and far-future (2071-2100) projection periods, the maximum temperature for the respective zones are projected to increase by (3.26, 3.18, 2.96, and 3.30 times) and (3.72, 3.72, 3.75 and 3.81 times)

The projected temperature increases amplify societal concern that more frequent and intense climate extreme events could occur in the 21st century. Without strong and focused adaptation strategies, climate change could generally be detrimental to cropping systems in agriculture. The most important cereal crops (maize, sorghum, and wheat) have been decreasing in production, the area planted and yield in the last few years due to recurring droughts (see Figure 4.26).[26,27]

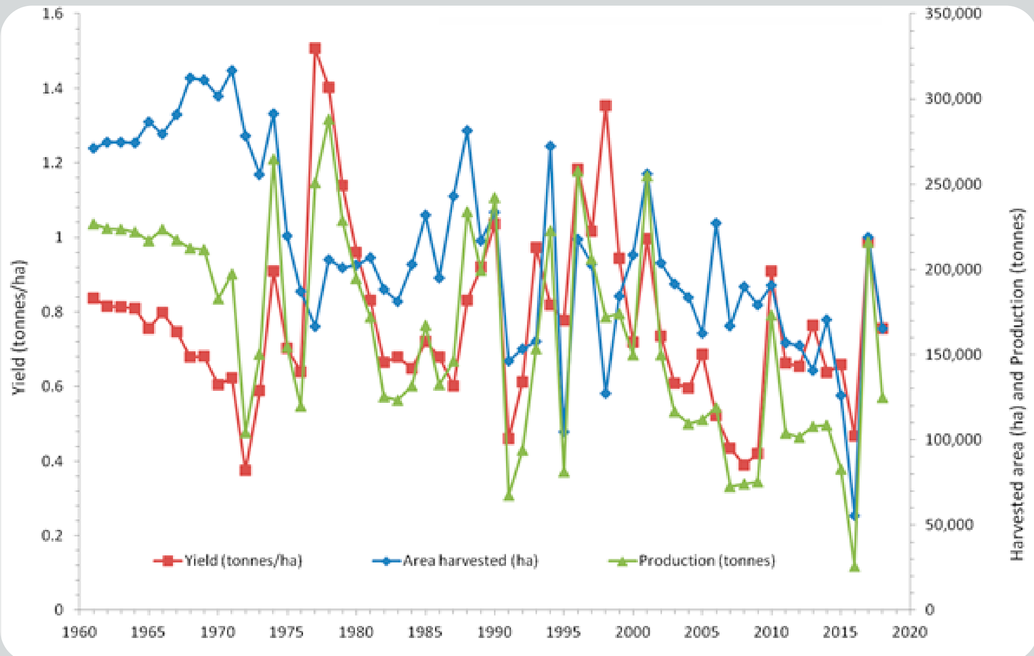


Figure 4.26: Trends for cereal production, area harvested, and yield in Lesotho.[29]

4.8.2.1 Climate change vulnerabilities

From early Spring to Autumn (September to April) in the near-term (2011-2040), precipitation is likely to decline under both scenarios relative to the baseline for all Livelihood Zones. However, in the long-term (2071-2100), models project drought conditions under the worst-case scenario, thus there is a likelihood of a significant shift in planting dates or crop failure if commensurate adaptation measures are not adopted During Autumn (March, April, May), the near-future projections indicate dry conditions along the Foothills, Senqu River Valley and Highlands although the signal of change for the Lowlands is inconclusive, this could hinder the crop's maturity as most of Lesotho's staple crops are at critical stages at this time (pollination to grain-filling) which has high rates of water requirements thus being at high risk or reduced yield. Dry conditions in Autumn also delay the onset of winter cropping with detrimental consequences on food security.

4.8.2.2 *Climate change impacts*

The crop modelling exercise deployed in this chapter showed that climate change is likely to affect the yields of common crops e.g., sorghum, beans, as follows:

- The increased temperatures will reduce the growing period of most crops (one week in the period 2011-2040, two weeks in the period 2041-2070 and three to four weeks in the period 2071-2100) by accelerating their physiological maturity.
- Because of dominant yield reduction over the evapotranspiration reduction, water use efficiency (WUE) will decrease for both the grains and legumes and biomass yields for maize, wheat, and beans.
- Overall, mean yield reductions are projected for maize, beans, and wheat, while the yields of sorghum are projected to increase by up to nine (9) %. The most significant yield reduction projected within the 21st century is for wheat (50%), and to a much lower yield reductions for other cereals e.g., maize (11%) and beans (9%). For all three crop types with yield reductions, decrease in yield is higher in RCP8.5 scenario compared to RCP4.5 scenario. This reveals the negative impacts of increased temperature and changes in precipitation on the yield (Table 4.4, and Appendix 4D for spatial variations of climate change-induced changes in crop yields in the 2011-2040, 2041-2070 and 2071-2100 periods relative to the baseline period of 1971 - 2000 for both the RCP4.5 and RCP8.5 scenarios). The yield increases in sorghum may be attributed to predicted increases in temperature. Climate change affects the physiology of most crops, mainly through hastening plant development due to increased temperature.[28,29]

Table 4.4: Simulated change in yields of beans, maize, sorghum, and wheat in both emission scenarios (RCP4.5 and RCP8.5) as time elapsed from the baseline to the future years of prediction.

Crop	Crop Variety	Simulated yields (t/ha) for 1971 –2000 period	Yield change under RCP4.5 scenario (%)			Yield change under RCP8.5 scenario (%)		
			2011 - 2040	2041 - 2070	2071 - 2100	2011 - 2040	2041 - 2070	2071 - 2100
Maize	DKC 7143	4.5	-8.1	-8.5	-3.6	-11.6	-8.9	-13.6
Sorghum	PANR 8862	4.3	6.2	10.5	8.9	5.4	8.8	5.8
Beans	PANR 149	3.6	3.9	3.4	-1.1	4.0	-0.9	-8.4
Wheat	PANR 3162	2.2	2.6	8.9	-20.4	-26.2	1.3	-50.4

4.8.2.3 *Adaptation options and strategies*

Addressing the challenges of climate change will ultimately require action to reduce emissions to prevent irreversible changes to climate (i.e., mitigation) and to limit the impact of projected climate change i.e., adaptation. Specifically, IPCC30,31 urges developing countries to prioritize climate change adaptation due to their high vulnerability. It is necessary to plan for and adapt to these changes. To do this, there is need to understand the dynamics of climate change e.g., the nature of change, the projected seasonal changes and the magnitude of projected change.

The projected climate change is expected to exert negative effects on crop production in Lesotho. The increase in temperature and decrease in precipitation is likely to reduce yields of maize, wheat, and dry beans to by about 13.6 %, 50.4%, and 8.4 % respectively by the end of the 21st century for the high GHG emission scenario. Lesotho should, therefore, initiate adaptive measures to offset the negative impacts of climate change on crop yields such as:

- **Shifting planting dates:** The need for farmers to change planting dates was also evident from the modelling exercise deployed. Planting is advised as soon as the cumulative rainfall exceeds 25 mm during a maximum period of seven days. This highlights the importance of institutional systems that can disseminate timely climate information, including planting dates, to smallholder farmers. The results also show that a combination of late planting and split fertilizer applications proved to be the most efficient adaptation option. Table 4.5 shows these results for the high emission scenario considered in this study (the worst-case scenario). The DSSAT model simulations predicted that climate change will shift planting dates towards delayed planting by around one week in the period 2011-2040, two weeks in the period 2041-2070, and three to four weeks in the period 2071-2100. The results show a reduction in the negative climate change impact on yields for maize, wheat, and beans and a positive impact on sorghum production in Lesotho. Yields for sorghum are projected to further increase by about 50% due to implementing the generated planting dates.

Table 4.5: The changes in the simulated yields of beans, maize, sorghum, and wheat in the high emission scenario (RCP8.5) as time elapsed from the baseline to the future years of prediction with FPDAT and DPDAT.

Crop	Yield change under RCP8.5 scenario (%)					
	2011 - 2040		2041 - 2070		2071 - 2100	
	FPDAT	DPDAT	FPDAT	DPDAT	FPDAT	DPDAT
Maize	-11.6	-5.1	-8.9	-6.4	-13.6	-2.0
Sorghum	5.4	49.2	8.8	54.9	5.8	52.7
Beans	4.0	31.8	-0.9	31.8	-8.4	18.1
Wheat	-26.2	-13.1	1.3	-4.8	-50.4	-22.6

- **Shifting to drought-tolerant crops and improved crop varieties:** The simulation results further show that yields of most crops are going to be negatively affected by rainfall variability. This signals a strong need to match crop types and varieties with climatic conditions being experienced or expected in the future. Alternatively, farmers should be encouraged to grow crops that are less climate-sensitive, such as sorghum, because of its drought-tolerance, sorghum is projected to be less affected by the slightly reduced rainfall, but more increased temperatures, leading to increased yields in most locations in Lesotho by 2100.

- **Irrigation and improved water availability strategies:** Maize is largely (about 80%) grown as a rain-fed crop in sub-Saharan Africa, Asia, and Latin America, and is particularly vulnerable to an array of abiotic and biotic stresses; consequently, yields are usually less than half of those under irrigated systems, which is the main focus of private sector investment.32 If the trend of increased rainfall variability and recurrent droughts found in this study continues in the near future as projected, Lesotho will experience more water shortages for agriculture, further threatening household food security. It is, therefore, recommended to establish irrigation facilities for communal farmers if they are to continue crop production. However, given the large costs involved in establishing irrigation facilities, the government is advised to organise small farming groups into larger farming communities and to aim for efficient irrigation or adopt other water availability options given in Table 4.6.

Table 4.6: Different adaptation options that can be applied for improved water availability for the agriculture sector and their costs

Adaptive strategy	Estimated costs of adaptation strategies
Large scale irrigation	US$6000/ha
Rehabilitation of irrigation schemes	US$3500/ha
Community gardens	$100/ha
Bucket drip irrigation	$3000/ha
Drum kit irrigation	$2200/ha
Treadle pump	$300/ha
In-field rainwater conservation technologies	$100/ha

- **Policy Direction:** The communities in Lesotho are extremely vulnerable to climate change and variability and are, therefore, urgently in need of assistance aimed at building resilience, and at undertaking climate change adaptation efforts to survive and to maintain their livelihoods. Adaptation projects should mobilize public and private stakeholders and, engage them in the problem-solving process. Scientists have an important role to play in such projects. Research geared towards the development of technologies that may equip farmers to adapt to climate change effects is recommended for the country.

4.8.3 Water resources

Water is one the most important natural resources of Lesotho and the water sector encompasses almost all aspects of life, the economy and the natural environment. The unique geographic location, high altitude and pristine natural quality of the mountain areas position Lesotho as the ('water tower') of southern Africa. The sustainability of water resources is threatened by the degradation of the catchment areas which is worsened by the climate change impacts. These threats will increase with the development of Phase 2 of the Lesotho Highlands Water Project (LHWP) and implementation of the Lesotho Lowlands Water Supply Scheme (LLWSS). A strong framework to guide the development and management of water resources in the face of increasing uncertainty is also central to long-term macroeconomic water security. In a country characterized by high levels of poverty, high unemployment rate and inequality, water contributes approximately 10 percent to the overall GDP and is central to long-term sustainable economic growth and development.

According to the INC[3] and the SNC,[4] the vulnerability of the water sector to future climate change is characterized by the erratic occurrence of precipitation about timing, frequency, and duration, extreme drought events in terms of frequency and magnitude, floods and increased temperatures. This vulnerability assessment is based on the simulated scenarios of temperature and precipitation that are recognized as key elements of climate change. Vulnerability is further exacerbated by uncoordinated efforts in the capacity of public and private sectors to develop and implement integrated water resources management policies, strategies, and programmes that link social and economic development with the protection of natural ecosystems and limited support to research and technological developments.

4.8.3.1 *Climate change impacts and vulnerabilities*

Lesotho is expected to experience increased frequency and intensity of droughts and heavy rains and increased temperature in all future periods (near term – 2011-2040, the midterm – 2041 -2070 and far future – 2071-2100). Results indicate that natural streamflow is expected to decrease spatially, seasonally, and annually towards the end of the century (see Table 4.7). The current vulnerability assessment of Lesotho's water resources to future climate change focused on natural streamflow using the WEAP model which uses projected temperatures and precipitation for the three future periods as described above.

Table 4.7: The results of trends analyse for balanced (median) scenarios RCP4.5 and RCP8.5.

Incremental catchments associated with River catchment	Projected annual flow rate change under RCP 4.5		
	Near future (2020-2040)	Mid future (2041-2070)	Far future (2071-2090)
Makhaleng River catchment • Makhaleng river @ Qaba MG 23 • D1H006 Makhaleng river @ Kornerspruit	Likely increasing annual rate of change of the flow regime in the river catchment - augmented natural streamflows.	The probable decreasing annual rate of change of the flow regime in the river catchment - reduced natural streamflows.	Continuing possible decreasing annual rate of change of the flow regime in the river catchment - reduced natural streamflows.
Mohokare (Caledon) river catchments • Mohokare (Caledon) river @ Maseru CG22 • Mohokare (Caledon) river Mohokare (Caledon) at Bolikela (CG70ds) downstream of CG22 also known as Caledon River at Wilgerdraai) in RSA • The incremental catchment of Mohokare River (LO) at Mafeteng district • The incremental catchment of Mohokare River (LO) at Mafeteng district	Likely increased annual rate of change of the flow regime in the river catchment - augmented natural streamflows.	The probable decreasing annual rate of change of the flow regime in the river catchment - reduced natural streamflows	Continuing possible decreasing annual rate of change of the flow regime in the river catchment - reduced natural streamflows.

Senqu river catchments: • Senqu river @ Mokhotlong SG4a • Senqu river @ Seaka Bridge SG3 • Senqu river @ Orangedraai (D1H009) includes Makhaleng and Senqu catchments located in the Republic of South Africa	The annual rate of change in the river flow regime is likely to increase – augmented natural streamflow.	The expected significant decreasing annual rate of change of flow regime – reduced natural streamflow.	The plausible increasing annual rate of change of the flow regime in the river - augmented natural streamflow.
River catchment with associated incremental catchment	Projected annual flow rate change under RCP 8.5		
	Near future (2020-2040)	Mid future (2041-2070)	Far future (2071-2090)
Makhaleng River catchment • Makhaleng river @ Qaba MG 23 • Makhaleng river @ Mo-hale's hoek also known as Kornerspruit in RSA - D1H006	Likely increasing annual rate of change of the flow regime in the river catchment - augmented natural streamflows.	The probable increasing annual rate of change of the flow regime in the river catchment - augmented natural streamflows.	The possible decreasing annual rate of change of the flow regime in the river catchment - reduced natural stream flows.
Mohokare (Caledon) river catchment • Mohokare (Caledon) river @ Maseru CG22 • Mohokare (Caledon) at Bolikela (CG70ds) down-stream of CG22 also known as Caledon River at Wilgerdraai) • The incremental catchment of Mohokare River (LO) at Mafeteng district	Likely slight decreased annual rate of change of the flow regime in the river catchment - reduced natural streamflows.	The possible increasing annual rate of change of the flow regime in the river catchment - augmented natural streamflows	The possible decreasing annual rate of change of the flow regime in the river catchment - reduced natural streamflows.
Senqu river @ Mokhotlong SG4a	The annual rate of change in the river flow regime is likely to increase – augmented natural streamflow.	Expected decreasing annual rate of change of flow regime – reduced natural streamflow.	The plausible decreasing annual rate of change of the flow regime in the river – reduced natural streamflow.

Senqu river catchment • Senqu river @ Seaka Bridge SG3 • Senqu river @ Orange-draai (D1H009) includes Makhaleng and Senqu catchments located in the Republic of South Africa	The annual rate of change of the river flow regime is likely to increase – augmented natural streamflow	The expected significant decreasing annual rate of change of flow regime – reduced natural streamflow	The plausible decreased annual rate of change of the flow regime in the river – reducing natural streamflow

Further typical graphical representations of analysed time series and trends of streamflow from three (3) major catchments for RCP4.5 and RCP8.5 are shown in Figure 4.27a and b, Figure 4.28a and b, and Figure 4.29a and b below respectively.

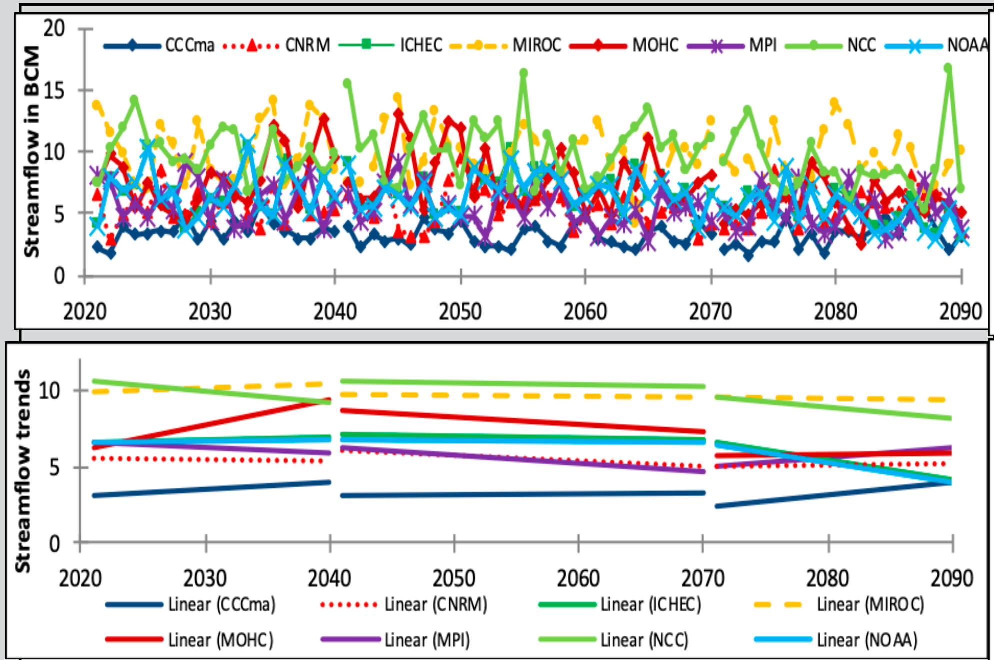


Figure 4.27: (a) Mohokare (Caledon) at Bolikela (CG70ds) downstream of CG22 for RCP4.5

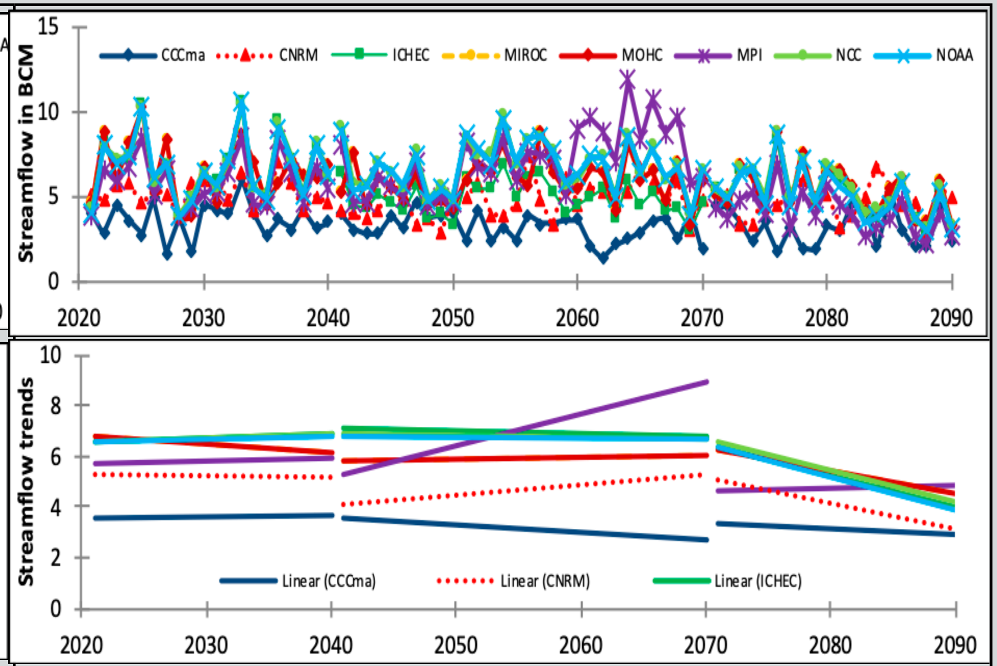


Figure 4.27: (b) Mohokare (Caledon) at Bolikela (CG70ds) downstream of CG22 for RCP8.5

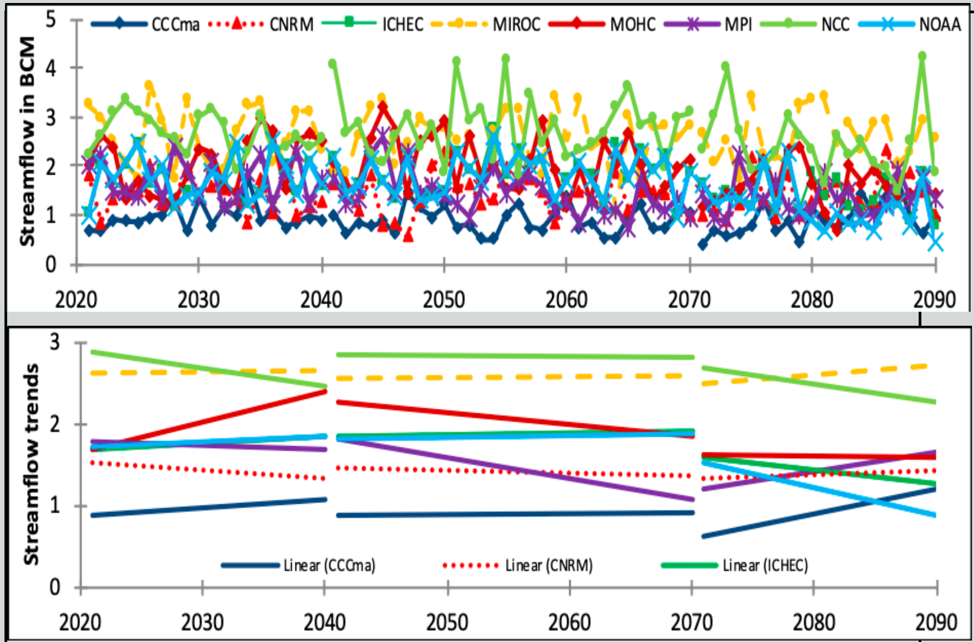


Figure 4.28: (a) Makhaleng River @ Mohale's hoek D1H006 for RCP4

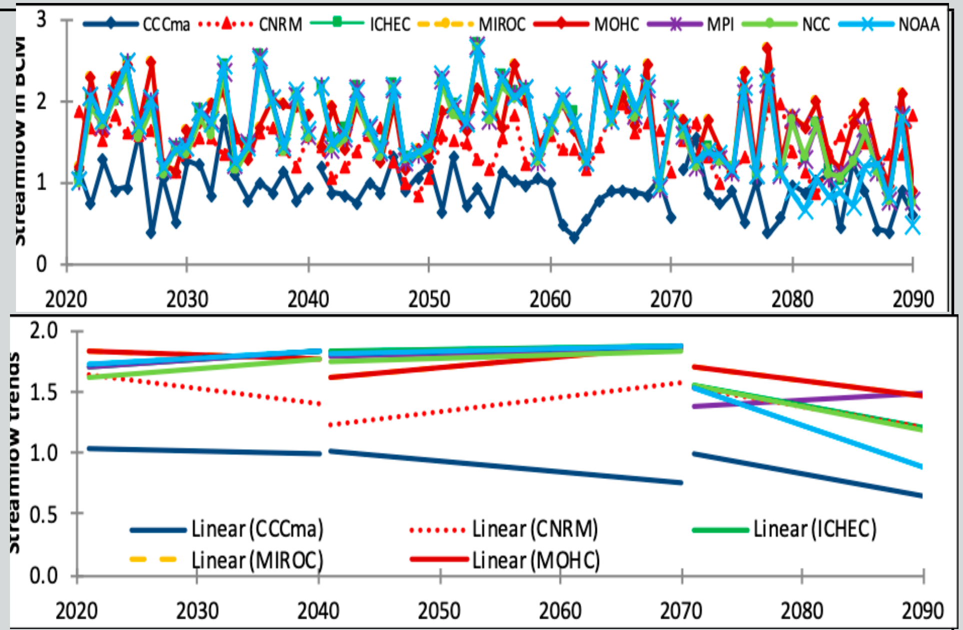


Figure 4.28: (b) Makhaleng River @ Mohale's hoek D1H006 for RCP8.5

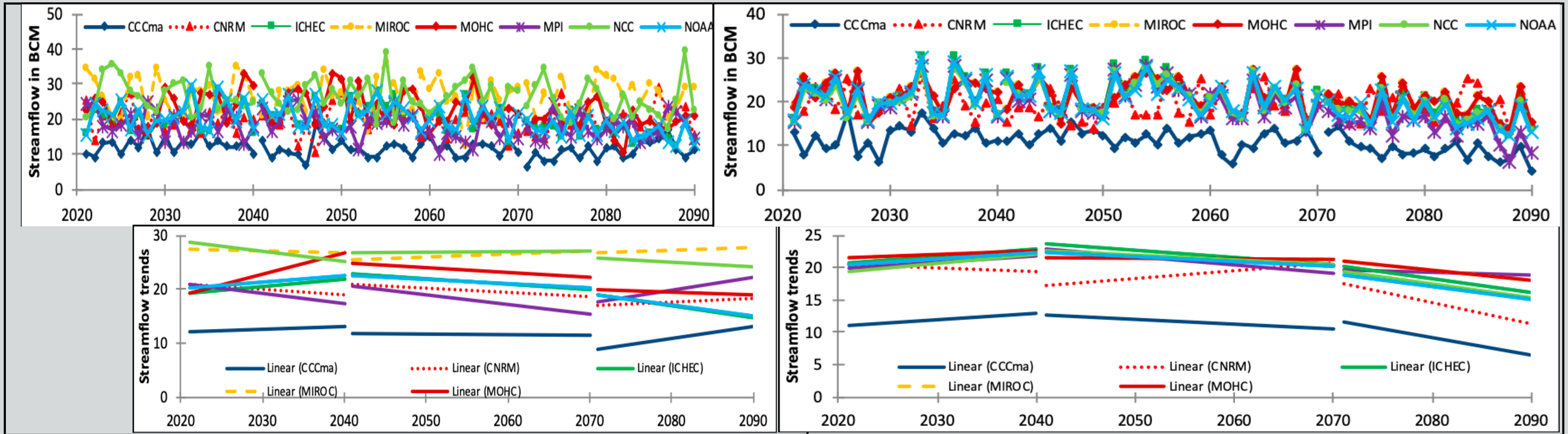


Figure 4.29: (a) Senqu River @ Seaka Bridge (SG3) for RCP4.5	Figure 4.29: (b) Senqu River @ Seaka Bridge (SG3) for RCP8.5

According to the Second National communication,[4] climate change scenarios indicate that Lesotho is likely to experience increasing temperatures, changes in precipitation patterns, decreasing summer precipitation, and increasing intensity and frequency of extreme weather events such as droughts and floods. Increased temperature projection discussed in Section 4.4,[18] lead to increased evapotranspiration that is considered as one of the hydrological losses. This loss impacts the water resources by changing the quantity and quality of water flowing in rivers and streams, wetlands, underground (aquifers), as well as water stored in dams and lakes changing moisture content in the soil.

The impacts of the projected decrease in water availability are the demands for water usage in activities such as irrigation, hydropower generation, urban, rural, domestic, industrial, environmental, recreational, fisheries activities; as well as maintenance of the ecosystems and habitats. This is exacerbated by the reduced reliability of water from various sources such as groundwater, surface water, and wetlands that have resulted in recurrent water shortages and dry flow regimes in the river networks. Reduced water availability has strong implications on emerging issues of disputes, competing and conflicting needs on the water by the communities as a basic economic good; as well as a competition over accelerated and improved allocation and distribution services of water to various communities in Lesotho. The deterioration of water quality is also impacted, leading to the pollution of water supplies and the degradation of natural ecosystems.

Projected extreme events lead to recurrent hydrological droughts and flash floods that also impact the reliability of sources and variable flow regimes of water resources usually resulting in flooding hazards e.g., the damage of infrastructure and loss of lives as illustrated in Figure 4.30.

Figure 4.30: (a) Truck drowned by flash floods in the Quthing district in 2018. Source: https://www.youtube.com; (b) Spherical pellets resulting from the hailstorm that occurred in the Quthing district. Source: Lesotho-hailstorm-claims-lives-destroys properties. https://www.africanews.com -2018/03/17/Lesotho-hailstorm-claims-lives-destroys properties.

4.8.3.2 *Adaptation options and strategies*

A key adaptation strategy is to optimize, develop, and implement integrated water resources development, equitable usage, and management plans for sustainable balanced socio-economic development activities to sustain livelihoods of Basotho without comprising the sustainability of vital natural ecosystems. Some of the adaption actions of the water sector that are currently being undertaken in Lesotho33 are highlighted in Table 4.8 below.

Table 4.8: Current adaptation actions of the water sector in Lesotho

Assessed Vulnerability	Impacts	Adaption actions
Increased temperatures and spatial, monthly and seasonal variability of rainfall/precipitation - Shortened rainfall season	Underground water not adequately recharged	Rainwater harvesting from roof-tops
	Water sources dry up	Proper management of land to enable re-vegetation and wetlands rehabilitation
Extreme temperatures and reduced precipitation – Droughts	The decline in water availability	Conserve water sources
	Stagnant water causes diseases	Water rationing
	Poor water quality	Encourage communities to protect natural springs
	The outbreak of water-borne diseases e.g., cholera	Wetlands Rehabilitation
An increase in extreme precipitation - Floods	The outbreak of water-borne diseases e.g., typhoid	Use domestic water purification systems

(Source: Climate Change Toolkit for Teachers[33])

Some of the adaptation actions that are based on the near (2020-2040) and mid-future (2041-2070) and far–future (2071-2090) vulnerability assessments and impacts on water resources are briefly described below. These include:

- Implementation of ICM and Long-term Water and Sanitation Strategies.
- Develop an over-arching adaptation strategy that can be used to analyse and manage risk associated with water resources and climate change.
- Accelerate implementation of the current activities in Lesotho on integrated water resources management; water demand and allocation; and integrated catchment management through multi-sectoral stakeholder participation and involvement approaches.
- Intensify the implementation (i.e., plan and design, construct, operate and maintain and manage) a cascade of multi-purpose reservoirs for increased water storage capacity, reliability of water at source,

treatability, supply and distribution services' levels as well as for flood control and management.

- Promote water recycling activities and to a large extend dredge some existing ponds and dams to collect and conserve water.
- Accelerate and expand the existing programmes on the rehabilitation of wetlands as key sources of water.
- Improve access to groundwater resources by identifying more boreholes where plausible within the country to warrant the assurance of water supply especially during periods of hydrological droughts.
- Quality water is to be monitored and supplied based on any existing water quality guidelines and standards for various water-using activities e.g., drinking, irrigation, effluent discharge, and natural aquatic ecosystems.

4.8.4 Livestock

Climate change and its effects are becoming more and more real as suggested by physical evidence of changes in rainfall patterns and temperatures. It is therefore imperative to understand the vulnerability and challenges that the livestock sector faces to the changing climate and identify adaptations options for future vulnerabilities. Proper understanding of challenges and vulnerability requires extensive research and engagement with communities to deduce the vulnerability and impacts of changing climate on livestock.

Livestock is a key economic sector within agriculture that has implications on employment, domestic consumption, trade, and culture. There have been fluctuations in the total number of livestock in Lesotho; there have been increases and declines from year to year. The contributing factors include, but not limited to deaths, theft, and offtake rates.[34] Climate change is another contributing factor in recent years causing declines in livestock (See Text Box 4.2). It is predicted that climate change will only have a mild impact on livestock production in the developed world35 because most livestock is kept in a protected environment and have supplementary feeding. The situation is different in developing countries like Lesotho where the impacts will be higher as animals are more exposed to the elements of weather due to their dependence on pasture and other natural forage for nutrition. Also, in developing countries, animals are more exposed due to lack of resources, veterinarians, extension services, and technology development.

Text Box 4.2: Lesotho's vulnerability to drought: 2015-2016 agricultural drought
In 2015/16, Lesotho experienced the worst drought in 35 years due to the El Niño phenomenon Livestock and crops were affected causing a massive decrease in food production because of poor rainfall and drought-related disease outbreaks. The Rapid Drought Impact Assessment Report conducted following the El-Niño phenomenon showed a 25% decrease in herd sizes for cattle, while for sheep and goats, the decrease was 9% between 2010 and 2015. The report indicated that over 20% of communities in Quthing, Mohale's Hoek, and Botha-Bothe reported drought-related deaths while other districts reported 5% - 15%. This exacerbated vulnerability amongst the poor and rural communities who tended to have lower coping capacities. This situation continued into 2017, with an estimated 465, 000 people still in need of food assistance. During the peak drought, other sectors were also affected such as education - schools, health - hospitals, and health centres.

4.8.4.1 *Climate change impacts and vulnerabilities*

It is always very important to understand livestock species and their requirements and behaviour as well as their production systems in Lesotho so that the impacts of climate change and vulnerability of the sector could be assessed accurately. In Lesotho, animals are individually owned but communally grazed. The grazing management systems/places for livestock especially sheep, goats, cattle, donkeys, and horses are divided into three categories depending on the seasons of the year.

These categories are:

- A- grazing in highlands
- B- grazing in foothills
- C- grazing near the homestead

During winter, animals are grazed in C, near the homestead, for ease of management during times of snow and/or cold conditions. In summer animals are grazed in A, cattle posts in the highlands because it is much warmer during summer months. During autumn, animals are moved from A to graze in B because it is much warmer compared to A during this period. For the villages in the mountains agro-ecological zone Level C is at homestead, level B is within 20 km from the villages while level A is more than 20 km from the villages. Dairy cattle, pigs, and chicken are kept under either intensive or semi-intensive systems in Lesotho. Therefore, understanding climate change and its impact on the livestock sector is very important especially with different production management systems and variable climatic conditions in Lesotho's agro-ecological zones. The temperature and precipitation variability affects livestock robustness, selection, and survival.

In 2010/11, Lesotho experienced heavy rains that lead to the destruction of roads and property and loss of lives and animals. According to the Post Disaster Needs Assessment Report, several diseases reported to have increased and affected the livestock sector as a result of the rains were foot rot, black quarter, anaplasmosis, lumpy skin disease and bluetongue. Moreover, the heavy rains partially coincided with the sheep shearing season which made the sheared sheep more susceptible to death due to exposure to temperature drops during the prolonged wet spell. Also, some livestock were reported to have drowned while crossing flooded rivers. Over 44,000 livestock died and another 25,000 were reported to have been sick at the time of the assessment. The reported higher incidences of diseases have also resulted in households spending more on veterinary drugs than they would normally do.

The assessment further indicated that there was a decline in income for livestock farmers due to delays in shearing of wool and mohair, the loss of animals due to drowning, and the loss of animal products. On the other hand, wool quality reportedly declined as a result of it being muddy and that resulted in lower prices.

As highlighted in Text Box 4.2, Lesotho experienced the worst drought to have hit the country in the last 35 years as a result of the 2015/2016 El-Niño phenomenon in Southern Africa, which resulted in poor rainfall seasons, decline in recharge of aquifers and springs, and loss of livestock. The recurring droughts and drought-related disease outbreaks resulted in the decline of livestock herd sizes. Further, as significant number of communities in Quthing, Mohale's Hoek, and Botha-Bothe reported drought-related deaths.

According to farmers interviewed in 2018, diseases and pathogens/parasites that were not seen in the past are now seen in many parts of the country especially in years of heavy rains and severe drought to mention but a few. This is in agreement with the reports cited above. For example, farmers reported that some species of external (ticks) and internal parasites (gastro-internal nematodes) on cattle, sheep, and goats which were not prevalent in the past are seen currently with little knowledge of their prevention and control. Farmers also claim that the outbreaks of diseases like anthrax increased as a result of the changing climate in Lesotho, resulting in loss of production and deaths, thereby negatively affecting the economy.

Recently, the country has seen increased episodes of snowfall even in summer months, which is unusual especially for the lowlands. Farmers have reported that extreme snow and frost that happened in November 2018 resulted in deaths of livestock especially sheep and goats. The numbers fluctuated from 2000 to 7000 between districts. The high deaths were reported in Qacha Nek, Mokhotlong, Thaba Tseka, and Maseru. The snow coincided with the sheep shearing season which made the sheared sheep susceptible to death by exposure due to very low temperatures. Animal feeds prices, for intensively reared animals like dairy, poultry and piggery increased due to adverse impacts of climate change on crop production.

According to the recent climate change scenarios report by the Lesotho Meteorological Services,18 the country is likely to experience an increase in temperatures, changes in rainfall patterns, increase in the rate of evaporation and increased intensity and frequency of extreme weather events in the near-future (2011-2040), mid-future (2041-2070) and far-future (2071-2100) time periods. Table 4.9 below presents different livestock species and associated impacts under various climatic conditions.

Table 4.9: Impacts of climate change events on livestock species reared in Lesotho.

	Increased temperature	Low temperatures/ snow	Drought	Heavy rains
Sheep and goats	• Heat stress • Delayed onset of the breeding season • Reduced reproduction and libido • Temporary/permanent infertility • Low mobility • Low food intake resulting in reduced growth • Decreased wool and mohair quantity and quality • Mortality in severe cases	• Cold stress • Mortality especially lambs and kids	• Reduced water points resulting in thirst stress • Reduced quality and quantity of products • Increased mortality • Reduced quality and quantity of feed-stuff-affecting nutrition.	• Increased incidences of diseases • Diseases outbreaks • Introduction of new diseases/water-borne diseases and patho-gens
Dairy	• Heat stress • Reduced production of milk • Low fertility/reproduction • Low food intake	• Cold stress • Decreased milk production • Increase feed intake resulting in the high cost of feeding		
Other cattle breeds	• Reduced production • Reduced mobility	• High food intake		
Poultry	• Reduced egg production • Low mobility • Low feed intake • High incidences of diseases	• High Mortality	• Reduced quality and quantity of raw materi-al for ration formulation resulting in reduced quality and quality of meat and number of eggs produced per chicken per clutch • Mortality in severe cases	
Piggery	• Heat stress • Reduced reproduction and/fertility	• Increased mortality especially in piglets	• Reduced quality and quality of raw material resulting in reduced quality and quality of meat	
Fisheries	• Reduced production • Reduced productivity • Reduced number of fish in dams		• Low levels of water resulting in waterborne diseased	

4.8.4.2 *Adaptation options and strategies*

The livestock sector also plays an important role in Lesotho's economy through wool and mohair production. Climate change adaptation interventions and measures should be developed to improve the resilience of both crops and livestock productivity to climate change, which intern will contribute to food security and poverty alleviation. Below are ways to increase the adaptive capacity of the livestock sector. Such adaptation ways should be geared at reducing animal's vulnerability to heat stress, disease, and pests, drought, and starvation (Table 4.10).

Table 4.10: Adaptation Options for the Livestock sector in Lesotho

Adaptation Strategy	Explanation
Livestock characterization	Phenotypic and molecular genetic characterization of animal genetic resource (AnGR) is used to measure and describe genetic diversity in these resources as a basis for understanding them and utilizing them sustainably. Information on morphological characteristics is a prerequisite to sustainable breed improvement and utilization (FAO, 2012).
Livestock Breeding	Breeding for robustness includes but not limited to i) identification and strengthening of indigenous breeds which are adapted to Lesotho's environment, ii) improvement of genetics through cross-breeding; not only with high producing breeds but with those that are tolerant to diseases and heat, as well as iii) development of new breeds specifically for local conditions.
Conservation of genetic resources	Conservation of genetic resources in livestock production (maintaining local breeds) is also essential for selection during a time of need. The current Livestock policy which is under development processes should explore the inclusion of other breeds of importance in Lesotho to improve the gene pool available for breeding and development.

Improved breeding strategies	Technologies such as synchronization and artificial insemination especially for dairy, piggery, sheep and goats are already available and practiced in Lesotho. These need to be up-scaled so that a bigger pool of farmers can benefit from it thereby increasing overall production and productivity of livestock.
Modification of production management (periodic migration of animals during hot drought seasons)	Diversification of crops and animals, integration of livestock systems with crop production, and changing the timing and location of farm operations from time to time. Diversification of livestock and crop varieties can increase drought and heatwave tolerance and may increase livestock production when animals are exposed to temperature and precipitation stresses. Besides, this diversification of crops and livestock is effective in fighting against climate change-related diseases and pest outbreaks.
Mixed crop-livestock system	Changes in the mixed crop-livestock system (Machobane system with livestock) are adaptation measures that could improve food security. Thus, changes in mixed crop-livestock are already practiced in Lesotho and can improve efficiency by producing more food on less land using fewer resources like water.
Improving feeding practices	Improving feeding practices like modification of diets composition, changing feeding time and frequency, and training producers in production and conservation of feed for different agro-ecological zones could directly improve the efficiency of livestock production.

Reduction in time spent by livestock in one location	The time spends by livestock in one location also needs to be changed as one of the adaptation strategies. This may aid in breaking the pathogens and disease cycle that are climate-related. Also, this shifting of the location of livestock could reduce overgrazing that will ultimately reduce soil erosion and improve moisture content for further production of range grasses.
Constant research, education, and sensitization of farmers	Research geared on climate change specifically for Lesotho needs to be done to inform decisions on adaptation and mitigation of climate change. Capacity building can be meaningful if directed to livestock owners and herders. Jones et al.[36] also emphasized the need to learn the farmer's perception and adaptive capacity to recognize the problem and adapt to it. Therefore, the collection of information about farmer's perceptions from time to time is imperative.
Construction of water points in rangelands/ water harvesting	There is a need to construct water points in rangelands to provide water for animals during the time of need and also to protect wetlands in Lesotho
Provision of shelter	Animal welfare issues indicated that animals should be provided with shelter and water ad-lib. Therefore, farmers need to construct water harvesting techniques that are simple and cost-effective to them as well as providing inexpensive shelter either through planting trees or using locally available material.
Livestock insurance	Livestock insurance could be another adaptation strategy. National banks and insurance brokers seemed to have a buy-in in the idea of insuring livestock in Lesotho. This coupled with subsidies; income diversification on farmer's side and establishment of the early warning system; and other forecasting and the crisis-preparedness system could be beneficial.
Selling animals before dry period	It could be beneficial for farmers to reduce the number of animals before dry periods for easy feeding management.

Livestock policy and legislation	It is imperative to periodically review and update livestock policies, plans, and strategies to mainstream climate change issues. The livestock policy that is currently being developed by The Ministry of Agriculture and Food Security through livestock division is an entry point.

4.8.5 Biodiversity and Environment

Lesotho like many African countries has abundant and diverse biodiversity and rich diversified ecosystems.[12] Biodiversity and ecosystems provide benefits to humans and these benefits are structured differently by many global assessments.[37] However, there is already overwhelming evidence that changes in land and sea use, direct exploitation of organisms, climate change, pollution, and invasive alien species have impacts on biodiversity and ecosystems' ability to support human well-being.[38] Due to the existing and predicted effects of climate change on biodiversity, there is an urgent need to develop and implement approaches in both mitigation and adaptation to reduce greenhouse gas emissions and adaptation to climate change.[39,40]

4.8.5.1 *Climate change impacts and vulnerabilities*

The climate change scenarios indicate that climate has been changing over the last three decades[41] and this may explain some of the significant declines in many groups and group sizes of species of carnivores, antelopes, hare/rock rabbits and small mammals,[42,43] although this may also be attributed to a loss in habitats. Other declines have been reported in the number of Gypaetus barbatus (bearded vulture) breeding pairs. The Aloe polyphyla (Spiral aloe) conservation project has also recorded a significant decline in the number of mature plants. The Papio ursinus (Chacma Baboon), once considered abundant, is now facing a significant decline, with only small populations scattered in few areas. Although these sivcvvvvvgnificant declines are attributed to climate change, in some instances it is a compounded effect of other environmental changes such as invasive alien species and/or habitat loss due to land-use changes. The classic example is that of the Pseudobarbus qauthlambae (Maloti minnow) which has been declining due to many threats; including the introduction of invasive alien trout species – *Oncorhynchus mykiss* (Rainbow trout) and Salmo trutta (the brown trout) that were introduced before the construction of the Katse dam.[42,43]. Habitat loss is attributable to dam construction and possibly climate change.

Species and ecosystems change as a result of habitat range shift is prevalent and may also explain some of the declines in species populations and ecosystem changes observed in these zones. There have been reports on degradation or even loss of wetlands functions and species associated with them due to changes in climate change. These include at least five wetlands that were lost between 1995 and 2013 in the Mohale Dam Catchment and an unknown number in the Katse Dam Catchment between 1999 and 2013.[43] Rangelands and their grazing potential have been lost over the last three decades and this is attributed to compounded effects of climate change, poor range management practices, habitat loss, and invasion by alien species (Table 4.11).

Table 4.11: Climate change impacts on biodiversity

Stressor(s)	Impact	References
Change in maximum temperature; Change in precipitation; Length of the dry season; Levels of evaporation	Some generalist species, with a wide range of habitats and high adaptive capability or phenotypic plasticities such as birds and insects, have less sensitivity to climate change impacts, making them less vulnerable.	Hoegh-Guldberg et al.[2]
	New opportunities for invasive alien species	Lovejoy and Hannah[44]
	Poor dispersal capability	Foden et al.[45]
	Significant declines in many groups and group sizes of species of carnivores, antelopes, hare/rock rabbits, and small mammals. For example, declines in the number of Gypaetus barbatus (bearded vulture) breeding pairs have been reported in Lesotho.	Turpie et al.[42,43]

4.8.5.2 *Adaptation options and strategies*

Biodiversity and ecosystems offer a huge potential for CCA and mitigation through ecosystem-based adaptation. However, this assessment could not find any records of this great opportunity except the study cited in Box 4.3. It is either there are no efforts on this, or the information is not accessible. It is important to lobby relevant government departments to promote this technique towards an effective response to the effects of climate change while addressing biodiversity conservation in the country.

Box 4.3: Creation of artificial wetlands

In Lesotho, wetlands are an integral part of the rangelands which provide a critical refuge and breeding ground for many species. Larger parts of the rangelands are found in the mountainous regions. Overgrazing of the rangelands has led to a decrease in the diversity of species. Construction of the wetland is one of the have proved successful towards the restoration of wetlands on account of Land use change.

Pictures below provide evidence of the first artificial wetland restoration, in the afro-alpine diamond mine in Lesotho. Before the year 2013, the wetland degraded, however, showed satisfactory signs of recovery of the endemic biodiversity in less than 6 years. The wetland itself provides suitable habitat for the breeding of Stronglyopus grayii, which were abundant in January 2020, and the outlet stream is suitable for Amietia vertebralis, of which two adults were recorded. The presence of this sensitive species is considered to be indicative of the successful remediation of the runoff from the mining rock dump associated with the stream leaving the mine premises.

The wetlands of the mountain grasslands are important because of the many critical functions that they perform. Their functions include supporting high levels of genetic and biological diversity. Traditionally in Lesotho, rangelands are considered a source of grazing, a source of materials for constructing homesteads and for livelihood support. The grasslands are also important for cultural and traditional use, such as providing veld food, medicines, and potions and to a lesser extent for the manufacture of crafts.

2013: Construction of the wetland

2020: Vegetation is at full growth performance and the finding of a good water quality amphibian, Amietia vertabralis (Maloti river frog). Image courtesy of Lets'eng diamond Mines.

Biodiversity and ecosystems are under threat from several environmental changes (e.g., invasive alien species, pollution, habitat loss from land-use change, etc) in addition to climate change. This lethal cocktail of environmental changes will further exacerbate the effects of climate change on the already declining biodiversity. It is important to intensify investments towards quantifying the effects of climate change and other environmental changes (on genetic, species, and ecosystems) across the agro-ecological zones. A coordinated monitoring programme is needed to better understand and quantify biodiversity and ecosystems towards a response to climate change.

This should be preceded by the development of indicators to measure progress on implementation. It is important to build and maintain existing strategic partnerships with other countries and organisations to build adequate management and research capacity and source funds for the implementation of response measures in different sectors including biodiversity. There is a need to host a regular climate change colloquium at least on an annual basis to discuss strategies and efforts across government and other affected organisations on climate change. This colloquium will also facilitate data and information exchanges amongst sectors (e.g., agriculture, health, biodiversity, environment, etc.), coordination, and collaboration across all affected sectors.

4.8.6 Forestry

The wide range of altitude and associated agro-ecological zones in Lesotho present varied landscapes and vegetation types from indigenous and planted forests to desert shrubs in the lowlands. It is a challenge to get a reliable estimate on forest change in Lesotho, due to limited data sources, therefore, there is a need to conduct national forest inventory. Currently, the total land area under tree cover is about 34,520 ha which is 1.1% of total land area (FRA, 2020). Changes in forest area and other wooded land are very small and this is due to lack of data to assess the magnitude of change hence it has been assumed that, there is no change since from 1990 to 2018.

The rate of forest loss in Lesotho (just like in other SADC countries) can be attributed to a combination of many factors local, national, and international levels (e.g., conservation policies, reigning economic and ecological conditions).[47] The ecological conditions include natural and anthropogenic drivers and pressures such as browsing, agricultural expansion, changing forest land into settlement, illegal logging, uncontrolled fires, low survival rate, increased reliance of rural households on biomass fuels– all are detrimental to growth and regenerative power of different forest species. In Lesotho, over 92% of the rural population to a large extent depends on forest resources for domestic consumption (e.g., fuelwood, as well as windbreaks, shelter belts, construction material, browse for animals and medicines.[48] Fuelwood derived from forests is one of the major sources of energy in Lesotho, especially among 64% rural communities.[49]

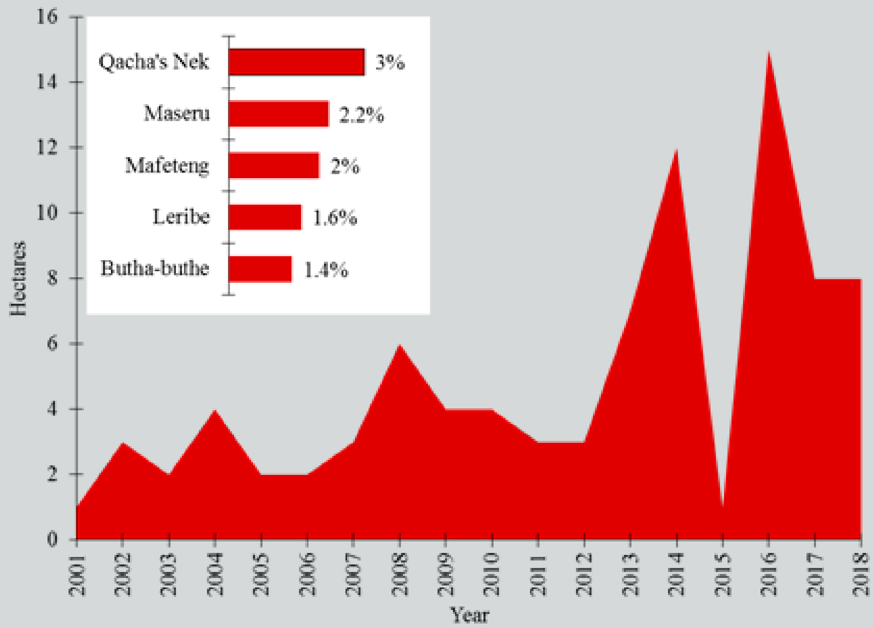


Figure 4.31: The tree cover loss in Lesotho between 2001 and 2018. The inset shows the 5 regions responsible for 74% of all tree loss cover. The estimates do not take tree cover gain into account. 46

4.8.6.1 *Climate change impacts and Vulnerabilities*

The forestry sector is considered to be one of the most critical economic sectors that is vulnerable to the impacts of climate change in Lesotho. Forestry is impacted directly by changes in precipitation, temperature, and evaporation and through secondary impacts and other social stresses. The most significant climate change impacts and vulnerabilities are summarized in Table 4.12 below.

Table 4.12: Potential climate change impacts on forest goods and services

Forest goods and services	Potential future consequences
Tree species suitability	The annual temperature increase is likely to have a positive effect on forest production in highlands areas (i.e., less water-limited areas) in the short to mid-term (up to 2050), but by the end of the century, elevated temperatures are likely to drive highlands forests to turn into a source of carbon. In water-limited regions (lowlands) temperature increases are likely to decrease carbon sequestration and forest productivity. Above temperature increases of about 1°C (without precipitation changes) can have significant impacts, making low-elevated sites unsuitable for indigenous forest species such as Leucosidea sericea as a forest species (e.g., Lasch et al.[50]) which may lead to its replacement by drought-tolerant alien forest species such as Acacia mearnsii and Eucalyptus spp.[51]
Pest and pathogens	Prolonged warmer vegetation periods associated with reduced precipitation are likely to strongly impact population dynamics (development, mortality rates), range expansion, and range shifts of various herbivorous insects. As a consequence, the occurrence of forest defoliators' mass outbreaks such as Hypopholis sommerii in neighbouring countries such as South Africa[52] will increase. Eucalyptus spp., being the well-known host plant of this defoliator is abundant in forest plantations found in Lesotho. Typical components of microscopic organisms colonizing forest species in Lesotho such as Diplodia pinea on Pinus spp. may evolve and grow rapidly on water-stressed host trees, causing sudden forest dieback.
The production of non-wood forest products[3]	Climate change may alter the production of non-wood products that are particularly important in Lesotho. There is a strong link between wild crop growth relative to their development and rainfall patterns. For example, a drop in precipitation with expanded dry seasons has been shown to decrease the productivity of wild mushrooms.[53]

3 Non-food products also known as non-timber products (NTFPs) are useful substances, materials and/or commodities obtained from forests which do not require harvesting (logging) trees. They include game animals, fur-bearers, nuts, seeds, berries, mushrooms, oils, sap, foliage, pollarding, medicinal plants, peat, mast, fuelwood, fish, spices, and forage.

Biodiversity	Biodiversity protection is an important part of sustainable forest management in Lesotho.[54] Different groups of species may react to changing climatic conditions differently. Rising temperatures are likely to result in shifts in plants, microbial and animal species phenology, response to herbivory, establishment, and competition (increased fungi, for example, since fungi are more resistant to drought than bacteria).[55]
Forest fire risks	From near-future data (2011-2040), there is good evidence that the main climate factors contributing to the dry season are now changing, as there has been a decrease in summer precipitation and increment in temperature.[18] Wildfire hazard is likely to increase under projected lengthy dry spells and hot spells. Frequent fires will in turn increment soil disintegration due to improved hydrophobicity (e.g., Certini[56]), reduce plant regeneration (e.g., Delitti et al.[57]) and affect soil physical and chemical characteristics. The increased risk of fire will further reduce the production of wood and reduce the value of wood in burned areas.
Water provisioning	Drinking water supply is a critical mountain forest ecosystem function. Intensified large-scale disturbances such as forest fires, the wind throws, and outbreaks of pests can lead to changes in the quality of drainage, percolation, and water (i.e., increased erosion and load suspension).

4.8.6.2 *Adaptation options and strategies*

Given the potential impacts of climate change on forest resources, the forestry sector urgently has to develop and enforce adaptation measures, strategies, and infrastructure that protects its various components (commercial, emerging, rainfed, irrigated, etc.) in the immediate future. Forests will need to adapt to changes in climate variables as well as increased occurrences of extreme weather events, such as prolonged dry spells and flooding. Examples of climate change adaption measures (based on resistance, resilience, and response concepts) that are locally appropriate in the forest sector are outlined below (Table 4.13).

Table 4.13: Adaptation Options and Strategies for the forestry sector in Lesotho

Option / Strategy	Explanation	Reference(s)
-Gene management	Species suitability is likely to change under projected climatic changes due to the high probability of wildfires occurrences, drought, outbreaks of pests and pathogens. Such knowledge on species vulnerability to climate change can be used with current climate projections to support adaptation towards: (a) planting tree species hybrids that are pest-, heat- or drought-resistant or cold tolerant, and (b) mixing species as an assurance against some of the impacts of climate change.	Spittlehouse and Stewart[58]
Forest protection	There is a high likelihood occurrence of frequent drier, warmer spring, and summer conditions in many parts of Lesotho in the near- and far- future and this would increment the likelihood of wildfire outbreak. This is consistent with some proof that there is already a rise of wildfires in Lesotho.[46] It is, therefore, crucial for forest managers to consider redesigning forest areas with different drought-tolerant species, manage forest fires and pests to reduce disturbance; restore degraded forests; protect trees against disease.	Gottschalk;[59] Parker et al.[60]
Forest regeneration	Artificial regeneration of drought-tolerant genotypes; manage invasive species; use matching site with species; use water harvesting methods during the establishment process to alleviate water pressure. Forest regeneration could stimulate livelihood activities such as beekeeping, production of treated and non- treated poles and the cultivation of native mushrooms.	Farnum;[61] Makundi[62]
Silvicultural management	Forests located on remote areas often implies that the control measure for many pests and pathogens are limited. Some changes in silvicultural practices (e.g., selective removal of poorly adapted trees, adjustment of species composition and forest structure; regulatory restrictions on infected planting stock).	Papadopol;[63] Dale et al.[64]

Non-wood Forest Products	Forests provide multiple benefits of non- wood products such as beekeeping, thatched grass, medicinal plants, animal feeds and enhancement of biodiversity. Minimise habitat fragmentation and maintain primary forests and the diversity of functional groups	Holling;[65] Noss[66]
Establishment and management of reserves	Conserve biodiversity; maintain connectivity between protected areas; employ adaptive management measures.	Suffling and Scott;[67] Henderson et al.;[68] Carey[69]
Community and ecosystem-based natural resource management	Supporting the improvement of livelihood and income-generating activities that back or depend on forest conservation and maintenance and enhancing agricultural practices ' sustainability and efficiency.	
Forest operation	Introducing measures to reduce rural and urban demand for fuelwood through promotion of farmers managed natural regeneration, selective harvesting and pruning.	Spittlehouse and Stewart[58]
Mainstreaming of stewardship programmes	Strengthening and improving local forest management and governance.	
Ecosystem interconnectedness	Strengthening the natural ability of ecosystems to resist or recuperate from pressures, or to adjust to new environments conditions.	

Forest adaptation strategies ought to be coordinated and integrated into other sectors and national programs and strategies for development. Adaptation to climate change can also be seen as an expansion of good development strategy, such as encouraging growth and economic diversification to increase demand, jobs, and farmers' incomes and setting up environmental services markets.[70]

4.8.7 Health

The links between biophysical factors in a form of climate change and human health consist of an intricate mix of elements which include gains and hazards. Adverse impacts of climate change can be seen in resources for human health, such as shelter, clean water, air quality, and food security and quality. Lesotho, like most of the least developed countries (LDCs), has among its key health priority a fight against communicable diseases, eradication of vector-borne-diseases, and improvement of nutrition and food security.[71] The level of health resilience is dependent on several socio-economic and biophysical factors. In the case of Lesotho, the socio-economic factors include (1) income levels, (2) housing standards, and (3) forms of labour. While on biophysical factors entail weather and climate conditions.

In Lesotho, quantitative linkages between human health and the climate hazards are yet to be developed therefore a justifiable approach to human health impacts and vulnerability assessment for climate change should emphasize the fact that study and monitoring of human disease concerning climate and environmental factors is still evolving, and should acknowledge a range of possible outcomes.[71]

Studies suggest that some of the impacts of climate change on human health are already being experienced in countries like Lesotho.[72,73] Heat waves, which are a general feature of the climate of Southern Africa under drought conditions[72] are an example of some of the physical hazards which are beginning to frequent the country. In 2015 and 2016, the country experienced record-breaking maximum temperature extremes associated with heat waves which accompanied a prolonged drought condition.[74] This necessitated the country to issue a warning to safeguard against human health. This confirms that the country is already experiencing some of the adverse effects of climate change, which are generally known to lead to human discomfort. The impacts associated with extreme climate events such as temperature discomfort leading to heat strokes are likely to add more pressure on Lesotho health system which is already burdened by communicable diseases. A summary of diseases that are recently the top course of death in Lesotho (see Figure 4.32).

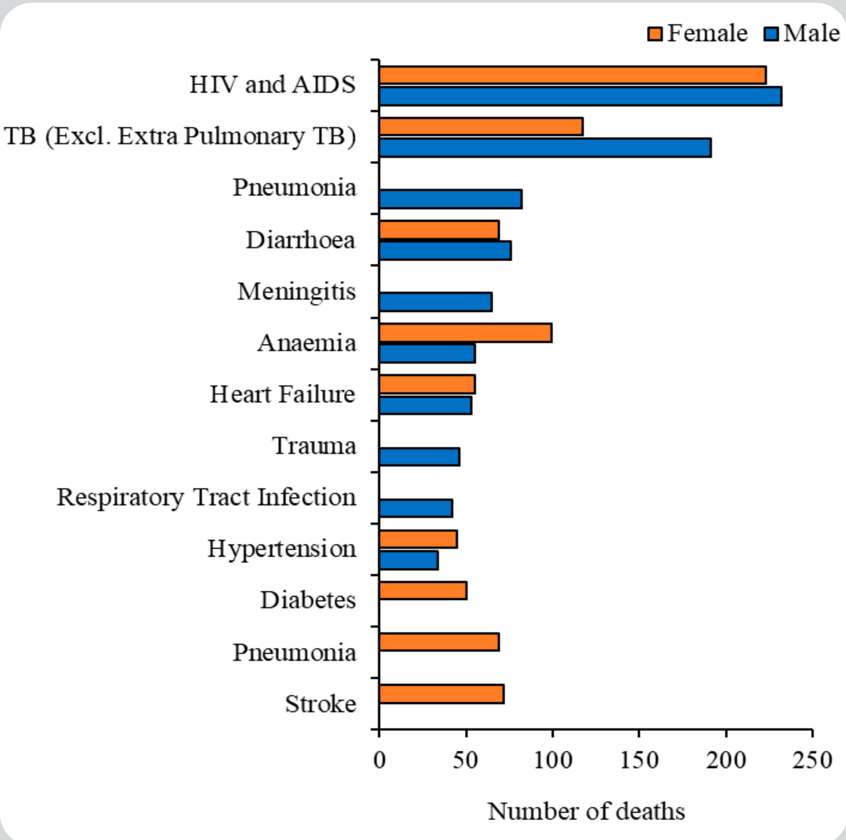


Figure 4.32: Top 10 Causes of death in adult males and females in Lesotho - 201571

Lesotho will achieve its public health surveillance objectives through the ongoing implementation of the Integrated Disease Surveillance and Response (IDSR) strategy. Public Health Surveillance is the ongoing systematic identification, collection, collation, analysis and interpretation of disease occurrence and public health event data, for the purposes of taking timely and robust action, such as disseminating the resulting information to the relevant people, for effective and appropriate action.

Surveillance is essential for planning, implementation, monitoring and evaluation of public health practice.

Table 4.14: Priority diseases, conditions and events for Integrated Disease Surveillance and Response - 2018[4]

<table>
<tr><th>Epidemic-prone diseases, conditions or events which require immediate reporting</th><th>Diseases targeted for eradication or elimination</th><th>Other major diseases, events or conditions of public health importance</th></tr>
<tr><td rowspan="3">1. Acute haemorrhagic fever syndrome*
2. Anthrax
3. Cholera
4. Diarrhoea with blood
5. (Shigellosis)
6. Listeriosis
7. Plague
8. SARIs**
9. Typhoid fever
10. COVID-19
11. Meningococcal meningitis

Also:
A cluster of deaths in the community (animal or human deaths)

A cluster of unwell people or animals with similar symptoms

* Ebola, Marburg, Rift Valley, Lassa, Crimean Congo, West Nile Fever, Dengue

** Influenza-like illnesses (pneumonia, and other ARIs)</td><td>1. Leprosy
2. Measles
3. Neonatal tetanus
4. Noma
5. Poliomyelitis***
6. Rabies

*** Disease specified by IHR (2005) for immediate notification</td><td>1. Acute and chronic viral hepatitis
2. Adverse events following immunization (AEFI)
3. Diabetes mellitus (new cases)
4. Diarrhoea with dehydration less than 5 years of age
5. Epileps
6. HIV/AIDS (new cases)
7. Hypertension (new cases)
8. Injuries (road traffic accidents)
9. Malaria
10. Malnutrition in children under 5 years of age
11. Maternal deaths
12. Non-neonatal tetanus
13. Perinatal deaths
14. Severe pneumonia less than 5 years of age
15. STIs
16. Soil transmitted helminths
17. Trachoma
18. Tuberculosis (new cases)
19. MDR/XDR Tuberculosis
20. Cancers
21. Bacterial Meningitis
22. Substance abuse
23. Obesity
24. AMR
25. Assault</td></tr>
<tr><td colspan="2">Diseases or events of international concern</td></tr>
<tr><td colspan="2">Human influenza due to a new subtype***
SARS***
Smallpox***
Zika virus disease
Yellow fever
Any public health event of international or national concern (infectious, zoonotic, food borne, chemical, radio nuclear, or due to unknown condition.

*** Disease specified by IHR (2005) for immediate notification</td></tr>
</table>

4.8.7.1 *Climate change impacts and vulnerabilities*

In Lesotho, some of the climate health hazards could be traced to dominating forms of labour practices. In the highlands, for example, the population is forced to practice primitive forms of farming due to poor road infrastructure or sloppy crop farming terrain that is mostly hard to negotiate through mechanised farming equipment. Natural hazards such as heavy snowfall, which often encroach into the farming season, as well as hail storms, come at such intensity that they lead to disruption of services and destruction of road networks, sometimes inflicting physical harm to an exposed population. This leads to a shortage of food and life-supporting supplies, such as medicines, and hence a challenge to disease control food and nutrition insecurity (refer to Appendix 4C).

The early onset of frost poses a major risk on cereal production thereby contributing to food and nutrition insecurity. The risk concerns a fraction of the population that relies on subsistence farming. In the face of increased frequency of drought and heatwaves, outdoor labour activities stand a chance to lead to heat-related complications nationwide, such as heat strokes and excessive dehydration. Farmers also have to deal with crop infestation by pests, apart from the farming challenges associated with the erratic onset and offset of the rainy season. Oftentimes, farmers have to manually spray insecticides and pesticides at risk of elevated exposure to summer temperatures and toxins. The health risks (Box 4.4) encountered by the population due to direct or indirect exposure to both insecticides and pesticides are poorly understood.

The persisting regular droughts causes many farmers, especially subsistence farmers, to leave their fields fallow and in time rodents will likely starve and migrate to households for survival. On their trails could be their predator snakes, some of which could be poisonous. This could lead to high incidences of plague and morbidity and mortalities from snake bites, or even shock for some from sights of rodents and snakes. (Draft report on vulnerability assessment and adaptation, 2012)

Box 4.4: Communicable diseases and Climate change

The first baseline study on GBV has been completed in Lesotho by the United Nations Population Fund (UNFPA), during the 2015/16 El Nino period.[75] The study uncovered that there are subtle gender dimensions of vulnerability to nutrition and food insecurity necessitating the mainstreaming of women in policies and programmes to attain zero hunger. Association between severe drought and Human Immunodeficiency Viruses (HIV) prevention and care behaviours were made through a population-based survey during the 2016/17 period. In the year 2015, HIV was recorded as one of the top 10 causes of death in Lesotho (Figure 4.32); the highest for that matter. The Lesotho Population-Based Impact Assessment (LePhIA) unearthed that drought in the country was associated with elevated HIV prevalence in girls 15-19 years old in rural parts of the country, with lower educational background and unsafe sexual behaviour for females aged 15-24 years old. The study emphasised that policymakers may consider the adoption of income shock impact mitigation measures to counter the natural climate hazards on populations that are vulnerable to HIV transmission.[76]

To date, scientific studies also found that there are linkages between drought and Gender-Based Violence (GBV).

Communicable disease burden: the projected intensification of meteorological drought, during the periods 2041-2070 and 2071-2100, and the associated socio-economic shocks are likely to distract social family structure through reduced food security leading to subsistence farmers resorting for migrant labour practises. This distracts the family structure and negatively impact risky sexual behaviour patterns that may promote HIV transmission, especially among young girls, at risk of slowing progress on the war against the HIV/AIDS pandemic. The availability and accessibility of potable water may minimize the prevalence of potentially fatal diarrheal diseases such as typhoid, cholera, and dysentery. However, many communities are sometimes forced to resort to unsafe sources such as unprotected wells, rivers and streams during drought periods when safe water sources dry up. (Draft report on vulnerability assessment and adaptation, 2012)

Nutrition and food insecurity: In Lesotho, crop and animal production is also sensitive to drought and infestation by pests. Should future climate favour an overlap between active stages of pests and critical stages of crop development such as the active reproductive phases, this could get detrimental to food security among poor farming communities. This is mainly because many of them will not be able to afford the cost of effective pest management through commercially available approved products. Considering the present economic climate in the country, exacerbated drought conditions are likely to increase food insecurity which may also lead to loss of lives among the most vulnerable age groups. Food insecurity forces a fraction of rural subsistence farmers to migrate to cities and other countries at risk of creating instability while putting more pressure on facilities for the health system and other forms of infrastructure.
Vector-borne diseases: Towards the end of the 21st century, climate models show an increase in the occurrence of tropical nights (TN) and summer days (SU), (i.e., nights when minimum

temperature > 20 °C and days when maximum temperature > 25°C). Even though increased temperatures also have significant implication on human temperature comfort at risk of heat strokes, the increase in TN and SU supports the notion that the probability of the malaria belt, which is anticipated to deepen in Southern Africa, may likely reach parts of Lesotho during the near-future and far-future period. The timing or breaking points in the size and shape of the malaria zones distribution in the Southern hemisphere is still an open research question.

4.8.7.2 *Adaptation options and strategies*

Effective measures for adapting to climate change in Lesotho have been suggested in various climate change documents that have been reviewed in the preparation of this report (e.g., Lesotho Nationally Determined Contribution (2017) report and Table 4.15). The most effective measure for adapting to climate change through improved resilience of the most vulnerable population lies in the provision of basic health services. In particular, the country should ensure that the health facilities are better prepared for supporting vaccination programs, child and elderly health services through adequate human capital and financial resources.

There is a need for enhanced disaster preparedness and disease outbreak responses at all levels of society and governance in the country. This can best be achieved through operationalizing integrated early warning systems. The country can benefit from a strengthened capacity for research, monitoring, and continuous evaluation of climate risks and hazards. To achieve these the country not only needs timely continuous data collection capabilities but also well-trained experts and computational facilities to convert the data into actionable information. In Lesotho, there is still a strong need for elevated efforts towards raising awareness about climate change through high impact national campaigns to ensure safe and healthy populations in the face of climate extremes. Another area that needs focus is the mainstreaming of climate change in national strategy documents. At the moment the translation of climate change issues into sector-specific policy and strategy documents reflects that there is a need for a concerted effort through focused exercises.

Table 4.15: Adaptation options, policy-based actions, and nature of barriers on adaptation[15]

Adaptation Options	Policy-based actions	Nature of barriers to adaptation	Possible implementation frame
Improve public resilience to climate change associated health risks	Develop programmes that enhance public awareness about Water and Sanitation Hygiene (WASH) practices.	Institutional	Short-term campaigns; revision of learning curricular at various educational levels
Develop an integrated rapid response mechanism to health hazards and disease outbreaks	Introduce programmes that strengthen coordination between health, disaster management, and climate service departments. Develop programmes that ensure the public and health workers are acquainted with emergency plans and routines. Strengthen the existing IDSR response mechanism to incorporate environmental and climate sensitive health conditions. Establish a coordinated rapid response programme within the health and water sectors to ensure the availability of potable water for all communities (long term water and sanitation strategy)	Institutional, financial, legal	Short-term on the job training workshops, and mandatory emergency simulation drills.

4.8.8 Tourism

Lesotho's key tourism assets and attractions include (a) distinctive flora and fauna, (b) Natural features such as its high altitude and magnificent landscape, (c) cultural heritage, and (d) sites of geological, historical and archaeological importance (Figure 4.33).[54] The Lesotho Review Report[54] indicates that in 2018, the contribution of travel and tourism to the national GDP was reported to be 15.6%. Though the contribution of travel and tourism to GDP fluctuated substantially in recent years, it tended to increase between 1999 to 2018 period.[77] The travel and tourism industry reportedly created 43 000 jobs in 2017, translating to 6.2% of total employment in that year. This figure is projected to rise by 2.7 percent per annum to 55 000 jobs (6.4% of total employment) in 2028. The industry's total contribution to employment, including jobs indirectly supported by tourism, was 13.5% of all employment (94 500 jobs) in 2017.[54]

Despite the potential of the tourism services sector, its contribution to the economy is still minimal, relative its full potential, has been characterized by stagnating growth. several areas require attention to ensure the sector's contribution to the economy of Lesotho is sustained and expanded which include among others:

a) need to distinguish Lesotho from key competitor destinations;
b) Need to create an enabling environment for rapid tourism growth including establishing appropriate policy, planning and legal frameworks;
c) improving access to local tourism enterprises to technology (particularly, information technology and travel distribution systems);
d) improving infrastructure development linked to tourism, for example, roads, utilities (water and electricity), telecommunications;
e) enhancing the full implementation of the Environment Act to manage, conserve and protect the environment;
f) need to climate-proof the tourism attraction areas and programmes;
g) strengthening the adaptive capacity of the tourism sector to the impacts of climate change; and
h) need to harness opportunities that come with climate change mitigation.

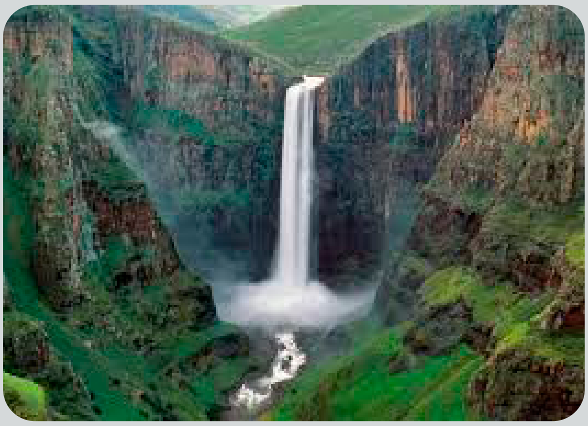



Figure 4.33: Many natural ecosystems that are key to tourist attraction are vulnerable to climate change.

4.8.8.1 *Climate change impacts, Vulnerabilities, and Adaptation*

Climate change is a threat to the sustainability of the tourism sector globally. The interaction between climate and tourism is multifaceted and complex. A country's climate can be both a resource supporting tourism as well as a potential limiting factor that can pose risks to the tourism industry as well as to tourists. Therefore, tourism is climate-sensitive, as it influences travel planning and the experience of tourists.[78] Lesotho is no different, with climate change posing a range of direct and indirect impacts on the sector that could threaten its growth potential (Table 4.15). This requires the consideration and application of climate information to manage risks to climate variability and facilitate adaptation to climate change, to sustain and grow the contribution that tourism makes to the economy.

This section highlights the predicted climate change impacts in the near future (2011-2040). The time horizon for tourism planning is typically short as forecasting (for example of tourism demand and the evolution of tourism markets) is largely short-term.[79] The predicted changes to the climate outlined in the climate change scenarios report will further increase the vulnerability of the tourism sector through the following direct and indirect impacts

Table 4.16: Main impacts of climate change and their implications for tourism

Climate change hazard	Tourist attraction	Tourist attraction	Adaptation/mitigation measure
Increasing frequency of drought	**Maletsunyane Falls** – Located in the central highlands of Lesotho in Semonkong. It boasts a 109m single-drop waterfall which is one of the highest in Africa. It offers 204m abseil cliffs adjacent to the falls. It attracts thousands of tourists from all over the world.	Prolonged droughts are predicted to decrease the functionality of wetlands and river systems, leading to severe water shortages (surface and groundwater). This can negatively affect tourism as tourists come to Semonkong with the view to witness this spectacular 109m single-drop waterfall, with an abseil cliff of 204m adjacent to the falls.	Prolonged droughts are predicted to decrease the functionality of wetlands and river systems, leading to severe water shortages (surface and groundwater). This can negatively affect tourism as tourists come to Semonkong with the view to witness this spectacular 109m single-drop waterfall, with an abseil cliff of 204m adjacent to the falls.
The coping capacity of Basotho to manage droughts can be improved by adoption of national drought policies that are focused on risk reduction and complemented by drought mitigation or preparedness plans at various levels of government.			
	Ketane Falls – Located in one of the remotest parts of the Mohale's Hoek district (very difficult to reach – requires 4x4 driving, pony trekking, and or hiking). Very few tourists have seen these falls with a drop of 122m	As above, reduced river flows associated with droughts can reduce the number of tourists who visit this natural wonder.	The coping capacity of Basotho to manage droughts can be improved by adoption of national drought policies that are focused on risk reduction and complemented by drought mitigation or preparedness plans at various levels of government.

	Qiloane Falls- Located in the Maseru district, along the way to Mohale upstream of the Makhaleng river. It does not have a long drop, but famous for its wide fan of water falling into the pools below.	Reduced river flows as a result of droughts can reduce the number of tourists who visit the falls	The coping capacity of Basotho to manage droughts can be improved by adoption of national drought policies that are focused on risk reduction and complemented by drought mitigation or preparedness plans at various levels of government.
	Lesotho Highlands Water Project Areas – Katse, Mohale and 'Muela Dams and Infrastructure located in the Botha-Bothe, Leribe and Thaba-Tseka districts	The thousands of tourists who visit the LHWP dams and infrastructure best enjoy the world-class engineering marvel of the built infrastructure at full capacity or when there is enough water collected in the impoundments. Droughts cause unsightly low dam levels dams, and visitors would not prefer to visit these destinations during periods of drought.	The Lesotho Highlands Development Authority should implement appropriate Integrated Catchment Management plans to best manage the country's water resources to ensure sustained production of water and ecosystem services.
	Afri-Ski Resort – Located in the North-Eastern part of the country (Botha-Bothe District)	The projected decrease in winter precipitation will affect the availability of natural snow for the resort. Also, drought affects the availability of water to generate artificial snow during the times when there is no natural snow.	Catchment management to conserve wetlands and ensure water availability and water quality. There are water harvesting measures already in place and there are plans in the pipeline to strengthen those. The resort has several other activities offered to attract tourists during seasons when skiing isn't offered. It should further diversify activities on offer so that it remains an attraction even during drought periods

Rising temperatures	**Afri-Ski Resort** – Located in the North-Eastern part of the country in the Botha-Bothe district	The projected increase in temperature through the winter season can affect snowfall patterns during winter months, (reduced snow), thereby negatively affecting the Afri-Ski's ability to offer natural high-altitude skiing experience to tourists. The number of tourists visiting this resort will, therefore, be reduced.	Although much costlier, operators could consider generating artificial snow. Tourists are however reported to prefer natural snow compared to artificial snow. Also, diversify activities on offer so that the resort remains an attraction even during drought periods e.g., pony trekking, mountain biking, hiking, etc.
	National Parks and other Protected Areas e.g., Sehlaba-Thebe National Park, Ts'ehlanyane National Park, Bokong Nature Reserve, Maloti-Drakensberg Transfrontier Park World Heritage Site, etc.	In the face of climate change, the predicted increase in temperatures combined with drought conditions will dry out vegetation, making the frequency and spread of wildfires more dominant. Wildfires are a risk to the health and safety of tourists as well as a detraction from the scenic beauty to tourists. These fires can trigger the loss of and/or changes in biodiversity and undesired migration of wildlife away from these tourist attractions, thereby affecting tourists' preference for such destinations. Also, ecotourism attraction of the country is reduced as a result of the loss of biodiversity and the potential extinction of endemic species and an increase in invasive species.	The Parks Management Authorities (i.e., MTEC) must implement appropriate fire management practices and undertake preventive educational/capacity-building campaigns to parks' stakeholders.
	Tourist attractions in general	An increase in temperatures can affect tourists' comfort levels, particularly those that prefer cooler climates. Human health could also be impacted upon, as warmer temperatures have a likelihood of introducing diseases that are otherwise not a threat to Lesotho.	The Health Sector should be adequately prepared and equipped with the necessary skills to deal with previously unrecorded or new diseases that could break out with increasing temperatures due to climate change.

Extreme Climate Events	Areas of historical, cultural, archeological and palaeontological importance e.g. Morija (museum with archives & dinosaur footprints), Matsieng (residence of His Majesty the King), Menkhoaneng (birthplace of King Moshoeshoe I), Liphofung (san paintings), Maphutseng (dinosaur footprints & grave of Gosselin), Moyeni – Quthing (dinosaur footprints, witch-doctors cave house, Kokobe rock paintings), Qomoqomong (san paintings), Masitise (Cave Mission established in 1866 by Rev. DG Ellenberger), Mount Moorosi (Chief Moorosi's treasures reported hidden in the cliffs of Mount Moorosi), Kome caves (national heritage site), Thabana-Ntlenyana (the highest mountain in Southern Africa, etc.)	A combination of multiple factors such as rising temperatures, abrupt cold spells, erratic rainfall patterns, and other anthropogenic influences could accelerate for example exfoliation processes on monuments with San rock art paintings or artefacts with remnants of dinosaur foot-prints causing their destruction. This can affect tourism patterns across these destinations.	Enhance stakeholder engagement to conserve and protect all designated areas of historical, cultural, archaeological and palaeontological importance
Increasing frequency of floods	Tourist attractions in general	Flooding conditions usually cause massive damage to road networks infrastructure and bridges and often render various tourist destinations unreachable. Also, roads in poor conditions impact tourists' comfort levels using such roads and further limit access to certain areas as tourists whether domestic or international would avoid such roads that could damage their vehicles. As such, tourism gets affected because only those with access to 4x4 vehicles can afford to reach such areas.	National agencies mandated to the sector e.g. The Roads Directorate are already in the right direction to climate-proof their infrastructure e.g., the Output and Performance-based Roads Contracting (OPBRC) approach that incorporates climate considerations in building and maintaining the roads asset.

		Due to the country's topography, floods have the potential to cause serious soil erosion challenges. This can impact negatively on biodiversity, causing the extinction of key biodiversity resources, some of which are endemic to Lesotho. Eco-tourism would, therefore, be directly impacted negatively.	Lesotho should prioritize and fund programmes to conserve and manage biodiversity and natural resources sustainably and to rehabilitate degraded areas.
Unseasonal Snowfalls	The highlands areas of Lesotho	Unseasonal, heavy or prolonged snowfall events are likely to damage buildings (settlements) and increase the number of impassable days on the national roads (road closures), cutting off accessibility of tourist attractions in areas most frequented by tourists. It can also reduce the attraction of key tourism activities such as pony trekking and 4x4 off-road activities.	Adequate budgeting required to facilitate snow clearing and road maintenance along major national routes during the winter season.
Increasing frequency and intensity of strong winds	Eco-Tourism destination areas in general	Gail-force winds usually cause massive damage to built infrastructure (housing and other settlements). This can have particularly devastating consequences in high altitude areas, where wind speeds are known to be much higher and therefore could affect eco-tourism in Lesotho. Strong winds and dust storms have also been cited in the literature to negatively affect the process of artificial snowmaking and the quality of the snow at the ski resort.	The building/construction industry to adopt roofing patterns that are less likely to be blown away by strong winds.
Increased frequency of severe hail	Tourist attractions in general	The predicted increase in frequency and intensity of extreme weather events such as hailstorms could affect agricultural production resulting in high food shortages and poverty levels which would be a deterrent to tourists.	There is a need to diversify livelihood sources, particularly for rural communities who depend mostly on natural resources for survival.

4.8.9 Gender and Youth

Climate change affects us all, but it does not affect us equally. The poorest and most vulnerable- those who have the least to contribute to global warming- are bearing the brunt of the impact today (UN Secretary General Ban Ki-Moon 2009). When it comes to gender dynamics in Lesotho, women are particularly vulnerable to climate change not because of natural weakness, but rather because of socially and culturally constructed roles ascribed to them as women. Also, they are highly dependent on climate-sensitive natural resources that are available within their locality (See Figure 4.34), for sustaining their livelihoods. For instance, when it comes to gender roles particularly in Lesotho, women are responsible for securing water, preparing food, and collection of fuel for cooking and heating. As such, women tend to face major challenges in performing these roles due to the effects of climate change, thereby increasing their levels of livelihood vulnerabilities. One cannot be oblivious to the fact that culture and traditional practices Economic constraints and cultural norms in Lesotho especially when it comes to decision making regarding the use of natural resources is mostly vested in men even though women are the users of such resources, resulting in them experiencing unequal access to natural resources. This is compounded by a lack of infrastructure that results in limited mobility in rural areas thus further exacerbating women and youth vulnerabilities.

On the other hand, youth unemployment remains a serious developmental challenge for Lesotho. High unemployment rates among the youth are attributed to inadequate technical skills; dropping-out of the school; limited work experience (some employers prefer experienced labour); mismatch between labour market needs and skills; lack of entrepreneurial skills and venture/seed capital; lack of access to finance; and lack of participation in decision-making (closely linked to the social exclusion). Youth unemployment and underemployment in Lesotho are chronic problems. There are few decent job opportunities for young people, resulting in poverty or "low-pay" traps that can have a potential of social unrest, exclusion, and migration. The effects of climate change are projected to create new poverty traps which will particularly affect those in vulnerable groups, such as women, children, and young people.


Figure 4.34: Climate change is a youth and gender issue. On the left: Students taking part in conservation agriculture and Women traveling long distances to fetch water for daily use (on the right).

4.8.9.1 *Climate change impacts and Vulnerabilities*

Evidence shows that youth unemployment alluded to earlier has contributed to an increase in HIV/AIDS with 38 percent female and 31 percent male. Impacts of unemployment among the youth have resulted in some of them resorting to drug and substance abuse; 20.8 percent of youth were found to smoke tobacco and 19.7 percent drunk alcohol. According to the Lesotho Population Survey of 2016, due to lack of jobs, the youth dependency ratio has increased from 40 percent in 2006 to 60.9 in 2016. This has heavily impacted on the ability of households to pull themselves out of poverty due to reduced income and consumption patterns. Furthermore, 12 percent of the younger population aged 12 - 30 are chronically poor, with higher poverty rates amongst the younger population aged 12 - 17 compared to those aged 18 - 30 (NSDP II 2018/19 - 2022/23). Potential climate change risks on gender and other vulnerable groups are summarized below:

- Increasing temperatures and more variable precipitation are likely to: (i) exacerbate food insecurity within households, (ii) increase youth unemployment especially in the agricultural sector, and (iii) create tensions between women and men who are responsible for food security to sustain their livelihood.
- Increased incidences of extreme weather events such as heatwaves, flooding, and drought may exacerbate the spread of infectious diseases such as cholera, typhoid, etc. to which young people are highly susceptible.

4.8.9.2 *Adaptation options and strategies*

According to the IPCC,25 by the year 2050, a child born in 2000 is likely to experience atmospheric concentrations of CO_2 of between 463 and 623 parts per million by volume (ppmv), compared with about 400 ppmv in 2016. They are likely to be living with 8.4 - 11.3 billion others on a planet that is 0.8°C to 2.6°C warmer, with sea levels higher by 5 - 32 cm compared with 1990.25 The wide range of potential futures is significant, as there is a tremendous difference between temperature increases of 0.8°C and 2.6°C in terms of impacts, risks, adaptation potential, loss, and damages. The impacts of these changes will be distributed unevenly, with the greatest risks experienced by the poor and marginalized, many of whose livelihoods are threatened by climate change. The policies and decisions made today will influence outcomes over the remainder of this century and beyond, and youth today will be most affected.

The list below highlights some of the adaptation strategies that could be undertaken by Gender and Youth sector to offset the adverse impacts of climate change:

- Promotion of grassroots participation of men, women, girls, and boys in planning for CCA.
- Develop and apply gender-sensitive criteria and indicators when analysing the effects of CC from both male and female perspectives.
- Stronger links between global policy and local level realities and innovations are needed to ensure that polices are informed by the voices of youth and women who deal with consequences of climate change every day.
- Mainstreaming of direct and indirect climate change contributory factors on the integration of gender equality and prevention of gender-based violence through policies and programmes.
- Capacity building, education, and training of women and youth in adopting climate-smart technologies such as drought-resistant crops.
- Create knowledge sharing platforms on climate change and provide practical guidance on how to adapt to climate change.

4.8.10 Cultural and historical heritage

Culture, heritage, and art evolve as society seeks to achieve a distinctive identity. In general, they are acquired to enable such a society to respond to environmental realities such as the climate as well as social challenges like war. Culture and heritage emerge as tools for self-preservation of a society or a group of people toward the attainment of nationhood and associated power. Cultural practices are acquired implicitly or explicitly and soon become a key component of resilience building and mitigation of threats that may be internal like food and water shortages and others that may be external such as invasion by other groups.

Climate change remains a major challenge to the preservation of the cultural heritage of Basotho. At the same time adaptation to this challenge provides an opportunity for the overall building of resilience of the population to the climate change phenomena, as culture permeates all aspects of life and would, in particular, contribute to Basotho's responses to climate change.

The Basotho culture is centred around village life, most traditions and festivals relate to the seasons of the year and their climate. The horse and the cow, as well as the land and its resourcefulness, are all ingredients to the cultural life. Basotho culture also includes various and elaborate food preparation and food preservation techniques. Some are specific for young children and would in the main contain milk and sorghum. Maize and sorghum provide staple food for Basotho. A daily diet would include milk prepared in a variety of styles and vegetables. Beef, mutton, and wildlife meat are consumed on special occasions. Cultural rites such as weddings, funerals, and others are centred around the sacrifice of a cow. Sorghum is mainly used for beer making and soft porridge. Food is prepared in a three-legged pot on a fireplace, oriented to face the direction of the prevailing wind to blow the fire.

Basotho possesses an immense knowledge of food preservation and storage techniques. This indigenous knowledge can still store uncooked foods and grains for a considerable length of time. Examples are the 'sesiu' constructed of reeds and hung to the rooftops in a thatched house to allow adequate air circulation and low temperatures. Raw meat can be salted and dried for future consumption. Similar techniques exist for fruits, vegetables, various legumes, and milk. Techniques also exist for the preservation of semi and fully prepared food for storage over months. Roasted and ground salted maize is popular on long trips. Various vegetables, crop seeds can also be dried and be readily consumed during times of food shortages.

Basotho cultural sports and cultural practises are aligned with seasonal climate patterns. In winter, after the cropping periods, when life stock is not under strict supervision young boys play Mock Stick fighting, which is a popular game in which young boys looking after cattle imitate battle heroes. At the beginning of the rainy season (in August) young girls play 'Lesokoana'. This is a game where young girls chase after one another to dispossess the stirring stick. When the rainfall is considered to be late in coming, the sport is considered to be part of rain inducing ritual. Years of good harvest are culturally accompanied by celebratory activities which include songs and dances. 'Mokorotlo' is a deep sound song conducted by men during the harvest of grains which goes along with men's single file rhythmic dance called 'Mohobelo'. Beer drinking is part of the culture that goes along with 'Mokorotlo' songs and 'Mohobelo' and 'Ntlamo' dances. There are less of the two dances during the seasons of poor harvest and drought.

Indigenous knowledge existed for the sustainability of all aspects of life. This included knowledge about the value and the healing power of the medicinal plants, and techniques to maintain harmony between agricultural practice, including hunting with the time of the year and the expected weather. Basotho have overtime developed methods to cope with extremes of weather including the ability to predict it using behavioural changes of domestic animals and wildlife, insects, trees, and wind direction.

The coping strategies included intensified production, improved food storages, rotation of pastures and even shifting of settlements when necessary.

4.8.10.1 *Climate change impacts and vulnerabilities*

Historically a high level of resilience to climate vagaries and other social factors has been a distinctive characteristic of the Basotho and is part of the cultural heritage. The Nation emerged stronger and united after the drought and food shortages of 1799-1802 (SEKOBOTO) and the ensuing wars that engulfed the sub-region at the same time. Basotho also showed great resilience during the heaviest snow on record in 1902 and 1964 (Lehloa-la-bonya-o-eme), as well as during the drought and locust invasion of 1933 (LEROLE-LE-LEFUBELU). However, climate resilience induced by cultural practises and heritage in the country is facing the increasing pressure due to land degradation and biodiversity loss. Efforts have always been made to protect the flora and fauna of the country and maintain agricultural productivity through various traditional means of soil and range management.

With the projected increase in the magnitude, frequency and duration of climate change extremes, culture in Lesotho face significant immediate and critical challenges even before the likely impacts and risks associated with climate change are considered below:

- Climate change disrupts activities associated with specific months of the year, thereby distorting the harmony between weather and agriculture that has existed for years. The effect of this social barrier cannot be underestimated.
- Climate change through its negative impacts on the ecosystem, particularly the rangeland and vegetation, directly affects the cohesion of the society at basic levels, where the young are attracted to values that among others discourage the vatu of protecting the environment. For example, the loss of medicinal plants reduces the incentive of biodiversity protection.

4.8.10.2 *Adaptation options and strategies*

Basotho history and cultural heritage have in the main being underpinned by practices that anticipate and respond proactively to climate, environment, and social challenges without benefitting from technologies and modern skills. The cultural heritage of the Basotho encompasses coping mechanisms that have a bearing on all aspects of life, including food and water security, health, wildlife preservation, and others. Above all, the coping mechanisms emphasise community approaches.

Therefore, the Basotho cultural heritage, adaptation to, and mitigation of climate change can be considered to be all in harmony, and not antagonistic to one another. The role of cultural heritage (Text Box 4.5) in addressing the climate change challenge can be classified into two forms: first, reviving the traditions and the customs that enabled Basotho in the past to cope, and adoption of new practices as necessary. Second, the Basotho cultural heritage will promote acceptance of new adaptation and mitigation strategies that may be introduced as options as the various sectors respond to climate change. The adoption of renewable energies is such an example.

Box 4.5: Lesotho's Maloti- cultural heritage preservation efforts

Maloti Drakensberg Park represents the most concerted effort to preserve the cultural heritage of Lesotho. Completed in 2001, the park remains the single Lesotho item listed in the UNESCO World Heritage Site. It is a transboundary site composed of the ukhamhlamba Drakensberg National Park in South Africa and the Sehlabathebe National Park in Lesotho; which comprises 6,500 hectares. The Park is renowned for its spectacular natural landscape and importance as a haven for many threatened and endemic species.

Lesotho's Sehlabathebe National Park also harbours the Maloti minnow (*Pseudobarbus, qauthlambae*); a critically endangered fish species only found in this park. This spectacular Natural site contains caves and rock-shelters with the largest and most concentrated group of paintings in Africa, South of Sahara. They represent the spiritual life of the San people, who lived in this area over 4,000 years

Maloti Drakensberg Park represents an effort to mitigate climate change by conserving the natural environment and cultural heritage. Efforts to replicate this park even at smaller scales are in progress and focus at preservation and restoring of traditional indigenous biota.

It cannot be that any adaptation and mitigation strategy foreseen in any sector will be against the cultural and traditional practices of the Basotho. This is because the history and cultural heritage of the Basotho, have in the main being underpinned by practices that anticipate and respond proactively to climate, environment, and social challenges. Basotho did this without benefitting from technologies and modern skills. Now with the ability, for example, to accurately predict the weather and future climate patterns and impacts, cultural heritage can be embedded in the measures Basotho adapt to respond to the climate change challenge. Techniques existed for food storages to await times of hardship, and for the food to maintain satisfactory nutritional levels.

Traditional foods to adapt to the various conditions include:

- Dried Foods: can be stored for long periods for recooking and consumption after many months.
- Milk: For preservation purposes, a container made of animal skin was utilised, where it would be filled with milk and hung preferably on a tree, for consumption after many months (Lekuka)

Immediate Adaptation programmes

- Public awareness
- Institutional arrangements including prioritisation of culture and heritage as an instrument for building resilience towards climate change.
- Policy (climate change and cultural heritage policy)
- Promotion of indigenous knowledge
- Cultural events and activities (sports, stories, folklore, etc)
- Traditional foods and their methods of preservation

4.8.11 Barriers to adaptation

While communities are generally becoming more innovative in coming up with response strategies, there is a need for research and development in collaboration with academia, communities, and government extension to look into the innovations and evaluate the extent they can be recommended for continued use. Lesotho has limited ability to guide change in the community response to climate change due to lack of financial capacity, institutional arrangements, technical and technological capacity (i.e., level of knowledge that most people have) available in the country.

Lesotho does not have financial capacity for climate change research and programmes.[4] There is a limited specific public budget allocation for a majority of government sectors and climate change issues. The majority of sector-specific programmes and studies about climate change conducted in Lesotho have been in collaboration with multilateral and bilateral organisations. Therefore, it is recommended that the government maintains links with these organisations and possibly form more links to acquire the aid required to develop its own financial and institutional capacity. The lack of funds prevents the regular monitoring of structures thus reduces the effectiveness of implemented strategies to offset the adverse impacts of climate change. Additionally, the lack of transparency due to political preference can in some cases lead to the vandalism of implemented technologies.

Similar to financial constraints, the literacy gap between urban and rural population represents a real obstruction to the distribution of knowledge and technological advances of climate-smart agriculture and sustainable land-use management. This is despite the non-negligible steps taken by NGOs like FAO to create and build capacities for research. It is therefore advised that Lesotho must encourage innovations in the development of scientifically robust technologies that are appropriate for resilient society and sustainable land-use practices. As part of the development of scientifically robust tools, training programmes awareness campaigns of climate issues are required to reinforce the operations of certain organizations and institutions involved in climate change.

Going forward, a comprehensive understanding of the multifarious nature and societal needs of Lesotho is required. Studies such as this, therefore, play a significant role in developing a better understanding of the possible impacts of climate change to ensure that the necessary adaptation and mitigation measures are implemented.

4.9 CONCLUSION

The multi-model ensemble climate change simulation outputs suggest that, climate change has been happening over the past 3 decades. The plausible increase in annual maximum and minimum temperatures suggested by the models is also reflected across the seasons. The increasing trends in temperature, during the historic period, are weak but statistically significant for all the seasons. Rainfall, on the other hand, shows high spatial variability, which is also higher in magnitudes relative to the established inter-annual variability for the region. The highest total precipitation accumulation, during the period, is in the Mountains while the Lowlands and Senqu River Valley have the lowest total precipitation accumulation.

From an expert judgement, it has been concluded that the models have a wet precipitation bias for Lesotho during the period. Undoubtedly, quantification of the extend of precipitation bias for Lesotho is important in its own right and can help in evaluating the model skill especially over the high lying areas. Much emphasis is placed on understanding model outputs on change in key climate parameters and related climate extreme indices, not on the model evaluation. Seasonal trends for precipitation are weak and mostly non-statistically significant. All the ensemble members project gradual warming trends until the end of the 21st century for all regions under all emission scenarios. The projected annual maximum temperature changes in the near-future (2011-2040) for the Mountains, Foothills, Lowlands and Senqu River Valley, respectively, include a temperature mean increase by at least 1.95, 1.83, 1.66 and 1.95°C compared to the five-decades global average of 0.65°C reported by IPCC AR4 under the low mitigation scenarios (RCP4.5). Under the non-constrained scenarios (RCP8.5), the mean increases relative to the global average increase by 1.92, 1.86, 1.73 and 2.00°C for the respective agro-ecological zones. During the mid- (2041 - 2070) and far-future (2071 - 2100) projection periods, the maximum temperature for the respective zones is projected to increase by 3.26, 3.18, 2.96, and 3.30°C and 3.72, 3.72, 3.75 and 3.81°C compared to the five-decade global average under the low mitigation scenario (RCP4.5). Despite the model's agreement on the sign of change, the signal is not well developed towards the end of the century, with the model projection indicating changes that are widely spread out in magnitude among the ensemble members. Relative to the IPCC AR4 reported five-decade global average, the median maximum temperatures increase by 7.04, 6.96, 6.8 and 7.24°C for the agro-ecological zones under the unconstrained scenario RCP8.5.

The minimum temperature increase for the three future projection periods is comparable to the associated minimum temperature increases. The temperature changes get so intense by the period 2071 - 2100 with the emergence of tropical nights whose signal is reflected as most intense in the Lowlands relative to the other agroecological zones. During the period 2011 - 2040, along the Foothills extending to the Senqu-river-valley, the signal of change in precipitation, including most of the precipitation-based indices, is mixed and weak. This is indicative of almost no change relative to the base-line rainfall conditions. Whereas there is no change in total annual precipitation in the Lowlands, the ensemble members suggest a possibility of increased very heavy precipitation days. This is tantamount to a shift in the annual precipitation frequency distribution. Since there is no change in the maximum one-day precipitation, such a shift in the projected precipitation distribution may not amount to changes that are beyond the inter-annual precipitation variability of the baseline period in magnitude.

During the period 2041-2070, the model projections are characterized by the highest degree of uncertainty. Under both the low mitigation emission scenario RCP4.5 and the unconstrained scenario RCP8.5, the Senqu River Valley and Mountains regions are projected to experience meteorological drought. In the case of Senqu River Valley, the drought conditions are concomitant with an increase in maximum 1-day precipitation amount. This suggests increased chances of occasionally heavy rain, hence the risk of flood along the river valley. On the other hand, the Mountains are projected to experience amplified meteorological drought in the climate future without mitigation while under low mitigation options, there is no clear interpretable signal of change for precipitation. In a nutshell, there is far more uncertainty in precipitation than in temperature over the historic and future periods. In general, the model projections suggest a clear benefit from global mitigation responses; this is in comparison to the unconstrained emission climate future (RCP8.5). This becomes clear as early as the mid-future period, 2041 - 2070.Although the models have a wet bias for Lesotho in general, based on expert judgement, the ensemble projected change, or anomalies' range, is within changes that can be attributable to the natural variability, at least on comparing magnitudes. Nevertheless, even under international mitigation responses, based on the present socioeconomic circumstances, Lesotho is potentially sensitive and vulnerable to the projected wetter and drier climate futures.

4.10 REFERENCES

1. McMichael, A.J., Woodruff, R.E. and Hales, S., 2006. Climate change and human health: present and future risks. The Lancet, 367(9513), pp.859-869.
2. Hoegh-Guldberg, O., Jacob, D., Taylor, M., Bindi, M., Brown, S., Camilloni, I., Diedhiou, A., Djalante, R., Ebi, K. L., Engelbrecht, F., Guiot, J., Hijioka, Y., Mehrotra, S., Payne, A., Seneviratne, S. I., Thomas, A., Warren, R., and Zhou, G. (2018). Impacts of 1.5 ¬∫C Global Warming on Natural and Human Systems. In: Global Warming of 1.5¬∞C. An IPCC Special Report on the impacts of global warming of 1.5¬∞C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. P√∂rtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. P√©an, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.
3. Lesotho Meteorological Services, 2000. Lesotho's Initial National Communication under the United Nations Framework Convention on Climate Change. Lesotho Meteorological Services, Lesotho. Retrieved from http://www.lesmet.org.ls/sites/default/files/publications/fnc.pdf
4. Lesotho Meteorological Services, 2013. Lesotho's Second National Communication under the United Nations Framework Convention on Climate Change. Lesotho Meteorological Services, Lesotho. Retrieved from http://unfccc.int/resource/docs/natc/lsonc2.pdf
5. Taylor, K.E., Stouffer, R. J., and Meeh, G.A., 2011. An overview of CMIP5 and the experiment design, Bulletin of the American Meteorological Society, 93(4), 485–498. https://doi.org/10.1175/BAMS-D-11-00094.1
6. Evans, J.P., 2011. December. CORDEX–An international climate downscaling initiative. In 19th International Congress on Modelling and Simulation, Perth, Australia, 12–16 December 2011.
7. Zhang, X., Alexander, L., Hegerl, G. C., Jones, P., Tank, A. K., Peterson, T. C., Trewin, B. and Zwiers, F.W., 2011. Indices for monitoring changes in extremes based on daily temperature and precipitation data, WIREs. Journal of Climate Change, 2, 851–870. DOI: 10.1002/wcc.147
8. Mahlstein, I., Spirig, C., Liniger, M.A., and Appenzeller, C., 2015. Estimating daily climatologies for climate indices derived from climate model data and observations. Journal of Geophysical Research: Atmospheres, 120(7), 2808–2818. http://doi.org/10.1002/2014JD022327
9. New, M., Hewitson, B., Stephenson, D., Tsiga, A., Kruger, A., Manhique, A., Gomez, B., Coelho, C., Masisi, D., Kululanga, E., Mbambalala, E., Adesina, F., Saleh, H., Kanyanga, J., Adosi, J., Bulane, L., Fortunata, L., Mdoka, M. and Lajoie. R., 2006. Evidence of trends in daily climatic extremes over southern and west Africa. Journal of Geophysical Research, 111, D14102.

DOI: 10.1029/2005JD006289

10. Gbode, I.E., Akinsanola, A.A. and Ajayi, V.O., 2015. Recent Changes of Some Observed Climate Extreme Events in Kano. International Journal of Atmospheric Sciences, 6. http://dx.doi.org/10.1155/2015/298046
11. Soltani, M., Laux, P., Kunstmann, H., Stan, K., Sohrabi, M.M., Molanejad, M., Sabziparvar, A.A., SaadatAbadi, A.R., Ranjbar, F., Rousta, I. and Zawar-Reza, P., 2016. Assessment of climate variations in temperature and precipitation extreme events over Iran. Theoretical and Applied Climatology, 126(3-4), pp.775-795.
12. IPBES, 2018. Summary for policymakers of the assessment report on land degradation and restoration of the Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services. Scholes, R., Montanarella, L., Brainich, A., Barger, N., Ten Brink, B., Cantele, M., Erasmus, B., Fisher, J., Gardner, T., Holland, T. G., Kohler, F., Kotiaho, J. S., Von Maltitz, G., Nangendo, G., Pandit, R., Parrotta, J., Potts, M. D., Prince, S., Sankaran, M. and Willemen L. IPBES Secretariat, Bonn, Germany.
13. UNDP, 2016. Climate change scenario modelling and Risk Assessment. Reducing Vulnerability from climate change in foothills, lower lowlands and Senqu River. Maseru, Lesotho.
14. Majara, N., 2005. Land degradation in Lesotho: A synoptic perspective. MSc dissertation. University of Stellenbosch, RSA
15. Lesotho Meteorological Services, 2017. Lesotho's national climate change policy. Ministry of Energy and Meteorology, Lesotho.
16. UN-OHRLLS, 2015. The impact of climate change, desertification and land degradation on the development prospects of landlocked developing Countries.
17. Lesotho Soils Information System. Site visited on: 14/11/2019. http://lesis.gov.ls/Data/primary%20data/soildepthmap.jpg
18. Lesotho Meteorological Services, 2018b. Guidelines for the integration of climate change in national, sectoral and local policies, strategies and development plans. Ministry of Energy and Meteorology.
19. Musa, J.J., Anijofor, S.C. and Obasa, P., 2017. Effects of soil physical properties on erodibility and infiltration parameters of selected areas in Gidankwano. Nigerian Journal of Technological Research, 12(1), 46–54.
20. Brevik, E.C., 2012. Soils and climate change: gas fluxes and soil processes. Soil Horizons, 53(4), 12-23.
21. Karmakar, R., Das, I., Dutta, D. and Rakshit, A., 2016. Potential effects of climate change on soil properties: a review. Science international, 4(2), 51-73.
22. UNCCD, 1999. Lesotho National Report on the Implementation of the United Nations

Convention to Combat Desertification.

23. Brevik, E.C., 2013. The potential impact of climate change on soil properties and processes and corresponding influence on food security. Agriculture, 3(3), 398–417.

24. IPCC, 2007a. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA: 996.

25. IPCC, 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp. Available at http://www.ipcc.ch/report/ar5/index.shtml.

26. FAO/WFP, 2007. Special report: FAO/WFP Crop and food supply assessment mission to Lesotho, FAO Corporate document repository, www.fao.org/docrep

27. FAOSTAT, 2015. Trends for cereal production, area harvested and yield in Lesotho.

28. Thornton, P.K., Jones, P.G., Ericksen, P.J. and Challinor, A.J., 2011. 'Agriculture and food systems in sub-Saharan Africa in a 4 °C+ world', Phil. Trans. R. Soc., 369, pp. 117-136. Available at http://rsta.royalsocietypublishing.org/content/369/1934/117.

29. Knox J., Hess T., Daccache A. and Wheeler T., 2012. 'Climate change impacts on crop productivity in Africa and South Asia', Environmental Research Letters, 7(3).

30. IPCC, 2007b. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Parry, M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, 976.

31. IPCC, 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 688.Jones, P.G. and Thornton, P.K. (2003) 'The potential impacts of climate change on maize production in Africa and Latin America in 2055', Global Environment Change 13(1), p. 51-59. Available at http://libcatalog.cimmyt.org/download/cis/76229.pdf, accessed 17 January 2017.

32. Shiferaw, B., Prasanna, B. M., Hellin, J. and Bänziger, M. 2011. Crops that feed the world 6. Past successes and future challenges to the role played by maize in global food security. Food security, 3(3), 307.

33. Lesotho Meteorological Services, 2015. Climate change tool kit for teachers. Ministry of Energy and Meteorology, Lesotho.

34. Ngambi, J.W. and Matebesi, P.A., 2001. Kidding, mortality and offtake rates of Angora goats in the mountains and lowlands of Molimo-Nthuse area in Lesotho. UNISWA Research Journal of Agriculture Science and Technology, 5 68-72.

35. Adams, R.M., McCarl, B.A., Segerson, K., Rosenzweig, C., Bryant, K.J., Dixon, B.L., Conner, A., Evenson, R.E. and Ojima, D., 1999. The economic effect of climate change on US agriculture. In: The Economic Impact of Climate Change on the Economy of the United States. Eds: Mendelsohn, R. & Neumann, J., Cambridge: Cambridge University Press.

36. Jones, A. K., Jones, D.L., Edwards-Jones, G. and Cross, P., 2013. Informing decision making in agricultural greenhouse gas mitigation policy; a best-worst scaling survey of expert and farmer opinion in the sheep industry. Environ. Sci. Policy. 29, 46-56.

37. Diaw, M. C., Tito de Morais, L., Harhash, K. A., Andriamaro, L., Archer, E., Batisani, N., Bornman, T., Fuashi, N. A., Golden, C., Hamed, Y., Ivey, P., Lindley, S., Mulongoy, K. J., Onyige, C. D., Matlhola, D. M., and Belhabib, D. Chapter 1: Setting the scene. In IPBES (2018). The IPBES regional assessment report on biodiversity and ecosystem services for Africa. Archer, E. Dziba, L., Mulongoy, K. J., Maoela, M. A., and Walters, M. (Eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem services, Bonn, Germany.

38. IPBES, 2019. Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. S. Díaz, J. Settele, E. S. Brondízio E.S., H. T. Ngo, M. Guèze, J. Agard, A. Arneth, P. Balvanera, K. A. Brauman, S. H. M. Butchart, K. M. A. Chan, L. A. Garibaldi, K. Ichii, J. Liu, S. M. Subramanian, G. F. Midgley, P. Miloslavich, Z. Molnár, D. Obura, A. Pfaff, S. Polasky, A. Purvis, J. Razzaque, B. Reyers, R. Roy Chowdhury, Y. J. Shin, I. J. Visseren-Hamakers, K. J. Willis, and C. N. Zayas (eds.). IPBES Secretariat, Bonn, Germany. 56 pages.

39. Bellard, C., Bertelsmeier, C., Leadley, P., Thuiller, W., Courchamp, F. 2012. Impacts of climate change on the future of biodiversity. Ecological Letters 15: 365–377. https://doi.org/10.1111/j.1461-0248.2011.01736.x.

40. Nunez, S., Arets, E., Alkemade, R., Verwer, C., Leemans, R. 2019. Assessing the impacts of climate change on biodiversity: is below 2 °C enough? Climatic Change, 154:351–365.

41. Lesotho Meteorological Services, 2018. Lesotho's Climate Change Scenarios Report. Ministry of Energy and Meteorology: Maseru, Lesotho

42. Turpie, A.G., Haas, S., Kreutz, R., Mantovani, L.G., Pattanayak, C.W., Holberg, G., Jamal, W., Schmidt, A., van Eickels, M. and Lassen, M.R., 2014. A non-interventional comparison of rivaroxaban with standard of care for thromboprophylaxis after major orthopaedic surgery in 17,701 patients with propensity score adjustment. Thrombosis and haemostasis, 111(01), pp.94-102.

43. Turpie, J., Feigenbaum, T., Hayman, M., Hutchings, K., Cousins, T., Chipeya, T., Talbot, M., 2014. Analysis of alternatives to determine the most feasible solution to the hydrological issues of the Lake St Lucia estuarine system: socio-economic assessment. Report. iSimangaliso Wetland Park Authority, 300.

44. Hannah, L., Lovejoy, T.E. and Schneider, S.H., 2005. Biodiversity and climate change in context. Climate change and biodiversity, pp.3-14.

45. Foden, W.B., Young, B.E., Akçakaya, H.R., Garcia, R.A., Hoffmann, A.A., Stein, B.A., Thomas, C.D., Wheatley, C.J., Bickford, D., Carr, J.A., Hole, D.G., Martin, T.G., Pacifici, M., Pearce-Higgins, J.W., Platts, P.J., Visconti, P., Watson, J.E.M. and Huntley, B. 2019. Climate change vulnerability assessment of species. Climate Change. 2019;10: e551. https://doi.org/10.1002/wcc.551

46. Global Forest Watch, 2019. Retrieved October 29, 2019, from www.globalforestwatch.org

47. Davis-Reddy, C.L. and Vincent, K. 2017. Climate risk and vulnerability: A handbook for Southern Africa (2nd ed.). CSIR: Pretoria, South Africa.

48. Food and Agriculture Organization, 2015. Global forest resources assessment country report: Lesotho. Rome, Italy

49. May, E.D. 1997. The forests, woodlands and shrublands of Lesotho in perspective: Case study- Lesotho. Ministry of Agriculture: Maseru, Lesotho.

50. Lasch, P., Lindner, M., Erhard, M., Suckow, F. and Wenzel, A., 2002. Regional impact assessment on forest structure and functions under climate change – the Brandenburg case study. Forest Ecology and Management, 162(1), 73–86. https://doi.org/10.1016/S0378-1127(02)00051-8

51. Crous, C.J., Jacobs, S. M. and Esler, K.J., 2012. Drought-tolerance of an invasive alien tree, Acacia mearnsii and two native competitors in fynbos riparian ecotones. Biological Invasions, 14(3), 619–631. https://doi.org/10.1007/s10530-011-0103-y

52. Graziosi, I., Tembo, M., Kuate, J. and Muchugi, A., 2019. Pests and diseases of trees in Africa: A growing continental emergency. Plants, People, Planet, 00, 1–15. https://doi.org/10.1002/ppp3.31

53. Martínez de Aragón, J., Bonet, J.A., Fischer, C.R. and Colinas, C., 2007. Productivity of ectomycorrhizal and selected edible saprotrophic fungi in pine forests of the pre-Pyrenees mountains, Spain: predictive equations for forest management of mycological resources. Forest Ecology and Management, 252, 239–256. https://doi.org/10.1016/j.foreco.2007.06.040

54. Lesotho Review, 2019. Environmental Conservation. Retrieved November 11, 2019, from https://www.lesothoreview.com/contents/environmental-conservation/

55. Treseder, K.K., Allen, E.B., Egerton-Warburton, L.M., Hart, M.M., Klironomos, J.N., Maherali, H. and Tedersoo, L., 2018. Arbuscular mycorrhizal fungi as mediators of ecosystem responses

to nitrogen deposition: A trait-based predictive framework. Journal of Ecology, 106(2), 480-489.

56. Certini, G., 2005. Effects of fire on properties of forest soils: A review. Oecologia, 143, 1–10. https://doi.org/10.1007/s00442-004-1788-8
57. Delitti, W., Ferran, A., Trabaud, L. and Vallejo, V.R., 2005. Effects of fire recurrence in Quercus coccifera L. shrublands of the Valencia Region (Spain): I. plant composition and productivity. Plant Ecology, 177(1), pp.57-70. https://doi.org/10.1007/s11258-005-2140-z
58. Spittlehouse, D. and Stewart, R.B., 2003. Adaptation to climate change in forest management. Journal of Ecosystems and Management, 4(1), 1–11
59. Gottschalk, K.W., 1995. Using silviculture to improve health in northeastern conifer and eastern hardwood forests. In L. G. Eskew (Ed.), Forest health through silviculture: General technical report (pp. 219–226). U.S. Department of Agriculture Forest Service: Fort Collins, Colo.
60. Parker, W.C., Colombo, S.J., Cherry, M.L., Greifenhagen, S., Papadopol, C., Flannigan, M.D., McAlpine, R.S. and Scarr, T., 2000. Third millennium forestry: what climate change might mean to forests and forest management in Ontario. The Forestry Chronicle, 76(3), pp.445-463. https://doi.org/10.5558/tfc76445-3
61. Farnum, P., 1992. Forest adaptation to global climate change through silvicultural treatments and genetic improvement. In N. Clark (Ed.), Implications of climate change for Pacific Northwest Forest management (pp. 81–84). Department of Geography, University of Waterloo: Waterloo.
62. Makundi, W., 2014. Climate change vulnerability of African forest plantations and the role of permanent sample plots in monitoring, reporting and verification for REDD+ in plantations. African Forest Forum: Nairobi, Kenya.
63. Papadopol, C.S., 2000. Impacts of climate warming on forests in Ontario: Options for adaptation and mitigation. Forestry Chronicle, 76(1), 139–149. https://doi.org/10.5558/tfc76139-1
64. Dale, V.H., Joyce, L.A., McNulty, S., Neilson, R.P., Ayres, M.P., Flannigan, M.D., Hanson, P.J., Irland, L.C., Lugo, A.E., Peterson, C.J. and Simberloff, D., 2001. Climate change and forest disturbances: climate change can affect forests by altering the frequency, intensity, duration, and timing of fire, drought, introduced species, insect and pathogen outbreaks, hurricanes, windstorms, ice storms, or landslides. BioScience, 51(9), pp.723-734. https://doi.org/10.1641/0006-3568(2001)051[0723:CCAFD]2.0.CO;2
65. Holling, C.S., 2001. Understanding the complexity of economic, ecological, and social systems. Ecosystems, 4(5), 390–405. https://doi.org/10.1007/s10021-001-0101-5
66. Noss, R.F., 2001. Beyond Kyoto: Forest management in a time of rapid climate change.

Conservation Biology, 15(3), 578–590. https://doi.org/10.1046/j.1523-1739.2001.015003578.x

67. Suffling, R. and Scott, D., 2002. Assessment of climate change effects on Canada's national park system. Environmental Monitoring and Assessment, 74(2), 117–139. https://doi.org/10.1023/a:1013810910748
68. Henderson, N., Hogg, E., Barrow, E. and Dolter, B., 2002. Climate change impacts on the island forests of the Great Plains and the implication for nature conservation policy. Prairie Adaptation Research Co-operative: Regina, Sask.
69. Carey, A.B., 2003. Restoration of landscape function: reserves or active management? Forestry, 76(2), 221–230. https://doi.org/10.1093/forestry/76.2.221
70. Kowero, G., and Yemshaw, Y., 2011. Climate Change in African Forestry: The Broader Policy Context. Climate Change and African Forest and Wildlife Resources, 214.
71. LNHSP, 2017. National Health Strategic Plan 2017-2022. https://www.childrenandaids.org/sites/default/files/2018-05/Lesotho_Nat%20Health%20Strat%20Plan_2017-2022.pdf
72. Davis, C.L. and Vincent, K., 2017. Climate risk and vulnerability: A handbook for Southern Africa (2nd Ed.). CSIR, Pretoria, South Africa.
73. Berhanu, M. and Wolde, A.O., 2019. Review on Climate Change Impacts and its Adaptation strategies on Food Security in Sub-Saharan Africa. Agricultural Socio-Economics Journal, 19(3), 145-154. https://doi.org/10.21776/ub.agrise.2019.019.3.3
74. Food and Agriculture Organization, 2016. El Niño-induced Drought Briefing – February 2016. http://www.fao.org/fileadmin/user_upload/emergencies/docs/FAOLesotho_ElNinoResponsePlanBriefing_February2016.pdf
75. Letsie, M.M.A., 2015. An Assessment of Place Vulnerability to Natural Hazard in South-western Lesotho (Quthing and Mohale's Hoek Districts) (Doctoral dissertation, University of the Witwatersrand, Faculty of Science, School of Geography, Archaeology & Environmental Studies).
76. Low, A.J., Frederix, K., McCracken, S., Manyau, S., Gummerson, E., Radin, E., Davia, S., Longwe, H., Ahmed, N., Parekh, B., Findley, S. and Schwitters, A., 2019. Association between severe drought and HIV prevention and care behaviors in Lesotho: A population-based survey 2016-2017. PLoS medicine, 16(1), e1002727. https://doi.org/10.1371/journal.pmed.1002727
77. Knoema, 2018. Lesotho - Contribution of travel and tourism to GDP as a share of GDP. https://knoema.com/atlas/Lesotho/topics/Tourism/Travel-and-Tourism-Total-Contribution-to-GDP/Contribution-of-travel-and-tourism-to-GDP-percent-of-GDP
78. Scott, D. and Lemieuc, C., 2010. Weather and climate information for tourism. Procedia Environmental Sciences, 1, 146–183. https://doi.org/10.1016/j.proenv.2010.09.011
79. Hall, C.M., Gossling, S. and Scott, D. eds., 2015. The Routledge handbook of tourism and sustainability. Routledge.

5.1 INTRODUCTION

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, industrial Processes, 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 it is faced with.

According to the country's Nationally Determined Contribution (NDC), Lesotho has already undertaken several actions to support mitigation based on national circumstances. Such actions include extensive investments in hydro, solar and wind power potential, as well as 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 Sustainable Development Goals (SDGs), AU Agenda 2063, NCCP 2017-2027, NSDP II, and other relevant national policies and plans.

Lesotho's NDC had set out the mitigation targets against a BAU projection considering reduction of emissions in four (4) socio-economic sectors, namely: Energy; Industrial Processes; 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. Increased waste incineration with energy recovery to reduce CH_4 emissions.

5.1.1 Objectives

The overall objective of the exercise was 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 carbon 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:

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

5.2 METHODOLOGY

5.2.1 Scope

The scope of the assessment was delineated based on three parameters, namely: primary sectors, the base year and projection period. Sectors considered as drivers for economic growth and major contributors to the national GHG emissions were considered. In uniformity with IPCC categories, the sectors include Energy, AFOLU, IPPU and Waste.

5.2.2 Multi-sectoral stakeholder approach

The UNFCCC Consultative Group of Experts (CGE) seven-step methodology and process was followed to conduct mitigation analysis and assessment of options to reduce GHG emissions and/or enhance Lesotho's carbon sinks. Besides facilitating concise reporting, this approach also enhances stakeholder capacity building and training on climate change mitigation assessment tools, concepts and steps. During this exercise, stakeholders from various sectors including Agriculture, Energy, Environment, Forestry, Range and Soil Conservation, Trade, Transport and Public Works, BOS, Private Sector and Industry, as well Academia and Research Institutions were engaged.

5.3 BASELINE SCENARIO

The Baseline Scenario was developed for a single BAU scenario that aims to represent the most likely future of Lesotho in 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. Assumptions were based on the dataset extracted from the Third National GHG Inventory report, Energy Balance 2010, BOS Census reports[1] and the Macroeconomic reports from the Central Bank of Lesotho (CBL).

Population Growth 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 national population censuses were interpolated. The population was estimated to be 1,926,761 for 2010 and average household size estimated to be four (4). To estimate population and household size up to 2030 linear extrapolation model was used. GDP Growth the governing assumptions for the baseline scenario are based on growth rate for the Actual GDP [2,3,4] contribution of the three (3) key economic sector, namely: manufacturing, construction and mining and Quarrying. The real GDP growth rate observed during the period 2010- 2016 has been 15 percent, 3 percent and 21 percent for the sectors respectively. The projected average growth for 2017 to 2030 for the manufacturing, construction as well as mining and quarrying sectors is 1.07 percent, 3.73 percent, and 4.83 percent respectively.

5.3.1 Baseline Emissions Projections for the Energy Demand

Assumptions for the baseline emissions projections for the energy demand are based on all activities identified in the national GHGI for 2010. Additionally, the reports from the BOS and the DoE are also used as a basis for the assumptions made in building the baseline scenario. The 2011 household survey was used to disaggregate household fuel use into space heating, cooking, water heating and lighting, and the rest allocated to others. 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).[5] were used to disaggregate the liquid fuels demand. 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.

5.3.2 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 percent annually. Due to lack of national data on number of vehicles, the assumptions made under the Third GHG Inventory report and the study by Tongwane et al.,[6] were used as a basis for modelling the baseline scenario. The overall fuel used by vehicles made approximately 75 percent of total petrol and diesel based on Lesotho.

5.3.3 Growth in Animal Population

Using base year as 2010, the livestock population from Lesotho Livestock Statistics Report 2013/14 was used to estimate the growth rate for dairy and non-dairy cows as well as poultry. Extrapolation methods were used to project change in population for sheep, goats, horses, mules and swine. The average growth rates were used to estimate GHG baseline projections associated with livestock.

5.3.4 Lesotho Baseline Trajectory (2010 – 2030)

Projections of all GHGs for both energy and non-energy sectors for baseline scenario are presented in Table 5.1 and Figure 5.1. The projections show that if no climate change mitigation measures are to be implemented, the emissions in 2030 will be 10 percent higher (at 5,739.9 ktCO_2e) than in 2010 (5,213.4 ktCO_2e). The contribution of the energy and non-energy sectors for 2010 and 2030 are compared in Figure 5.2.

Table 5.1: Projections of Greenhouse Gases under Baseline Scenario

Sectors	2010 ($ktCO_2e$)	2020 ($ktCO_2e$)	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**

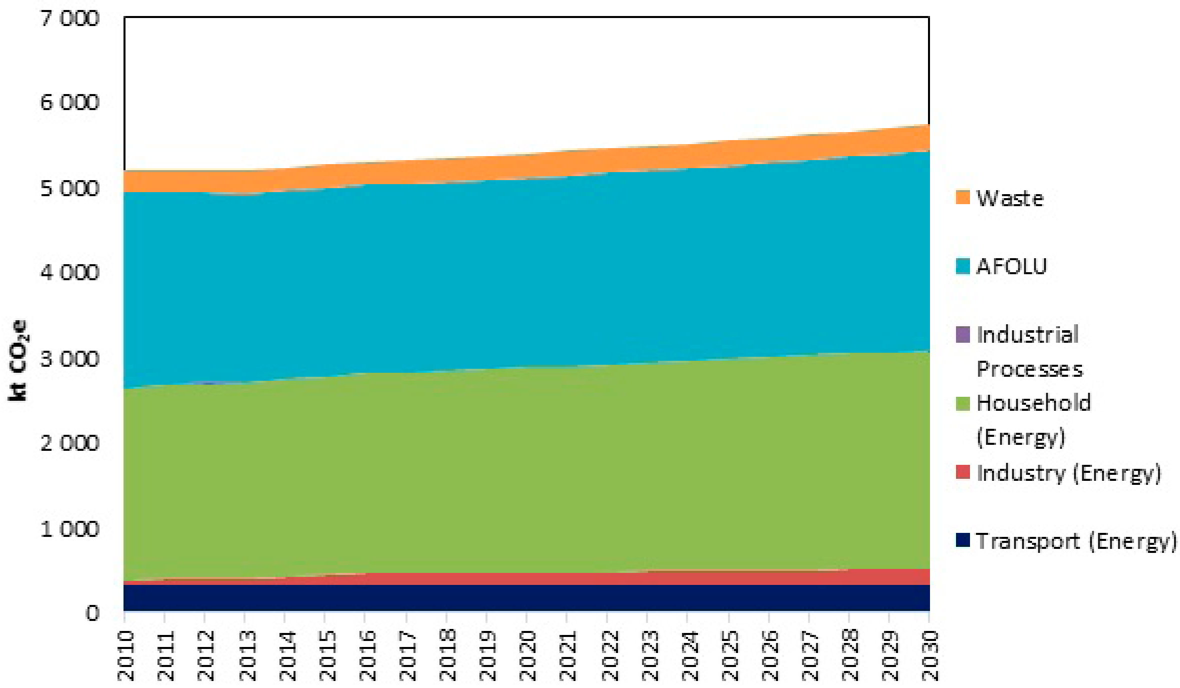


Figure 5.1: Projection of Greenhouse Gases for all Sectors under Baseline Scenario

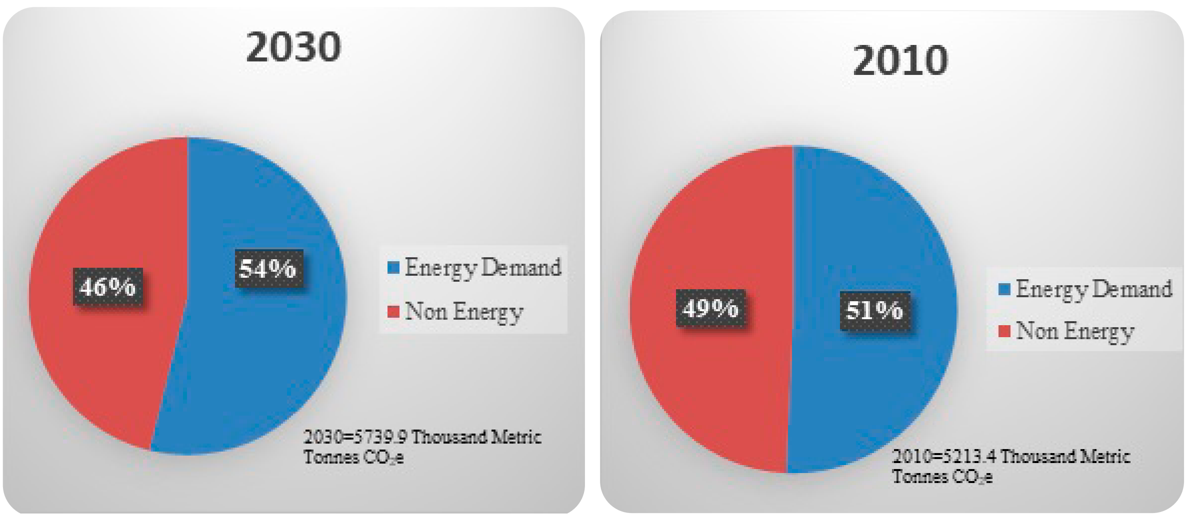


Figure 5.2: Contribution of Greenhouse Gases as per sector

5.3.4.1 *Energy Sector*

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 percent 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 percent of total energy demand. The emissions associated with energy demand are projected to steadily increase by about 14 percent to 2,571.8 ktCO_2e by 2030. Emissions due to the future demand for energy use in industry (construction, mining and quarry, and manufacturing) have been projected to rise from 62 ktCO_2e in 2010 to 185.1 ktCO_2e in 2030. Currently, the industries contribute just about 3 percent of the total energy demand, but their projected rate of increase is higher than of any other sector within energy demand (see Figure 5.3 and Table 5.2).

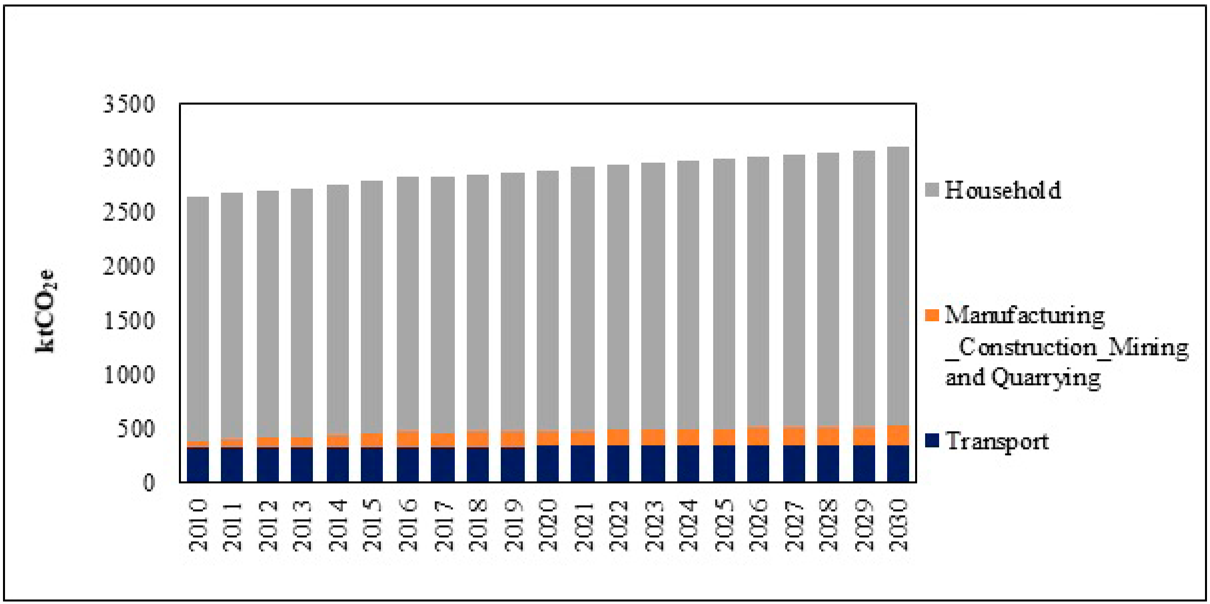


Figure 5.3: Energy Demand Baseline Scenario Projections Per Sectors (2010-2030)

Table 5.2: Energy demand Baseline Scenario Projections per Sectors (2010-2030)

Energy demand sectors	2010	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		**2,887.2**	**3,093.2**

5.3.4.1.1 *Transportation Sector*

The mitigation analysis and assessment depict transportation as the second largest contributor to the energy demand associated GHG emissions. The sector therefore is, and will continue to be, an important source of GHG emissions. Emissions are projected to increase from 324.8 $ktCO_2e$ to 336.3 $ktCO_2e$, approximately 4 percent increase within the 2010-2030 timescale (Figure 5.4). Of the 2030 transportation related GHG emissions, passenger transportation will account for approximately 51 percent of the total emissions, while freight and aviation will account for 48 percent and 1 percent, respectively. Private vehicles will account for about 58 percent of passenger's transportation emissions by 2030 under the baseline scenario (Figure 5.5).

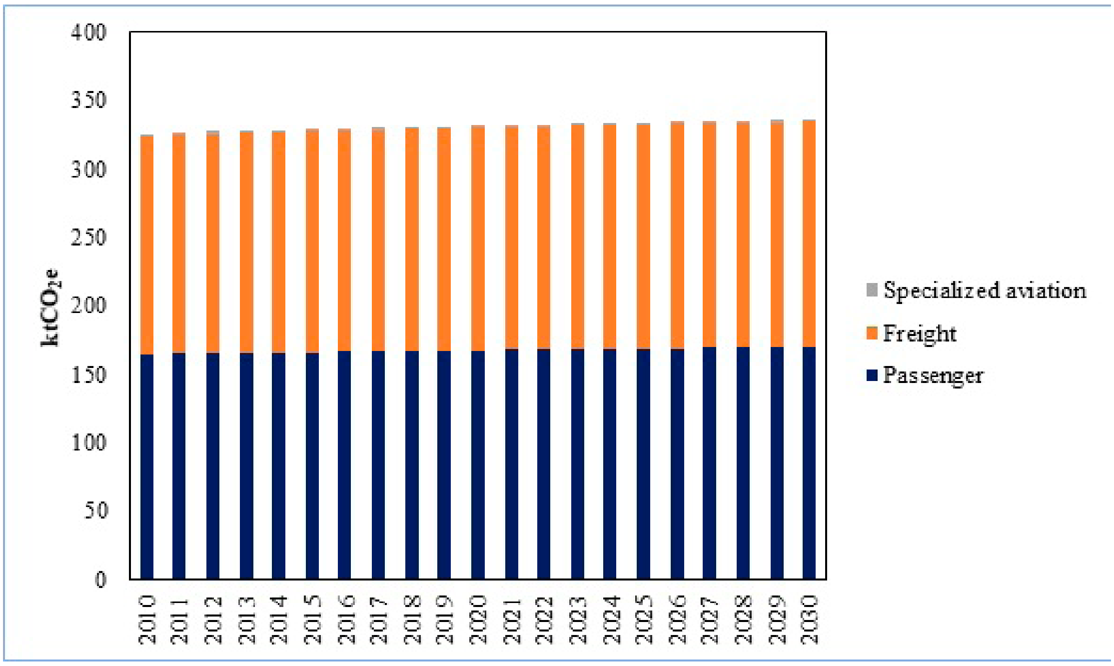


Figure 5.4: Transportation Baseline Scenario Emission Trajectory

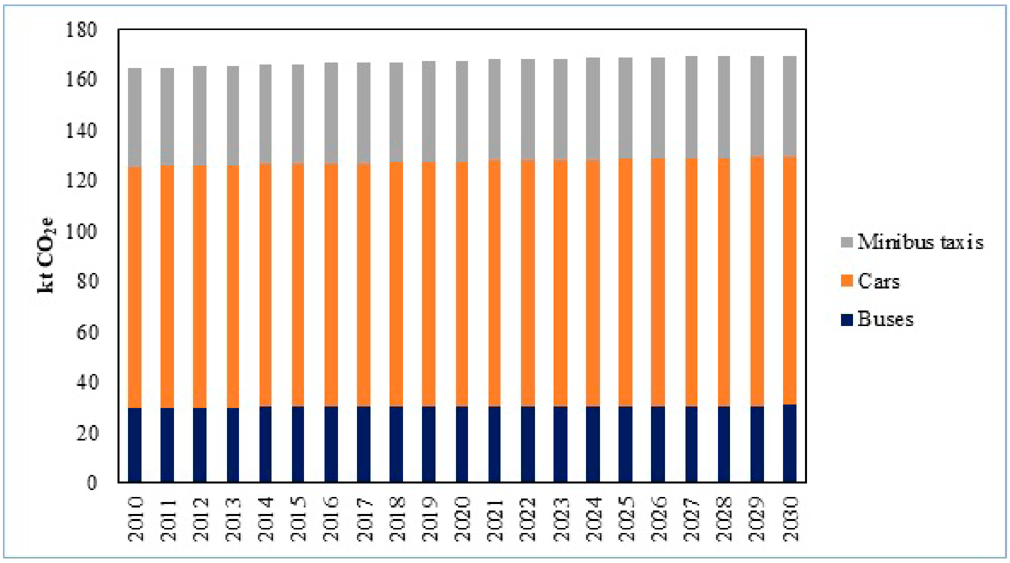


Figure 5.5: Road Road/ Passenger's Transportation

5.3.4.2 *Non- Energy Baseline Trajectory*

In 2010, GHG emissions from non-energy sources accounted for 49 percent of Lesotho's emissions. The emissions are expected to account for 46 percent in 2030 under the baseline scenario. Specifically, about 3 percent decrease in emissions is forecasted for the 2010-2030 projection period. These emissions are from LULUCF, biomass burning, agricultural soils, livestock, IPPU (refer to Figure 5.6 and Table 5.3). IPPU emissions are composed of emissions from brick manufacturing only.

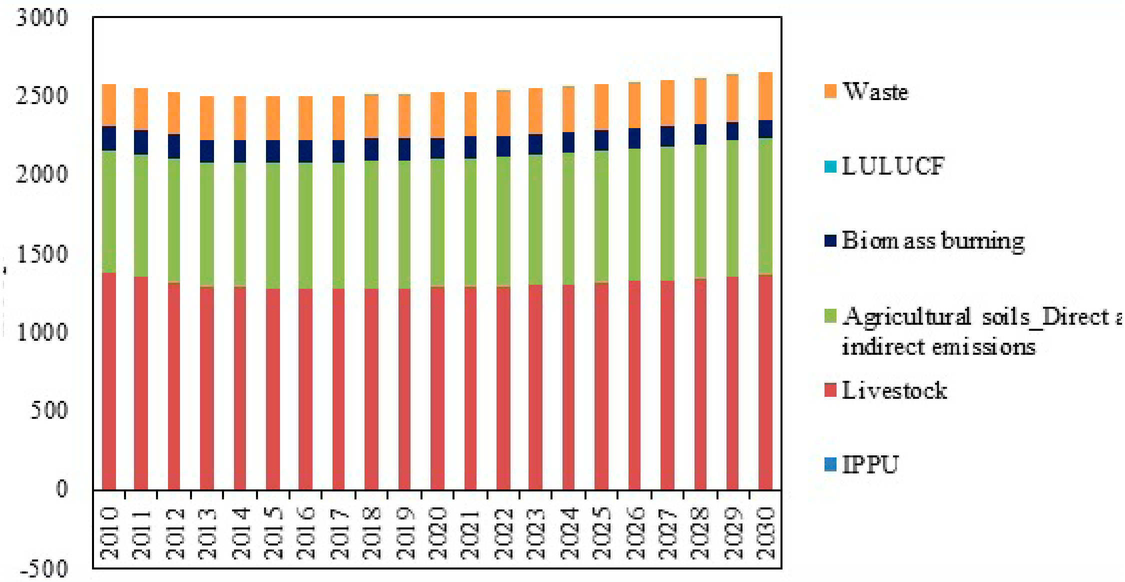


Figure 5.6: Non-Energy baseline greenhouse gas projections

Table 5.3: 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**

5.3.4.2.1 Livestock Baseline Emissions

Livestock GHG emissions contribute 54 percent (1,382.42 ktCO_2e) of the non-energy baseline emissions for the base year 2010 and ae expected to decrease by about 2 percent to 52 percent (1,366.28 ktCO_2e) by 2030 (see Figure 5.7). Enteric fermentation contributes 64 percent (889.0 ktCO_2e in 2010) of livestock emissions. These emissions are expected to decrease by 2030 to 58.2 ktCO_2e by 2030. The assessment indicates a decrease in enteric fermentation emissions from non-dairy cows, horses, mules and asses by 2030 (see Figure 5.8 and Table 5.4). The trend could be attributed to the decline in livestock population numbers especially non-dairy cows.

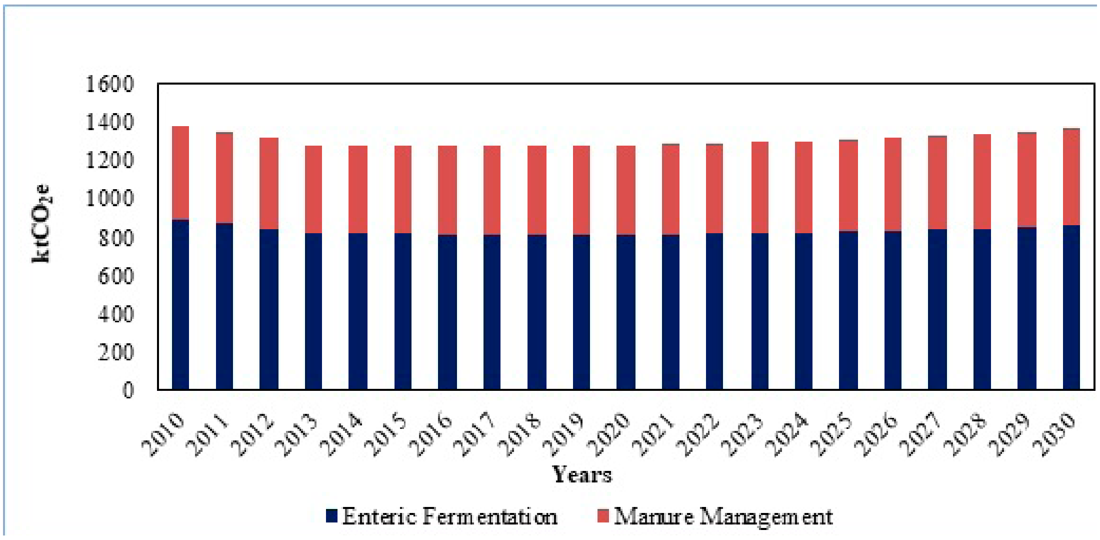


Figure 5.7: Livestock Baseline Emissions Projection

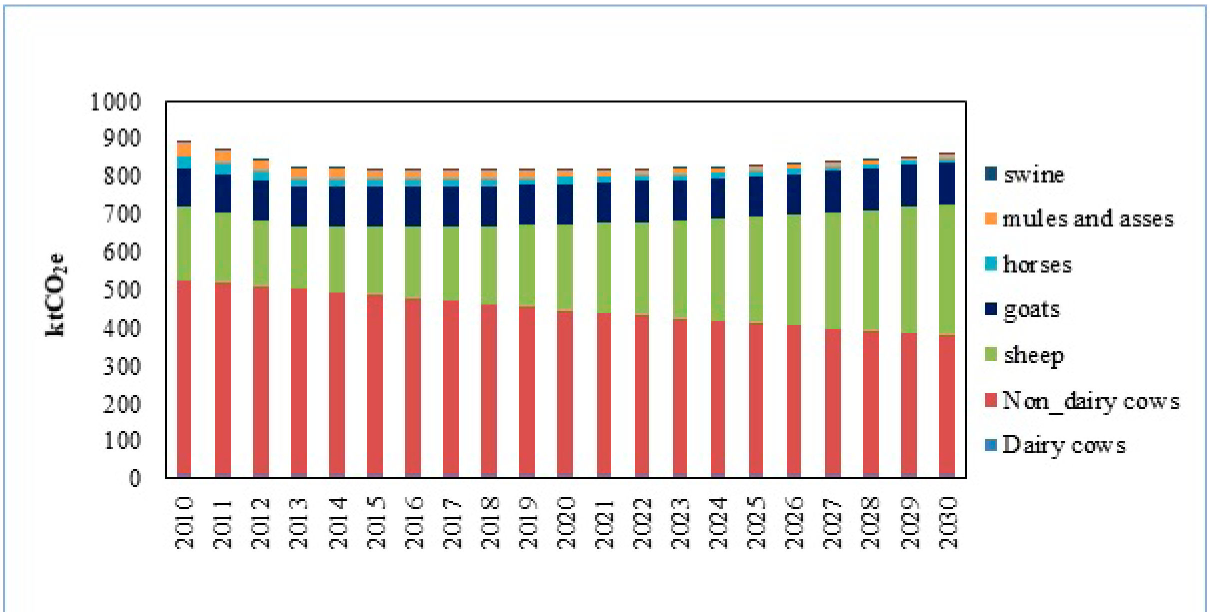


Figure 5.8: Enteric Fermentation Baseline Emissions

Table 5.4: Livestock Enteric Fermentation Baseline Projections

Livestock	2010(ktCO$_2$e)	2020 (ktCO$_2$e)	2030 (ktCO$_2$e)
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

5.3.4.2.2 Waste Sector Baseline Projections

Emissions from the waste sector are primarily from methane from wastewater treatment, which accounts for about 90 percent of total emissions for the base year 2010. Under the baseline scenario, these emissions are expected to increase from 266.20 ktCO$_2$e in 2010 to 303.26 ktCO$_2$e due to population increase (Figure 5.9). Table 5.5 presents the baseline emissions for the waste sector.

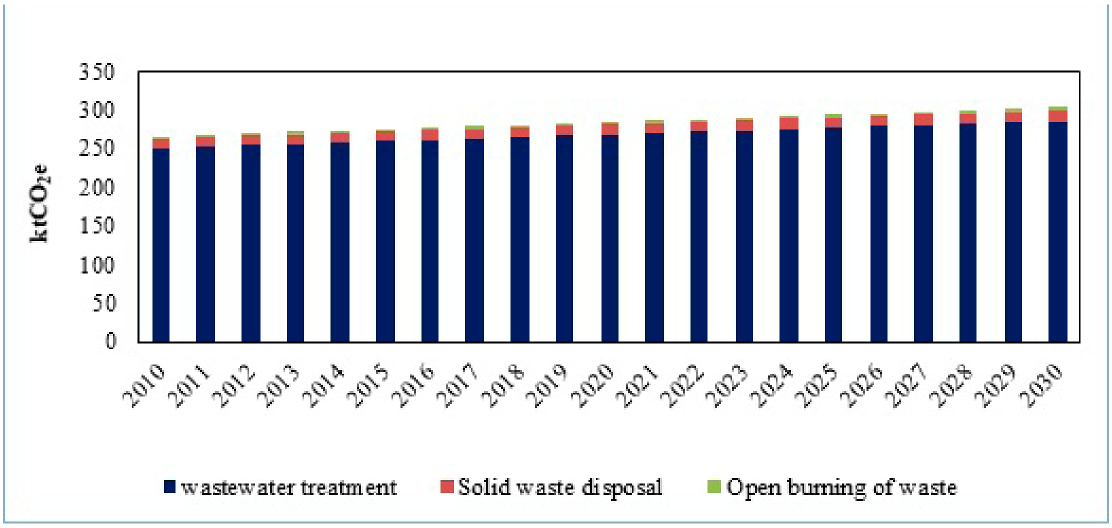


Figure 5.9: waste Sector Baseline Projection Emissions

Table 5.5: Waste Baseline Emissions

	2010 (ktCO$_2$e)	2020 (ktCO$_2$e)	2030 (ktCO$_2$e)
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**

5.4 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 measures was selected.

5.4.1 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 reduction of GHG emissions on 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.

5.4.2 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, namely: the Marginal Abatement Cost assessment, as well as the Multi-criteria assessment. Figure 5.10 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).

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.

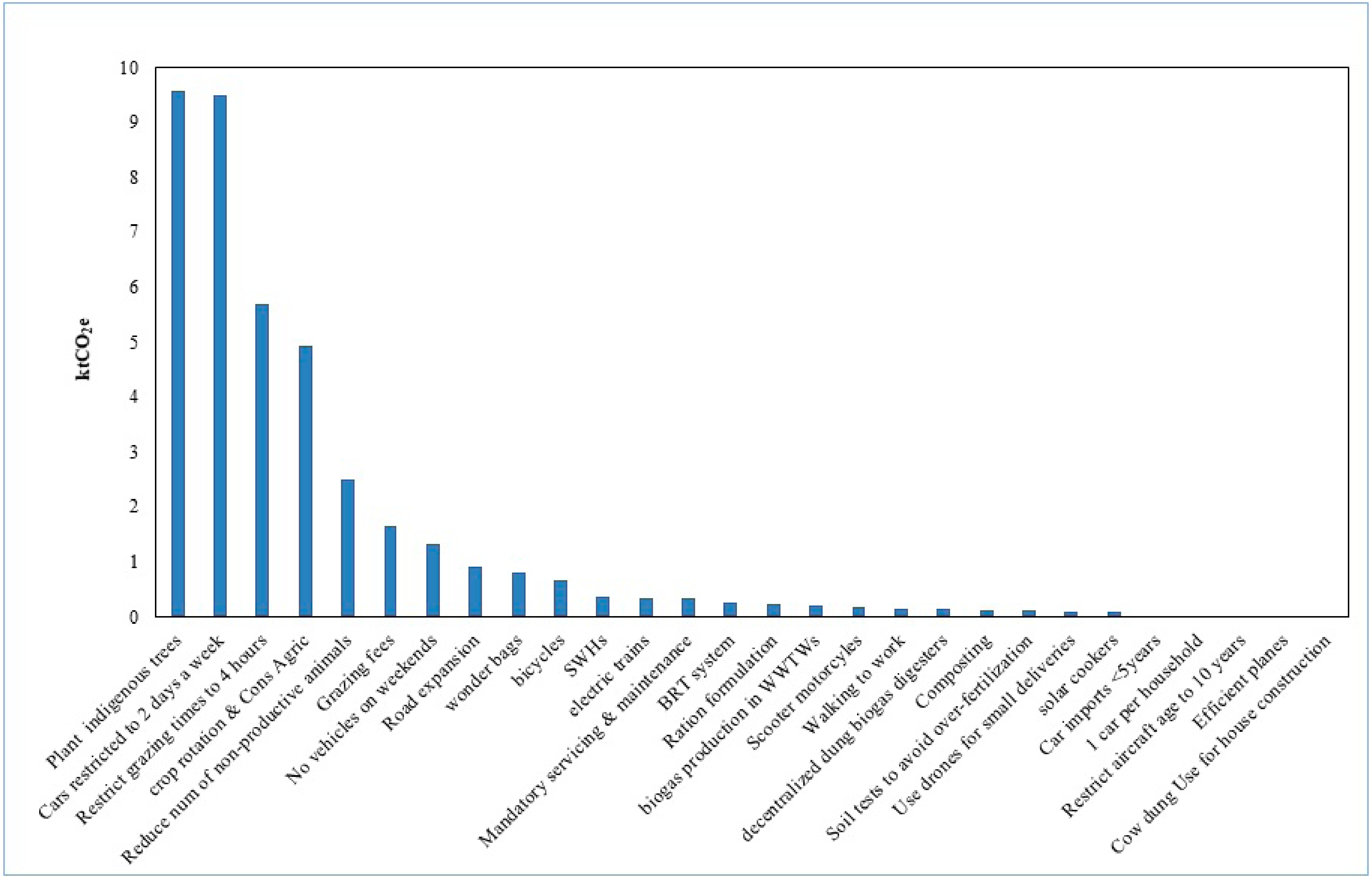


Figure 5.10: Mitigation potential of each measure

5.4.2.1 *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 4 below:

Equation 4

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

Figure 5.11 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 M 41,274 / tCO_2e), followed by walking to work (it saves M 3,771 / 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 M 2 / tCO_2e.

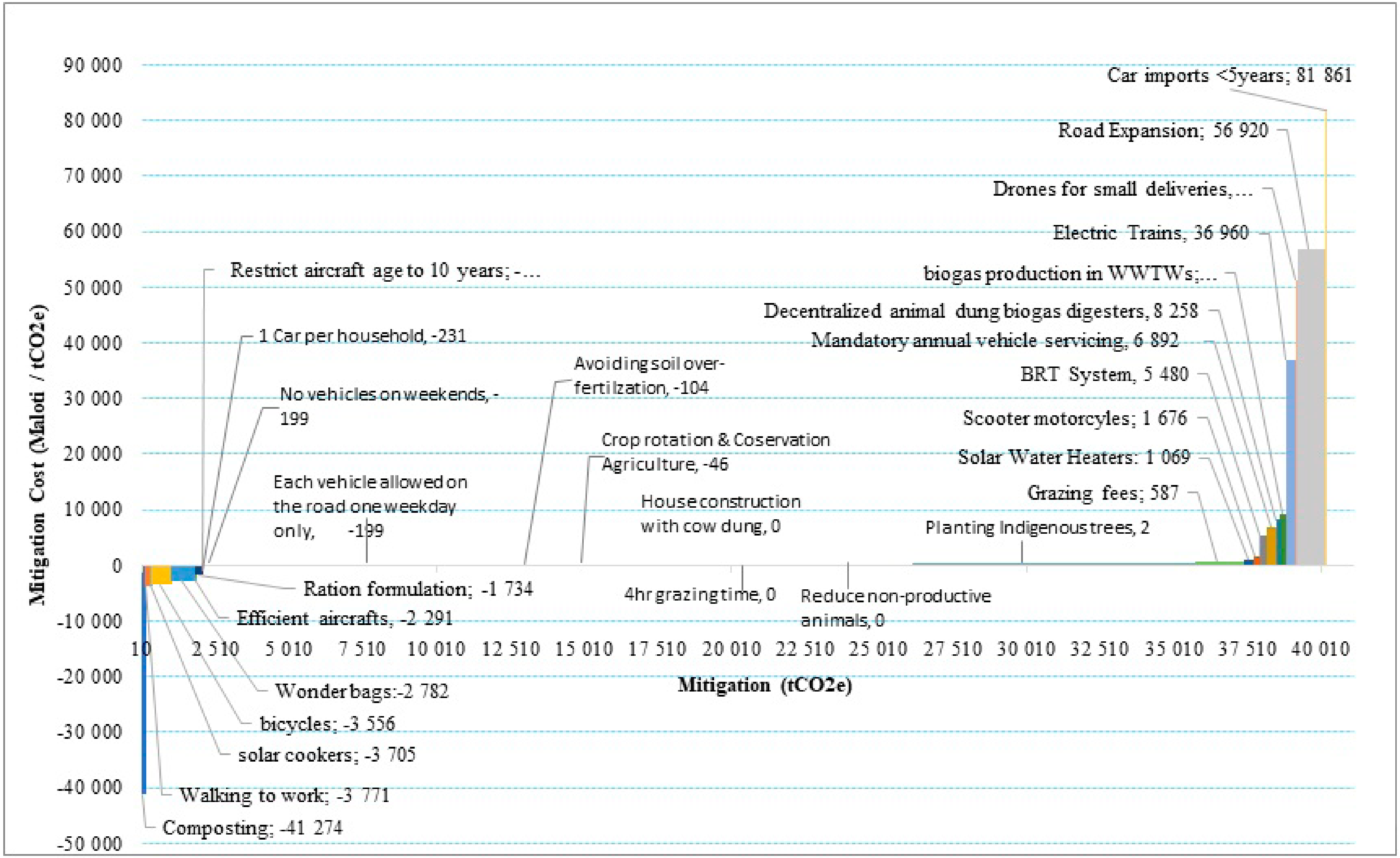


Figure 5.11: The Marginal Abatement Cost Curve (MACC)

5.4.2.2 *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 5.6 below presents all the criteria used in the multi-criteria assessment as well as their allocated weights.

Table 5.6: 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 percent, while the ability to boost other sectors was allocated the least weight of 4 percent. 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 percent and 15 percent, respectively.

Figure 5.12 below present the results of the multi-criteria assessment of mitigation measures. 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.

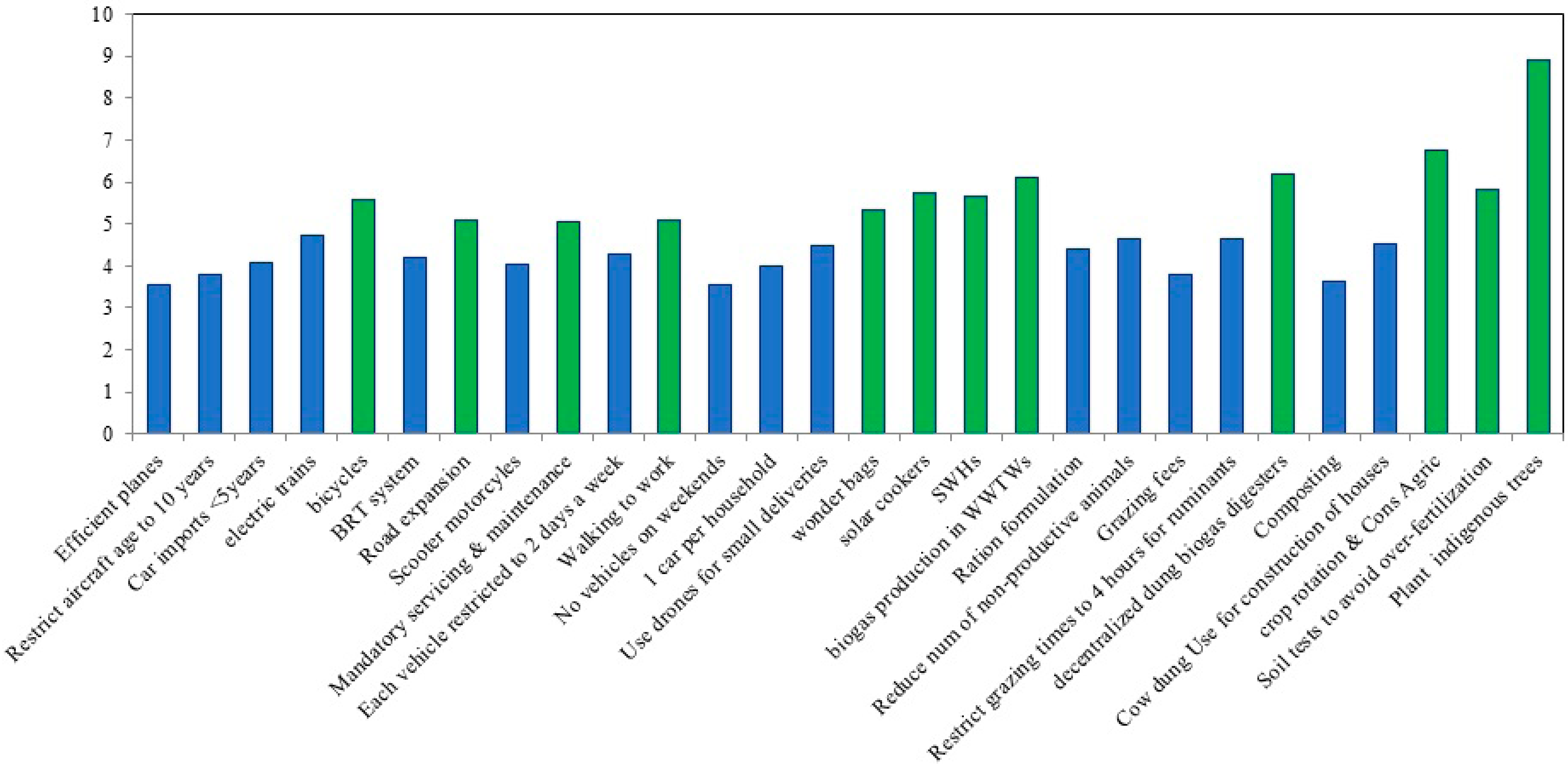


Figure 5.12: Results of the multi-criteria assessment of mitigation measures

5.5 MITIGATION SCENARIO

While the assessment of mitigation measures was based on mitigation potential in the various sectors for the period of 2011 to 2030, two alternative mitigation scenarios are presented below, depending on the year in which implementation of mitigation measures 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.

5.5.1 2011 – 2030 Mitigation Scenario

Figure 5.13 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$_2$e in the first year and increases to 1,142 ktCO$_2$e in 2017 and finally to 1,183 ktCO$_2$e by 2030.

The total cumulative mitigation for the entire period amounts to 20,276 ktCO$_2$e. The planting of indigenous trees is the highest contributor at 47.22 percent, followed by crop rotation coupled with conservation agriculture at 24.34 percent. The least contributor is the introduction of solar cooker boxes at 0.41 percent. 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 5.14 below. Figure 5.15 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$_2$e in 2011 (from 5,215 ktCO$_2$e) and ultimately to 4,557 ktCO$_2$e from 5,740 ktCO$_2$e by 2030. This implies a 20.6 percent reduction from baseline. The net implementation cost of this mitigation scenario is estimated at M 51.3 billion.

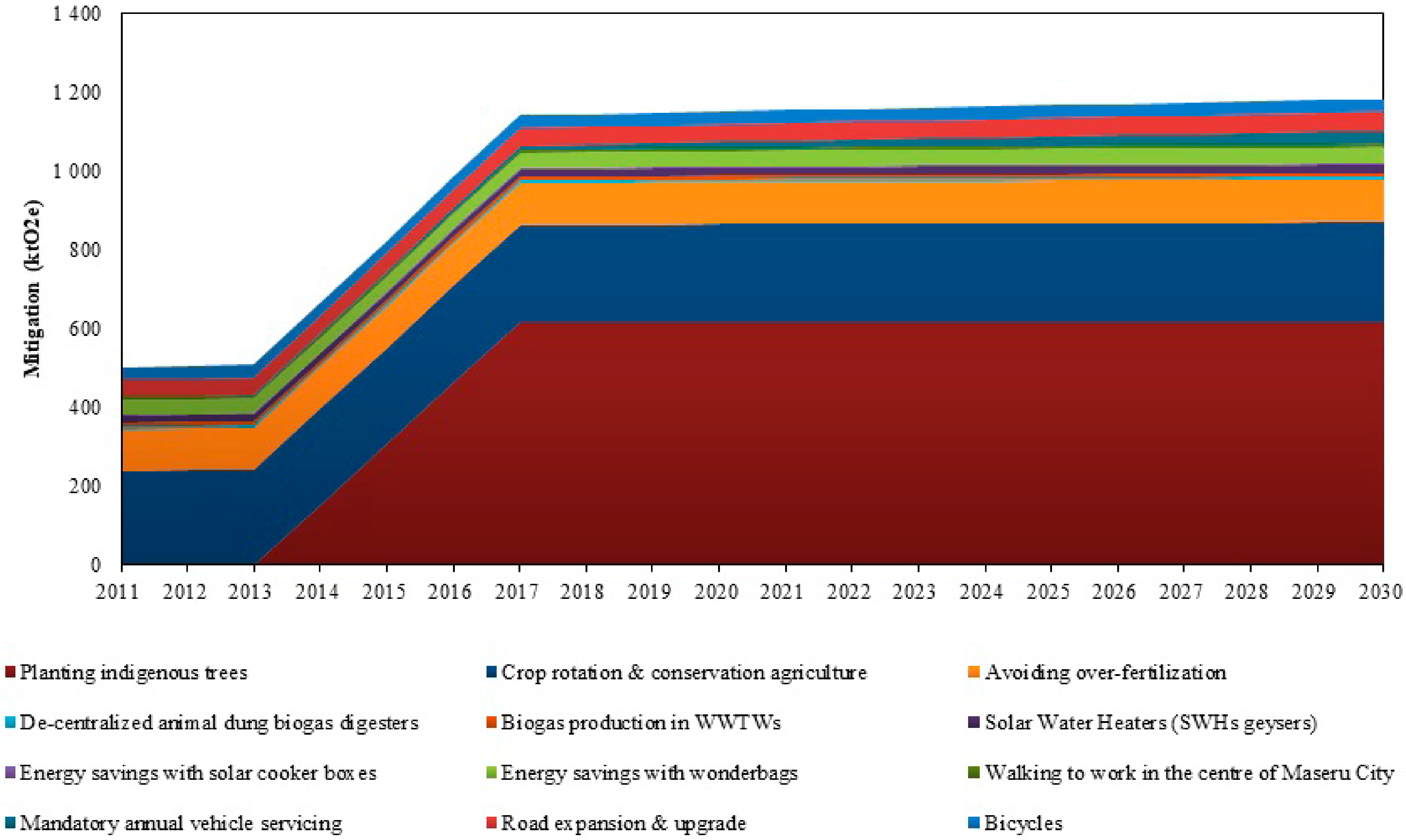


Figure 5.13: Mitigation potential of the twelve (12) selected measures between 2011 and 2030

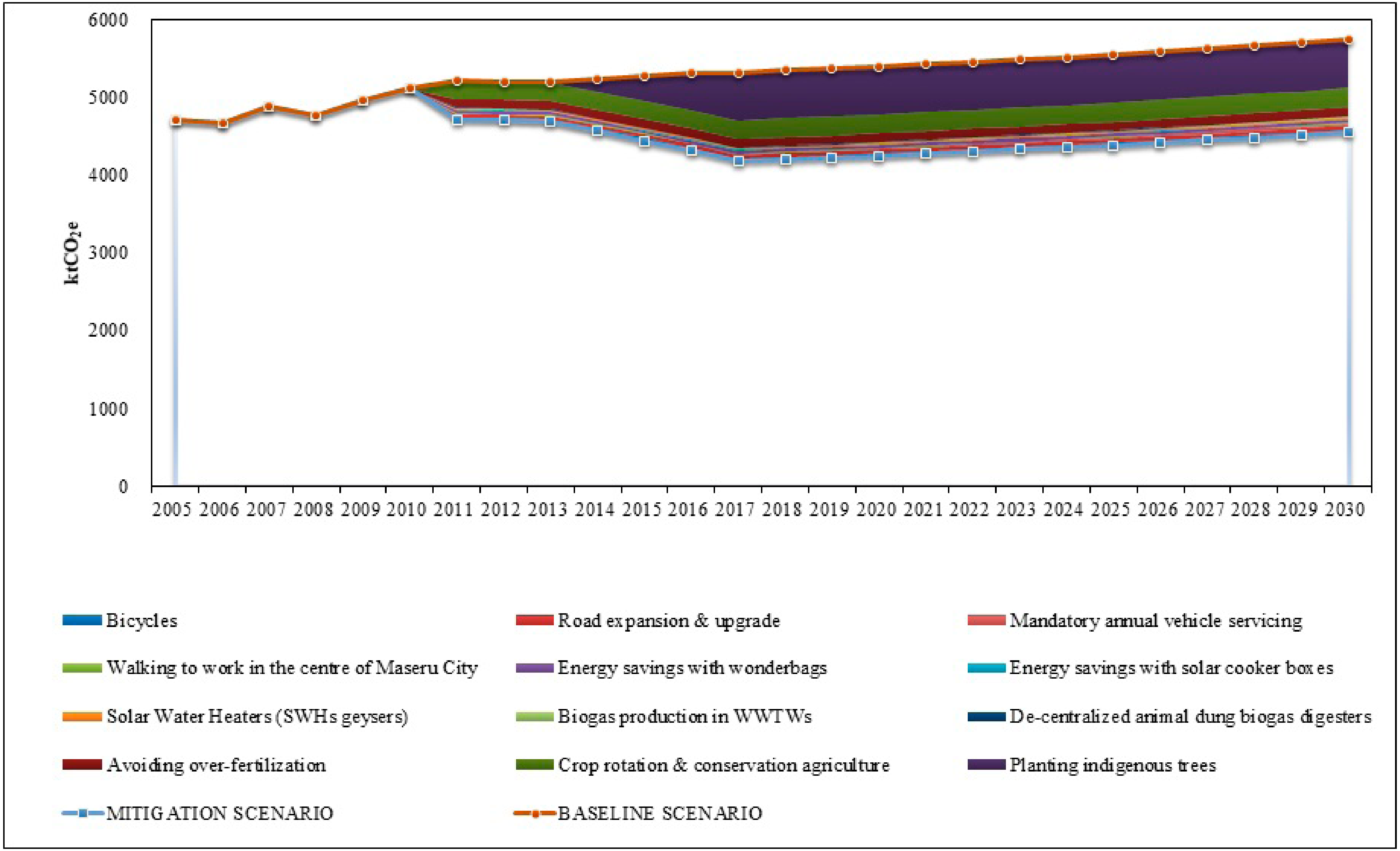


Figure 5.14: Development of the mitigation scenario

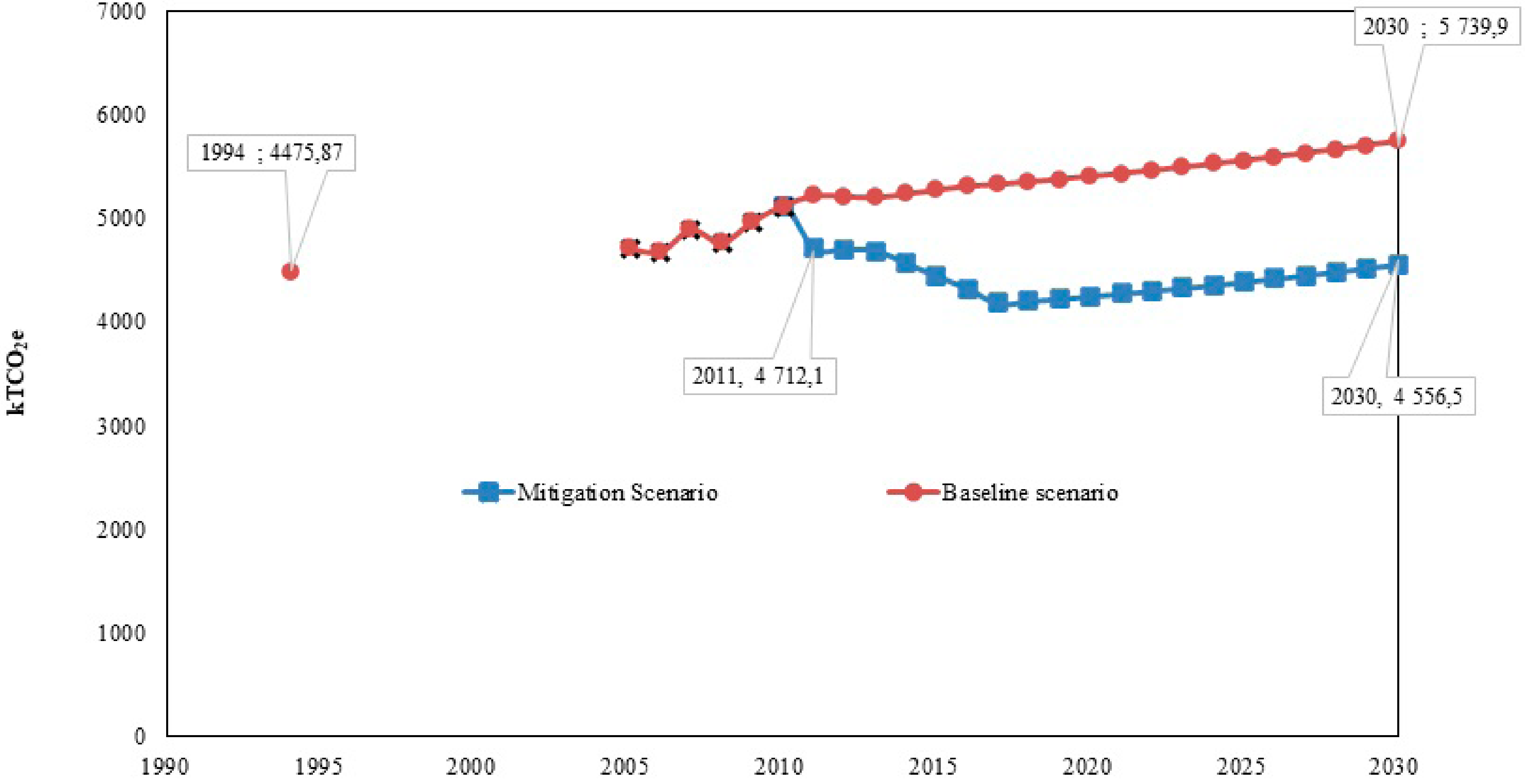


Figure 5.15: The 2011 – 2030 mitigation scenario compared with the baseline scenario

5.5.2 2020 – 2030 Mitigation Scenario

In this version of the mitigation scenario, implementation is assumed to only start in 2020 as shown in Figure 5.16. The mitigation scenario is made up of the same twelve (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 5.17 below presents the 2020-2030 mitigation scenario and compares it with the baseline scenario. Under this mitigation scenario emissions are reduced from 5,403 $ktCO_2e$ to 4,714 $ktCO_2e$ in 2020 and from 5,740 $ktCO_2e$ to 4,557 $ktCO_2e$ in 2030. This is also a 20.6 percent reduction from baseline.

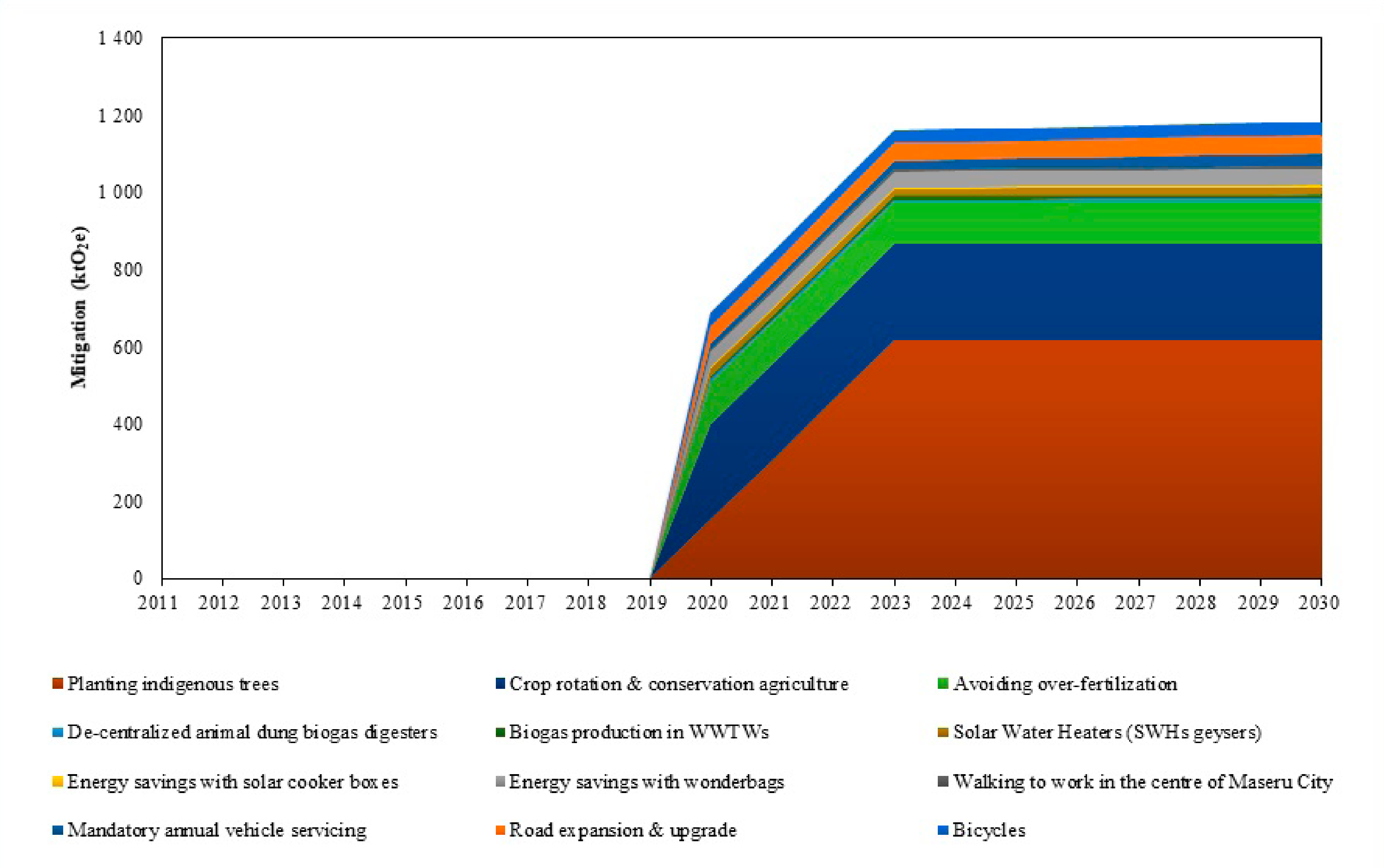


Figure 5.16: Mitigation potential of the selected mitigation measures implemented from 2020

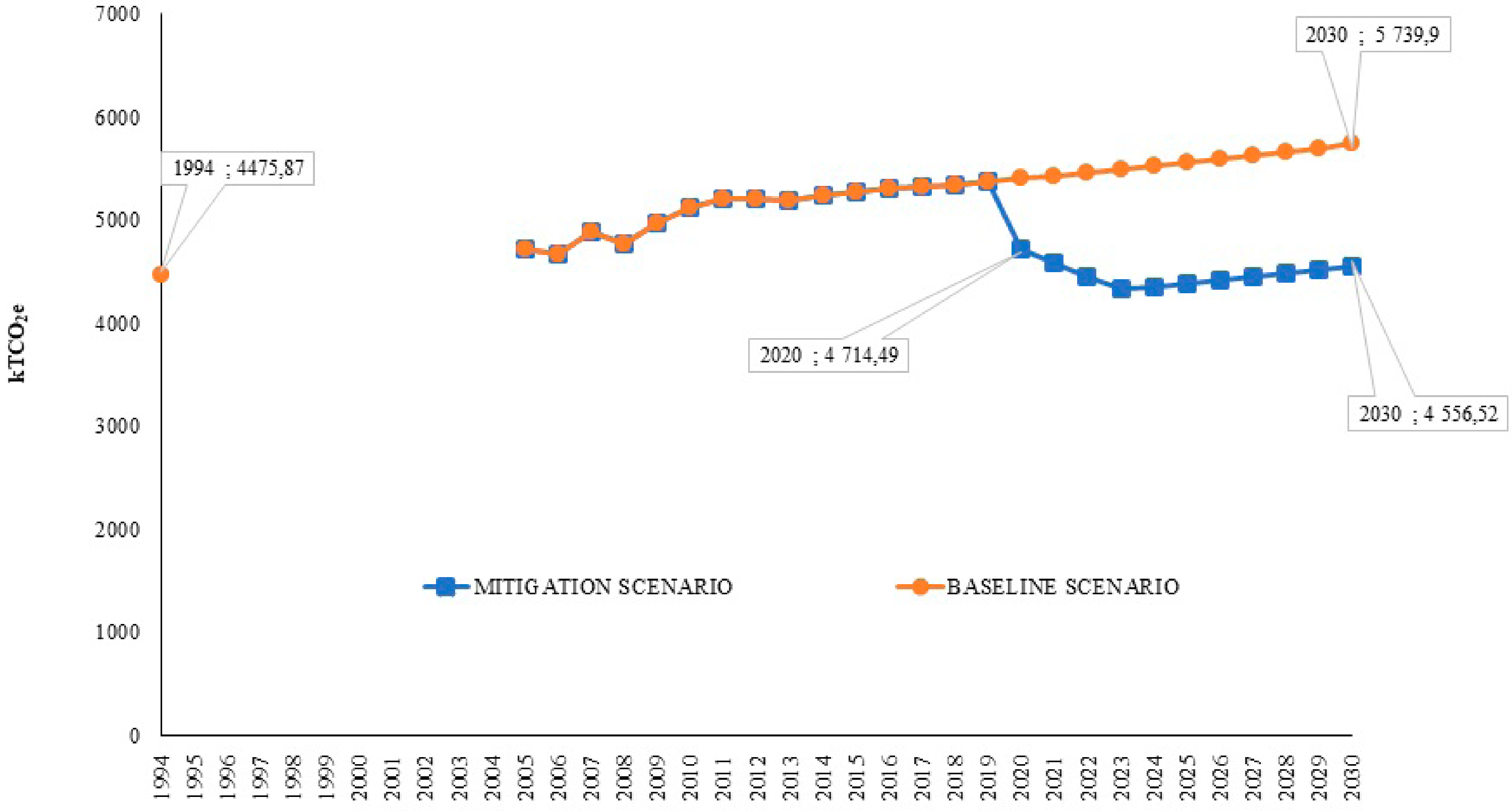


Figure 5.17: The 2020 – 2030 mitigation scenario compared with the baseline scenario

5.5.3 Benchmarking

The NDC submitted by Lesotho under the UNFCCC was used to benchmark the emission reduction potential determined in this study. Figure 5.18 is an extract from Lesotho's submitted NDC, showing the conditional and unconditional mitigation scenarios, while Figure 5.19 compares the reductions from those scenarios with the reduction of the mitigation scenarios in this study by 2030.

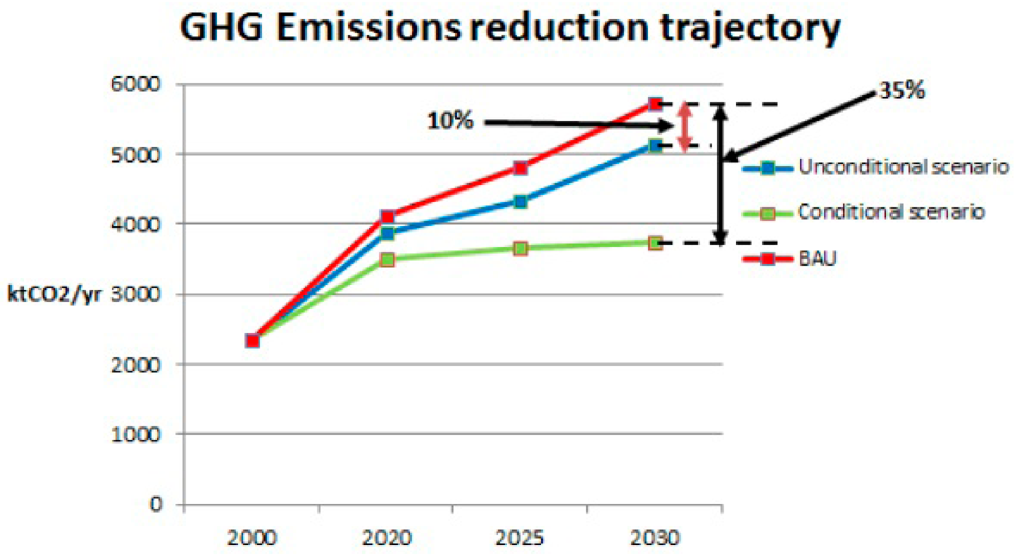


Figure 5.18: Lesotho's GHG emissions reduction trajectories in the NDC

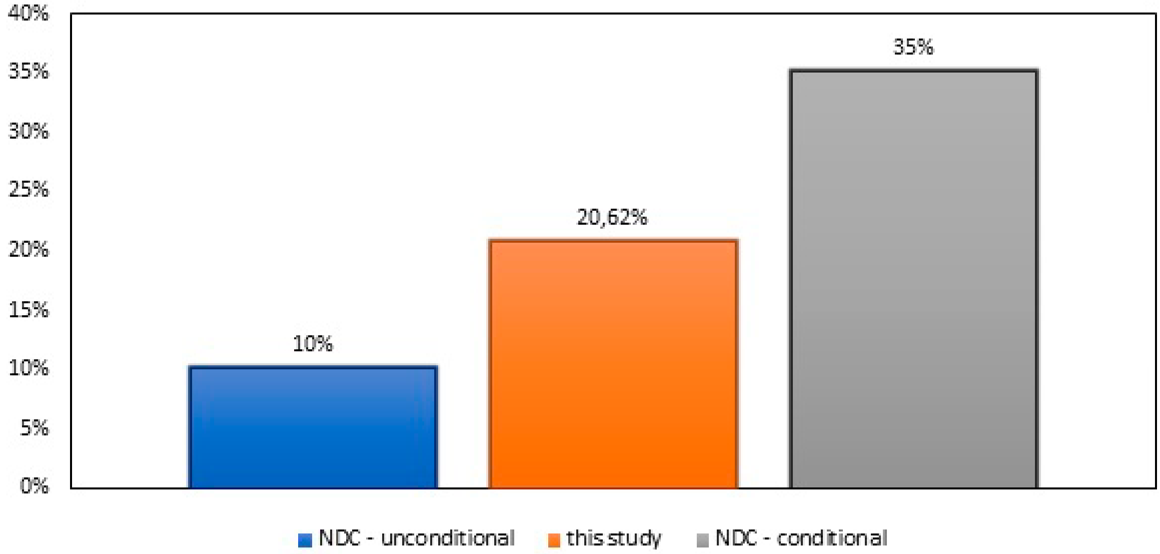


Figure 5.19: Comparison of the GHG reductions in this study and in the NDC

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 percent, but not sufficient to achieve its conditional target of 35 percent. The 10 percent unconditional target could be achieved at a net saving of M5.9 billion, though the mitigation measures shown in Table 5.7 below.

Table 5.7: The Mitigation Measures & Costs that could be used to Achieve Lesotho's unconditional NDC Target

	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	**-5,896.4**

The study presents this as the most effective way of achieving the 10 percent unconditional target, based on the results of the Multi-Criteria Analysis. Achievement of the conditional target of 35 percent would require additional mitigation measures over and above the twelve (12) measures selected through the multi-criteria analysis.

5.6 CONCLUSION

Lesotho has already undertaken several actions to support mitigation based on national circumstances. Such actions include extensive investments in hydro, solar and wind power potential, as well as embarking on rural electrification and afforestation projects. For the country to realize full potential in contributing to global mitigation efforts, substantial support from the international community is imperative.

Lesotho's NDC had set out the mitigation targets against a BAU projection considering reduction of emissions in four (4) socio-economic sectors, namely: Energy; AFOLU; IPPU; 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.

5.7 REFERENCES

1. Bureau of Statistics, 2009. 2006 Lesotho Population ANALYTICAL REPORT Volume IIIA Population Dynamics. Ministry of Finance and Development Planning Bureau of Statistics, Maseru. Maseru, Lesotho.
2. Central Bank of Lesotho, 2013. Lesotho Outlook Report- October 2013. Central Bank of Lesotho, Maseru. Maseru, Lesotho.
3. Central Bank of Lesotho, 2015. Lesotho Outlook Report- November 2015. Central Bank of Lesotho, Maseru. Maseru, Lesotho.
4. Central Bank of Lesotho, 2018. Lesotho Outlook Report- December 2018. Central Bank of Lesotho. Maseru, Lesotho.
5. LMS, 2018. Lesotho's Third Greenhouse Gas Inventory Report. Lesotho Meteorological Services. Maseru, Lesotho.
6. Tongwane, M., Piketh, S., Stevens, L. and 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.

CHAPTER 6

OTHER INFORMATION

6.1 INTRODUCTION

This chapter provides a synopsis on other related information relevant to the achievement of the Convention. This incorporates the Government of Lesotho's policies, strategies and programmes. It contends that Lesotho needs a long-term climate change strategy which will assist to integrate climate change into national policies and programmes. There is need to capacitate institutions such as LMS so that they will be able to effectively plan and implement climate change initiatives.

The chapter explains that the National Curriculum Development Centre (NCDC) must incorporate climate change and related issues in the primary and secondary school syllabi. A Climate Change Education Toolkit for Teachers has been developed which covers the basics of climate, global warming, climate change, mitigation and adaptation, the UNFCCC, government policies and plans and climate change mainstreaming.

The chapter also raises the need to improve the level of awareness and understanding climate change issues. Efforts to promote information sharing at national, regional and international levels are discussed, with an emphasis on stakeholder involvement at all levels.

Technology transfer developments since the previous first and second national communication are also presented in this chapter together with identified needs that still exist in key economic sectors in Lesotho. A number of sector specific technology transfer projects, needs and limitations are also discussed.

6.2 RESEARCH AND SYSTEMATIC OBSERVATIONS

The climate system is complex, and any enduring policy direction can only be based on long-term, high-quality observations and comprehensive assessments of the best available science. The UNFCCC calls on country Parties to promote and cooperate in Research and Systematic Observation (RSO) of the climate system, through exchange of information and support to international programmes and networks. The scientific understanding of climate change is based on a solid physical – theoretical foundation supported by long-term observations and research.

The Government of Lesotho, in its pursuit of sustainable socio-economic development, drives a continuing effort to promote the development of collaborative programmes in building resilience to climate change through research and systematic observations. This endeavour is supported by the Lesotho's NCCP (2017-2027) where '*strengthening of climate warning systems including research and systematic observations*' has been identified as one of the policy statements.

6.2.1 Research

Climate change poses challenges that are different from other risks that people normally deal with. Climate change processes have considerable long lag times so consequences of decisions made today will be dealt with by the future generations. Research efforts over time have provided much needed information to decision makers about the known and potential risks posed by climate change. Experts from a diverse range of disciplines have also identified and developed a variety of actions that could be taken to limit the magnitude of future climate change or to adapt to its impacts. However, there is still much that needs to be learned. Investments in scientific research can be expected to improve understanding of the causes and consequences of climate change. In addition, the nation's research initiatives could potentially play a much larger role in addressing questions of interest to decision makers as they develop, evaluate and execute plans to respond to climate change.

Due to the complicated nature of decision making which involves assessment judgments, science alone cannot prescribe the decisions that should be made. However, scientific research can play a key role by informing decisions, by expanding and improving the portfolio of available options. Decision makers of all types, including businesses, government and individual citizens, are beginning to take actions to reduce the risks posed by climate change, including actions to limit its magnitude and actions to adapt to its impacts. Effective management of climate risks requires decision makers to take actions that are flexible and robust, to learn from new knowledge and experience and to adjust future actions accordingly. The long-time lags associated with climate change and the presence of differential vulnerabilities and capacities to respond to climate change represent tough management challenges. These challenges also have significant implications for the nation's climate science initiative.

Additional research, supported by expanded observational and modelling capacity, is needed to improve understanding of key climate processes, improve projections of future climate change and evaluate the potential for abrupt changes in the climate system. The following are some of the most critical research needs for continued improvements in the country's ability to understand, observe and project the behaviour of the climate system:

- Improve understanding of how the climate system will respond to different forcings;
- Refine the ability to project interannual, decadal, and multidecadal climate change, including extreme events;
- Advance understanding of feedbacks and thresholds that may be crossed that lead to irreversible or abrupt changes; and
- Expand and maintain comprehensive and sustained climate observations to provide real-time information about climate variability and change.

Lesotho, like the rest of the LDCs is considered to be data poor and lacking in peer reviewed research to facilitate trend analysis as it relates to climate change and the incorporation of findings into key assessment reports, such as those prepared by the Intergovernmental Panel on Climate Change. However, Lesotho continues to play its part by carrying out climate change related research. Climate change related research is carried out by a limited number of institutions. In most cases climate change related research is mainly driven by project initiatives, which are largely donor funded.

A great majority of climate change vulnerability and adaptation research in Lesotho is mainly focused on ecological assessment and identifying the vulnerability of households. In addition, most research is conducted at national and regional levels, with a gap in scientific evidence at a local level to inform policy decisions for effective smallholder adaptation.

Climate change mitigation research has focused on issues related to GHG emissions reductions in the highly emitting sectors and on the enhancement of GHG sinks and reservoirs. Research has also been undertaken to investigate issues related to the development and promotion of technologies that reduce or prevent anthropogenic emissions of GHGs.

6.2.2 Research institutions

The core of Lesotho's policies and national plans including research plans is the National Vision 2020 which was developed in 2001. In most cases research is embedded within the mandates and objectives of some institutions and sectors. As such climate change related research is carried out by quite a number of institutions when there is need for such research. For example, the Ministry of Forestry, Range and Land Reclamation is responsible for protection and rehabilitation of the physical environment through forestry, management of rangeland resources and control soil erosion. These interventions can only be properly implemented if they are well informed by scientific research. In this regard the ministry undertakes climate change and variability research to employ strategies that will withstand conditions brought about by the changing climate. The department also addresses issues that are related to curbing climate change such as rehabilitating degraded lands thus enhancing carbon sinks.

By virtue of LMS being the Government's arm on weather and climate related matters, the Department is the forefront runner in climate change related research. LMS through the National Climate Change Team has initiated and undertaken a number of climate change studies and assessments over the past several years to provide guidance on steps to be taken in responding to climate change and variability. Understanding of climate risks, however, is still limited and this is further compounded by lack of technical capacity to integrate climate risk management into national planning and development processes. In addition, systems to facilitate effective data management (data collection, analysis and dissemination/access) are still inadequate.

The NUL through its different faculties has in the past and continues to undertake climate change and variability related research. Most research in climate change looks into the impacts of climate change on different sectors such as agriculture, health, rangelands and water resources and also on mitigation of climate change.

The Energy Research Centre of the National University of Lesotho was established for the sole purpose of responding to the country's energy and climate change challenges. The Centre responds to the challenges by developing and adapting knowledge and technologies that enable smooth transition to a sustainable energy system. The Centre also carries out an all-inclusive low carbon research work which covers solar, wind, hydro and bio-energy among others. The research work informs the formulation of the national energy policy for sustainable

development.
Research work under mitigation of climate change, especially in the energy sector, is undertaken in close collaborative work by the Energy Research Centre, DoE, Appropriate Technology Section and Non-Governmental Organisations (NGOs). Research activities in the energy sector mainly focus on the development of renewable energy technologies and consideration of alternative renewable energy sources with reduced GHG emissions. However, research is mainly driven by availability of funds.

The Appropriate Technology Section (ATS) within the Ministry of Communications, Science and Technology is mandated to carry out research, develop and apply appropriate technologies to achieve sustainable development, directed by continuous needs assessment and to foster a culture of continuous improvement. The section carries out research related to renewable energy technologies which in a way addresses issues of climate change mitigation although it is implicitly indicated. However, research is being carried out to a limited extent due to inadequate research capacity and management to carry out research agenda.

Agriculture is the backbone of Lesotho's economy and as such agriculture is given high priority in the country while at the same time the sector's activities are driven by weather and climate conditions. The Department of Agricultural Research by virtue of being the Government's arm on all agricultural related research has been in the forefront in assessing impacts of climate change on the agriculture sector and developing strategies on how best to respond to the impending weather and climate conditions. In its research, the department also takes into consideration ways in which the sector can reduce its GHG emissions. In undertaking these research initiatives, the department works in close collaboration with LMS, Lesotho Agricultural College, Lesotho College of Education, the National University of Lesotho and NGOs.

While working in close collaboration with other role players in the water sector, the Department of Water Affairs (DWA), also undertakes research on the impact of climate change on Lesotho's water resources and has come up with strategies on how well the sector can adapt to the impending climate variability and change. As in the other sectors' undertakings, research in this sector is mainly driven by donor funding.

Climate change and climate variability related research can be further enhanced through strengthened collaboration between research institutions such as NUL, Lerotholi Polytechnic, Limkokwing University of Creative Technology, Lesotho College of Education, industry, government departments and NGOs. Strengthened collaboration among major role players in research can alleviate the problem of lack of funding resources. It can also curb the issue of duplication of activities.

6.3 SYSTEMATIC OBSERVATIONS

Long-term, high quality observations of the environmental system are essential for defining the current state of the earth's system, its history and its variability. The task requires both upper air and surface-based observation systems. Climate observations encompass a broad range of environmental observations, including a) routine weather observations which when collected over a long period of time, can be used to help describe a region's climatology; b) observations collected as part of research investigations to explain processes that contribute to the maintenance of climate patterns or to their variability; c) continuous observations of climate variables collected for the purpose of documenting long-term change; and d) observations of climate proxies, collected to extend the instrumental climate record in remote areas and back in time to provide information on climate change for longer time periods/scales.

Data management is an important aspect of any systematic observing effort. Different institutions have separate mandates for climate focused and related systematic observations, and for the attendant data processing, archiving and use of the important information from these observing systems. In Lesotho, systematic observations which include weather surface based and hydrometric observations are carried out by different institutions in order to address their institution's mandates and needs.

6.3.1 Weather Surface Based Observations

Lesotho, like the rest of the global community, contributes to the development and operation of global observing systems that combine data inputs from operational observing platforms to provide a comprehensive measure of climate system variability and climate change. Lesotho also collaborates with other international partners to enhance observations and improve data quality and availability.

By virtue of being a Member State of the Southern African Development Community (SADC) and of the World Meteorological Organization (WMO), Lesotho therefore constitutes an integral part of the regional and global system or network of the WMO programmes and structures. As a member state of SADC, it has obligations under the SADC Protocol on Transport, Communications and Meteorology (1996) which states that member states shall develop a co-operation framework with the aim of among others, to strengthen weather and climate monitoring systems; strengthen meteorological research capacity in the region; improve climate monitoring network and to make use of new technology especially satellites and other sensing applications.

6.3.1.1 *Lesotho Meteorological Services*

LMS is the custodian of weather and climate data records in the country. LMS operates a network of 117 stations, some of which have records dating as far back as the late nineteenth century. However, there is inconsistency in the distribution of weather stations between the different agroecological zones. There is a high concentration of stations in the lowlands and few stations over the mountain areas mainly due to vandalism and limited accessibility.

Out of the 117 meteorological stations operated by LMS only 3 have been registered with WMO. Data from these registered synoptic stations are supposed to be shared according to Global Climate Observing Systems (GCOS) requirements. However, due to financial and security constraints these synoptic stations only operate during daytime. A total of 21 stations have been automated, with some being fully operational while others require technical assistance to operate fully. Of the remaining stations that are not automated, 37 are climate stations most of which are still using mercury containing equipment therefore there is need for replacement, in compliance with the Minamata Convention on the phase-out of the use of mercury by 2020. There are 47 manual rainfall stations and 3 solar radiation stations measuring Global irradiance, direct irradiance and diffused irradiance since 2012. There are also 6 wind stations, measuring Wind Speed and Wind Directions at different heights and some date as far back a 2000 while others started operating in 2012.

6.3.1.2 *Others*

Other than the LMS, there are other institutions which carry out their own weather observations and keep their own records. Institutions such as the NUL, Lesotho Highlands Water Authority (LHWA) and DAR have their own weather stations. NUL used to have one meteorological observation station and keep its own weather and climate records. Department of Agricultural Research operates 1 weather stations in Mohale's Hoek since 2017. Lesotho Highlands Development Authority operates 11 meteorological stations around the Katse and Mohale catchment areas. It also has three functional Automatic Weather Stations which are located at the Katse, Mohale and 'Muela dam sites. However, stations which do not fall under the jurisdiction of LMS do barely make use of WMO reporting Guidelines on Global Observing Systems. This impediment calls for a coordinated effort among different role players in weather and climate observations to avoid duplication of activities and standardized way of reporting and archiving weather and climate information.

6.3.2 Hydrometric Observations

DWA is the custodian of hydrometric observations in the country. DWA operates a network of 105 hydrometric stations. The network dates as far back as 1956. DWA also operates 4 SADC HYCOS stations. The Lesotho Highlands Development Authority operates a network of 19 hydrometric stations along the tributaries of the Senqu River upstream in the Mokhotlong district and downstream in the Quthing district. LHDA's network is mainly intended to monitor flow of water to South Africa in order to avoid mismanagement of water flows.

6.3.3 Satellite Observations

Lesotho has also benefitted from the Monitoring for Environment and Security in Africa (MESA) programme, a European Union funded project that was aimed at generating and providing decision-makers with regular and sustainable access to earth observation information relating to drought, agriculture, wildfires and floods. The information produced under this programme is kept in different institutions' databases such as LMS, DoC, DOE, DWA and the NUL.

In as much as the country has advanced so much in trying to meet its systematic observations obligations, there are still issues that need to be addressed. There are challenges related to the observational network which does not address the needs of the country. Siting of stations is compromised by issues related to safety and accessibility to sites, inadequate instrumentation due to limited financial resources, inefficient data management systems and poor telecommunication systems for collecting and disseminating information.

6.4 CAPACITY BUILDING

Capacity building is a wide-ranging concept that includes, amongst other activities, human resources development through focused training; adoption of mentoring and learning-by-doing approaches; empowerment of relevant institutions at various levels and enhancing observations, research and knowledge management. In addition, it also focuses on strengthening communication, education and awareness-raising at all levels, especially at local levels; strengthening and using regional networks of information and knowledge sharing; encouraging and strengthening participatory and integrated approaches in planning and decision-making; sharing experiences, information and best practices; development of tools, methods and technologies, and support for their application; and assessing, strengthening and mobilizing the capacities of existing relevant facilities and institutions.

In this respect, this section deals with the needs, options and priorities in building capacity for climate change initiatives in Lesotho; capacity solutions resulting from the promotion of south-south cooperation; the promotion of stakeholder involvement in climate change initiatives and the status of climate change capacity-building activities.

6.4.1 Needs, Options and Priorities

As early as 2000 when Lesotho prepared its INC, capacity constraints to sensitize both policy-makers and planning authorities about the risks of climate change and possible mitigation and adaptation measures, as well as to directly influence either sectoral programme content or the nationwide allocation of resources, were cited as major challenges to the development of a National Climate Change Action Plan.[1] Following this observation, in 2007 Lesotho concluded its National Capacity Self-Assessment Project[2] whose objective was to identify national capacity needs to address environment and climate change issues in the country. The assessment concluded that there was a severe lack of capacity at all levels to effectively develop and implement environmental and climate change initiatives in Lesotho.

Lesotho also concluded its National Adaptation Programme of Action (NAPA) in 2007.[3] This document also recognized that insufficient financial resources, inadequate institutional capacity, the shortage of human resources with requisite environmental expertise and skills, both at the community and institutional levels, and low awareness levels hindered progress towards the implementation of climate change initiatives. This conclusion was echoed by the Stakeholder Capacity Development Needs Assessment in CCA that was carried out in 2011 with the assistance of the Africa Adaptation Programme (AAP) Lesotho.[4]

Amongst several capacity challenges that were singled out by the above assessments were: limited availability of technical skills, lack of up-to-date climate information and technology, limited availability of best-practice and experiences to inform the design of locally appropriate solutions, weak institutional coordination and low research capacity.[5] To deal with these challenges, six of the eleven priority development areas that were identified under NAPA either focused on climate change or related educational, training and public awareness components. Similarly, of the 51 adaptation actions that were listed in Lesotho's Nationally Determined Contribution under the UNFCCC,[6] 30 and 34 respectively included capacity-building and technology requirements as major components, and of the 24 mitigation actions that were listed, 22 and 23 respectively included the same as major components.

A stocktaking and gap analysis, amongst other initiatives, that was undertaken in 2010 under the auspices of the SADC Sub-Regional Framework for the Development of Climate Change Programmes,[7] found that technology transfer, capacity-building and financing were specific measures that would be required in order to enhance the implementation of climate change programmes in Southern Africa in general, and in Lesotho in particular. The Gap Analysis emphasized the need to strengthen national government institutions through various capacity building interventions that include training to acquire requisite technical skills, policy review to inculcate climate change issues as an emerging phenomenon in sectoral policies and accessing and using appropriate technologies.

At the sector level, the challenges were identified as inadequate expertise and low institutional capacity, as well as unclear policy guidance on appropriate adaptation and mitigation actions; weak climate related data; inadequate funding for implementation, and the absence of a coordinated reporting system. A 2011 assessment of capacity strengthening for CCA in agriculture in Lesotho[8] also found that inadequate institutional and technical capacity at the national, district and community levels presented itself as one of the main barriers to the implementation of NAPA priorities. In terms of capacity-building, the country intends to focus on strengthening the climate change governance framework; enhancing communities' resilience; promoting stakeholder involvement at all levels particularly focusing on the youth, civil society, women and the private sector; implementing education, training, public awareness and communication programmes and promoting research and development, innovation and technology transfer.[9]

Frameworks for capacity building in developing countries were agreed to during the COP 7 in Marrakech, Morocco in 2001. These frameworks are also intended to serve as a guide for climate change capacity building activities of the Global Environment Facility (GEF) and other funding bodies[10] that support adaptation and mitigation actions in Lesotho.

6.4.2 Promotion of South-South Cooperation

South-South Cooperation (SSC) is "a process whereby two or more developing countries pursue their individual and/or shared national capacity development objectives through exchanges of knowledge, skills, resources and technical know-how, and through regional and interregional collective actions, including partnerships involving governments, regional organizations, civil society, academia and the private sector, for their individual and/or mutual benefit within and across regions".[11]

Lesotho has not yet taken full advantage of cooperation through the SSC and Triangular Cooperation mechanism. However, during the Fourth Tokyo International Conference on African Development (TICAD) in May 2008, the Africa Adaptation Programme (AAP) was established with the objective to enhance the adaptive capacity of vulnerable African countries and to promote early adaptation action and lay down foundations for long-term investment to increase resilience to climate change across 20 African countries.[12] The AAP implemented several projects, produced posters in the areas of wind and solar energy and built capacity in strategic development planning and climate change impacts assessment in health. In Lesotho, in particular, the AAP programme developed solar and wind atlases that identified the most efficient energy sources for rural communities.

The AAP also worked closely with the GEF funded Early Warning Project[13] to support the procurement, installation and maintenance of a high-performance computer (HPC) that is capable of storing and managing large data sets, facilitated the generation and analysis of climate data using models and promoted sharing climate data amongst participating countries. It also laid down a framework for the development of sectoral and multi-sectoral decision support tools, as well as for the development of an early warning system (EWS) that was inspired by that which was developed by AAP Ghana. The two projects also trained youth ambassadors who sensitised local communities on climate change; improved climate change institutional coordination; supported preparatory steps for the development of a Renewable Energy Policy and facilitated the inclusion of a climate change budget in the planning process.

Unfortunately, the AAP Team of Professionals had limited contacts with participating institutions in Lesotho since they were working with 20 African countries, a situation which eroded the sustainability of activities under this capacity building programme. On the other hand, NSDP I witnessed the implementation of several adaptive research activities by the Department of Agricultural Research (DAR) of the Ministry of Agriculture and Food Security (MAFS). Supported by SADC's Pan-African Bean Research Alliance (PABRA) Project through a north-south arrangement, and by the Food and Agricultural Organization's (FAO's) Technical Cooperation Programme (TCP), the trials included the nutritionally bio-fortified bean, early maturity maize and bean and high yield wheat varieties.

According to DAR researchers, evidence shows that farmers that practise conservation agriculture have been able to increase their yields even under drought conditions. However, the success of adaptive agricultural research in Lesotho and the application of research recommendations will depend on whether NSDP II will deal with, amongst others, the following capacity building challenges:

a. High staff turnover due to low salaries and poor working conditions;
b. Unstable policies due to frequent changes in government;
c. The absence of a clearly defined research policy with priorities; and
d. Lack of operational independence to propel collaboration with other research institutions in Southern Africa and with the private sector.

6.4.3 Promotion of Stakeholder Involvement

The successful implementation of climate change initiatives depends on the active support and effective participation of all stakeholders. Such participation offers an opportunity to build institutional and technical capacities, stimulate policy integration and promote inclusive development.[14] Awareness in climate related issues has thus been generated in every climate-sensitive sector of the Lesotho economy through, amongst others, attendance at international, regional and sub-regional events such as conferences, workshops and negotiating forums. Some of these engagements have been hosted by Lesotho itself with international risks, challenges and responses.

There are many other events that brought local, national and international stakeholders under a single roof which had capacity building impacts amongst staff of the LMS and other climate-sensitive sectors. Amongst others are the preparation of the 1st, 2nd and (currently) 3rd National Communications and the compilation of other reporting mouthpieces like the 2005 United Nations Development Programme (UNDP) - supported Nationally Determined National Assessment, the 2007 GEF/UNEP supported NAPA, the 2008 Africa Adaptation Programme (AAP) under the Japan-UNDP supported Joint Framework for Building Partnership to Address Climate Change in Africa, the 2017 Lesotho's Nationally Determined Contribution (NDC) under the UNFCCC and more than 9 pieces of policies that were developed in climate-sensitive sectors.

The above events and actions have demonstrated the importance of stakeholders in identifying the most important issues emanating from climate change impacts and prioritizing adaptation and mitigation response measures. The stakeholders whose participation has often been solicited include climate sensitive government ministries, civil society organizations, academia, the private sector, the media, the cabinet, development partners and international NGOs at the national level and local councils, traditional authorities, traditional healers, community-based organizations (CBOs) and faith-based organizations (FBOs) at the local level. However, other than simple listing, no rigorous stakeholder analysis has been undertaken other than what is contained in the Draft National Climate Change Communication Strategy.

In 2013, LMS established a National Climate Change Committee (NCCC), an advisory body that acts as a stakeholder forum. However, of the 27 listed members of this Committee, 21 are drawn from government ministries. The rest represent NUL, non-governmental organizations, the private sector, community-based organizations and faith-based organizations.[15] UNDP, the European Union (EU) and the media are listed as observers. While the NCCC facilitates the coordination of climate change actions in various sectors, the non-state sector is underrepresented. However, at the sectoral level, government ministries and departments are encouraged to bring sector stakeholders into the fold of climate change issues in their respective sectors.

As expected, inclusive and participatory approaches have been used in the development of policies that have climate change content such as in agriculture, water resources, human health, renewable energy, gender and vulnerable groups, infrastructure development, environment, biodiversity and ecosystems, industry and industrial processes, tourism, land use, culture and other cross-cutting issues. Some of these policies and climate change guidelines were developed with the assistance of the Early Warning System Project, making climate change awareness raising campaigns quite effective.[16] There are also numerous projects whose implementation requires the extensive involvement of wide ranges of stakeholders, including development partners, national and international NGOs, local governments, the private sector, CBOs and other civil society organizations.

6.4.4 Status of Capacity-Building Activities

Lesotho recognizes that to effectively integrate climate change into national policies and programmes, there should be a long-term strategy to strengthen institutional capacities across focal, sectoral and local level institutions. During NSDP I, capacity-building activities at the national level focused on strengthening institutions for vulnerability assessments, the review of sector plans and programmes to improve the mainstreaming of climate change, upgrading of standards of infrastructure to climate-proof developments, promotion of access to climate change technologies and their usage, the promotion of climate smart agriculture, promotion of foreign and domestic investment in the production and utilization of environmentally friendly technologies, etc.[17]

Policy actions that have been adopted in support of capacity-building for climate change include, amongst others, strengthening the LMS to international standard of service provision so that it can give adequate support to climate-sensitive sectors and other stakeholders. In addition to AAP activities, the GEF and government of Lesotho funded and UNEP/UNDP executed Early Warning System Project undertook a number of capacity building activities that included the upgrading of the LMS website (www.lesmet.org.ls), setting up an early warning system, promoting climate change awareness in the media, facilitating the integration of climate change into the NSDPI, designing and piloting climate change syllabi for schools, facilitating the formulation of the NCCP and supporting the establishment of a multi-sector NCCC.

In 2009, the three-year Japanese Government funded project Supporting Integrated and Comprehensive Approaches to Climate Change in Lesotho was launched with the overall objective to improve technical knowledge, skills, information and resources to plan for and implement effective and timely climate change responses of all participating individuals, institutions and communities.

In 2015, staff from LMS, the Disaster Management Authority (DMA), the Ministry of Development Planning, and several climate-sensitive sectors participated in capacity building programmes under the auspices of the Early Warning System Project. Capacity improvements were reported in the areas of the reliability of hydro-climatic data, climate modelling, the early warning system operation, etc. However, the majority of sectors are still experiencing capacity deficits since the 'skills gap' at pre-project baseline has not shifted significantly.[18]

Another capacity building initiative worth mentioning is the Support to the Climate Change Response Strategy (2016/2017), a project that was supported by the Irish Government through the European Union (EU). This project assisted the development of the 2017 NCCP and its Implementation Strategy, the formulation of the National Sustainable Energy Strategy (NSES) and institutional capacity building for the implementation of these policies and strategies.

During the NSDP I period, a number of donors, notably the Food and Agricultural Organization (FAO) and UNDP, together with the Government of Lesotho, funded livelihood support adaptation programmes and projects in a wide range of NAPA priority areas where capacity building at the community level was a major component. The Lesotho Government, on its part, allocated between M130million and M150million per annum in support of sustainable integrated land and water management programmes that involved capacity building campaigns amongst communities and livestock herders. The country is also in the process of developing renewable energy potential maps, with the assistance of the Italian Government. It is expected that these maps will be published in February 2020.

The impacts of capacity-building programmes at the local level in Lesotho are severely constrained by challenges that include inadequate financial resources, overreliance on biomass for energy sources, overgrazing and poor law enforcement. In addition, while conservation delivers long-term benefits, poverty, which is widely prevalent in rural Lesotho, compels communities to pursue unsustainable immediate benefits.[19] These challenges tend to undermine the resilience of rural populations to climate change and threaten the sustainability of endemic natural resources, with the probability of propelling some of these resources to extinction.

6.4.5 Dissemination and Sharing of Information

Lesotho's Climate Change Policy (paragraph 3.1) recognizes that lack of information dissemination mechanisms on climate change and limited early warning dissemination networks pose challenges for the planning and implementation of the country's adaptation and mitigation programmes. As a result, one of the key objectives of this policy is to embark on capacity building; to create a platform for information sharing on climate change issues in the media community and to improve climate information dissemination networks.[20]

6.4.5.1 *Activities of the AAP and the Early Warning Systems Project*

During NSDP I, many climate change projects in Lesotho mounted capacity strengthening workshops for climate change information dissemination and sharing. The AAP and the Early Warning Project, in particular, supported institutional and community capacities and climate change information sharing that, amongst others, embarked on technological improvements at LMS, ran climate change workshops and launched climate inspired competitions for staff from print and electronic media houses.

As reiterated in earlier sections of this chapter, in 2015 an HPC computer was procured and installed at LMS with the support of the AAP and Early Warning Project. This has improved climate data dissemination by enhancing the capability of storing and managing large datasets, generating data to feed climate models and facilitating data analyses. Other capacity enhancement actions included sharing climate data with other stakeholders through a newsletter, an activity which has since collapsed due to funding limitations and the absence of communication and information technology positions in the staff complement of LMS. As a result, the LMS website (www.lesmet.org.ls) has not been updated to support the dissemination and sharing of climate data and information.

In 2013, the Early Warning System Project supported the mobilization of electronic and print media personnel for climate change reporting. After running a training workshop that was attended by 29 participants, the latter were invited to participate in competitions in the areas of climate related newspaper articles, feature stories, radio segments and television shows, adaptation and mitigation stories and climate reports. This initiative, which ran for two years, created extensive interest in climate change reporting in the local media, with 13 of the participants scooping prizes which were presented at a media covered Climate Change Media Awards Ceremony in 2015.

The second climate change Workshop and Media Competitions were held in 2016/2017 with government funding where 11 prize winners, including two radio stations, were presented with awards. During the same period, multi-sectoral Climate Change Women Awards were also held for contestants from all the districts of Lesotho, with climate change project themes that included leadership, innovation, adaptation, mitigation, disability, youth and research. Funded by UNDP, the competition awarded 17 out of 92 contestants that participated, with prizes that represented the needs of the contestants.

6.4.5.2 *The Climate Change Communication Strategy*

There are severe financial and other resource constraints for mounting effective follow-up climate change information dissemination activities. The institution is currently in the process of developing a Climate Change Communication Strategy[21] that will assist the dissemination of climate information.

The overall objective of the communication strategy is to increase and improve the level of awareness, interest, positive attitudes, behaviours and practices towards CCA and mitigation among the public, vulnerable communities and stakeholders in Lesotho (p.11). Although the Draft Climate Change Communication Strategy was crafted in 2011, implementation has faced several challenges amongst which are limited financial and technical resources and low coverage by communication networks in the rural areas, particularly in the Mountain region

The National Climate Change Communication Strategy calls for material to be available in both Sesotho and English, depending on the target audience, for effective communication. The Strategy also calls for the use of a wide range of communication channels that includes the LMS notice board, electronic communication (Intranet, e-mail, telephone and the information technology server), the multimedia (Television, radio and internet) and the print media (newsletters, bulletins, flyers, booklets, brochures, newspapers), workshops and public meetings, and mobile networks (SMSs and social media).

There are six high circulation newspapers in Lesotho, four English newspapers (Lesotho Times, Public Eye, the Post and Informative) and two Sesotho papers (Leselinyana and Moeletsi oa Basotho).

6.4.6 Integration into Medium- and Long-Term Planning

The successful implementation of climate change initiatives depends on, amongst others, the mainstreaming of climate change activities into policy documents and plans in different sectors of the economy. Climate change should therefore be viewed as a strategic theme in all areas of public policy, and, through mainstreaming, its themes should be clearly linked to the development planning and finance processes.[22] In addition, the integration of climate change should become a standard practice in administrative procedures, systems and tools at all levels of the national economy, from national, sectoral to local levels.

In line with the above thinking and as a strategy to advance to a climate resilient pathway, a sub-chapter on climate change and related issues was included in NSDP I. Climate change has also been incorporated into policy and planning documents in several sectors such as water, agriculture, energy, land use, transport, health, biodiversity, etc. However, Lesotho is still struggling to match policy and plans on the one hand, and budget processes on the other, with the result that many policy statements have not been matched by the requisite allocation of the needed resources. The mainstreaming of climate change is also severely constrained by limited technical skills.

In 2015, the Early Warning Systems Project ran a one-week course to build capacity on assessing climate change vulnerability, using the agriculture sector as a case study. Attended by 28 participants from the ministries of Agriculture and Food Security, Energy and Meteorology, Forestry and Range Management, the Prime Minister's Office and Development Planning, and by the Rural Self-Help Development Association (RSDA) and the NUL, this capacity-building initiative was made up of 6 modules. In general, the application of skills that were acquired from the modelling course referred to above faces challenges amongst which are poor data quality, the short duration of the course and associated deficits in mastering the software.

In 2017/2018, LMS secured support from the GEF funded Reducing Vulnerability from Climate Change in the Foothills, Lowlands and the Lower Senqu River Basin (RVCC) Project to mainstream climate change into the Second Strategic National Development Plan (NSDP II) as a strategy to enhance the country's advancement towards a low emissions and ecologically sustainable development path; to reduce sector vulnerability and to increase the mitigation and adaptive capacity of national institutions and local communities. The exercise also developed Guidelines for the Integration of Climate Change[23] in policies, strategies and development plans for use by staff of focal and of climate-sensitive sectoral institutions in the planning and implementation of adaptation and mitigation programmes in the country.

6.5 EDUCATION, TRAINING AND PUBLIC AWARENESS

Article 6 (a) of the UNFCCC[24] obliges Parties to the Convention to promote and facilitate, at various levels and in accordance with their national laws and regulations and within their respective capacities,[25] the development and implementation of educational and public awareness programmes and public access to information on climate change and its effects; the promotion of public participation in addressing climate change and its effects and developing adequate responses and training of scientific, technical and managerial personnel for these initiatives.

Lesotho is aware that education, training and public awareness are key elements in building capacity for CCA and mitigation.[26] In pursuit of this Convention objective, the national institutional framework for climate change is now strengthened; awareness campaigns continue to be implemented using different strategies; a number of initiatives and programmes have been mounted; several legal frameworks are now in place and international, regional and sub-regional cooperation continues to grow, albeit at a snail's pace.

Education is seen as an important strategy in humanity's global response to climate change as it makes people acquire a better understanding of the impacts and risks of global warming, change their lifestyles, improve their resilience and adapt to prevailing changed climate conditions. According to Lesotho's Climate Change Policy, education enables informed decision-making, plays an essential role in increasing adaptation and mitigation capacities of communities, and empowers people to adopt sustainable lifestyles.[27] However, there is also a recognition that there is a critical dearth of climate change content in the curricula at all levels of the education system in the country.

Despite an increased awareness of the need to integrate climate change issues and information into the school curricula, developments in this direction have been very limited, with only a casual reference to environmental and climate change issues in selected subjects at primary and secondary schools and at tertiary level. There are still gaps, therefore, that need to be addressed if objectives of Article 6 of the UNFCCC are to be realized in Lesotho.

6.5.1 Institutional Framework for Article 6

The institution that is mandated to deal with issues of climate change in Lesotho is the LMS, a Department of the Ministry of Energy and Meteorology. As a focal point for several international conventions, protocols and agreements on climate and the O3 layer, LMS acts as a climate advisor to the Government of Lesotho on, amongst others, climate change education, training and public awareness. However, LMS has no capacity to plan and implement measures in this area without either capacitating itself or seeking the assistance of other institutions.

6.5.1.1 *The National Climate Change Committee (NCCC)*

NCCC was created by the LMS as a multi-sectoral advisory body with a mandate to validate climate change information; monitor climate change integration in members' respective sectors; assist the integration/mainstreaming of climate change in policies, plans and action programmes; enhance coordination and dialogue amongst national stakeholders; mobilize resources nationally and internationally for the implementation of climate change programmes and act as a platform for the collection, sharing and archiving of climate change data and information. At its formation, therefore, it was hoped that the training and capacitating of members of the NCCC would create nuclei for education and public awareness campaigns in all the climate-sensitive sectors.

A number of workshops were organized for members of the NCCC in order to strengthen their understanding of climate change issues and to standardize approaches. In 2015, some of the members of this Committee were trained in model building for vulnerability assessments with the hope that they would advance climate change programming in their respective sectors. Several members of the NCCC have also attended meetings of the COP to the UNFCCC. The Committee works closely with development partners such as UNDP and the Food and Agriculture Organization (FAO) who are also members of NCCC, in the formulation of climate change projects in various climate-sensitive sectors, most of which include climate change public awareness messages for rural communities.

6.5.1.2 *The National Curriculum Development Centre (NCDC)*

The NCDC under Ministry of Education and Training (MoET) is a key institution that is responsible for the review and development of curricula at primary and secondary school levels in Lesotho. In this respect, LMS has worked closely with NCDC to audit education curricula and pilot an education toolkit at these school levels with the objective to incorporate climate change and related issues in the school syllabi.

Lesotho's tertiary education institutions develop their own curricula independent of the NCDC. Some of them offer climate change-related topics in their course content although there are no fully-fledged formal programmes on climate change. NUL, in particular, offers courses that have integrated issues of climate change. However, there are also no stand-alone courses on climate change at this tertiary institution. Research institutions such as the Department of Agricultural Research in MAFS conduct adaptive crop research activities that have produced positive results. However, the findings have not been systematically incorporated into school curricula.

6.5.1.3 *Challenges Encountered*

So far members of the NCCC have focussed their efforts on mainstreaming climate change education in sectoral plans, with varying degrees of success. However, there have been extremely limited attempts to integrate climate change education in the curricula of various sector educational institutions. On the other hand, the LMS is not adequately equipped to lead the integration of education, training and public awareness into curricula of education institutions in the country without overstretching the current staff complement. Without communication and information technology specialists and outreach staff, coordination with NCDC and tertiary education institutions has not been an easy task. Follow ups have also been weak. On the other hand, the full roll out of revised syllabi will need funding allocations over which LMS has no control.

6.5.2 Level of Awareness and Understanding

The issues of climate change have dominated the development agenda in Lesotho in recent years, with the major driving forces being international, regional and sub-regional protocols and agreements; priorities of development finance institutions; international corporate responsibilities; and national policies and legislative and development frameworks. There is a growing awareness that climate change affects all and that it is through knowledge that societies can make informed decisions and effectively identify their coping mechanisms. However, according to Lesotho's Climate Change Policy, there are glaring gaps in the mainstreaming and integration of climate change in policy and planning documents resulting from inadequate awareness about the risks posed and the opportunities presented by climate change, from the national to local levels,[28] hence the need for climate change education, training and public awareness.

Lesotho recognises that the understanding of climate change issues by both practitioners and policy makers is a prerequisite for the successful mainstreaming of these issues in policies, plans and programmes. On the other hand, the understanding of these issues at the local level is a prerequisite for the successful implementation of CCA and mitigation measures on the ground. To this extent, therefore, awareness programmes have been implemented with the objective to build the capacity of staff of various climate-sensitive line ministries and their stakeholders, not only on issues relating to climate change but also around how to effectively integrate climate change into policy formulation and development planning.

The deficit in the level of awareness and understanding about climate change is exacerbated by, amongst others, the absence of local language climate change materials that can be easily understood by the majority of the population, the absence of climate change information dissemination mechanisms at the community level and inadequate integration of climate change issues into education curricula and community-level programmes and projects. Some of these challenges will be partially addressed by the Climate Change Communication Strategy which is currently at its draft stage.

Climate change awareness campaigns by LMS that were supported by the Early Warning System Project in 2015 resulted in the inclusion of a sub-chapter on climate change in NSDP I, as was revealed in earlier sections of this chapter, and in the mainstreaming of climate change in NSDP II. This mainstreaming has encouraged many sectors to take climate change messages to local communities through sector programmes and projects, mainly using public participation meetings (lipitso) that are organized by traditional authorities. The Early Warning System Project also supported LMS to take climate change awareness campaigns to local communities in the Thaba Tseka, Quthing and Mafeteng Districts by holding public meetings for community members, councillors, traditional leaders and other local stakeholders. The campaign messages demonstrated the linkages between environmental, social and economic impacts of climate change on one hand, and poverty alleviation or impact on livelihoods on the other, leading to improved local stakeholder awareness.[29]

In addition to public meetings, electronic and print media have been used, albeit on an ad hoc basis and with support from the Early Warning Project, to promote communities' understanding of climate change and how it could be mainstreamed in local level planning processes. In general, there is a widespread acknowledgement of the changing climate and its devastating impacts in recent years. However, this does not seem to have led to significant improvements in the understanding of the causes and in the formulation of the needed responses. This is more so at the local or community level.

6.5.3 Initiatives and Programmes

Key climate change capacity building objectives in Lesotho emphasize, among others, the integration of climate change into education curricula and developing a continuous program for the training of trainers on climate change issues; enhancing climate change education, public awareness and communication, the enhancement of communication and dissemination networks for climate change education and public awareness; and ensuring that climate change information is simplified and understood by local communities for ease of policy and programme implementation.[30] To this extent, a number of curriculum development initiatives were introduced during NSDP I. At the local level, several donor-funded projects that carried climate change messages and public awareness campaign components were implemented with the aim, amongst others, to build capacity for local resilience to climate change.

6.5.3.1 *Audits of School Curricula*

In 2015, attempts were made by LMS and the National Curriculum Development Centre (NCDC) to integrate climate change education into school curricula with funding from the Early Warning Systems Project. The first step was to undertake curriculum audits, an activity that carried the following three objectives:

- To identify areas of formal and non-formal education that covered issues of climate change;
- To identify areas where climate change issues could be integrated into formal and non-formal education programmes; and
- To make recommendations for the development and implementation of educational, training and public awareness programmes on climate change issues.

The curriculum audits covered both secondary and tertiary education institutions. The findings indicated that both formal and non-formal education programmes and textbooks had useful climate change information. However, the coverage of climate change related issues and concepts as conceptualized in the UNFCCC was found to be limited.[31] The same conclusion was made in respect of tertiary education institutions, where climate change concepts that were covered in Geography were found to be covering less than what is conceptualized in the UNFCCC. At NUL, emphasis was mainly put on the physical environment and natural resource management, with limited reference to climate change. However, course electives on Terrestrial Paleoclimate and Paleobiology, Climate Variability and Change, Climate Change Impacts and Mitigation and Adaptation Strategies were offered.

The curriculum audit recommended the enhancement of climate change content in school curricula, the sensitization and training of educators in both formal and informal educational institutions, a review of textbooks to make them more appropriate for the teaching of climate change and a broadening of the scopes of school curricula in accordance with the requirements of the UNFCCC and the integration of climate change in all school subjects.[32]

6.5.3.2 *The Climate Change Education Toolkit*

Following the audits of school curricula, LMS and NCDC then used the results to develop a Climate Change Education Toolkit for Teachers[33] which was piloted in 56 schools after training teachers from the same schools. The Toolkit covered the basics of climate, global warming, climate change, mitigation and adaptation, the UNFCCC, government policies and plans and climate change mainstreaming. The performance of these schools was monitored over a year, resulting in positive results. Unfortunately, there were no resources to roll out the toolkit across all the schools in the country. The toolkit development went hand-in-hand with advancing climate change education in schools through competitions in song, poetry, debates and speeches; with prizes that included trophies, medals and T-shirts.

6.5.3.3 *The Teacher's Manual*

In 2018, the Department of Basic Education in the MoET and the MFRSC embarked on the development of a climate change Teacher's Manual which represented a direct response to address climate change issues through schools that fell within the project area in Lesotho's southern District of Mohale's Hoek. The objective of this initiative was to build the capacity of students by increasing their knowledge of climate change issues using the motto Addressing vulnerability from climate change through the voice of the child.[34]

6.5.3.4 *Youth Guide to Climate Action*

The Lesotho Youth Empowerment Survey (2014) that was undertaken under the auspices of the Early Warning Systems Project found that youth could make a significant contribution towards the promotion of Education for Sustainable Development (ESD), within the framework of Article 6 of the UNFCCC, which in turn can contribute towards achieving SDGs, the NSDP, the NCCP etc., provided they receive appropriate education, information and support.[35] To this extent, therefore, youth could lead the whole society towards a low carbon and climate resilient future. The Project then assisted the development of a Youth Guide to Climate Action whose aims are to build a cohort of youth facilitators and implementers who would mobilise, inspire and apply youth leadership for community resilience to the changing climate, and create a new climate regime that would fully unleash the potential and harness the capability of the youth and create youth employment.

The Youth Guide to Climate Action targets primary and secondary school learners, tertiary students, out-of-school youth and youth in non-formal education institutions and colleges. The content covers the basics of climate change, climate change impacts and public awareness, education and training. The latter includes recognition and celebration of world and national environment and climate change dates, developing climate change newsletters, creating climate change corners, and participation in climate change campaigns and networks.

6.5.4 Institutional and/or Legal Frameworks

6.5.4.1 *National Level Institutions*

The current structure of LMS has no provision for the effective coordination of initiatives and programmes aimed at advancing UNFCCC Article 6 objectives of education, training and public awareness. This requires a lot of reliance on line ministries that use public participation staff from their own establishments or from running projects.

For the development of climate change education and training materials under the Early Warning Systems Project, LMS worked closely with NCDC, the institution that also assisted the selection of participating schools for piloting the proposed syllabi. However, the coordination of climate change education, training and public awareness programmes in other sectors has been on an ad hoc basis.

6.5.4.2 *Local Level Institutions*

The traditional structure for public participation in Lesotho is the pitso, a public meeting of village adults that is convened by traditional authorities for information dissemination or for deliberations. It is this social structure that has been used by national, district and local government officials and by various climate change programmes and projects to promote the understanding of climate change issues in rural areas. In 2015, LMS used this institutional structure as part of awareness campaigns in the Districts of Thaba Tseka, Quthing and Mafeteng.

6.5.4.3 *Legal and Related Frameworks*

Lesotho's National Environment Policy was drawn in 1998 by, amongst others, consolidating numerous pieces of legislation that addressed environmental issues. This legislative framework underlines the importance of getting people involved in development through the dissemination of environmental education and the promotion of public awareness and public participation,[36] both of which are key to addressing the issues of climate change risks and identifying opportunities and responses thereof.

The above requirement is contained in the Environment Act (No. 10) of 2008[37] which devotes a section on Information, Education and Public Awareness and makes provision for the Environmental Authority to disseminate information to public and private users; carry out public information and educational campaigns; and exchange information with non-governmental organizations or any other regional and international organizations among other things.

A number of documents on Lesotho's climate change strategy and agenda have also been compiled in recent years, the latest effort being the publication of the Climate Change Policy in 2017, with a section (3.19) devoted to education, training and public awareness as has been discussed in earlier sections of this chapter. This policy is being developed into a Climate Change Act to become a framework for ensuring that, amongst other issues, there is adequate educational, training and public awareness in the development and implementation of climate change initiatives and programmes in the country.

6.5.4.4 *Information and the Participatory Approach*

Experience in Lesotho has shown that the participatory approach that is promoted through education, training and public awareness should be pursued at all stages of the development of climate change initiatives, from the identification of needs, prioritization of proposals to the implementation of these initiatives. Stakeholders' involvement at all levels and the dissemination of information on climate change impacts and "know-how" is beginning to be recognised as a critical social tool in the implementation of climate change interventions. This ensures that there is a clear understanding of the identified risks and opportunities at all levels, and that there is a satisfactory degree of acceptance of the adopted response measures.

6.5.5 Sub-Regional, Regional and International Cooperation

The UNFCCC advocates for cooperation amongst Parties to the Convention to promote sustainable economic growth and development, particularly in developing country Parties, in order to enable them to better address the problems of climate change.[38] The Convention further requires that all Parties to the Convention, within the confines of their specific national and regional development priorities, objectives and circumstances, should promote and cooperate in education, training and public awareness related to climate change and encourage the widest participation in this process, including that of non-governmental organizations. In this regard, several sub-regional, regional and international programmes that aim at strengthening capacity and building resilience to climate change through education, training and awareness campaigns in support of Article 6 of the UNFCCC have been implemented in the country.

It has been shown in earlier sections of this chapter how the AAP promoted cooperation amongst 20 African countries, with notable impacts on the development of an Early Warning System, undertaking curriculum assessments and developing the climate change education toolkit, training journalists and mounting climate change awareness programmes. Frameworks to advance climate change education, training and public awareness have also been developed by SADC, the Common Market for East and Southern Africa (COMESA) and the AU as part of their broad strategies to guide the promotion of climate change resilience in member states.

6.5.5.1 *The SADC Climate Change Adaptation Strategy*

With measures to be taken over a 20-year period, the SADC Climate Change Adaptation Strategy (CCAS) [39] was formulated in 2011 with the aim to improve climate resilience in Southern

Africa through integrated and adapted water resources management at regional, river basin and local levels. The implementation of the Strategy is to be achieved mainly through the SADC Regional Strategic Action Plan whose objectives include supporting awareness and communication, education and capacity building, research and development and stakeholder participation.

The SADC CCAS is coordinated by the SADC Secretariat, with very limited activities so far. A Baseline Assessment of climate change conditions and responses in Lesotho was undertaken in 2014. A two-day SADC Media Sensitisation Workshop to learn about Climate Change, Climate Smart Agriculture and agriculture related business opportunities that come with adverse climatic conditions was also held for 20 journalists in June 2014 in Lilongwe, Malawi. Other than this there has been very limited activity coming from the SADC Climate Change Adaptation Strategy.

6.5.5.2 *Programme on Climate Change Adaptation and Mitigation in the Eastern and Southern Africa Region*

The Programme on Climate Adaptation and Mitigation in Eastern and Southern Africa was developed as a cooperation programme amongst COMESA, the East African Community (EAC) and SADC. Amongst its specific objectives, the Programme aims at preparing tools/instruments to facilitate learning and knowledge transfer on climate change for member countries to identify, formulate, and implement mitigation and adaptation projects in the agriculture, forestry and other land use sectors, and to benefit from climate change financing mechanisms.[40]

Also adopted as a specific objective by the above Programme is the packaging and communication of the knowledge and evidence gained to reach different target audiences that include civil society organisations that are working with farmers, agricultural departments and extension agencies. Unfortunately, none of these specific objectives has been realized to-date.

6.5.5.3 *African Strategy on Climate Change*

Developed in 2014 by the AU, the African Strategy on Climate Change aims at promoting national and regional capacities for CCA and mitigation by a host of actions amongst which are the development of a framework for advocacy, training, education and awareness, in partnerships with member states, in support of multi-disciplinary capacity development; development of the capacity of scientists, technicians and users of climate risk information; assessment of science and technology capacity needs and development of curriculum guidelines and standards.[41]

The African Strategy on Climate Change also undertakes to enhance networking and to provide support to regional climate centres, universities and research institutions to contribute to capacity building and development of new and emerging research, education, awareness raising and advocacy tools. However, like sub-regional programmes of action, no practical action has been forth-coming from the African Strategy on Climate Change to-date.

6.5.6 Gaps, Needs and Priorities

6.5.6.1 *Gaps and Needs*

Although the climate change toolkit was piloted in 56 schools in the country, with positive results, the administrative establishment in MoET were not adequately sensitized to support the allocation of resources for the revision of both the syllabi and textbooks for both schools and teacher training colleges, and for the retraining of teachers on the revised syllabi. It is clear that there is as yet no coherent strategy on how climate change could be integrated into the current education system in the country.

Although Lesotho has developed policies and strategies to deal with climate change mitigation and adaptation in various sectors, these have not been packaged together with poverty alleviation and livelihoods recovery programmes and sold to a broad spectrum of stakeholders through, amongst others, education, training and public awareness campaigns. On the other hand, the current staff complement of the LMS is not adequately capacitated to facilitate and coordinate the development and implementation of such packaged programmes. The absence of communication, information technology and outreach positions, therefore, puts limitations on the impacts that LMS can make in the areas of education, training and public awareness.

Most of the substantive climate change materials are available in the English language. They are therefore not easily understood by the majority of the population. This puts some limits on climate change information dissemination mechanisms at the community level. In any case, while this limitation could be relaxed by the conclusion of the Climate Change Communication Strategy, low educational attainments in rural Lesotho will always pose challenges to climate change awareness campaign efforts.

6.5.6.2 *Priorities*

For the LMS to effectively deal with climate education, training and public awareness, the institution's structure needs to be revisited to include communication, information technology and outreach positions. This will speed up the conclusion and application of the Climate Change Communication Strategy, strengthen the monitoring of climate change education, training and public awareness programmes in various sectors, and improve the mobilization of resources from regional and international sources in support of the same programmes.

For the integration of climate change education into school curricula to be effective, a conscious allocation of resources is necessary to cover the costs of reviewing the syllabi for schools and teacher training colleges, for the revision of textbooks and for teacher refresher courses. This requires awareness raising workshops for administrative and planning staff of MoET. The school syllabi should also be strengthened with results of various climate change research activities in support of educational institutions.

6.6 INFORMATION AND NETWORKING

6.6.1 Efforts to Promote Information Sharing

Lesotho has been an active participant in the promotion of climate change information sharing both at the regional and international levels. With international support, the country has met her obligations under the UNFCCC by preparing three National Communications, including the current one, to the COP. These communications give information on the inventory of GHG emissions; vulnerability and adaptation assessments; mitigation assessments; mainstreaming of climate change in policy and planning documents; implementation issues covering capacity building, education and training, information generation and public participation, networking and information sharing; gaps, needs and priorities.

As a preparatory exercise for the TNC, Lesotho embarked on the First Biennial Update Report (2017-2019), a document that contains updates of national GHG inventories, information on mitigation actions, and details about the country's climate change needs and support received. This exercise will also assist the development and implementation of a Measuring, Reporting and Verification (MRV) system in an effort to track progress of the country towards achieving the objectives of the UNFCCC and the Paris Agreement.

Other major interventions which promoted information sharing, include the UNEP regional initiative to assist LDCs in developing their Intended Nationally Determined Contribution (INDC) that was prepared for COP 21 in 2015. The Paris Agreement of December 2015 provided for the conversion, after ratification, of each country's **INDC** to a Nationally Determined Contribution (**NDC**). In April 2017, a 5-year Italian Government funded project entitled 'Support to Climate Change Vulnerability Risk Assessment, Adaptation and Mitigation Project' was launched with the objective to strengthen and coordinate efforts to combat climate change and address its adverse effects. One of the objectives of this 5-year project is to give support to the identification, implementation and communication of the NDCs.

In general, the sustainability of capacity building for climate change information sharing programmes in Lesotho has been constrained by weak data sharing platforms, poor data collection and archiving by relevant institutions and related scarcity of high-quality scientific information, the high-cost and unsuitability of available information technologies, insufficient technical capacity to undertake effective research on climate change and risks, inadequate monitoring of climate change impacts and low implementation of recommended measures. There is therefore a need to capacitate relevant institutions to continuously collect data and archive it in a way that is easily accessible.

6.6.2 Participation in and Contribution to Information Networks

It is one of the objectives of LMS to generate and provide accurate, reliable and timely weather and climate services for sustainable socio-economic development, and to document learning experiences thereof for national, regional and international sharing. The institution therefore applies and integrates the science of meteorology with social and economic activities, particularly involving poverty reduction, employment creation, protection of the environment, and promotion of measures that increase resilience to the adverse impacts of climate change. The climate information that is generated or gathered is disseminated through the LMS website, workshops, regular news bulletins, social media and advisories and posters.

As a main repository of most of the information that is generated or gathered, the LMS website (www.lesmet.org.ls) contains information on the history of climate change in Lesotho, climate change scenarios, impacts and adaptation efforts and possibilities, GHGs and mitigation, climate finance, ongoing and planned programmes and projects, relevant publications, climate change coordination, news and updates. On the other hand, weather forecasts have also become part of both radio and television news bulletins. Advisories are often issued as press releases to warn communities of impending potential disasters and possible negative impacts. Posters on climate change and its negative impacts have also been distributed to several institutions and schools. Unfortunately, there is no regular update of the LMS website since there are no in-house communication specialists.

There are no standalone climate change columns in the local electronic and print media. However, at the local level several projects have been implemented with the aim to disseminate climate change information and build capacity for local resilience. Amongst some of these is the FAO supported Strengthening Capacity for Climate Change Adaptation through Support to Integrated Watershed Management Project (2015-2019), which aims at strengthening the climate change adaptation capacities of several government and non-state institutions and local communities through integrated watershed management.

6.6.3 Access to, and use of Information Technologies

Information and communication technologies (ICTs) play a critical role in climate modelling, information sharing and dissemination and programme/project monitoring. For Lesotho, ICTs that are in service include computers and associated internet networks, radio networks, the television station, cellular phones and social media and telephone lines. The affordability and distribution of these ICTs in the country is highly skewed in favour of the Lowlands region in general and Maseru City in particular. For rural areas, dependence on cell phones and radios is quite high, giving some opportunities for the dissemination of climate change information. However, there is a challenge of poor network coverage in many areas, particularly in the Foothills and Mountains regions where transport infrastructure has a thin coverage.

The scenario is about to change due to a Lesotho e-Government Infrastructure Project that aims at enhancing good governance by deploying a modern and secure e-Government broadband infrastructure. Under there project, service centres with internet connectivity shall be spread I many areas around the country. Two service centres have been completed in the Kubake and Mantsonyane Councils, others have been developed as part of the postal services infrastructure. There are two in the peri urban centres of Mount Moorosi and Mapholaneng, and three in the remote areas of Ketane, Sehlabathebe and Sehonghong. An added advantage is that mobile network connectivity is widespread increasing the ease of connecting service centres. Under this project a Government Notification System is also being developed and this can also add to the information dissemination infrastructure.

There are 18 FM radio stations in Lesotho 15 of which are transmitting from the Lesotho National Broadcast Service (LNBS/Radio Lesotho) transmitters on the Beria Plateau, about 7 kilometres east of the city centre, and 3 from the Qoatsaneng Hill to the south of the city centre. Of the 18 radio stations, 15 also use the face book platform while 11 also run websites. Only 5 radio stations run live radio. A number of these radio stations use both English and Sesotho and therefore are quite appropriate for disseminating climate change messages in rural areas. Community radio stations were recently opened in the districts of Butha-Buthe, Mafeteng, Thaba-Tseka, Quthing and Berea.

Unfortunately, there is very little use of radio stations for the dissemination of climate change information by LMS due to internal capacity constraints. The other challenge is that FM transmission has a low coverage range, meaning that most of the rural areas are not covered except in some areas by Radio Lesotho which also makes MW and SW transmissions. Currently, only weather news is dispatched to radio stations using daily telephone calls and e-mails.

There are two television stations in Lesotho, a national station (Lesotho National Broadcasting Service/TV Lesotho) which airs a single channel, and a private station that provides content to TV Lesotho. There are currently efforts to migrate from analogue transmission to a digital system in order to expand capacity. Presently, LMS runs three weather bulletins per day, one in the morning and two in the evening. These bulletins are recorded in-house using own studio. Plans are under way to install digital technology before the end of the year to be compatible with

TV Lesotho.

The LMS runs a network of about 100 weather and climate stations throughout the country, of which 5 percent is classified as automatic. All climate related data that is generated by these stations and related information are stored in the recently installed HPC at the LMS headquarters. The HPC serves as an information sharing hub for climate change activities by various actors, although it is not yet used to its full potential.[42] Attempts are under way to convert some of the conventional stations to automatic weather stations in order to strengthen the EWS and reduce climate related risks. It will also be critical to build technical capacity on how to maintain the new technology.

The issue of how to access ICT remains a challenge in most of the areas in Lesotho. Internet connectivity is still low due to high connection, device and data costs and limited coverage with reliable electricity sources. The use of computers and other ICT technologies are similarly constrained. As was earlier, the use of televisions is also limited to urban areas and a few rural areas, mainly in the Lowlands. Another challenge is adapting ICT technologies to the context of Lesotho, implying that the country must begin to identify, document and use effective indigenous knowledge systems that have historically been used or are currently used by rural communities to share information. Equally important is developing policies that integrate climate change into ICT policies to facilitate innovative and flexible climate change responses.

6.7 STATUS OF TECHNOLOGY TRANSFER IN LESOTHO

6.7.1 Introduction

Technology transfer plays a critical role in the effective global response to the climate change challenge. Since technology is a source of GHG emissions, achieving global reduction of GHGs requires innovation to make current technologies cleaner and climate-resilient. There are some evident efforts to integrate climate change concerns into sector policies, strategies and plans. The INC and SNC on Climate Change were completed and submitted to UNFCCC Secretariat and they represent significant documents for understanding and monitoring the climate change phenomenon in Lesotho.

In addition, National Energy Policy (NEP) 2015 and NCCP 2017 were developed and adopted. The preparation of the First Biennial Update Report (FNUR) and Nationally Appropriate Mitigation Actions (**NAMA**) are also underway. The NDC was developed in 2017 and outlined that there is lack of tools and techniques which hinders adaptation and mitigation to climate change. Limited national research capacity and technical analysis are some of the key barriers for technology development in Lesotho. There is insufficient technological capacity to undertake effective research on climate change modelling and risks, monitoring of climate change impacts and implementation of adaptation measures. To address these challenges, alliances and cooperation with overseas partners including development partners need to be continued. There is a need to design a national inventory system and to develop a framework for domestic Monitoring Reporting and Verification (MRV) of GHG emissions. There is a further need to access expertise and develop capacities for technology development and transfer. It is also worth mentioning that the implementation of measures aimed at introduction of ecologically clean technologies for reduction of CO_2 emissions and/or reduction of vulnerability to climate change impacts is integrated with various actions aimed at supporting sustainable development of the country's economy within the framework of Lesotho's national development programmes.

The UNFCCC's Kyoto Protocol clean development mechanism (CDM) also provides a number of opportunities for technology transfer by offering a legal framework and a marketplace for Parties that are required to reduce GHG emissions.[43] Though the CDM does not have an explicit technology transfer mandate, it may contribute to technology development and transfer (TDT) by financing emission reduction projects using technologies currently not available in the host countries.

The Climate Technology Centre and Network (CTCN) is the operational arm of the UNFCCC Technology Mechanism that is established to promote the accelerated transfer of environmentally sound technologies for low carbon and climate resilient development at the request of developing countries. CTCN mandate includes support to develop and build on Technology Needs Assessment (TNAs), technology roadmaps and actions plans, through their national designated entities (NDEs). The ministry of communication, science and technology (MCST) in Lesotho was nominated in 2015 to be the NDE for CTCN activities. The main function of the NDE is to identify technology needs and facilitate the preparation and implementation of technology projects and strategies that support action on mitigation and adaptation. Lesotho has already requested technical assistance on the development of a Regional Efficient Appliance and Equipment Strategy in Southern Africa and leapfrogging Lesotho's market to energy-efficient refrigerators and distribution transformers. It is expected that this assistance will help Lesotho to prioritize relevant energy efficient products and concrete actions to capitalize on country's financial, energy, and climate benefits by 2030.

UN Environment in collaboration with the UNEP DTU Partnership and its regional collaborating centres for the TNA project is providing targeted financial, technical and methodological support to assist participating countries, such as Lesotho, to prepare new or updated and improved TNAs, including Technology Action Plans (TAPs), for prioritized technologies that reduce GHG emissions, support adaptation to climate change, and are consistent with NDCs and national sustainable development objectives in the TNA Phase IV.

The level of technology adoption, transfer, innovation and support for Research and Development remains relatively low. The 2017 Global Competitiveness ranking shows that Lesotho ranks 115 and 125 (out of 137 economies) on innovation and technological readiness, respectively (see Table 6.1); much lower than Botswana, which ranks 90 on both technological readiness and innovation, and Namibia which ranks 89 and 78 on the two indicators.

Table 6.1: Lesotho's Level of Technological Readiness and Innovation in Global Competitiveness Ranking compared to that of Botswana and Namibia in 2017/2018

	Lesotho		Botswana		Namibia	
	World Ranking	Score (1-7) or Values	World Ranking	Score (1-7) / Values	World Ranking	Score (1-7) / Values
Technological readiness Index	**125**	**2,6**	**90**	**3,6**	**89**	**3,6**
Availability of latest technologies	134	3,0	95	4,3	58	4,9
Firm-level technology absorption	133	3,2	98	4,2	69	4,4
FDI and technology transfer	132	2,9	91	4	76	4,3
Internet users % pop.	103	27,4	92	39,4	98	31
Fixed-broadband Internet subscriptions /100 pop.	126	0,1	97	2,8	102	2,2
Internet bandwidth kb/s/user	121	4,5	114	7,9	103	15,9
Mobile-broadband subscriptions /100 pop.	98	36,9	54	67,9	62	66,1
Innovation	**115**	**2,8**	**90**	**3,2**	**78**	**3,2**
Capacity for innovation	130	3,2	108	3,7	77	4,0
Quality of scientific research institutions	108	3,1	92	3,5	87	3,5
Company spending on R&D	101	2,9	91	3,0	63	3,4
University-industry collaboration in R&D	98	3,1	82	3,3	83	3,3
Gov't procurement of advanced technology products	77	3,2	30	3,8	65	3,3
Availability of scientists and engineers	129	2,9	99	3,5	103	3,5
PCT patents applications /million pop.	119	0.0	119	0.0	96	0,1

The technology development and transfer related to climate change, particularly mitigation and adaptation, have been concentrated in the following issues: (a) technologies for mitigation, especially technologies and know-how on improving energy efficiency, biomass and solar energy; (b) technologies and know-how on impact, vulnerability, and adaptation.

6.7.2 Technology Needs Assessment

Technology Needs Assessment (TNA) is a set of activities that determine the priorities for mitigation and adaptation to climate change in a country. The purpose of TNA is to identify technology needs (needs for new equipment, techniques, practical knowledge and skills, approaches, etc.) and prepare programmes and projects that will support and accelerate the transfer of technology and knowledge, in accordance with the negotiations held globally under the umbrella of the UNFCCC and the recommendations arising from them. The technology needs assessment process is consultative, and it includes the involvement of a broad range of stakeholders in a society in order to consider priorities, identify barriers and propose priority measures for the deployment of low emissions and technologies for adaptation to climate change.

Article 4.5 of the UNFCCC requires developed country Parties to promote, finance, transfer and create access to environmentally sound technologies by developing country parties. Article 3 paragraph 1480 of the Kyoto Protocol identifies transfer of technology as an issue to be considered in minimising adverse effects of climate change and/or the impacts of response measures on (developing country) Parties (United Nations, 1998). All Parties are expected to cooperate in promoting effective modalities and means to facilitate technology transfer. As part of the Marrakesh Accords (COP 7) (United Nations, 2002), Parties agreed to work together on a suite of technology transfer activities within a framework aimed at enhancing implementation of Article 4.5 of the Convention, to address among other themes, technology needs and assessments.

In Article 10 of the Paris Agreement (UN, 2015), "Parties share a long-term vision on the importance of fully realizing technology development and transfer in order to improve resilience to climate change and to reduce GHG emissions." The Agreement commits Parties to strengthen cooperative action on technology development and transfer and establishes a technology framework to provide overarching guidance to the Technology Mechanism established under the Convention.

Subsequent to the INC, in 2002, TNA was prepared for the Energy and LULUCF Sectors as they were found to be the major emitting sectors in the INC. That exercise sort to identify, select and prioritize technologies that were needed in order to effectively mitigate and adapt to climate change. However, the output document was skewed towards adaptation. TNA for mitigation and adaptation has been done piecemeal within the framework of the preparation of national communications, when identifying potential mitigation and adaptation measures. Lesotho's SNC states that a number of sectors will be affected by climate change including land, agriculture, water, forestry and health, and it also elucidated many capacity and technology constraints that the country faces in addressing climate change challenges.

The SNC suggested technologies for adoption in Land-Use Change and Forestry Sector (LUCF) included attempts to match cultivars with agro-ecological conditions, the promotion of production and productivity enhancing technologies, promoting the use of animal manure, soil liming, crop densification, multiple cropping, efficient irrigation technologies, breed improvement, grazing control, and reforestation. In meteorology the need for equipment to monitor extreme events, automatic weather stations and instruments for soil moisture and temperature measurements were highlighted. In the energy sector, technologies for reducing domestic and industrial energy usage (Energy conservation technologies and practices) as well as for increasing generation in climate friendly ways (Application of renewable energy technologies) were discussed. Lesotho lacks a central database, which contains the required information for systematic and continual vulnerability, impact and adaptation to climate change assessments, and very little has been done to implement these measures in the reporting period. This communication captures technology transfer developments since the previous communication and identifies needs that still exist in key economic sectors in Lesotho. A number of sector specific technology transfer projects, needs and limitations are discussed.

6.7.3 Technology Needs

6.7.3.1 *Technology transfer in the Agriculture, Forestry and Land Use Sectors*

Agriculture remains a key economic activity in Lesotho and is heavily affected by increasing evapotranspiration due to rising temperatures as well as by dry spells and recurrent droughts. The solution to water demands in agriculture lies with effectiveness of water management strategies including water supply technologies as well as the ability of crop varieties to survive under water stress.

Improved irrigation techniques such as drip irrigation are useful in conserving water. Solar panels can also be used to power electric pumps so that water can be drown from the rivers or boreholes to an elevated water tank for irrigation. However, most communal farmers cannot afford the equipment required to operate drip irrigation systems thus limiting its widespread use in the country. Other affordable irrigation technologies such as use of trenches to channel water towards agricultural fields can be promoted.

Development of new crop varieties and cultivars: New varieties of crop species and cultivars that are more heat tolerant and, in some cases, more drought tolerant, will be needed. This is an option, which requires links with major international agricultural research centres, the application of gene technologies and possibly some indigenous knowledge. The Agricultural Research Centre and National University of Lesotho have initiated various R&D collaborations in this regard.

Information technology: The development of information, raising of awareness and knowledge sharing are critical components in an adaptation and mitigation strategy for agriculture.

Macro-economic diversification and livelihood diversification in rural areas: Another way of adapting to increased rainfall variability and the possible reduction in precipitation is by way of diversification. Macro-economic diversification is suitable for commercial farmers as a means of evaluating and testing alternative crops to enhance diversification of production and reduction of risk. However, livelihood diversification for rural subsistence farms should also be supported. The focus for this option is on education and knowledge sharing, an option that is regarded as a ***"soft technology".***

Pest management: Department of Agricultural Research has taken the lead in investigating diagnostic methods and other control technologies; however, it is important that investments and technology transfer are made in this domain.

Inadequate funding for public technology transfer means that the smallholder farmer will not be able to keep up. Government in partnership with development partners, Civil Society Organizations, research and academia are facilitating the dissemination, testing and adoption of conservation agriculture among smallholder farmers. Sustainable technology transfer involves long-term commitment to work with farmers and communities to test and adapt technology options while most NGO projects have a limited lifespan and scale. It is therefore imperative for the Government to collaborate with all partners to scale up initiatives and enhance sustainability.

Other technologies that have been identified and adopted as options for CCA and mitigation in agriculture include:

- *Sustainable Fodder Production and Livestock Feed Mixing (as shown in Figure 6.1),* helps increase the availability of quality food resources for livestock during the dry season, and reduced emissions due to less land tillage using farm machinery, currently done at small scale.

Figure 6.1: Sustainable Fodder Production and Livestock Feed Mixing

- *Keyhole Gardens,* shown in Figure 6.2, can be used to reduce soil erosion, enhance water infiltration, retains moisture thus reducing crop water stress during drought periods. Since their inception, 23,150 keyhole gardens have been built across the country, in eight of the ten districts, impacting an estimated total of 115,590 people (about 5 percent of the population). Keyhole gardens have continued to be widely adopted by farmers in the country. The Ministry of Agriculture and Food Security has helped in development of training manuals for the approach. FAO in collaboration with other partners such as the Unites States Agency for International Development (USAID) and the UK Government's Department for International Development (UKAid) has trained farmers on growing, improving yields, crop diversification through extension workers and schools. Local NGOs such as the Rural Self-Help Development Association and Good Shepherd Sisters are also involved in dissemination of the practice.

Figure 6.2: Keyhole Garden

- Soil moisture conservation technology such as use of surface mulches, retains residues, reduces soil and water loss, improves infiltration, reduces soil temperatures and in time, improves soil fertility. *This is currently done at small scale*.
- Compost application: enhances soil water conservation and soil fertility, use of less mineral fertilizers hence lower emissions, reduced methane emissions from manure left on pastures. *This is currently done at small and medium scale*.
- Crop rotation, intercropping and crop diversification for reducing the risk of crop failure. *This is currently practiced at small to medium scale*.
- Contour ploughing for increased yields due to accumulation of water and nutrients on contours, reduces

soil erosion, improves soil quality and reduces use of fertilizer and water, improves soil water storage, reduces emissions by maintaining soil structure. ***This is currently done at small to medium scale***.

- Conservation agriculture for increases yield over time, reduces land degradation, reduces soil erosion, conserves soil moisture for use by plants during dry spells and improves soil fertility. To achieve an increase in crop production, while conserving the environment, conservation agriculture adopts three basic principles, i.e., minimal soil disturbance, permanent soil cover and crop diversification.[44] Additional principles are integrated soil fertility management and integrated weed and pest management. ***This is currently done at small to medium scale***.
- Research and technology transfer are needed to enhance the application of these technologies for Lesotho.

6.7.4 The Manufacturing and Industrial sectors

There is a need to continually improve processes by adopting appropriate technologies that increase energy use efficiency which leads to reduction in emission of GHGs in industry. Technologies for improving water-use efficiency and wastewater recycling are essential for CCA in the manufacturing sectors. There is also need for promoting climate resilient infrastructure.

Mitigation options in the industrial sector include the following:

- Water conservation;
- Up scaling of Biological Nutrient Removal (BNR) systems in wastewater treatment plants;
- CH_4 recovery and use as energy source at sewage works: This has the potential to generate at least 10 MW of electricity and plans should be put in place to pursue the generation of electricity from dump sites; and
- More efficient use of energy, and promotion of renewable energy.

6.7.4.1 *Technologies for sustainable transportation*

With increase in the number of motor vehicles in Lesotho, the transport sector is considered as priority sector where new technologies may need to be applied. Transport-related emissions, which can be expressed as emissions per person, per person-kilometre and per ton-kilometre, are all relatively high at present.[45] The technologies identified for the Transport Sector serve both mitigation and adaptation objectives. The following technologies and practices are recommended in the transport sector:

- Improvement of urban mass-transport systems: At present Lesotho has a poor urban mass-transport system, with the public transport system being dominated by minibus taxis. The majority of Basotho are dependent on public transport, yet it is currently very inefficient and even unsafe. There are a number of options that could be considered for the improvement of urban mass-transport systems, such Bus Rapid Transit (BRT) System in Maseru and Maputsoe, and incentives to encourage people to use public transport instead of their own vehicles. Inefficient single occupant private car usage is a cause of growing congestion, especially in

- Maseru and other major towns. Public transport systems will require major improvements in road and communication infrastructure and developing this infrastructure will entail significant investment.
- Improvement of traffic flow in urban areas: Traffic flow can be improved by city planning, including bicycle lanes, pedestrian assistance and traffic light synchronisation. Traffic light synchronisation technology requires computer-assisted traffic-control systems. There are a number of opportunities to improve existing traffic flow systems in Lesotho.
- Non-motorized transport (walking and biking);
- Reducing travel demand through ICT use, e.g., telecommunications;
- Less carbon-intensive fuels and technologies; and
- Restrict age of vehicle imports to 5 years: All vehicle imports to be 5 years old or newer.

The NDCs also recognize the potential benefits of adopting more energy efficient transport technologies. However, that cannot be achieved without a significant investment in national infrastructure so as to give residents the option of accessing such technologies.

6.7.4.2 *Technologies for energy sector*

The most promising areas of technology development are those related to energy efficient buildings, use of renewable energy sources and more efficient use of wood for energy. Lesotho's greatest challenge over the coming decades is to find solutions that meet the growing demand for energy and at the same time satisfy the criteria of security of supply, public health, universal access and environmental sustainability. In order to satisfy these criteria, significant efforts in research, development and innovation must be initiated immediately, rather than later, if the country is to meet expected energy demands between 2030 - 2050.

Lesotho has agreed to undertake nationally appropriate, measurable and verifiable actions aimed at reducing GHG emissions by 35 percent below 1990 levels by 2030. This is supported by the country's recently submitted NDCs. To date, there is NCCP 2017, the National Energy Policy (NEP) 2015, and NSES 2017. The NEP and NSES 2017 attempt to reduce energy costs by, among others, diversifying and enabling efficient use of energy sources; ensuring reliable supply of electricity; environmental Protection; and stimulating new economic/business opportunities.

Lesotho's SNC to UNFCCC presents a detailed list of technology needs in renewable energy and transport sector. Identified technology needs remain unfulfilled. Lesotho continues to have a specific interest in energy efficiency and renewable energy sources.

The following technologies and practices are recommended for the energy sector:

a. Adoption of solar energy for domestic and industrial uses; some entities have begun to roll out solar energy for residential homes;
b. Improved cook stoves – stove efficiency is at 30-50 percent;
c. Energy efficiency in buildings – including the use of natural lighting in building;
d. Low carbon electrification of remote areas - Rural Electrification Unit is promoting solar technologies;
e. Scaling up renewables in the energy sector – the techniques for energy acceleration include the installation and use of solar energy technology, small hydropower (SHP) and wind technology.

6.7.4.3 *Technologies for water sector and climate monitoring*

With regard to the water sector and climate monitoring, the following needs are noted:
a. An improvement and rationalization of the hydrometric network;
b. Additional river gauges and more automatic weather stations to aid in data collection and planning to reduce vulnerability;
c. Flood warning systems; and
d. Software such as water ware, river ware, and mike basin to aid in improvement of water management.

For climate monitoring, the need for technology transfer in the field of earth data collection cannot be over emphasized. This includes the hardware setup of the automated weather stations, satellite receiving stations, radar for earlier detection of extreme weather events, the operating software for both analysis and data transmission and the necessary training of personnel in working with the supplied tools.

6.7.5 Enabling Environment for technology development, transfer and diffusion

The transfer of climate change technologies has been implemented in a number of key areas such as energy, industry and waste. However, technology transfer has not been up-scaled and developed in depth. In order to enhance the transfer of climate change technologies, a number of priority policies and strategies on research, application and development of climate change technologies such as **National Science and Technology Policy**, *2006;* **ICT Policy for Lesotho, 2005;** *NCCP 2017;* **National Energy Policy**, *2015; NSES 2017; and NSDP II 2018* have been formulated.

The National Science and Technology Policy, 2006 calls on the Basotho to harness science, technology and innovation (STI) as tools to reduce poverty, create jobs and transform the country into a dynamic economy and informed society. The vision for Lesotho S&T policy is to create and sustain a progressive and prosperous economy and society through intelligent use of S&T assets.

In line with provisions of the UNFCCC, the National Science and Technology Policy puts a lot of emphasis on the identification, assessment and development of technologies that promote sustainable development without any significant contribution to GHG emissions increase. It calls on the citizenry to harness Science, Technology and Innovation (STI) as tools to reduce poverty, create jobs and transform the country into a dynamic economy and informed society.

The ICT Policy, 2005, aimed at the development and promotion of the ICT sector to ensure its effective use to achieve development goals. ICT Policy, 2005 paid particular attention to the need for use of ICT for Health, Agriculture and Food Security, Tourism, Environment and Natural Resources, and the use of GIS techniques for environmental monitoring.

The NEP, 2015 – 2025 stressed the need for energy efficiency, **diversification energy mix** and the establishment of Rural Energy Service Companies. This policy was formulated by the government in line with its vision that 'energy shall be universally accessible and affordable in a sustainable manner, with minimal negative impact on the environment.' One of the major reasons behind formulating this policy was to facilitate reducing global emissions for mitigating climate change. In line with this, the policy identified different renewable energy sources such as solar, wind energy, biomass, biogas and hydro-power. To facilitate the technology transfer process, the policy prioritizes the option of harnessing the potential of renewable energy resources and dissemination of renewable energy technologies in all settings of the country - rural, peri-urban and urban areas. It has set objectives to create an enabling environment and support to encourage the use of renewable energy. The policy also proposed providing financial support in the research and development of renewable energy. Moreover, proposals have been made to establish a renewable energy financing facility that is capable of accessing public, private and donor funds and providing financing for renewable energy investments.

The NCCP, 2017 is the first document in Lesotho dedicated to addressing the threats posed by climate change, and it emphasizes the vulnerability of the Lesotho economy to climate change. The Policy notes that climate change is considered one of the most serious threats to sustainable development globally and nationally. The primary focus is ensuring that adaptation measures are integrated in all government plans and development objectives. This requires collaborative and joint action with all stakeholders including the private sector, civil society, Non-Governmental Organizations (NGOs), and Community Based Organizations (CBOs) in tackling the impacts of climate change. Policy directions as well as adaptation measures in various sectors are also outlined. The need for technology development, transfer and utilization is also evident as a major action for alleviating the impacts of climate change. Furthermore, the need to focus on activities and technologies that have the most potential to mitigating GHG and supporting efforts to reducing vulnerability to climate change to enable the country to meet its development priorities outlined in the NSDP II is also recognised.

Policy Statement [20] of the National Climate Change Policy 2017 calls for promotion of research and development, innovation and technology transfer, and encourages cooperation of technology transfer among south-south and north south that is appropriate to Lesotho. The NCCP also identifies scientific innovation and technology development and transfer as one of the seven cross-cutting themes that will enhance effective, efficient and sustainable implementation of the proposed climate change mitigation and adaptation measures.[46]

National Sustainable Energy Strategy 2017 calls for promotion of innovation and technology transfer through energy centres, and promotion of technology exchange programmes regionally and internationally.

National Strategic Development Plan II 2018: While the emphasis of the NSDP II is on economic growth and development, it does acknowledge the need to protect the country's natural environment. The NSDP II further recognises that climate change is already having an impact on Lesotho with marked temperature and rainfall variations, and this is likely to affect the ability of the country to meet its developmental goals.

6.7.6 Other Mechanisms for technology development and transfer in Lesotho

Lesotho actively contributes to and fully benefits from its bilateral cooperative agreement for the transfer of knowledge and know-how on a range of STI-related areas. For instance, at the sub-regional level, it is a member of the NEPAD Southern Africa Network for Biosciences (SANBio). Lesotho has a bilateral cooperative agreement with South Africa, for the transfer of knowledge and know-how on the following areas: technology business incubation of SMMEs; a National Science Centre for Promotion of Public Understanding of Science, Engineering and Technology; biotechnology for health and food security; indigenous knowledge systems and advocacy for indigenous technological capability; Square Kilometre Array; and tissue culture to improve potato seed and other local crops.

In Lesotho, technology is not only acquired from offshore sources. Certain amounts of conventional and indigenous technologies are also acquired within the country through research and development and on-job innovations.

In the renewable energy sector, technology transfer is being carried out with installation of photovoltaic and thermal solar systems for lighting and heating throughout the country, though not in an organised fashion. Lesotho will also develop a 20 MW Solar Photo Voltaic (PV) plant, the first utility-scale solar PV project in Mafeteng, Lesotho and the power will feed into the national grid. The Project will contribute to a strategic phase-out of costly power imports from Mozambique and to reducing reliance on imported coal-generated power from South Africa, thereby promoting independence of power supply, achieving substantial savings in the national budget and abating regional CO_2 emissions.

LMS has benefitted from the provision of a number of automatic meteorological stations through various projects. The provision of these stations has allowed LMS to significantly enhance and improve its ability to provide quality and efficient meteorological data and information. These stations have also allowed the LMS to contribute to agriculture, water sector, disaster planning and many others. In addition to new weather stations, the LMS has also begun to utilize the DEWETRA platform, which is a real-time integrated system for hydro-meteorological and wildfire risk forecasting, monitoring and prevention. The platform allows the LMS to effectively combine different types of data so as to develop up-to-date and reliable risk scenarios.

MEM and the Italian Ministry for the Environment, Land and Sea (IMELS) have signed a Memorandum of Understanding on Cooperation in the Field of Climate Change Vulnerability, Risk Assessment, Adaptation and Mitigation. The Government of Italy is assisting the Government of Lesotho in developing Renewable Energy Resource Maps covering hydro, solar and wind, and the two governments have engaged Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) to carry out this task. The overall budget is EUR 1,205,000. The project started in March 2018 and has duration of two years. The project is funded by IMELS in fulfilment of the Paris Agreement, adopted under the UNFCCC, and the 2030 Agenda for sustainable development. The exercise for developing maps was successfully completed toward the end of 2019. ENEA is conducting training packages on Renewable Energy Potential Maps for Lesotho and Geographic Information System (GIS) database to key stakeholders.

6.7.7 Capacity building for technology development, transfer and diffusion

Capacity building is core to technology adoption at all levels. In the case of capacity-building the following areas identified during the SNC remain important:

- Continuous monitoring of weather parameters and events and their analysis for forecasting future changes both in the short- and long-term;
- Long-range weather forecasting;
- Analysis of future climate change and its sectoral, temporal and spatial dimensions; and
- Integration of climate change impacts in designs of plans, programmes and projects.

Lesotho believes that up-skilling of climate technology adopters is an important step that needs to be taken in order to catalyse technology diffusion. Pursuant to that, the Government of Lesotho and its development partners are engaged in a number of capacity development programmes. Some of the programmes are as described in Table 6.2 below.

Table 6.2: Programmes Offered on Technology Capacity Building

Initiative	Type of technology capacity building	Implementing Agencies
• Masters (M.Sc.) and short courses on Sustainable Energy	• Formal training on Sustainable Energy Technologies	• NUL
• Sustainable Land and Water Management Project (SLM)	• Hands-on training on soil and land management technologies	• Ministry of Forestry and Land Reclamation (MFLR)
• Southern African Solar Thermal Training and Demonstration Initiative (SOLTRAIN)	• Awareness creation and building up training capacities in the field of solar thermal technology and the improvement of the quality, performance and lifetime of solar thermal systems.	• TVET, Solar Thermal Instollar (Private Sector),

- Capacity is also built under projects through workshops and attendance of conferences locally, regionally and internationally in all environmental areas. Local and Regional fairs of innovative ideas, technologies and projects are important tools for promotion of the national scientific and technological designs. Under the Cartagena Protocol on Biosafety for example, public sector workers and members of the general public have been trained in biosafety, risk assessment, and administrative systems, in an effort to create a biosafety framework. Training available through Multilateral Environmental Agreement (MEA) and related projects is provided to persons from all Ministries and the MEA focal points. The National Association of Refrigeration and Air Conditioning and the Customs Department received training under the Montreal Protocol. The Ministry of Agriculture relies on cooperating agencies such as FAO and GIZ to bring in new and appropriate technologies to build farmer's capacity;
- Lesotho has benefited from participation in many international technical workshops, where participants learn about and share expertise and experience on the various facets of combating climate change. One such workshop is the UNFCCC-GIR-CASTT Programme on Greenhouse Gases Using 2006 IPCC Guidelines and Software, which was offered in collaboration by the UNFCCC and the Greenhouse Gas Inventory and Research Centre of Korea (GIR). It has strengthened capacity and familiarity in using the 2006 IPCC guidelines and software, with training that comprised both lectures and hands-on practice sessions. It covered energy, industrial processes, agriculture, forestry and other land use, and waste sectors;

- UNDP Country Office and Government of Lesotho are implementing a five-year (2016 – 2021) GEF-financed project ***'Development of Cornerstone Public Policies and Institutional Capacities to accelerate Sustainable Energy for All (SE4AII) Progress.'*** The objective of the project is to catalyse investments in renewable energy-based mini-grids and Energy Centres to reduce greenhouse gas emissions and contribute to the achievement of Lesotho's Vision 2020 and SE4All goals. The project is expected to deliver 10 mini-grids and 10 Energy Centres providing modem energy services to 1,000 rural households in the 5 districts of Mohale's Hoek, Mokhotlong, Thaba-Tseka, Qacha's Nek and Quthing. This objective will be achieved through the participation of the private sector working hand in hand with communities in the five selected districts; and
- A number of technologies, shown in Table 6.3, have been approbated and introduced at the local level with support from the GEF Small Grants Program (GEF SGP).

Table 6.3: GEF Small Grants Relevant climate change Technology Transfer Projects (the list is not exhaustive)

GEF Small Grants Related Technology Transfer Project	Dates	Project's Main Objective
Adoption and Promotion of Renewable Energy Technologies through Construction of a Biogas Digester at Matelile Community Development Centre (MCDC),	6/2009 - 6/2010	To demonstrate and promote renewable energy technologies that are environmentally friendly, through installation of a biogas production system at the Matelile Community Development Centre.
Improved Stoves - Improved Livelihoods - Improved Environment	10/2012 - 9/2014	To Save family fire wood consumption through introducing improved cook stoves and planting fast growing trees for fire wood.
Support for Solar Technology Economic Activity in Lesotho via Education, Training, and Technology Transfer	10/2012 - 9/2013	To build capacity within Lesotho for the design, manufacture, installation, and use of solar thermal technologies to supply electricity and thermal by-products (heat, hot water, etc.) to rural institutions in Lesotho.
Climate Change Education and Mitigation Activities with Maseru Primary Schools and Local Communities	11/2012 - 12/2014	To begin to educate young people, and teachers about the issues surrounding climate change, its causes, effects and mitigation.
Protection and sustainable use of soil and water resources in Likhetlane	11/2012 - 12/2014	To rehabilitate the degraded land through adoption of sustainable range management, construction of soil and water conservation structures for cropland protection, introduction of agro-forestry, promotion of fish farming and initiation of eco-tourism activities within the project area.
Demonstration and Promotion of clean energy technologies and water harvesting techniques for improved household vegetable production	11/2012 - 12/2014	To equip the children with knowledge about the environmental challenges facing the country with demonstration of simple technologies and strategies for addressing the challenges.
Sustainable Fodder Production and Livestock Feed Mixing: Building Resilience of Smallholder Dairy Farmers to Severe Climate Variations	7/2013 - 12/2014	to promote the increased productivity and resilience to climate variations that can be experienced through the production of fodder and the application of improved practices for storage and fodder banks.
Sustainable production of biofuel and agricultural inputs from sewage water microalgae and its impact to the environment and community, Hata-Butle, Roma,	8/2013 - 10/2015	To develop safe disposal, treatment and utilization of sewage water for production of energy and agricultural inputs (bio-fertilizers).
Strengthening use of local seeds for seed sovereignty, biodiversity conservation and climate change adaptation	7/2013 - 6/2015	To improve the conservation of agricultural biodiversity by promoting the use of local seed varieties.

6.7.8 Other existing climate-related technology transfer programmes and projects

LASAP 2019-2025: The project is aiming to increase the resilience of small-scale agriculture to climate change impacts by promoting climate-proofed investments for agriculture-based development, as well as by enhancing the resilience of agricultural productivity under increased climate variability. Among other activities, the project includes a component aimed at increasing awareness and capacity for government and local stakeholders for reducing risks of climate induced losses in the agriculture sector. This component will, among other things, work with LMS to improve agro-meteorological capacity in the country, through installation of a number of automated agro-meteorological stations, preparation and validation of local level climate/ production models for agriculture (through set up of test plots in different microclimates and training of LMS staff). It also involves working with ministry of agriculture and its extension services to increase capacity for 'translating' climate bulletins into production relevant advice at community and farm levels.

Reducing Vulnerability from Climate Change in the Foothills, Lowlands and Lower Senqu River Basin (2015-2020): This project is, using an Ecosystem-based **Approaches** to mainstream climate change into the on-going Land Rehabilitation Programme, through a variety of adaptation measures including establishment of a geo-based ecological and hydrological information system to increase the understanding of the relationships between climate change, ecosystems, and resilient livelihoods.

Strengthening Capacity for Climate Change Adaptation through Support to Integrated Watershed Management (2019-2026): This project focuses on implementation of adaptation measures related to sustainable land management and integrated water management. While it primarily focuses on community level activities, it also includes a component on data, tools and methods for assessment of climate change impacts on land suitability and livelihoods. Scaling-up and transfer of climate resilient measures are also been considered.

Technical support for the establishment of the Lesotho Soils Information System (2016 – 2018): This programme is aimed at creating a data base on the country's soil types in an appropriate and web-based information system that is easily accessible to different users including farmers. FAO will provide support in terms of procurement and installation of the necessary infrastructure and supplies for the establishment of the web-based information systems, support for field surveys and laboratory analysis and the associated training. It focuses on increasing and improving provision of goods and services from agriculture, forestry and fisheries in a sustainable manner. One of its key outcomes is to provide capacity development support to institutions at national and regional levels to plan for and conduct data collection, analysis, application and dissemination.

6.7.9 Challenges and recommendations related to transfer of environmentally sustainable technologies

The aim of the Climate Technology Centre Network (CTCN) is to accelerate the transfer of environmentally sound technologies through technical assistance, capacity building through knowledge sharing and enhancing global corporation and networking. These services, by the CTCN, largely address the barriers to technology transfer. However, domestic measures as identified by a detailed barrier analysis (to be discussed further below) should be conducted to optimise domestic systems as much as possible. A complete list of barriers and suggestions for an enabling environment are provided in Appendix 6A. This list can be used as a checklist for evaluating intervention strategies and clarifying which of the technology needs could benefit from technology transfer from the developed world. Suggestions for the enabling environment that require technology transfer from developed countries are marked in bold.

The main barriers to the transfer of environmentally sustainable technologies in Lesotho include high costs of purchase and maintenance of technologies; limited institutional capacities; low capacity in terms of skilled personnel to absorb and repair the technology in breakdown situations; costs of the supporting institutional structures (regulations, personnel, equipment); inadequate awareness of available technologies; resistance to change in adopting new technologies; lack of data, particularly with regards to vulnerability issues which prevents adoption and applications of technologies for adaptation; limited access to financial resources, especially in low income communities; lack of technologies' registry; and lack of technology research and development (R&D) Centre.

The technologies identified are typically imported from developed countries, and the two main barriers to adopting them in Lesotho are cost, intellectual property rights and scale. Requirements identified to accelerate technology transfer to Lesotho include:

- Skills training and development by technology manufacturers dispatching trainers to regional/national training institutions, so that the requisite skills for maintenance and operation are resident in the country or sub-region;
- Development of stakeholder networks to facilitate public discussion of technology on the ground before the policy approval level;
- Creation of regional technology production centres or effective distribution hubs in the country or sub-region be created; and
- Creation of an enabling environment/policy framework through appropriate policies,

price regulators and incentives.

The following recommendations are considered important in advancing Lesotho's technology development thrust:

- Establishing a registry of technology; and
- Establish a technology R&D Centre to monitor operating technology, identify appropriate technologies and propose modifications, including replacement with regional alternatives where possible.

It is important that new technologies are screened to ensure they will be appropriate, cost effective and sustainable in the national and local context. Otherwise, scarce investment funds are wasted on costly infrastructure that is underutilized. GIS and modelling capacity in many sectors need to be built. Civil society needs to be exposed to new technologies and how they can be integrated into their daily lives.

There are at best, sporadic efforts to build private sector capacity, and there is no coordinated programme for the transfer of technology to that sector. More needs to be done to target the private sector as well as civil society, to encourage broader participation in climate adaptation and mitigation. There is need for a more structured approach for dissemination of technological information to the public. A summary of the key actions to support roll out of the technologies is shown in Appendix 6B.

6.8 CONCLUSION

This chapter has analysed other information relevant to the achievement of the objectives of the Convention. It has debunked on research, necessary approaches to strengthen communication, education and awareness-raising at all levels, especially at local levels; strengthening and using regional networks of information and knowledge sharing. It has looked at ways of encouraging and strengthening participatory and integrated approaches in planning and decision-making; sharing experiences, information and best practices; development of tools, methods and technologies, and support for their application; and assessing, strengthening and mobilizing the capacities of existing relevant facilities and institutions.

Scalable and sustainable technologies are available for adoption locally and regionally. The last technology-needs assessment was done almost two decades ago and needs to be updated. Summary of adaptation options and selected technology for each priority sector are listed in Appendix 6C, and Summary of mitigation options and selected technologies for each priority sector in Appendix 6D.

6.9 REFERENCES

1. Ministry of Natural Resources, 2000. National Report on Climate Change, p.69
2. National Environment Secretariat, 2007. National Capacity Development Action Plan to Implement the Rio Convention and Related Multilateral Environmental Agreements in Lesotho, GEF/UNDP/National Capacity Self-Assessment Project/Ministry of Tourism, Environment and Culture.
3. Ministry of Natural Resources, 2007. Lesotho's National Adaptation Programme of Action (NAPA) on Climate Change, GEF/UNEP/Ministry of Natural Resources.
4. Eco Africa, 2011. Stakeholder Capacity Development Needs Assessment in Climate Change Adaptation: Lesotho, AAP/ Ministry of Natural Resources.
5. Ministry of Energy and Meteorology, 2017. National Climate Change Policy, paragraph 3.15.
6. Lesotho Meteorological Services, 2017. Lesotho's Nationally Determined Contribution under the UNFCCC, Ministry of Energy and Meteorology, Table 2.
7. SADC, 2010. Southern Africa Sub-Regional Framework of Climate Change Programmes, UNEP, pp 25-48.
8. Dejene, A., Midgley, S., Marake, M.V. and Ramasamy, S., 2011. Strengthening capacity for

Climate Change Adaptation in Agriculture: Experience and Lessons from Lesotho, FAO, p.46.

9. Ministry of Energy and Meteorology, 2017. National Climate Change Policy, Chapter 3.

10. Ministry of Energy and Meteorology, 2017. National Climate Change Policy, Paragraph 2.5.5.1.

11. Framework of operational guidelines on United Nations support to South-South and tri-angular cooperation SSC/17/3, 2012. Note by the UN Secretary-General, High-level Com-mittee on South-South Cooperation Seventeenth session, New York, May 2012.

12. Inter-Regional Technical Support Component, 2013. Africa Adaptation Programme: Ter-minal Report, Africa Adaptation Programme. www.undp.aap.org

13. Lesotho Meteorological Services, 2007. Improvement of Early Warning to Reduce Im-pacts of Climate Change and Capacity Building to Integrate Climate Change into Develop-ment Plans, GEF/GOL/UNEP/UNDP.

14. Lesotho Meteorological Services, 2017. Lesotho's Nationally Determined Contribution Under the UNFCCC, Ministry of Energy and Meteorology, paragraph 7.1.

15. Lesotho Meteorological Services, 2014. National Climate Change Committee: Terms of Reference, Annex A.

16. Evaluation Office of UN Environment, 2018. Terminal Evaluation of the Lesotho NAPA Project titled "Improvement of Early Warning System to Reduce Impacts of Climate Change and Capacity Building to Integrate Climate Change into Development Plans", GOL/UNEP/UN Environment, p.73.

17. Mhlanga, M.L., 2018. National Strategic Development Plan (2012/13-2016/17) - Environ-ment and Climate Change: Lessons and Experiences, RVCC Project/MDP/UNDP/GEF, An-nex 4.

18. Evaluation Office of UN Environment, 2018. Terminal Evaluation of the Lesotho NAPA Project titled "Improvement of Early Warning System to Reduce Impacts of Climate Change and Capacity Building to Integrate Climate Change into Development Plans", GOL/UNEP/UN Environment, p.75.

19. Mhlanga, M.L., 2018. National Strategic Development Plan (2012/13-2016/17) - Envi-ronment and Climate Change: Lessons and Experiences, RVCC Project/MDP/UNDP/GEF, pp.19 and 21.

20. Ministry of Energy and Meteorology, 2017. National Climate Change Policy, Paragraph.

21. Lesotho Meteorological Services, (Undated): (Draft) Climate Change Communication Strategy, Ministry of Energy and Meteorology.

22. Ministry of Energy and Meteorology, 2017. National Climate Change Policy, paragraph

113.

23. Ministry of Energy and Meteorology, 2018. Guidelines for the Integration of Climate Change in National, Sectoral and Local Policies, Strategies and Development Plan, GEF/UNDP.

24. The United Nations, 1992. United Nations Framework Convention on Climate Change, Article 6(a).

25. United Nations, 1992. United Nations Convention on Climate Change, Article 6(a).

26. Ministry Energy and Meteorology, 2017. National Climate Change Policy, The Kingdom of Lesotho, paragraph 2.3.

27. Ministry Energy and Meteorology, 2017. National Climate Change Policy, The Kingdom of Lesotho, paragraph 3.19.

28. Ministry of Energy and Meteorology, 2017. National Climate Change Policy, paragraph 3.19.

29. Evaluation Office of UN Environment, 2018: Terminal Evaluation of the Lesotho NAPA Project titled "Improvement of Early Warning System to Reduce Impacts of Climate Change and Capacity Building to Integrate Climate Change into Development Plans", GOL/UNEP/UN Environment, p.72.

30. Ministry of Energy and Meteorology, 2017: National Climate Change Policy, paragraph 3.19.

31. Lesotho Meteorological Services, (Undated). Education, Training and Public Awareness on Climate Change: Curriculum Audit Report, Ministry of Energy and Meteorology (Draft), p.12.

32. Lesotho Meteorological Services, (Undated): Education, Training and Public Awareness on Climate Change: Curriculum Audit Report, Ministry of Energy and Meteorology (Draft), p.13-14.

33. Lesotho Meteorological Services, 2015. Climate Change Toolkit for Teachers, LMS/NCDC.

34. Department of Basic Education and the Ministry of Forestry, Range and Soil Conservation, 2018. Towards Mainstreaming Climate Smart Ecosystems Rehabilitation and Management in the Lesotho School Curriculum, Reducing Vulnerability from Climate Change Project/GOL/GEF/UNDP, p.2.

35. Lesotho Meteorological Services, 2018. Youth Guide to Climate Change, Ministry of Energy and Meteorology, p.2.

36. Department of Environment, 1998. National Environment Policy (1998), paragraphs 4.26 and 4.27.

37. Environment Act, 2008. Part XIII: Information, Education and Public Awareness, paragraphs 96 and 97.

38. United Nations, 1992. United Nations Framework Convention on Climate Change, Article 3, Paragraph 5.

39. SADC, 2011. Climate Change Adaptation Strategy in SADC. a Strategy for the Water Sector, Part II: Adaptation Measures, Paragraphs 2.1.1 - 2.1.4

40. COMESA/EAC/SADC, 2011. Programme on Climate Adaptation and Mitigation in Eastern and Southern Africa (COMESA/EAC/SADC) Region.

41. African Union, 2014. African Strategy for Climate Change, p.30

42. Lesotho Meteorological Services, 2015. Lesotho Climate Change Baseline and Trend Analysis Report, Ministry of Energy and Meteorology, p.50

43. UNFCCC, 2010. Fact sheet: A technology revolution to address climate change. Climate Change Secretariat, Bonn, Germany.

44. Food and Agriculture Organization, 2007. Conservation Agriculture. http://www.fao.org/ag/ca/

45. Tongwane, M., Piketh, S., Stevens, L. and 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.

46. Lesotho Meteorological Services, 2017. "Lesotho's National Climate Change Policy 2017 – 2027." Lesotho: Ministry of Energy and Meteorology.

CHAPTER 7 CONSTRAINTS & GAPS

7.1 INTRODUCTION

The process of the preparation of the Kingdom of Lesotho's TNC to the UNFCCC has revealed some gaps and constraints that should be addressed adequately in order to ensure the successful implementation of future National Communications and other reporting systems including the Biennial Update Reports. In line with decision 2/CP.17 of the Convention, under the UNFCCC, this section provides updated information on constraints and gaps, and related financial, technical, and capacity-building needs for Lesotho.

7.2 CONSTRAINTS

In the implementation of climate change initiatives in Lesotho, there are a number of constraints identified amongst which are the following: financial, technical and capacity needs, technology needs and transfer. Further support is needed in building technical and institutional capacities and efforts in integrating climate change into national policies, plans and programs.

7.2.1 Financial options

Lesotho mainly relies on the donor financial support to meet national adaptation and mitigation costs. However, the level of support/funding is insufficient for the country to meet its climate change intervention obligations and integrating climate change into national policies, plans and programs. The country has not been able to adequately tap into most of the available climate change financing windows in implementing climate change initiatives due to low levels of capacity to develop bankable project proposals. To curb this barrier, the private sector, civil society and other sectors should be capacitated and encouraged to develop project proposals.

7.2.2 Technical/ Technology needs

Technology is a necessity to enhancing adaptive and mitigation capacity of a vulnerable country like Lesotho. Climate change technology transfer needs assessment was undertaken in 2004 with a view to prioritize technologies that would contribute towards mitigation efforts. However, Lesotho needs to build local capacity to apply and/or develop various analytical models in order to acquire maximum benefits from a wide range of climate change mitigation options. This could best be taken by research institutions and universities. Nonetheless, despite the fact that science and technology are key to development, the use of technology for economic development is not common in Lesotho due to lack of knowledge.

Different sectors such as Government, society institutions, institutions of learning, the private sector and communities need to be well-informed about climate change and its likely impacts on the economy and livelihoods. Therefore, it is crucial to provide people of Lesotho with information on alternative approaches and technologies to increase resilience. Methods and strategies to increase resilience could be realized through appropriate knowledge, skills and attitudes that identify, develop, and implement adaptive, low carbon technologies. However, for all this to happen, a large proportion of the population would need to have access to finance and the necessary technical support.

7.2.3 Capacity needs

There is limited capacity to implement climate change related initiatives, including running of climate change related models, research and innovations. There is a need to enhance technical capacity of local experts to run and analyse climate change sectoral models. Furthermore, to manage climate risks and opportunities in an integrated manner, there is a need for improved leadership capacities, proper coordination mechanisms and institutional frameworks. All projects and programs implemented in the country should be profiled for better coordination and avoidance of duplication of efforts. Further, there is need for strengthened decentralized approaches at the local and national levels.

Climate systematic data observation collection and storage is limited. Knowledge on adjusting national and sub-national development processes to fully incorporate climate change risks also need to be adjusted. Climate change opportunities should be shared across all levels. The level of awareness to the stakeholders on the importance of data collection, sharing and archiving needs to be increased.

The level of awareness on the impacts of climate change on people's livelihoods is still low and this poses a barrier to proper implementation of climate change interventions. Thus, there is need to sensitize people on climate change through awareness campaigns including integration of climate change in education curricula and dissemination of climate change related information through proper channels at district level.

Limited human resources capacity in terms of number, skill, range and depth in the field of climate change is also another key challenge. Willingness to delegate resources to the local level through Local Government is yet another constraint to implementation of climate change. Delegation of resources to establish fully functional decentralized offices at local level dealing with issues of climate change is essential.

7.3 GAPS

Between information provision and users demand of the information, there is a huge gap. The demand for climate information is diverse and localized. Information should be provided in an easily understandable format and in a timely manner. Resources are needed to translate information into action. Below are several constraints and gaps identified in climate change implementation.

7.3.1 Policies

Most sectoral policies in Lesotho that are directly or indirectly relate to climate change have not adequately integrated issues of climate change. Climate change is mentioned as a cross cutting issue in the country's National Development Frameworks (NDFs) and hence clear modalities should be outlined to ensure proper implementation across sectors.

The 2017 Lesotho Climate Change Policy clearly considers elements of mitigation and adaptation and views these elements as raising the complexity of climate change as a social and environmental problem. Policy makers and experts can use this policy to ensure that appropriate strategies on mitigation and adaptation are identified and instituted.

Lesotho lacks capacities and institutional frameworks to manage climate change risks and opportunities in an integrated manner, including a decentralized approach at the local and national levels. Knowledge on adjusting national and sub-national development process to fully incorporate climate change risks should be increased, and opportunities geared towards addressing climate change should be shared across all levels.

Effective communication and team approach are essential to planning and implementation through programmes aimed at achieving social integration and integrated management approaches.

7.3.2 Greenhouse Gases

Improving data collection, access and quality checks are the backbone of every national Greenhouse Gas (GHG) Inventories and it is critical for various reasons. Firstly, improved data collection is important for reporting major sources and sinks of GHGs with high confidence to identify the most appropriate national mitigation measures and strategies. Secondly, it is crucial for developing low carbon development policies. Thirdly, it is required to meet data reporting obligations and develop GHG mitigation strategies.

Lesotho lacks appropriate processes for collection, analysis, documenting and archiving data. This is the reason why certain capacities should be developed within key stakeholders to be able to process the data into the required reporting format using EFs and other working sheets from the Intergovernmental Panel on Climate Change (IPCC). Data sharing protocols and guidelines should be developed within the GHG inventory processes including the quality assurance/quality control plans that provide a detailed description of all technical steps required for data collection and processing. Thus, a system for the collection and processing of GHG inventory data on a sustainable level should be developed. This system should go beyond personal arrangements and relationships, to one that is grounded in statutory or legal requirements, memoranda of understanding and other national formal data sharing protocols. Establishment of a robust Monitoring, Verification and Reporting (MRV) system is therefore required.

An intensive national training program on the development of a GHG inventory including detailed use of IPCC guidelines and data sheets and calculations should be conducted. This will widen the base of national experts. The country should explore the potential to develop national emission factors for major GHG sources like energy, waste, agriculture, land use and industrial processes based on available capacities.

7.3.3 Vulnerability and adaptation assessments

This section has been elaborated on in Chapter 4 on Vulnerability and Adaptation Assessment.

7.3.4 Summary of Constraints and Gaps

A summary of constraints, caps and remedial actions identified in the development of the TNC presented in Table 7.1 below:

Table 7.1: Summary of Constraints and Gaps

Constraints/Gaps	Recommendations
Coordination a. Lack of legislative or regulatory frameworks for coordination of climate change nationally b. Lack of data sharing protocols c. Climate change not adequately mainstreamed in national policies, strategies and plans d. Sectorial collaboration structures are built around individual arrangements e. Weak enforcement mechanisms	a. Institutionalize appropriate legal mechanisms for coordination of climate change in the country b. Strengthen coordination amongst state and non-state actors at all levels including local level c. Mainstream climate change across all sectors of the economy to ensure a coherent response d. Develop working protocols and guidelines including assurance / quality control plans
Capacity a. Lack of appropriate tools and technical capacities to undertake assessments and run climate models b. Weak institutional capacities c. Poor archiving facilities d. High staff turnover and none consistency in participation e. Experts engaged in the development of INC and SNC were not available for TNC f. Limited modelling capacities and low technical capabilities to analyse and interpret model outputs	a. Strengthen capacity of national experts in data collection, analysis, processing and running of climate and sectoral models b. Enhance climate change training programs c. Strengthen networking with other relevant institutions

Constraints/Gaps	Recommendations
GHG a. Lack of reliable and updated to feed into GHG calculations b. Lack of disaggregated data c. Lack of data sharing protocols d. Lack of a sustainable system to collect, process, archive, monitor and report on the sources of GHG emissions and their sinks e. Data accessing is mostly based on informal arrangements with no clear reporting obligations by data providers f. None availability of national emission factors g. Data gaps h. Data captured in unfriendly formats	a. Improve information sharing and dissemination within and across sectors b. Develop reliable data collection and reporting systems c. Train national Experts in the development of national emission factors d. Institutionalize and well document GHG processes
Adaptation and Mitigation a. Lack of technical Experts to undertake both adaptation and mitigation assessments which require extensive modelling capabilities b. Expert judgment was made for most sectors due to lack of modelling knowledge c. Lack of appropriate climate change policy and regulatory frameworks d. Limited climate change integration to guide policy direction e. Single scenario projection undertaken resulting in high degree of output uncertainty	a. Train and improve capabilities of national experts in climate modelling b. Strengthen research and development on climate change c. Improve local participation d. Mainstream climate change in all national planning processes e. Conduct technology needs assessments f. Break silo mentality and address climate in a holistic and all-inclusive manner g. Identify opportunities for private sector participation
Finance a. Limited financial support to implement climate change initiatives b. Climate change actions are still limited to donor funded projects	a. Financial support is needed to stimulate climate change integration and implementation b. Climate change should be mainstreamed into budgetary and financial processes

7.4 NEEDS AND SUPPORT RECEIVED

7.4.1 Needs

Different sectors need to be capacitated on GHG inventory processes. Further, support is needed in building technical and institutional capacities and efforts in integrating climate change into national policies, plans and programs. There is need for Lesotho to build local capacity to apply and/or develop various analytical models to achieve the essential benefits from a wide range of CCA and mitigation options. Research institutions and universities should be encouraged to actively participate and undertake research on climate change. There should be programs in place to enhance resilience of Lesotho society to the negative impacts of climate change.

Table 7.2 below describes specific needs identified for various sectors.

Table 7.2: Identified needs to address climate change

Need identified	Support needed	Specific type of support requested [technology transfer, capacity building, financial support]	When is support needed?
a. Improve accurate activity data for all sectors including vehicle statistics, amount of fossil fuels consumed in the country, complete datasets of bricks, ceramics, food and beverages production, accurate inventory of new refrigerators and air-conditioning units imported, amount of lime imported in the country.	• Survey to be undertaken at national level for such information	c. Financial support, capacity building	As soon as possible
b. Need for collection of information on existing units (refrigerators and AC), particularly in all shops, dis- aggregated by sub-application, name of ODS substance, quantity of ODS substance, year of introduction and year of import.	• Survey to be undertaken at national level for such information	d. Financial support	2021

Need identified	Support needed	Specific type of support requested [technology transfer, capacity building, financial support]	When is support needed?
c. Limited understanding of IPCC first order decay model and how to apply country specific data to it	• Capacity building for sectoral experts on country-specific methodology	e. Capacity building	As soon as possible
d. Develop emission factor for road transport, solid waste and waste water.	• research programme with the university	f. Financial support, Technical Support	2023
e. Monitor waste water flows going to all Waste Water Treatment Works (WWTW) and evaporation ponds around the country	• Sanitary and industrial sewer flow measurement	g. Financial support, technology transfer	As soon as possible
f. Need for improved data on national solid waste generation	• Survey to be undertaken at national level to determine the amount and composition of waste generated nationally.	• Financial support	As soon as possible
g. Need for improved estimates of waste going to Tsosane Landfill	• Installation of weighbridges at Tsosane Landfill. • Recruitment of 8 extra personnel at the landfill for determination of waste composition in each truck load	• Financial support	2021
h. Improved data on clinical waste incinerated in medical healthcare facilities	• Surveys of the quantity of clinical waste incinerated in medical healthcare facilities be undertaken more frequently	• Financial Support	2022
i. Long term capacity building program for GHG inventories and Mitigation Assessment and climate change related policy formulation	• Development of training programme with the University	• Financial support, Technical Support	As soon as possible

Need identified	Support needed	Specific type of support requested [technology transfer, capacity building, financial support]	When is support needed?
j. Expertise on 2006 IPCC Guidelines	• Online short courses	• Financial support, Technical Support	As soon as possible
k. Improve the nitrous oxides emission estimates from manure management	• Conduct a survey on various manure management systems used for the various livestock	• Financial support	As soon as possible
l. Improved national land monitoring systems including national forests inventories, Land Use, Land Use Change and Forestry (LULUCF) assessments, monitoring agricultural land and urban areas, quantifying deforestation, reforestation and desertification.	• Training/ capacity building on land monitoring tools such as Collect Earth	• Capacity Building	As soon as possible
m. There is need to have in-country expertise to undertake mitigation assessments	• Short /long-term training on mitigation assessment through university programmes or on-line short courses	• Capacity building	2021
n. There is need to monitor/ track, evaluate and document information on mitigation actions and their effects	• Develop national monitoring and evaluation	• Technical support	As soon as possible
o. Improve capacity for resource mobilization for implementation of NAMAs, Mitigation actions and all climate change related activities	• Capacity building on development of development of bankable projects with sound climate rational	• Financial support, Technical support	As soon as possible

Need identified	Support needed	Specific type of support requested [technology transfer, capacity building, financial support]	When is support needed?
p. Promote renewable energy/ energy efficient technologies	• Introduce RE energy tariffs, RE/ develop energy efficiency legislation	• Technical and financial	As soon as possible
h. Accelerate research and development of renewable energy/ and energy efficient technologies	• Research programmes with Universities	• Technical and financial	As soon as possible
i. Promote climate smart agriculture	• Implement country's Climate Smart Agriculture Investment Plan	• Financial	2021
q. Need to enhance the country's carbon sink capacity	• Introduce afforestation and reforestation programmes • Review and implement national forestry policy and National Rangeland Management Policy	• Technical and Capacity Building	As soon as possible
r. Strengthen existing institutional frameworks including sustainable GHG Inventory Management system, MRV system and NAMA coordination	• Legalise National Climate Change Committee	• Technical assistance	2021
s. Reduce emissions from the industry sector, manufacturing	• Adopt green technologies in manufacturing industries.	• Technology transfer, technical, financial	2023
t. Need to track financial resources from donors	• Implement MRV System	• Capacity Building	As soon as possible
u. Need to improve capabilities for reporting to the Convention (UNFCCC)	• Formalise GHG Inventory institutional frameworks • Implement MRV System	• Technical Assistance	As soon as possible

Need identified	Support needed	Specific type of support requested [technology transfer, capacity building, financial support]	When is support needed?
v. Need to strengthen climate change data archiving system	• Procurement of a climate change data archiving system	• Financial	2021

7.4.2 Support received

Lesotho has received support on various projects on adaptation and mitigations through different supporters such as LDCF- GEF, USAID, Government of Japan, IFAD, World Bank Italian, EU- GCCA, FAO, African Development Bank (AfDB) and through other windows. Some of the projects supported are ongoing, while others have been completed. Table 7.3 below provides detailed information on support received.

Table 7.3: Support received from government and donors to address climate change

Source	Description	Sector	Type of support (Mitigation Adaptation Cross-cutting, Other)	Duration	Status of implementation	Co-financing (USD)	Amount (USD)
LDCF- GEF	• National Adaptation Programme of Action (NAPA)	Multi-sectoral	Adaptation	2007	Completed	N/A	190,000
Government of Japan	• African Adaptation Programme	Multi-sectoral	Adaptation	2009-2012	Completed	520,300	2 881 200
LDCF- GEF	• Improvement of Early Warning System to Reduce Impacts of Climate Change and Capacity Building to Integrate Climate Change into Development Plans	Multi-sectoral	Adaptation	2012-2016	Completed	2,721,500	1,735,000
GEF	• Renewable Energy-based Rural Electrification	Energy	Mitigation	2008-2012	Completed	4,228,500	2,500,000
USAID	• Climate Change Adaptation in the Lesotho Highlands	Multi-sectoral	Adaptation	2010-2014	Completed	N/A	1,100,000

Source	Description	Sector	Type of support (Mitigation Adaptation Cross-cutting, Other)	Duration	Status of implementation	Co-financing (USD)	Amount (USD)
LDCF- GEF	• Strengthening Capacity for Climate Change Adaptation through Support to Integrated Watershed Management Programme in Lesotho	Water	Adaptation	2015-2020	Completed	8,437,000	3,592,694
LDCF- GEF	• Reducing Vulnerability from Climate Change in the Foothills, Lowlands and the Lower Senqu River Basin	Multi-sectoral	Adaptation	2015-2021	ongoing	27,600,000	8,398,172
LDCF- GEF	• LASAP	Agriculture	Adaptation	2015-2020	ongoing	21,146,000	4,330,000
LDCF- GEF	• Strengthening Climate Services in Lesotho for Climate Resilient Development and Adaptation to Climate Change	Multi-sectoral	Adaptation	2020-2025	ongoing	37,060,000	5,000,000
GEF	• Development of Cornerstone Public Policies and Institutional Capacities to Accelerate Sustainable Energy for All (SE4ALL) Progress	Energy	Mitigation	2016-2021	ongoing	19,267,837	3,500,000

Source	Description	Sector	Type of support (Mitigation Adaptation Cross-cutting, Other)	Duration	Status of implementation	Co-financing (USD)	Amount (USD)
IFAD	• WAMPP	Agriculture	Adaptation	2014-2022	Ongoing	20,350,000	18,610,000
United Nations Economic Commission for Africa (UNECA)	• Enhancing and improving access to energy services through development of public-private renewable energy partnerships	Energy	Mitigation	2013-2015	completed	N/A	91,000
African Development Bank (AfDB)	• Urban Distribution Rehabilitation and Transmission Expansion Project	Energy	Mitigation	2016-2020	Ongoing	N/A	9,534,754
Government of Lesotho	• Integrated Watershed Management (Poverty Alleviation) Project	Multi-sectoral	Adaptation			N/A	7,500,000

7.5 CONCLUSION

In Lesotho, there are several constraints and gaps that have resulted in low climate change adaptive and mitigation capacity. These constraints and gaps range from limited funding to lack of technological advancements and technical knowhow. The country also lacks capacity and institutional frameworks to manage climate change risks and opportunities in a coordinated manor. Various remedial actions have also been identified to address the gaps and constraints in the country.

With a view to improve adaptive capacities and to reduce or reverse expected economic development losses likely to occur without adaptation and mitigation, this chapter concludes that the following issues are to be considered:

- Strengthening institutional and human resource capacities;
- Improving climate change modelling capabilities;
- Strengthening mitigation and vulnerability assessments;
- Undertake integrated sectorial approach;
- Risk management through building resilience to existing risk and to changes in a progressing setting;
- Building resilience to climate change; and
- Developing innovative sustainable financing options to meet national adaptation and mitigation demands or cost.

These interventions, however, will require strong coordination and integration across various sectors (state actors) as well as effective participation of non-state actors.

APPENDICES

APPENDIX 4A

Classification of RCPs and their forcing description (Source: O'Neill & Schweize, 2011) [82]

RCPs	Category	Forcing generic rule
RCP8.5	High pathway (extreme case scenario)	Reaches > 8.5 W/m^2 (~940 ppm CO_2) by year 2100 and continues to rise for some time
RCP6	Intermediate pathway (stabilizing pathway)	Stabilizes at 6 W/m^2 (~800ppm CO_2) after year 2100
RCP4.5	Intermediate pathway (stabilizing pathway)	Stabilizes at 4.5 W/m^2 (~540ppm CO_2) after year 2100.
RCP2.6	Lower pathway	Peaks at 3W/m^2 (~400ppm CO_2) before year 2100 and then declines 2.6 W/m^2 by end of the 21st century.

APPENDIX 4B

The analysis of change in extreme climate indices is performed in conjunction with that of changes in annual total wet-day precipitation (PRCPTOT) with a special focus placed on deriving the implications of change from a combination of indices per agro-ecological zone. Tabled below are the key messages under the emission scenarios RCP4.5 and RCP8.5 for the four agro-ecological zone (Table 4.1 & Table 4.2. For each time period, a set of indices whose ensemble projection of the relative change is conclusive are indicated. Within the tables the indices which are projected to increase are presented adjacent to an upward pointing arrow (↑) while the indices that are projected to decrease are adjacent to a downward pointing arrow (↓). In the case where the multi-model projection for a set of indices is suggestive of no change a filled circle (●) is placed adjacent to such indices. The abbreviation (NA) is used to denote an absence of indices that are projected to increase, decrease or remain the same as that of the reference period.

Summary of projected extreme precipitation key messages under RCP4.5

Agro-ecological zones	Time-period (Years)	Conclusive extreme climate indices projection	Extreme precipitation projection key message
Mountains (HL)	2011-2040	↑ CWD ● NA ↓ NA	Signal of change inconclusive
	2041-2070	↑, CDD ● NA ↓ PRCPTOT, R10mm	Intensification of meteorological drought.
	2071-2100	↑ CDD ● NA ↓ PRCPTOT, R10mm, R20mm	Intensification of meteorological drought.
Foothills (FH)	2011-2040	↑ NA ● CDD, R20mm, R95pTOT, ↓ NA	No change in extreme precipitation relative to the period 1971-2000
	2041-2070	↑ CDD ● NA ↓ R10mm, PRCPTOT	Intensification of meteorological drought.
	2071-2100	↑ CDD ● R20mm ↓ NA	No clear derivable Signal of change in extreme precipitation conditions.
Lowlands (LL)	2011-2040	↑ CWD, R10mm ● R99pTOT, RX1day ↓ NA	Intensification of wet period of the year.
	2041-2070	↑ CWD, R99pTOT ● PRCPTOT ↓ NA	Shift in the rainfall distribution.
	2071-2100	↑ CDD ● NA ↓ NA	No conclusive derivable signal of change in extreme precipitation conditions.

Senqu River Valley (SRV)	2011-2040	↑ R10mm ● RX1day, RX5day ↓ Rnnmm	Mixed inconclusive signal of change among indices.
	2041-2070	↑ CDD ● R10nnmm, RX5day, R99pTOT ↓ PR, PRCPTOT, Rnnmm, CWD	Generally dry precipitation conditions
	2071-2100	↑ CDD ● NA ↓ PR, PRCPTOT, Rnnmm, CDD, R95pTOT	Generally dry precipitation conditions

Agro-ecological zone	Time-period (Years)	Conclusive extreme climate indices projection	Extreme precipitation projection key message
Mountains (HL)	2011-2040	↑ CWD ● NA ↓ NA	Inconclusive signal of extreme precipitation condition.
	2041-2070	↑ NA ● NA ↓ PRCPTOT, R10mm, CDD	Intensification of meteorological drought.
	2071-2100	↑ CDD ● NA ↓ PRCPTOT, R10mm, R20mm	Amplified intensification of meteorological drought
Foothills (FH)	2011-2040	↑ NA ● PRCPTOT, CWD, R95pTOT, RX1day ↓ NA	No change in extreme climate conditions
	2041-2070	↑ NA ● R95pTOT, CDD ↓ NA	No clear derivable change in extreme indices
	2071-2100	↑ CDD ● NA ↓ PRCPTOT, R10mm, R95pTOT	Amplified intensification of meteorological drought

Lowlands (LL)	2011-2040	↑ R10mm ● CWD ↓ NA	Intensification of the wet periods of the years.
	2041-2070	↑ R99pTOT, R95pTOT, CDD, RX1day. ● NA ↓ NA	Shift in rainfall distribution with an aggravated risk of flood.
	2071-2100	↑ CDD ● NA ↓ Rnnmm, R10mm	Intensification of meteorological drought
Senqu River Valley (SRV)	2011-2040	↑ NA ● NA ↓PR, Rnnmm, CWD	Generally dry
	2041-2070	↑ R99pTOT, RX1day, CDD ● RX5day, R20mm ↓ PR, Rnnmm, CWD	Generally dry with elevated risk of occasional flooding indicating a shift in the precipitation distribution.
	2071-2100	↑ CDD, R10mm, R20mm ● NA ↓PR, R95pTOT, Rnnmm, CWD	Shift in precipitation distribution leading to amplified chances of intense precipitation leading to an elevated risk of heavy flooding while the regions remain generally dry during most of the year including presently wet seasons

APPENDIX 4C

Summary of the Lesotho health sector perceived vulnerability to climate change.

Health Outcome/risk	Vulnerability group	Vulnerability factor	Source of data approx. data	Indicator	Indicator value (%)	Period of approx.
Extreme heat exhaustion and heat strokes	Old age under a social protection programme.	Heatstroke, heat exhaustion or respiratory complications	World Bank, 2013.	Percent of the population	4.4, 8.02	2013, 2016
	Infants, young children under the age of 5 in poor households.	Heatstroke, heat exhaustion or respiratory complications	LDHS, 2014	National Average standing (%)	33.2	2014
	Subsistence farming households within the annual income level 0-9,999 (Maloti)	Heatstroke, heat exhaustion or respiratory complications	Bureau of Statistics, 2012; FAO, 2016; Letete, 2016	% distribution of dependence on farming	70.0	2010/11
Injuries from severe hail storms and floods	School kids from rural areas who often walk to and from distant schools	Physical harm from exposure to extreme weather events.	MoET, 2016	Beneficiaries of the School Feeding Programme as a % of population	20.4	2016

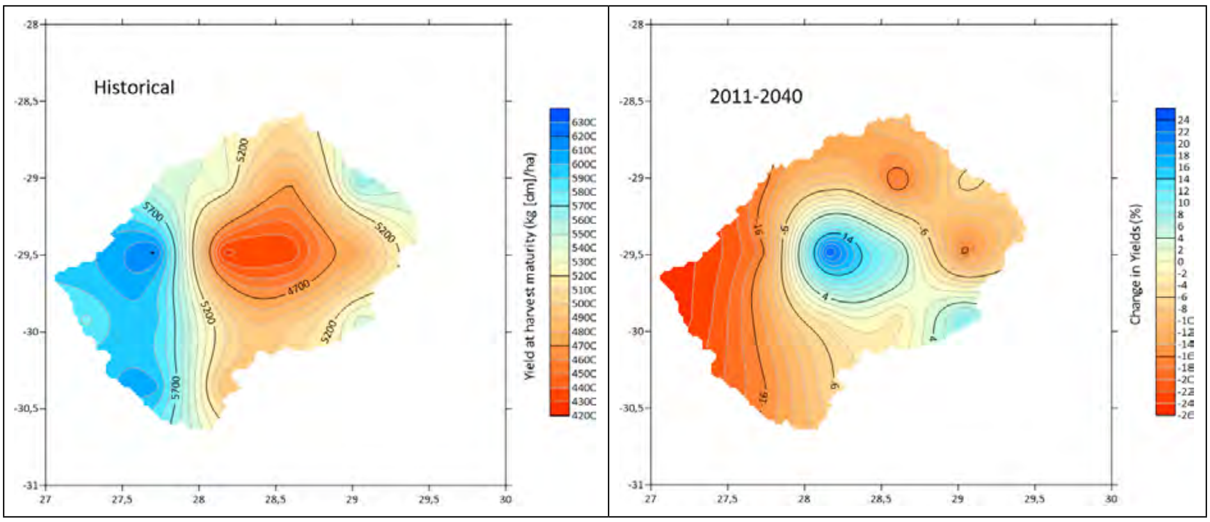
Food insecurity	Urban households living below the poverty line	□ Vulnerability to food price increases due to limited purchasing power □ Elevated poverty levels and nutrition-related health complications □ A challenge to the control of diseases like HIV and AIDS	Bureau of Statistics, HBS 2002/03; HBS, 2010/11	% of the population	39.0, 39.6	2002/03, 2010/11
	Rural households living below the poverty line	□ Vulnerability to food price increases due to limited purchasing power □ Elevated poverty levels and nutrition-related health complications □ A challenge to the control of diseases like HIV and AIDS	Bureau of Statistics, HBS 2002/03; HBS, 2010/11	% of the population	60.9, 61.2	2002/03, 2010/11
Snow and extreme cold exposure	Rural households		Bureau of Statistics, HBS 2002/03	% of the population	> 60	

Food & vector-borne diseases	Informal settlement on the outskirts of cities with poor sanitation, drainage ditches, ventilation, and water supply systems, lighting, proper sewage, and waste disposal	Exposure to infectious and water-borne diseases through an accumulation of water in rainy seasons.	Bureau of Statistics, 2019	% of the household population with E. coli in drinking water	53.2	2018
	Urban area residents	Increased exposure risk due to high population density			30.6	
	Infants	Rate of mortality related to diarrhoea & other water quality associated diseases.				
	Herd boys and farmers	Often drink water from unprotected natural springs and streams which get contaminated in times of floods.			72.0	

APPENDIX 4D

Spatial variations of the climate change induced changes in crop yields in the 2011-2040, 2041-2070 and 2071-2100 periods relative to the baseline period of 1971-2000 for both the RCP4.5 and RCP8.5 scenarios

Figures 4D (a) to 4D (h) show the spatial variations of the climate change induced changes in crop yields in the 2011-2040, 2041-2070 and 2071-2100 periods relative to the baseline period of 1971-2000 for both the RCP4.5 and RCP8.5 scenarios. Although the simulation results indicate a general decrease in maize yields across the country, some regions of the country are projected to experience an increase in yields. The central highland areas are projected to experience increases in maize yield of around 10% using the RCP4.5 scenario and 20% by the RCP8.5 scenario. This will most likely be mainly due to increased temperatures rather than precipitation changes. Although the precipitation in these areas is projected to decline, it is still expected that annual precipitation will range from 700 to 1400 mm; which is still adequate for maize production. For sorghum, the whole country is projected to experience increased yields of between 5.4 - 10.5%, except the lowlands and foothills regions that are projected to have decreased yields of around 20% below the baseline period of 1971-2000. Although the yields of dry beans are projected to decrease across the whole country, the lowlands, Senqu River Valley and the extreme eastern highlands regions are projected to have yield increases of between 10 to 20% for both RCP4.5 and RCP8.5 scenarios. The yields of wheat are projected to decrease across the whole country except in some areas of Qacha's Nek District, where in comparison to the baseline period (1971-2000), they are expected to increase by 50 - 67%, 110-190% and 50 - 120% in the 2011-2040, 2041-2070 and 2071-2100 periods, respectively, for the RCP4.5 scenario.



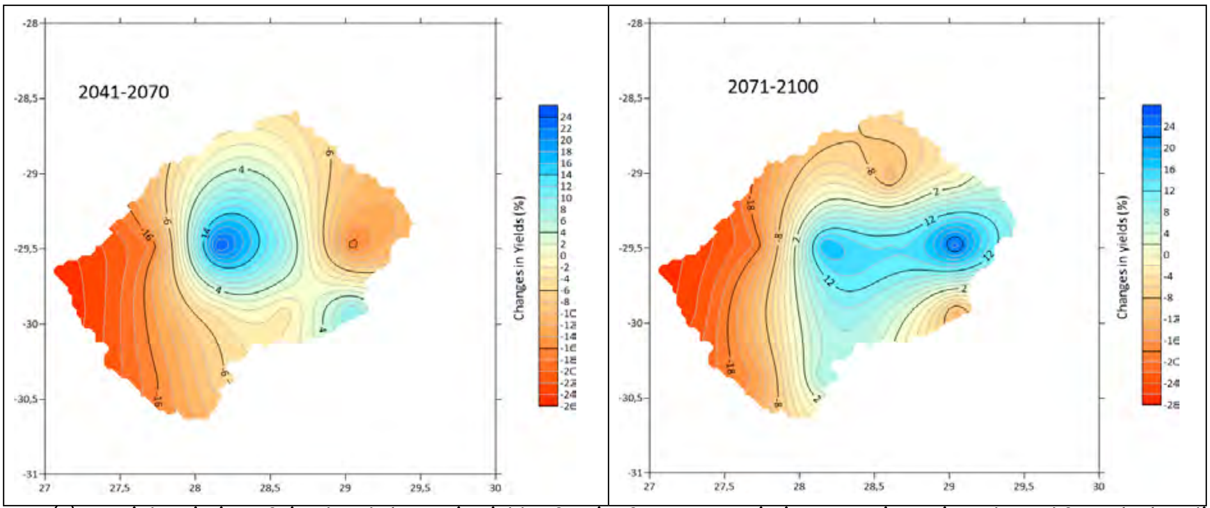


Figure 4D (a): Spatial Variation of simulated change in yields of maize for RCP4.5 emission scenario as time elapsed from the baseline to the future years of prediction

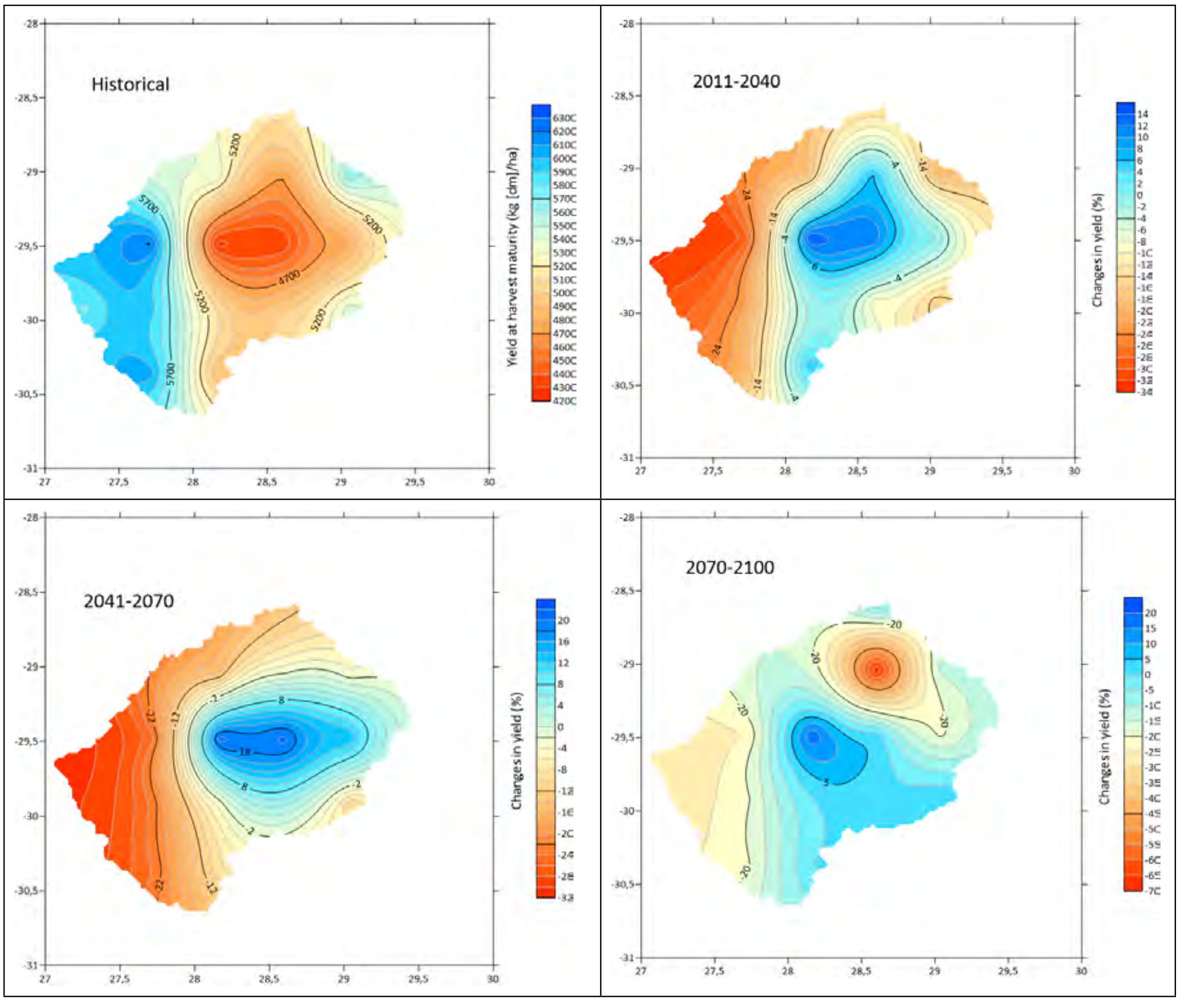


Figure 4D (b): Spatial Variation of simulated change in yields of maize for RCP8.5 emission scenario as time elapsed from the baseline to the future years of prediction

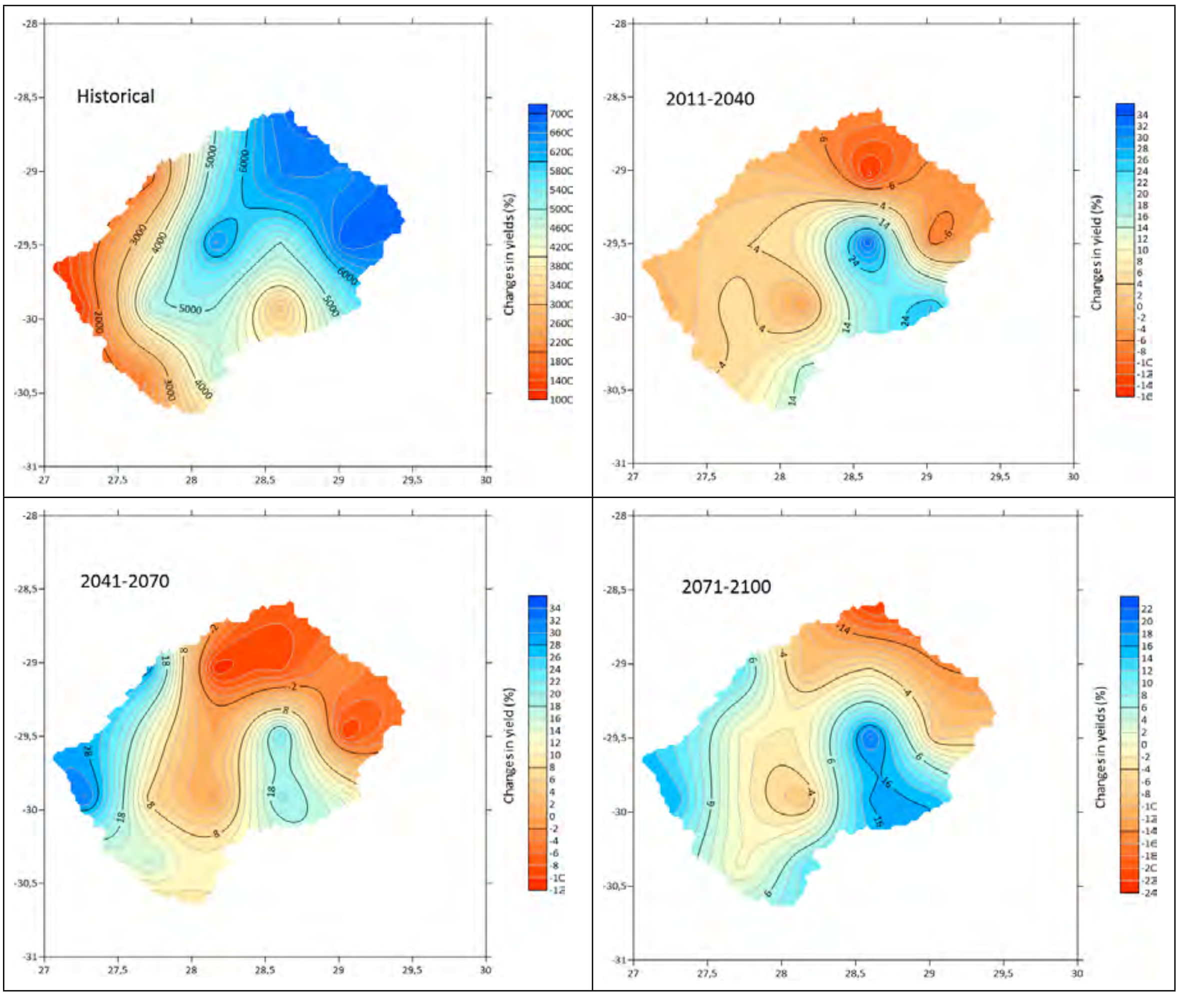
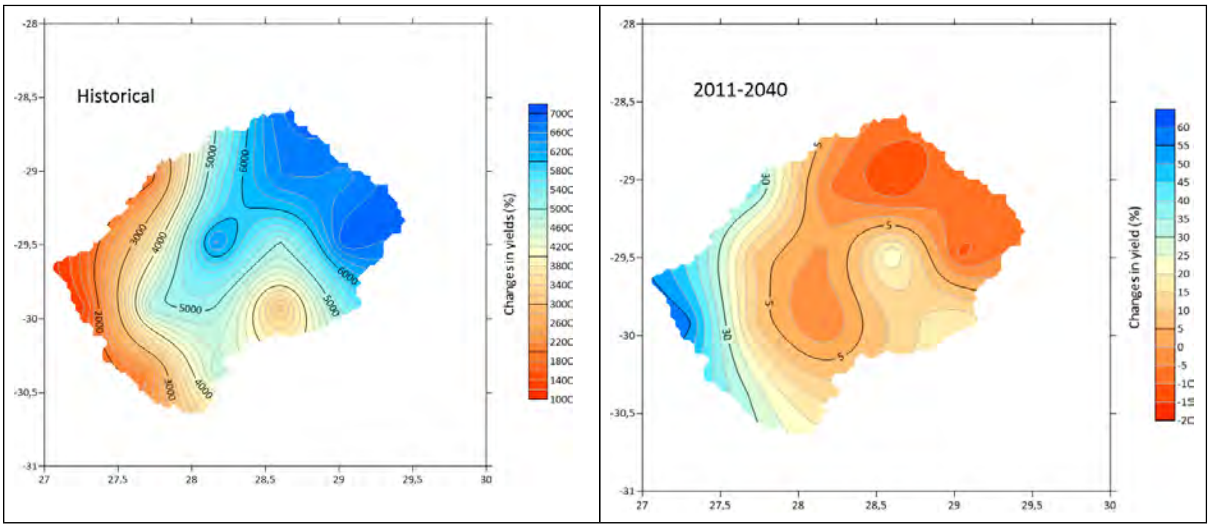


Figure 4D (c): Spatial Variation of simulated change in yields of beans for RCP4.5 emission scenario as time elapsed from the baseline to the future years of prediction



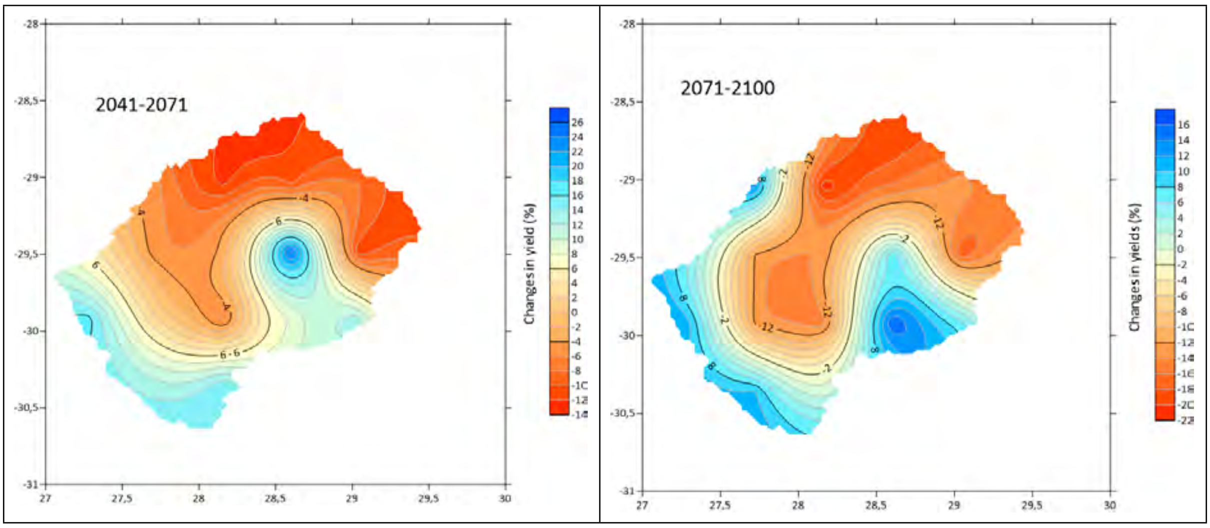


Figure 4D (d): Spatial Variation of simulated change in yields of beans for RCP8.5 emission scenario as time elapsed from the baseline to the future years of prediction

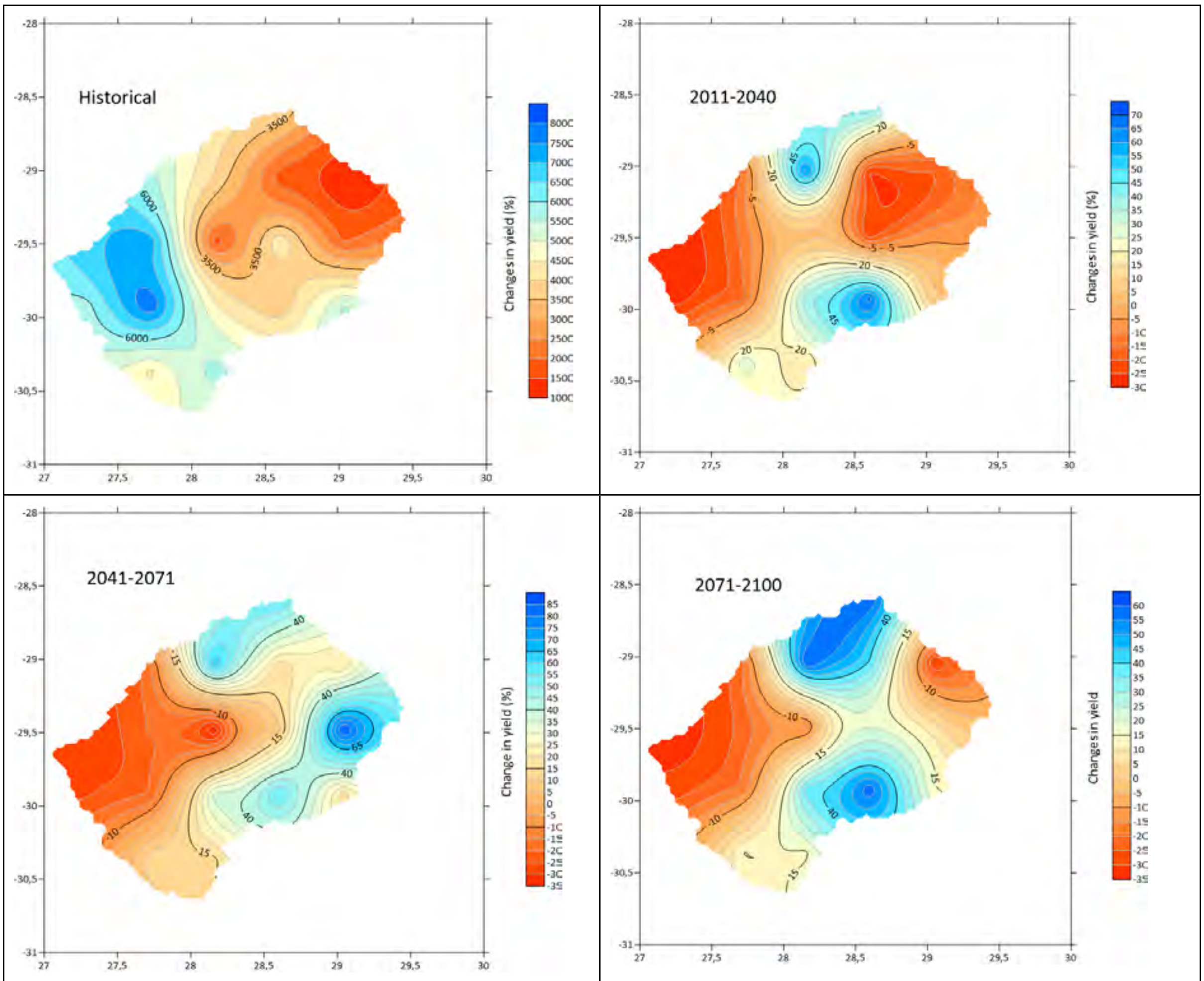


Figure 4D (e): Spatial Variation of simulated change in yields of Sorghum for RCP4.5 emission scenario as time elapsed from the baseline to the future years of prediction

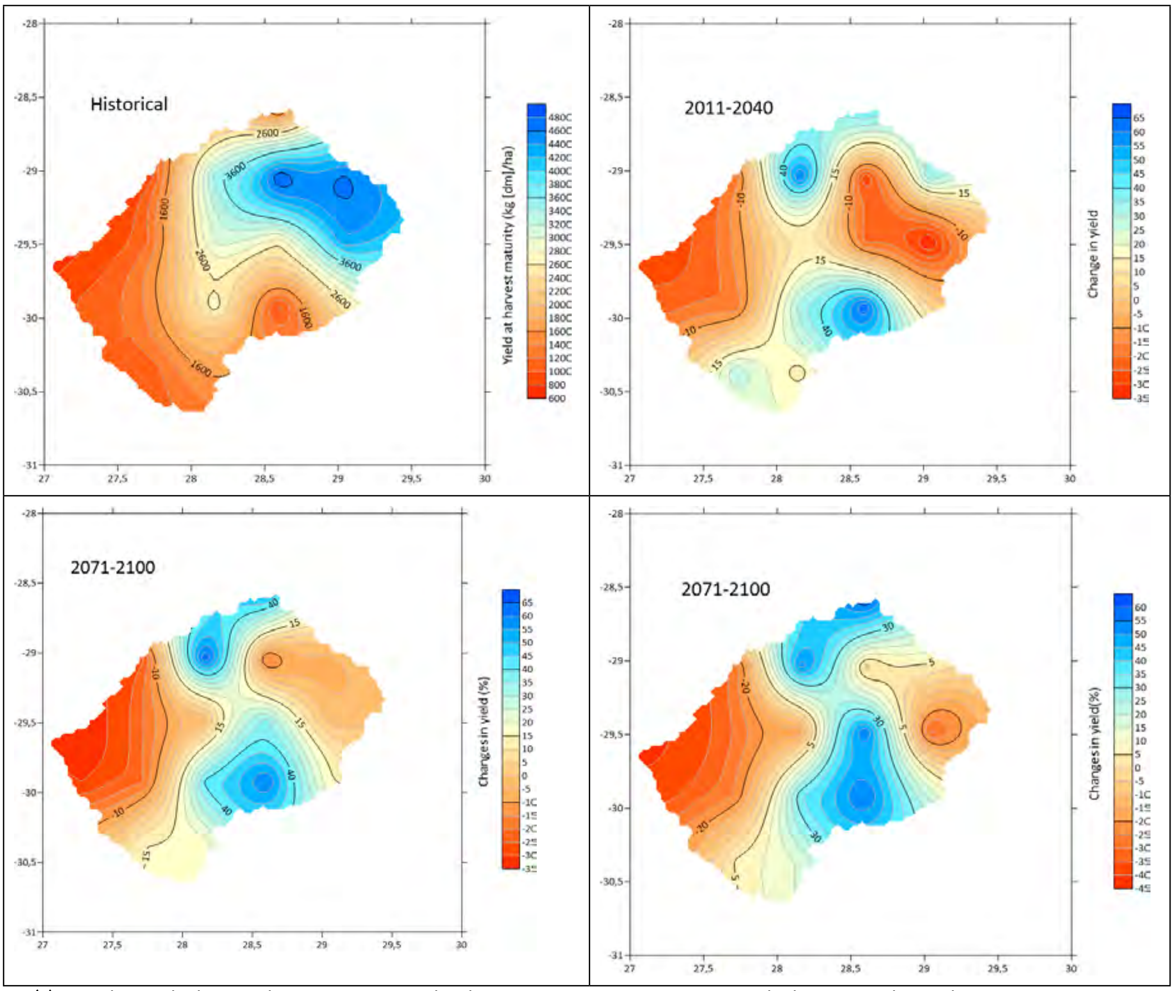
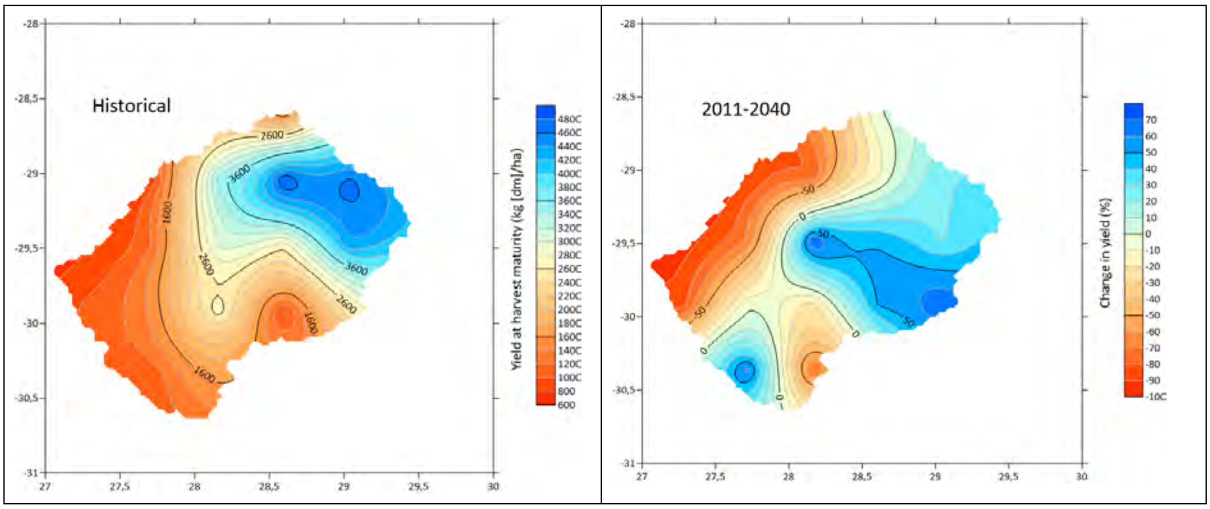


Figure 4D (f): Spatial Variation of simulated change in yields of Sorghum for RCP8.5 emission scenario as time elapsed from the baseline to the future years of prediction



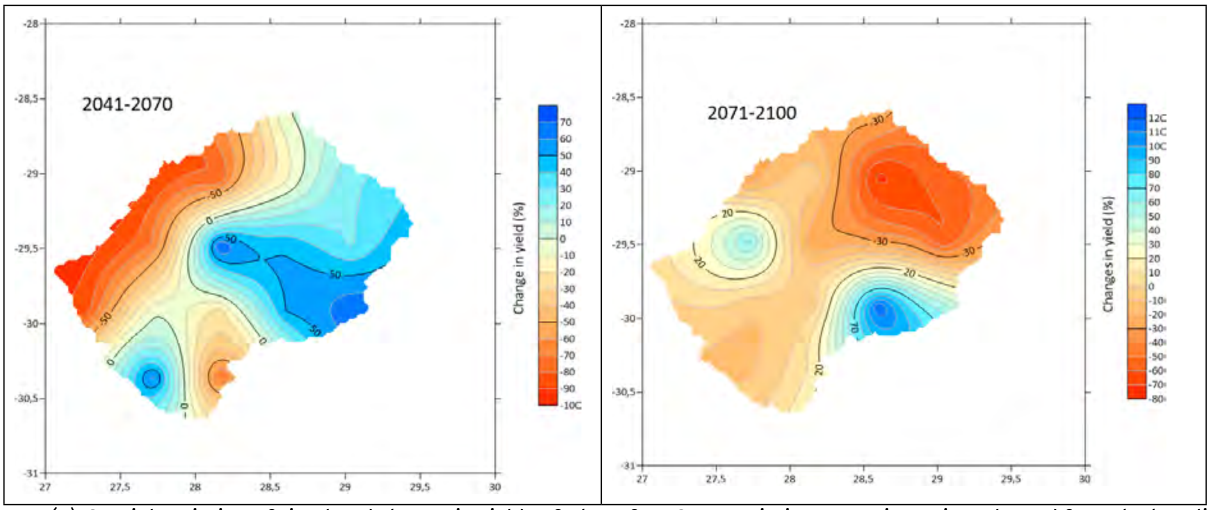


Figure 4D (g): Spatial Variation of simulated change in yields of wheat for RCP4.5 emission scenario as time elapsed from the baseline to the future years of prediction

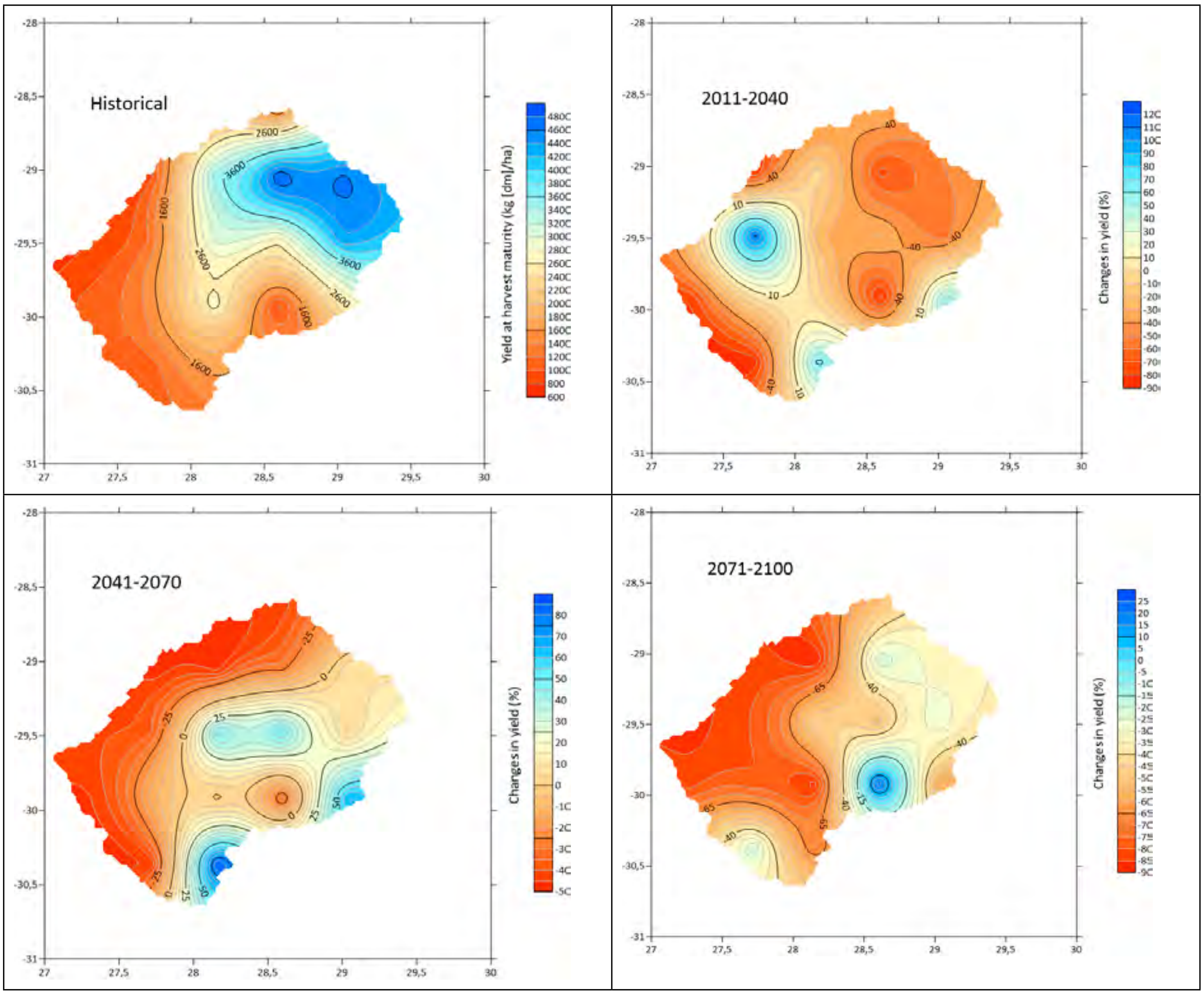


Figure 4D (h): Spatial Variation of simulated change in yields of Wheat for RCP8.5 emission scenario as time elapsed from the baseline to the future years of prediction

APPENDIX 6A

Barriers and suggestions for enabling environment

Barriers	Suggestions for enabling environment
Intellectual property issues: payments required limit innovation in developing countries	International and bilateral negotiations, research partnerships, treating critical technologies as public goods
Technology contributes to the advancement of knowledge on climate change, but is too costly	Government support; International cooperation and knowledge transfer; international funding
New technology with promise for local application, but too costly to develop	Government support; International cooperation and knowledge transfer; international funding
Technology has not yet been proven for local application	Pilot and case studies in cooperation with developers
Lack of knowledge by potential users of the technology and its benefits	Communication and education; development of a critical mass of human capital via appropriate policies; development of adequate support for the national education system, awareness and marketing (branding)
Lack of technical capacity to establish and maintain the technology	International cooperation and knowledge transfer; technology-related capacity building; development of a critical mass of human capital via appropriate policies; development of adequate support for the national education system
High cost of establishment of the technology	Re-evaluation taking full cost into account; R&D for local substitutes; removal of import tariffs, international funding or subsidies
High cost of operation and maintenance for the technology	Re-evaluation taking full cost into account; R&D for local substitutes; subsidies
Cultural preferences impeding uptake of technologies	Communication and education; culturally appropriate modification of the technology
Inadequate macro-economic policies	Changes in the macro-economic environment; improving financial and administrative efficiencies
Low perception of importance by economic actors	Necessity of an explicit national policy supporting technology development

Lack of suitable small and medium-sized firms for subcontracting	Provision of support to small and medium-sized firms for productive activities in the economy
Lack of appropriate financial systems	Cooperation with financial institutions, such as the African Development Bank (AfDB)
Absence of feasible and appropriate standards based on local conditions	Establish appropriate standards
Institutional inertia and unwillingness to change	Restructuring and introducing corporate and personal accountability
Lack of adequate government support facilities	Government investments; international funding
Lack of access to global information (e.g., expensive technology for attending conferences)	Establishment of effective linkages with national education systems, web-based information dissemination, international cooperation and knowledge transfer
Lack of local data for design of good investment projects and for appraisal (monitoring, assessment and evaluation)	Develop and maintain integrated and accessible information systems
Lack of engineering procedures for testing, commissioning, and supporting equipment purchases (e.g., PV technology), leading to poor performance, maintenance and operation, and making the technology appearing to be dysfunctional	Develop engineering procedures for testing and commissioning of equipment and system of support to users, international knowledge transfer
Relatively weak enforcement mechanisms for legislation relating to investments and companies	Legal system reform ensuring transparency of investment considering triple bottom line

APPENDIX 6B

Summary of the key actions to support roll out of the technologies

Technology	Actions required to support large scale roll-out	Estimated Cost of Implementation
Energy Efficient Lighting	a. Availability of less energy efficiency alternatives could be restricted or the use of taxes to make them more expensive could be expanded b. Distribution schemes where LEDs are distributed at no or low cost would increase uptake and change purchasing behaviour c. Public awareness campaigns to promote the life cycle benefits of LEDs would increase the uptake thereof d. DOE or other relevant institutions should monitor developments in the use of LEDs in data transmission applications, and identify opportunities in the global markets	USD 660,000
Energy Efficient Appliances	e. Establish broader incentives for disposal of older refrigerators. Incentives aimed at lower end of market/first time buyers could be considered f. Mandatory energy efficient standards and labelling requirements need to be implemented efficiently and enforced	USD350,000
Solar Thermal	g. Quality issues need to be addressed. Developing a self-regulating body to monitor and enforce quality of installations and follow-up services would help in this regard h. Skills shortages also need to be addressed through expanding technical training initiatives i. A review of the National Solar Water Heater Programme is urgently required, and the long-term future of the programme needs to be outlined, to provide certainty to the industry j. Public awareness campaigns are required to promote the uptake of SWHs k. Roadmaps under development may help to provide strategic direction for the industry	USD500,000

Solar PV	l. Concerns regarding availability of grid connections must be addressed m. For distributed solar PV, funding models (*for both PV installations and network operator models that decouple link between electricity supply and revenues*), local content requirements, incentives, market rules and regulations, certification, training, and ways to encourage PV connections to the grid (i.e., prevent a large-scale move to off-grid applications) are all aspects that need to be addressed	USD750,000

APPENDIX 6C

Summary of adaptation options and selected technology for each priority sector

Fresh Water Adaptation Options	Technology Needs	Scale of Technology Status since SNC
Water Conservation including reduction in line losses.	Low flow water Technologies for Domestic uses (e.g., toilets and faucets).	Small
	Institutional Strengthening for water conservation including line loss;	Small to Medium
	Drip and trickle irrigation technologies;	Small
	Water treatment facilities;	Small to Medium
	Geographic Information Systems.	Small to Medium
	Water harvesting/ building standards	Small to Medium
Maintain high quality water.	Pollution prevention and control technologies;	Small to Medium
	Water monitoring equipment;	Small
	Laboratory Services.	Small to Medium
Tourism Adaptation Option	Technology Needs	
Protecting existing tourist facility and infrastructure.	Floods/storm resistant physical structures;	Small
	Information technologies;	Small
	Human resource development.	Small
Diversification of the tourism product.	GIS tools;	Small
	Human resource development;	
	Information technologies: The development of information, raising of awareness and knowledge sharing are critical components in an adaptation strategy	Small to Medium
	Tourism development planning	Small
Adaptation Option for Agriculture	Technology Needs	Scale of Technology Status since SNC

Increased use of heat and drought tolerant plants and animal species.	Agriculture Diagnostic Adaptive Research for plant & animal species;	Small to Medium
	Seed and propagation materials;	Small to Medium
	Agro-Meteorological Monitoring equipment;	Small
	Artificial cooling technologies for animal species;	None
	Modernized artificial insemination equipment;	Small
	Adoption of climate-smart agricultural (CSA) practices Technologies for efficient water use	Small to Medium
	Application of water saving irrigation technologies (drip irrigation).	Small
	Construction of greenhouses with regulatory temperature facilities	None
	Drip and trickle irrigation technologies	Small
	Hail nets for crop protection	Small
Improved pest and disease management.	GIS technologies.	None
	Information technologies.	None
	Environmentally friendly determinants and control materials and equipment.	Small
Adaptation Options for Health	Technology Needs	Scale of Technology Status since SNC
Strengthen Development controls.	Information technologies.	Small
	GIS technologies to support EIA.	Small
Medical Intervention.	Vaccination equipment and supplies.	Small to Medium
	Medical facilities.	Small to Medium
Adaptation Option for Human settlement	Technology Needs	
Improvement of Hazard Mapping/Monitoring.	Automatic Weather stations;	Small to Medium
	Early warning systems.	Small to Medium
	Radar	Small to Medium
Strengthening Development Control	Technology to enhance Integrity of physical structures;	Small
	Technology to improve climate resilience of infrastructure.	Small
Adaptation Options for Disaster Response	Technology Needs	Scale of Technology Status since SNC
Hazard and Risk Management.	Geospatial technologies.	None
	Information technologies	Small
	Human resource development.	Small to Medium
Community Response.	Information technologies - (computers, internet, GIS).	Small to Medium
	Environmental engineering (e.g., Contour terracing, human resource).	Small to Medium

APPENDIX 6D

Summary of mitigation options and selected technologies for each priority sector

Mitigation Options for Energy Sub-Sector	Technology Needs	Scale of Technology Status since SNC
Increased renewable energy penetration.	Introduction of photovoltaic power plants and solar collectors	Limited
	Grid-Interconnection capabilities.	None
	Storage technology	None
	Construction of small and micro hydropower plants in remote mountains and hard-to-reach areas, wind-driven electric power plants, biogas power units for energy supply to private farms	Limited
Transportation of electric energy	Reconstruction and new construction of transformer substations	Small to Medium
	introduction of more cost-efficient electrical equipment, and automatic voltage regulation devices	Small to Medium
Metering and regulating electric and thermal energy consumption	Countrywide introduction of computer-aided systems for electric energy metering	Introduced
	Installation of equipment controlling and regulating heat consumption in residential buildings	None
Mitigation Option for Transportation	**Technology Needs**	**Scale of Technology Status since SNC**
Develop and implement a comprehensive road transport plan	Information management technologies.	None
	GIS Technologies.	None
	Activities for supporting optimal transport and logistics planning, vehicle emission standards, fleet renewal, and other regulatory action	None
Improved Mass transit public system.	Energy efficient transport system;	None
	(Smart) Public buses;	None
	Information management technologies;	None
	Activities for supporting optimal route and passenger terminals, Bus Rapid Transit (BRT) System in Maseru and rush hour lanes	None

Mitigation Option LULUCF and Waste	Technology	Scale of Technology Status since SNC
Data Collection and analysis.	Information technology.	Limited
	Data collection technologies for waste	Small
	Laboratory testing equipment.	Small to Medium
Forest Management GHG Mitigation.	Automatic weather stations.	Small to Medium
	GIS technology for mapping and monitoring forest cover.	Small to Medium
	Forest hydrology.	Small

Lesotho Meteorological Services (LMS)

PHYSICAL ADDRESS
2nd and 3rd floors, Options
Building, Pioneer, Road
Maseru 100
Lesotho

POSTAL ADDRESS
Lesotho Meteorological Services
PO Box 14515
Maseru 100
Lesotho

HEAD OFFICE CONTACTS
Tel: +266 22325057 / 22317250
Fax: +266 22325057

WEATHER OFFICE CONTACTS
Tel: +266 22350701
Fax: +266 22350325

www.**lesmet**.org.ls