THE KINGDOM OF LESOTHO'S FIRST

BIENNIAL UPDATE REPORT 2021

UN environment
United Nations Environment Programme

INTRODUCTION

MINISTERIAL FOREWORD

Lesotho has always appreciated that the two-fold objective of the United Nations Framework Convention on Climate Change (UNFCCC), adaptation and mitigation, is an issue of critical importance to the survival of Lesotho's people. Loyal to this noble objective, as a country, we have striven to adhere to our national commitments under the UNFCCC, nationally, regionally and internationally. We will remain committed to combatting climate change. Our country is landlocked, mountainous, semi-arid with a variable climate and characterised by extremes of weather. We appreciate the fact that the goal of achieving sustainable development at the global level will remain elusive if climate change issues are not addressed.

In line with our commitments and our desire for the globe to adopt measures that will halt the climate change, Lesotho ratified the Kyoto protocol and acceded to the Paris agreement. At the national level, one of the ongoing activities is the initiative towards completing the Nationally Appropriate Mitigation Actions (NAMAs). Notable milestones include the formulation and adoption of National Climate Change Policy (2017), the completion and submission of the Nationally Determined Contributions (NDCs), and the operationalization of the National Climate Change Implementation Strategy (2019). Further, the national development plans and policies on energy development have been adjusted to emphasis development on renewable energy mainly hydro, solar and wind, which Lesotho has in abundance.

To remove barriers towards implementation of the broad national climate change programme, recent measures undertaken by Government of Lesotho include overhauling the legislative, legal and institutional frameworks to fast-track mainstreaming of climate change. The role of Lesotho Meteorological Services (LMS) as our National Authority and Focal Point on climate change issues, has been elaborated. Similarly, the roles of key climate change have been identified and coordinated under the all- inclusive National Climate Change Committee (NCCC).

We prioritise adaptation in our strategies and view climate change mitigation programmes as tools to enable acquisition of technologies and capacity building that would result in demonstrable and sustainable social and economic development. To ensure mainstreaming of climate change, our approach is to strenuously shift from project based approaches to adopting institutionalised formats. For instance, we will soon be implementing a greenhouse gas (GHG) inventory management systems which will be more effective in monitoring GHG emissions in Lesotho. This system will be based on participation by various institutions on a continuous basis. It will thus ensure reporting, documentation and archiving of these gases at various sectoral levels resulting in a sustainability of efforts. This format will be replicated to other tasks under the national climate change programme.

Mohapi Mohapinyane

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Acronyms and Abbreviations

AC	*Air Conditioning*
AFOLU	*Agriculture, Forestry and Other Land Use*
AGOA	*African Growth and Opportunity Act*
AMCEN	*African Ministerial Conference on Environment*
AMESD	*African Monitoring of the Environment for Sustainable Development Bureau of Statistics*
ATS	*Appropriate Technology Services*
AUC	*African Union Commission*
BAU	*business as usual*
BBCDC	*Bethel Business and Community Development Centre*
BEDCO	*Basotho Enterprise Development Corporation*
BoS	*Bureau of Statistics*
BUR	*Biennial Update Reports*
CCA	*Climate Change Adaptation*
CDM	*Clean Development Mechanism*
CO_2e	*CO2-equivalent*
COMESA	*Common Market for Eastern and Southern Africa'*
COP	*Conference of the Parties*
CP	*Conference of the Parties*
CSOs	*Civil Society Organisations*
DEWATS	*Decentralized Wastewater Treatment Systems*
DF	*Default Factor*
DOE	*Department of Energy*
EAC	*East African Community*
EEP	*Energy and Environment Partnership*
EF	*Emission factor*
ERM	*Environmental Resources Management*
ES	*Executive Summary*
EU	*European Union*
FAO	*Food and Agriculture Organization*
FOLU	*Forestry and Other Land Use*
FRA	*Forest Resource Assessment*
GCCA	*Global Climate Change Alliance*

GDP	*Gross Domestic Product*
GEF	*Global Environment Facility*
GHG	*Greenhouse gas*
GoL	*Government of Lesotho*
GWPs	*Global Warming Potentials*
HDI	*Human Development Index*
HFCs	*Hydrofluorocarbons*
ICM	*Integrated Catchment Management*
IFAD	*International Fund for Agricultural Development*
IP	*Investment Plan*
IPCC	*Intergovernmental Panel on Climate Change*
IPPU	*Industrial Processes and Product Use*
ISWMP	*Integrated Solid Waste Management Plan*
ISWMS	*Integrated Solid Waste Management System*
IWM	*Integrated Watershed Management*
LASAP	*Lesotho Adaptation of Small-Scale Agriculture Production*
LDCF	*Least Developed Countries Fund*
LDF	*Lesotho Defense Force*
LDN	*Land Degradation Neutrality*
LESES	*Lesotho Solar Energy Society*
LFDS	*Lesotho Flying Doctor Service*
LHWP	*Lesotho Highlands Water Project*
LMS	*Lesotho Meteorological Services*
LNDC	*Lesotho National Development Corporation*
LPG	*Liquid Petroleum Gas*
LREBRE	*Lesotho Renewable Energy-Based Rural Electrification Project*
LULUCF	*Land use Change and Forestry Sector*
M&E	*Monitoring and Evaluation*
MAF	*Mission Aviation Fellowship*
MAFS	*Ministry of Agriculture and Food Security*
MCC	*Maseru City Council*
MDGs	*Millennium Development Goals*
MEAs	*Multilateral Environmental Agreements*
MEM	*Ministry of Energy and Meteorology*
MESA	*Monitoring for Environment and Security in Africa*

MIA	*Moshoeshoe International Airport*
MRV	*Measuring, Reporting and Verification*
MSMEs	*Micro, Small and Medium Enterprises*
NA	*Not Applicable*
NAMAs	*Nationally appropriate mitigation actions*
NAPA	*National Adaptation Programme of Action*
NCCC	*National Climate Change Committee*
NCCP	*National Climate Change Policy*
NCCPIS	*National Climate Change Implementation Strategy*
NCDC	*Curriculum Development Cente*
NCs	*National Communications*
NDC	*Nationally Determined Contributions*
NDPs	*National Development Plans*
NE	*Not Estimated*
NGO	*Non-Governmental Organizations*
NO	*Not Observed*
NSDP	*National Strategic Development Plan*
ODS	*ozone depleting substances*
PID	*Project Information Document*
PMT	*Project Management Team*
PV	*Photovoltaic*
QA	*Quality Assurance*
QC	*Quality Control*
RE	*Renewable Energy*
REDD	*Reducing Emissions from Deforestation and Forest Degradation*
REEEP	*Renewable Energy and Energy Efficiency Partnership*
SA	*South Africa*
SACU	*Southern Africa Customs Union*
SADC	*Southern Africa Development Community*
SAR	*Second Assessment Report*
SDGs	*Sustainable Development Goals*
SE4All	*Sustainable Energy for All*
SHS	*Solar Home Systems*
SMART	*specific, measurable, achievable, relevant and time-bond)*
SNC	*Second National Communication*

SOC	*State-owned Company*
SREP	*Scaling up Renewable Energy and Energy Efficiency Programme*
SWH	*solar water heater*
TAM	*Typical Animal Mass*
TED	*Technologies for Economic Development*
TEG	*Thematic Expert Group*
TSP	*Target Settling Programme*
U.S	*United States*
UNCCD	*United Nations Convention to Combat Desertification*
UNDP	*United Nations Development Programme*
UNEP	*United Nations Environment Programme*
UNFCCC	*United Nations Framework Convention on Climate Change*
USGS	*United States. Geological Survey*
VIP	*Ventilated Improved Pit*
WAMPP	*Wool and Mohair Promotion Project*
WASCO	*Water and Sewerage Company*
WWTW	*wastewater treatment works*

Gases

CH_4	*Methane*
CO_2	*Carbon Dioxide*
N	*Nitrogen*
N_2O	*Nitrous Oxide*
NH_3	*Ammonia*
NMVOCs	*Non-methane Volatile Organic Compounds*
NO_x	*Nitrogen Oxide*

Units

Gg	*Gigagram*
Kg	*Kilogram*
Km	*Kilometre*
L	*Litre*
MJ	*Megajoule*
Mm	*Millimetre*
MW	*Megawatt*

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Executive Summary

As signatory to the United Nations Framework Convention on Climate Change (UNFCCC), and a Non-Annex I Party, Lesotho is obliged to submit to the Conference of the Parties, information relevant to the achievement of the objective of the Convention, in accordance with Articles 4 and 12 of the Convention. Pursuant to Decision 1CP/16, Non-Annex I Parties should also submit Biennial Updates Reports (BUR), every two years, hence the preparation of the first Lesotho BUR. The Government of Lesotho is submitting its First Biennial Update Report (BUR) under the United Nations Framework Convention on Climate Change (UNFCCC. The report is an update of the Third National Communication and follows the Biennial Reporting Guidelines for Parties not included in Annex I to the Convention. Therefore comprises of the following seven chapters:

- 1. National circumstances
- 2. National greenhouse gas (GHG) inventory
- 3. Mitigation actions and their effects
- 4. Domestic Monitoring, Reporting and Verification
- 5. Constraints and Gaps,
- 6. Any other information

ES1: NATIONAL CIRCUMSTANCES

ES1: National Circumstances

Located in Southern Africa an enclave of South Africa, Lesotho stretches Lesotho is a landlocked country, completely surrounded by South Africa (SA) with an area of 30,355 square kilometres. It lies between latitudes 28° and 31°S, and longitudes 27° and 30°E. T he landscape is a rugged terrain with elevation from 1,388 m to 3,482 m. Only 10% of the country's land is arable. Lesotho is segregated into four (4) distinct agro- ecological zones/regions, namely, the Lowlands (17%), Foothills (15%), Mountains (59%) and Senqu River Valley (9%) Significant climatic and ecological differences characterize these zones. The geo-morphological and topographic conditions have largely confined favourable socio-economic conditions to the lowlands, the foothills and the Senqu River Valley, leaving the mostly barren and rugged mountain region mainly for grazing. Lesotho has an estimated population of 2 million people, with 48.9% male and 51.1% female. The population in Lesotho has risen from around 851 590 people in 1960 to 2 007 201

Country	**Kingdom of Lesotho**
Location	Southern Africa, an enclave of South Africa, at 29 30 S, 28 30 E
Total Surface Area	30, 355 km²
Population and Growth Rate	2,007,201 ((BOS, 2016) 0.8% Population growth rate per annum.
Economy	Water, Manufacturing, Mining, and Agriculture, SACU Customs duties. GDP : $2.13 billion nominal (2010 est)GDP Growth: 3.3% (2016 est.)GDP per Capita: $1,670 (PPP) (2011 est.)
Climate	Continental temperate climate, with hot summers and cold winters. Highly variable characterized by droughts, floods, frosts, snow, hail-storms and windstorms.
Government	Constitutional Monarchy

Climate of Lesotho

Lesotho has a continental temperate climate, with hot summers and cold winters. The seasons comprise of spring (September, October, and November), summer (December, January, February), autumn (March, April, May) and winter (June, July, August). Due to the overall altitude of the country, temperatures are generally lower than those of other inland regions of similar latitude. Maseru, the capital city and its surrounding lowlands often reach above 30°C in the summer. Normal monthly mean winter minimum temperatures range from -6.3°C in the Highlands to 5.1°C in the Lowlands. However, extremes of monthly mean winter minimum temperatures of -10.7°C can be reached and daily winter minimum temperatures can drop as low as -19°C in the highlands. The mean summer temperature is about 25°C and the mean winter temperature about 15°C (LMS, 2013).

Climate Change and Lesotho

Lesotho is one of the countries that are very susceptible to the negative impacts of climate change, and has already, in recent years, been affected by climate change impacts include storms, droughts and floods and an increase in the incidences of natural disasters. Precipitation has become unpredictable leading to droughts and dangerous farming conditions. Exacerbated by climate change, farming in Lesotho is in a fixed decline and the below aspects are on the increase:

- Depletion of the country's natural resources;
- Food insecurity;
- Loss of biodiversity;
- Human, animal as well as crop diseases, and
- Soil loss, land and environmental degradation. (Lesotho's National Climate Change Policy, 2017)

Institutional Arrangements

Institutional Framework for Addressing Climate Change

The Ministry of Energy and Meteorology (MEM), through the Department of Meteorology (LMS) is the focal point on climate change. LMS leads the efforts to implement the National Climate Change Policy1 and National Climate Change Implementation Strategy. Key functions of LMS are to monitor the weather and climate, ozone layer protection and climate change detection. It also assesses vulnerability to climate change and response measures and coordinates activities emanating from Lesotho's obligations and related agreements. The government of Lesotho established the National Climate Change Committee (NCCC) in 2013. Its main function is to advise the MEM on effective implementation of the National Climate Change Policy, acting as well as a link between the LMS and the various social and economic sectors.

To effectively achieve the objective of the Policy, all institutions have a responsibility to participate in the NCCC in order to be familiar with projected climate change episodes and events in the short and long term, to be appraised of the likely impacts of climate change. Institutions, as a result, should have in place, adequate response measures to the effects of climate change. Educational institutions and all tiers of

1 National Climate Change Implementation Strategy (NCCPIS)

government including central government, local government as well as NGOs have a role to institutionalise climate change. A culture of networking and building on synergies at all levels and amongst the institutions is key to achieving the objective of the NCCC.

Institutional arrangements for the GHG Inventory Compilation

Figure ES 1 below presents the institutional arrangements for compilation of Lesotho's 4th National GHG inventory. LMS is the national agency with the overall responsibility for compiling the national GHG inventories. Other departments and institutions support LMS with data and expert input.

Each sector in the GHG compilation has a number of national departments and institutions that contribute to data-collection. Table ES 2, Table ES 3, Table ES 4 and Table ES 5 present a breakdown of the institutional arrangements and roles per sector.

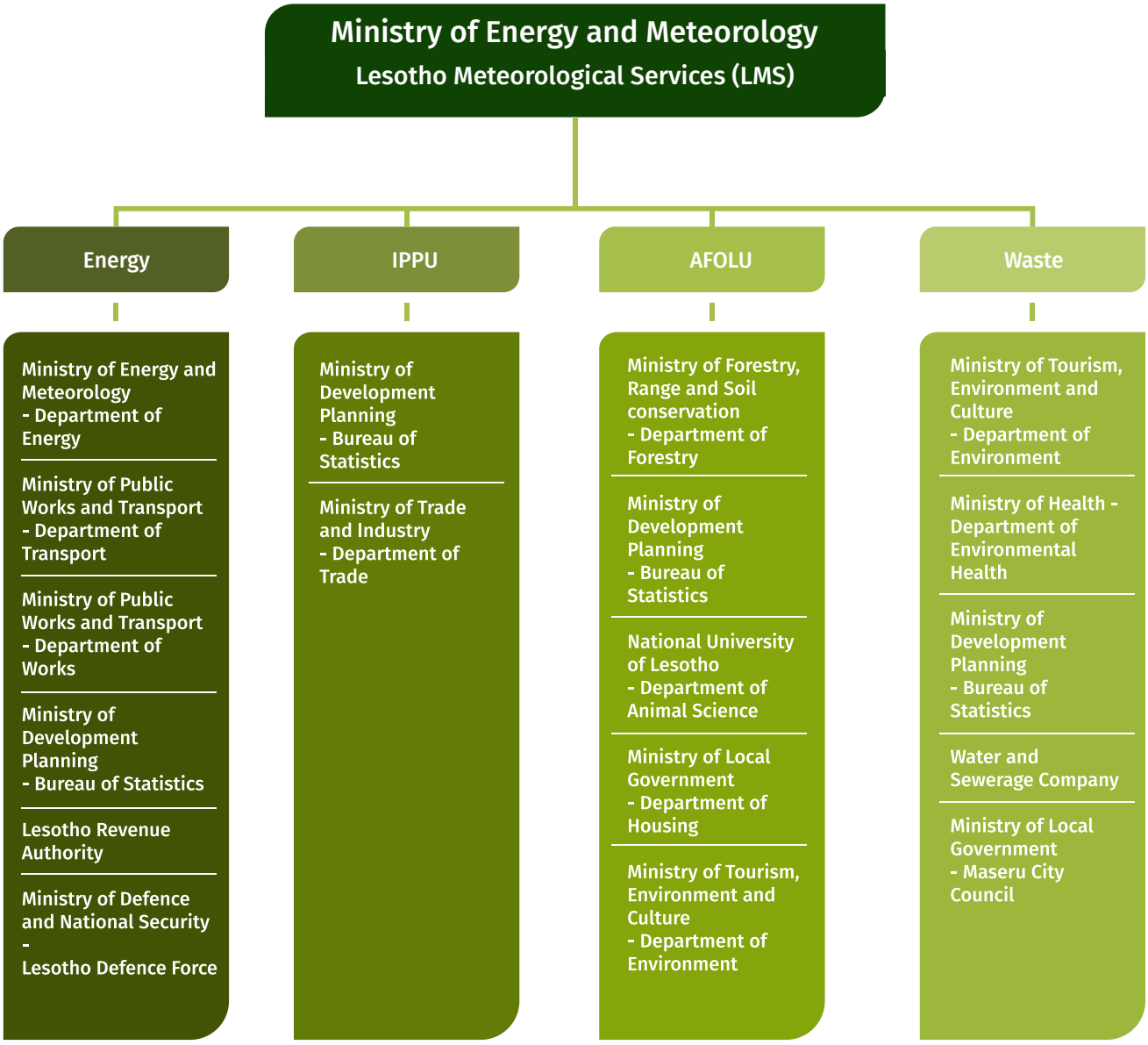


Figure ES 1: Institutional arrangements for the GHG compilation

Table ES 2 Roles of the Institutions in the Energy sector

Ministry / Agency	Role
Department of Energy	Provides: National Energy Balances Imports of petroleum fuels
Bureau of Statistics	Provides information on all fuels consumed
Department of Transport	Provides vehicle statistics
Lesotho Revenue Authority	Provides information on: vehicle imports Imports of all fuels
Ministry of Defence Force	Provides data on fuel consumed by the Ministry
Lesotho Meteorological Services	Collects data on aviation fuel consumed by Non-Governmental Organizations (Mission Aviation Fellowship)

Table ES 3: Roles of the Institutions in the IPPU sector

Ministry / Agency	Role
Lesotho Meteorological Services – Ozone Unit	Provides quantities of HFCs consumed / imported
Bureau of Statistics	Provides refrigeration data
Lesotho Meteorological Services	Collects data on: Ceramics and bricks Beverages

Table ES 4:Roles of the Institutions in the AFOLU sector

Ministry / Agency	Role
Department of Crops	Provides information on: Fertilizer, urea & lime application info; Cultivated area per year; Landcover atlas, Agricultural production survey – crops.
Bureau of Statistics	Provides the Lesotho Agricultural Census Report and Livestock Report
Department of Forestry	Provides forestry and land used data
Department of Environment	Provides data on burnt areas

Table ES 5: Roles of the Institutions in the Waste sector

Ministry / Agency	Role
Department of Environment	Provides information on solid waste per capita for Maseru and Lesotho Provides information on Open Burning of waste
Department of Environmental Health	Provides information on incineration of medical waste
Bureau of Statistics	Provides information on population data and solid waste
Water and Sewerage Company	Provides information on Waste Water Treatment - Domestic Waste

Building Sustainable Future GHG Inventory Management System

With the view to enhance a more systematic approach in monitoring GHG inventories and tracking the effectiveness of the climate change mitigation in Lesotho, it is paramount that the country establishes a sustainable national GHG Inventory Management System. The system will ensure a shift of the GHG preparation process from a project-based approach to a more internalized and institutionalized approach which will support the timely delivery of the required information; more efficient use of available resources; and ownership of the GHG inventory process by various institutions. Such a system should address the key elements of the GHG inventory process such as: planning; preparation; reporting; documentation and archiving; as well as inventory improvement strategy.

Domestic Measurement, Reporting and Verification

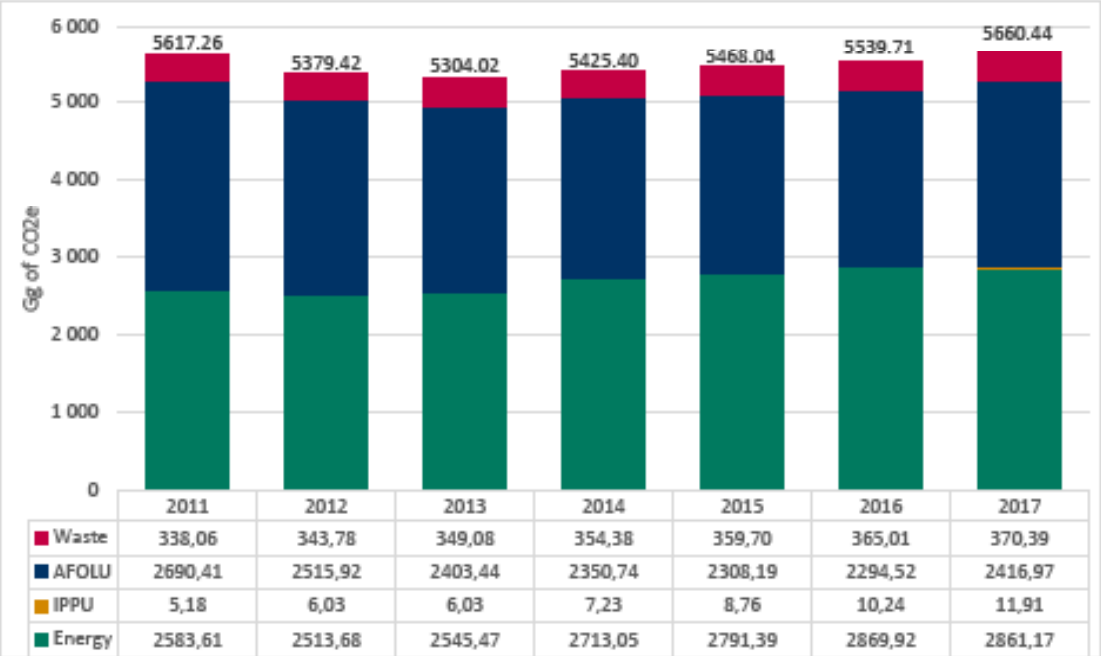
Lesotho has designed the Domestic Measurement, Reporting, and Verification (MRV) System as a fundamental requirement for the country to meet the reporting requirements of the UNFCCC. Aimed at enhancing tracking of: GHG emission levels; the impact of mitigation and adaptation actions; and international, regional and domestic climate finance flows, the system will constitute institutional, regulatory, technical, and sectoral bodies at multi-levels of government, all interacting to track down the quantity of GHG emissions, the quality of GHG inventory and monitoring, the effectiveness of mitigation actions and support received (domestic and international). The system will therefore be premised on national climate change policy, and in line with national plans and programmes. The system will be anchored by Climate Change Monitoring and Evaluation (M & E) Framework. Furthermore, Lesotho's MRV System should be robust enough to effectively deliver the following key outcomes:

- Deliver quality data to help report and evaluate climate change policy and action;
- Promote transparency of GHG reporting;
- Give clear picture of national priorities, strengths and weaknesses which provides clarity on future capacity building needs and financial support;
- Help reporting entities to assess their climate risks and opportunities.

ES 2: Lesotho's National GHG Inventory

Lesotho has compiled four National GHG inventories to date. Based on the revised 1996 IPCC guidelines the country compiled two inventories for the year 1994 and 2000. While under the 2006 IPCC guidelines the 3rd inventory was compiled covering the years 2005 to 2010 under the Third National Communication and 4th inventory covered the years 2011 to 2017. Lesotho has experienced a decrease in GHG emission between 2011 and 2013 due to the decrease in energy sector emissions resulting from decreased consumption of petroleum fuels over that period as well as decrease in AFOLU emissions. The country's net GHG emissions amounted to 5 660.44 Gg CO_2e in 2017, with the energy, AFOLU, waste and IPPU sectors contributing 50.5%, 42.7%, 6.5% and 0.3% respectively. Residential energy consumption is the biggest contributor to the energy sector emissions.

As depicted in energy sector had been the most contributing sector to the inventory followed by AFOLU sector between the years 2013 and 2017. The opposite was observed for the years 2011 and 2012 from the same figures, while the IPPU sector was the least contributor throughout the period averaging 0.14%.



	2011	2012	2013	2014	2015	2016	2017
Waste	338,06	343,78	349,08	354,38	359,70	365,01	370,39
AFOLU	2690,41	2515,92	2403,44	2350,74	2308,19	2294,52	2416,97
IPPU	5,18	6,03	6,03	7,23	8,76	10,24	11,91
Energy	2583,61	2513,68	2545,47	2713,05	2791,39	2869,92	2861,17

Figure ES 2: Summary of GHG Emissions

ES3: Mitigation actions and their effects

The Kingdom of Lesotho's approach to climate change mitigation is enshrined in the National Climate Change Policy (NCCP) 2017-2027 which envisions "to build climate change resilience and low-carbon societies including a prosperous economic environment in the country". The Policy underscores the implementation of concrete climate change adaptation and mitigation measures, advancing low-carbon development pathways and building more sustainable development outcomes that consider on-going and future climate-related impacts.

In addition, the Policy emphasizes the need to ensure active participation of all stakeholders in the social, environmental, and economic sectors. This endorses climate-smart agriculture, renewable energy sources and energy efficiency, best practice for forestry and rangelands as well as low-carbon transport systems; which are identified as sectors with mitigation potential.

In pursuit of the above aspirations, Lesotho is guided by relevant international, regional and national guidelines and principles. One of the main guiding principles is to develop and implement cost-effective integrated mitigation solutions, which have environmental and socio-economic benefits. Furthermore, Nationally Determined Contribution (NDC) has identified 10% unconditional and 25% conditional target reduction in Greenhouse gas (GHG) emissions compared to business as usual (BAU) by 2030; Lesotho has set an ambitious, fair and responsible contribution to global efforts towards meeting the objective of the United Nations Framework Convention on Climate Change (UNFCCC) and the goal of limiting global average temperature rise to below 2.0°C aligning with the set emission targets under the Paris Agreement.

Nationally Appropriate Mitigation Actions

This project supported the technical development of NAMAs that are presented under chapter three of this report. The NAMAs are expected to fulfil Lesotho climate goal under the NDC. Lesotho's NAMAs are sector based and specific activities that are readily Measurable, Reportable and Verifiable. Five projects were identified as NAMAs through participatory approach.

[1]LMS 2017. Lesotho's National Climate Change Policy. Ministry of Energy and Meteorology, Lesotho.

ES4: CONSTRAINTS AND GAPS, AND RELATED FINANCIAL, TECHNICAL AND CAPACITY NEEDS, INCLUDING A DESCRIPTION OF SUPPORT NEEDED AND RECEIVED

Constraints and Gaps

Lesotho has been compiling and reporting its GHG inventories since the First National Communication. The country is committed to implementing low carbon development strategies, and this commitment requires high-quality GHG inventories that are sustainable and consistent with the Intergovernmental Panel on Climate Change (IPCC) sectors and methodologies. However, there are three main constraints related to achieving such a quality inventory namely activity data, emission factors and capacity.

Support Recieved and Needed

For Lesotho to fulfil obligations under the convention, the country has received financial and technical support from the bilateral and multilateral agencies. About 43% financial support received was from Global Environmental Facility (GEF) and Least Developed Countries Fund (LDCF) for the implementation of adaptation priorities identified under the National Adaptation Programme of Action (NAPA) (see figure ES 1). The country also received a total of 351,000 from GEF for the preparation of the first Biennial Update Report. The Other climate change projects have been implemented through technical and financial support from bilateral and multilateral financing mechanisms. Initiatives including sustainable land management, reforestation and afforestation as well as Integrated Watershed Management (IWM) have been implemented through the national budget support.

Figure ES 3: Financial Support received for climate change projects

1. NATIONAL CIRCUMSTANCES

The Government of Lesotho signed the United Nations Framework Convention on Climate Change 1992, and deposited her accession to the same in 1995. Notwithstanding the fact that the country possesses limited resources as a Least Developed Country, Lesotho has adhered to her commitments under the Convention and its Protocols and Agreements, such as the Kyoto Protocol and Paris Agreement (Lesotho Meteorological Services, 2014).

At the same time, Lesotho is a signatory to other Multilateral Environmental Agreements (MEAs) and Protocols such as: United Nations Convention to Combat Desertification (UNCCD), United Nations Convention on Biological Diversity, the Vienna Convention on Substances that deplete the Ozone Layer, in particular its Montreal Protocol for Protection of the Ozone Layer, Stockholm Convention on Persistent Organic Pollutants Ramsar, Convention on the Protection of Wetlands of International Importance; Cartagena Protocol on Bio-safety and Basel Convention on Trans-boundary movement of hazardous wastes and their disposal. The country is also guided among others by the African Union Commission (AUC) Agenda 2063: the Africa We Want; Southern Africa Development Community (SADC), the African Ministerial Conference on Environment (AMCEN), the SADC-Common Market for Eastern and Southern Africa - East African Community (SADC-COMESA-EAC) Tripartite Programme on Climate Change Adaptation and Mitigation.

1.1 Geographic Profile

Lesotho is located in the south eastern part of Southern Africa between 28°S and 31°S Latitude and 27° E and 30°E Longitude. It is a landlocked country, entirely surrounded by the Republic of South Africa and occupies a total land surface area of 30, 3 55 km². It possesses a mountainous and rugged terrain with elevation ranging from 1,388m to 3,482m above sea level. It is divided into four distinct geographical zones characterized by significant climatic and agro-ecological differences, namely: the Lowlands (17%); Foothills (15%) Mountains (59%); and the Senqu River Valley (9%). Most socio-economic activities are confined to the lowlands and the foothills. The mostly barren and rugged mountain region as well as the Senqu Valley are mainly for livestock grazing and water resources development initiatives.

Figure 11: Location map of The Lesotho Kingdom showing administrative divisions

1.2 Climate

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 zone. 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 transition seasons (Autumn and Spring). Winters (May June July) are dry and cold. Winter precipitation is mainly in the form of snow, which occurs annually over the Highlands, and occasionally over the Lowlands. Heaviest snowfalls occur at the beginning or the end of the winter season. Summers (November, December January) are hot and humid. The average annual precipitation for Lesotho was found to be about 720 millimeters, 85 percent of which falls between October and April with a standard deviation of rainfall of about 130 millimeters, resulting in a coefficient of variation of about 20 percent. Summers are hot and moist.

Precipitation is highly variable both temporally and spatially. Annual precipitation ranges from as low as 500 mm in the Senqu River Valley area to as high as 1,200 mm in the northern and eastern escarpment, which provide the critical headwaters of the main river systems in Southern African Sub region, the Senqu, the Lekoa and the Tugela, and are part of the Highlands region (Figure 1-3: Annual Precipitation in Lesotho). Precipitation show considerable variation from year to year. Most of the precipitation comes in the seven-month wet summer season from October to April. The peak rainfall period is from December to February when most parts of the country record over 100 mm per month at an average of 6 days with a precipitation of at least 5.0 mm. The lowest rainfall occurs in July when the monthly totals of less than 15mm are recorded at most stations.

Total monthly evaporation ranges from 60 mm to 70 mm during June – July period, to between 175mm and 225mm in during December – January period. The annual mean for the whole country ranges from between 1,400mm in the Highlands to 1,600mm in the Lowlands. Evaporation is greater than rainfall, except for the month of April. The deficit is greatest in summer. In general Lesotho enjoys relatively low humidity, and very clean air.

The country enjoys 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 5,700MJ/m2 and 7,700MJ/m2. 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 of both north 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. January records the highest mean maximum temperatures throughout the country, ranging from 20°C in high

altitudes to 32°C in the Lowlands (Figure 1-2: Annual mean temperatures). On the other hand, minimum temperatures of around 0°C are frequent in June, 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, and highest daily temperature can reach 37.7 oC.

Figure 1-2: Annual mean temperatures

On average, the first and last days of frost occurrence in the lowlands are respectively around the 18th April and 6th September, while those for the mountains are 16th March and 19th November. These respectively give a frost risk of 111 days for the Highlands and 276 days for the Lowlands. However, sub-zero temperature can occur on any day throughout the year in any region of the country. Monthly mean wind speed range from 1.4m/s in October to 8m/s in August and are generally westerly varying between 200° and 300°. High winds of up to 20m/s can sometimes be reached associated with summer thunderstorms.

Figure 1-3: Annual Precipitation in Lesotho

1.3 Population

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. The population declined in 2005-2010 only to rise again by 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 (Human Development Report, 2019) 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.

1.4 Economy

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 (Bureau of Statistics, Annual National Accounts of Lesotho 2010-2019, 2019).

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 percent (Bureau of Statistics, Lesotho Labour Force Survey, 2019). 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 be severely compromise productivity of all arms of the economy.

1.5 Energy

Lesotho's primary energy base consists of hydroelectricity, biomass, and petroleum products. These energy bases comprise about 10% of Lesotho's gross domestic product and employment generation rate of about 0.1% of the population. Energy consumption has grown at the rate of about 9.0% per annum (REEEP, 2012). 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 (Commission of Water, 2012) 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 hold 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.

Emissions from the sector of Energy make a total of 1,079.43 GgCO_2eq which mostly originate from residential fuel combustion, followed by the similar use of petrol and diesel by road transportation. Residential emissions emanate from the use of imported fossil fuels including coal, Liquid Petroleum Gas (LPG) and paraffin. CO_2 can be traced as the major contributor, making about 75% of total sectoral emissions. Therefore, focusing on energy efficiency, security of supply and import substitution, the country's energy sector policies accordingly put more emphasis on expanding renewable energy sources and implementing biomass and biogas development programmes. The substitution of fossil fuels with green power household, industrial and commercial sectors will substantially reduce the amount of GHG emissions (LMS, 2013).

1.6 Transportation

Lesotho's transport system encompasses road, rail, air, animal transport and ferry This sector's infrastructure consists of: road network of 7,437 km, Moshoeshoe I International Airport in Maseru and 12 operational airstrips throughout the country; 2.5km railway line from Maseru industrial area to the Maseru Bridge border as well as a network of bridle paths and footpaths. Road transport is the main mode of transport and the fleet is characterized by light vehicles; trailers; heavy vehicles; tractors; construction vehicles; goods delivery vehicles; motor cyclist; and buses and mini - buses. The less developed and sparsely populated mountainous areas are serviced by ferry services at river crossings, animal transport and pedestrian travel. Congestion prevention and pollution reduction, informed town planning, and the development of integrated/inter-modal transport system, are identified as factors of strategic importance in shaping the future of the country's transport sector (Lesotho Government, Ministry of Development Planni, 2012).

1.7 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 (Lesotho Review, Lesotho Review: An Overview of the Kingdom of Lesotho's Economy, 2014) (Lesotho Review, 2014). 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.

Source: IPTC Photos (Metebong Waste Solutions)

1.8 Waste Sector

The waste sector in Lesotho is composed of two distinct sectors, namely; the solid waste and waste-water treatment. The textile; brewery and soft drink; and commercial industries; as well as residential household, educational and administrative institutions are identified as major generators and sources of waste in the country. The overall annual waste generated by various sectors in the capital city of Maseru were estimated at 244 702 ton/year as of year 2006. The projected waste potential in 2020 is estimated at 205 000 t/a (Blottnitz, 2009).

The country's waste management situation is characterized by absence of waste management system, insufficient informal collection system and widespread use of random, illegal and open dumpsites in both rural and urban areas, thus unsustainable and wasteful with regard to potentially reusable and recyclable resources.

1.9 Agriculture

Agriculture (crop farming and livestock production) is a major source of livelihood, which accounts for about 80% of the rural households in Lesotho. Agriculture is predominantly subsistence, with farmers cultivating less than half a hectare of land. Of the 55% of the total population which mainly depends on agriculture for livelihood, only 9% practice commercial farming (Lesotho Government, 2012). Agricultural productivity is highly variable (especially due to erratic precipitations), and it has steadily declined over the latest 30 years – maize yields have fallen from an average 1,200 Kg per hectare in the mid 1970s to a current 450-500 Kg per hectare in most of the districts. The livestock sector provides a significant proportion of rural income and is well integrated in the national and the regional economy through the export of wool and mohair. However, the importance of livestock in income generation has also started to decline due to the recurrent droughts, poor animal quality and inadequate disease control (FAO, Conservation Agriculture and Sustainable Crop Intensification in Lesotho, 2010).

The national greenhouse gases inventory results for 2000 indicate that agriculture sector accounts to the larger contribution of Lesotho GHG emissions. Emissions from this sector make a total of 2,230.43Gg CO_2eq. The main GHG is Nitrous Oxide (N_2O) with 61.6% of the total emissions. The sources of N_2O are from agricultural soils which include use of synthetic fertilizer, nitrogen from animal wastes, nitrogen from increased biological N-fixation and crop residues. Other emissions are Methane (CH_4) caused by enteric fermentation from animal manure and manure management. Anaerobic decomposition of manure also produces some CH_4. These conditions often occur when a large number of animals are managed in a confined area (e.g. dairy farms, beef feedlots, and swine and poultry farms). Most cultivated soils in Lesotho are considered to have low contamination of chemicals because of minimal use of synthetic fertilizers (LMS, 2013).

1.10 Forestry

Lesotho is one of the least forested countries in the world. Forest resources are categorized into five main groups according to patterns of ownership. This being: indigenous trees and shrubs, government owned plantations; private treelets; trees in individual homesteads; and trees in the urban environment. Regardless of the low extent of their occurrence, forests remain valuable resource extensively used by the majority of rural communities for: fuel, wood for tools and house construction, medicines for both humans and livestock, sites for traditional ceremonies, browse and shelter for livestock. Despite the existence of management schemes backed by regulatory measures, loss of forests continues unabated. It is therefore necessary to ensure the systematic management and sustainability of forest resources based on a sound understanding and integration of biological and socio-economic issues (Nchemo, 2001).

1.11 Climate Change

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 14 that shows an increasing trend in average temperatures in representative districts for

lowlands and highlands of Lesotho for the period 1967-2010.

Figure 1-4: Annual mean temperature 1967-2010 (Source: Lesotho Meteorological Services)

1.11.1 *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 1-5: 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 2016.7

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 crops.8 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 First1 and Second9 National Communications to the Conference of the Parties (COP) to the UNFCCC.

1.11.2 *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 & 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). According to 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.

1.11.3 *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 is the secretariat of the National Climate Change Coordinating Committee as it pursues and implements the NCCP.

The NCCP and the National Climate Change Implementation Strategy (NCCPIS) were both adopted in 2017. The document "Guidelines for the Integration of Climate Change in National Sectoral and Local Policies Strategies and Development Plans" 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 Center (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 National Strategic Development Plan (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.

1.12 Institutional Arrangements

1.12.1 *Institutional Framework for Addressing Climate Change*

The Ministry of Energy and Meteorology (MEM) through the Lesotho meteorological services (LMS) remains the focal point on climate change and leads the efforts to implement the National Climate Change Policy (Lesotho Meteorological Services, National Climate Change Implementation Strategy , 2017). Key functions of LMS are to monitor the weather and climate, protect ozone layer, and climate change detection. 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 National Climate Change Policy, acting as well as a link between the LMS and the various social and economic sectors.

To effectively achieve the objective of the Policy, all institutions have a responsibility to participate in the NCCC in order to be familiar with projected climate change episodes and events in the short and long term, to be appraised of the likely impacts of climate change. Institutions, as a result, should have in place, adequate response measures to the effects of climate change. Educational institutions and all tiers of government including central government, local government as well as NGOs have a role to institutionalise climate change. A culture of networking and building on synergies at all levels and amongst the institutions is key to achieving the objective of the NCCC.

1.12.2 *Institutional arrangements for compilation of the National Communication and the Biennial Update report*

Figure 1-6 below illustrates the current set-up on institutional arrangements for the first Biennial Update Report and the Third National Communication. A more comprehensive institutional arrangements for sustainability of the preparation of National Communications, Biennial Update Reports and any other reporting requirements under the Convention and national policies, is proposed under chapter 4 - Domestic Measuring Reporting and Verification.

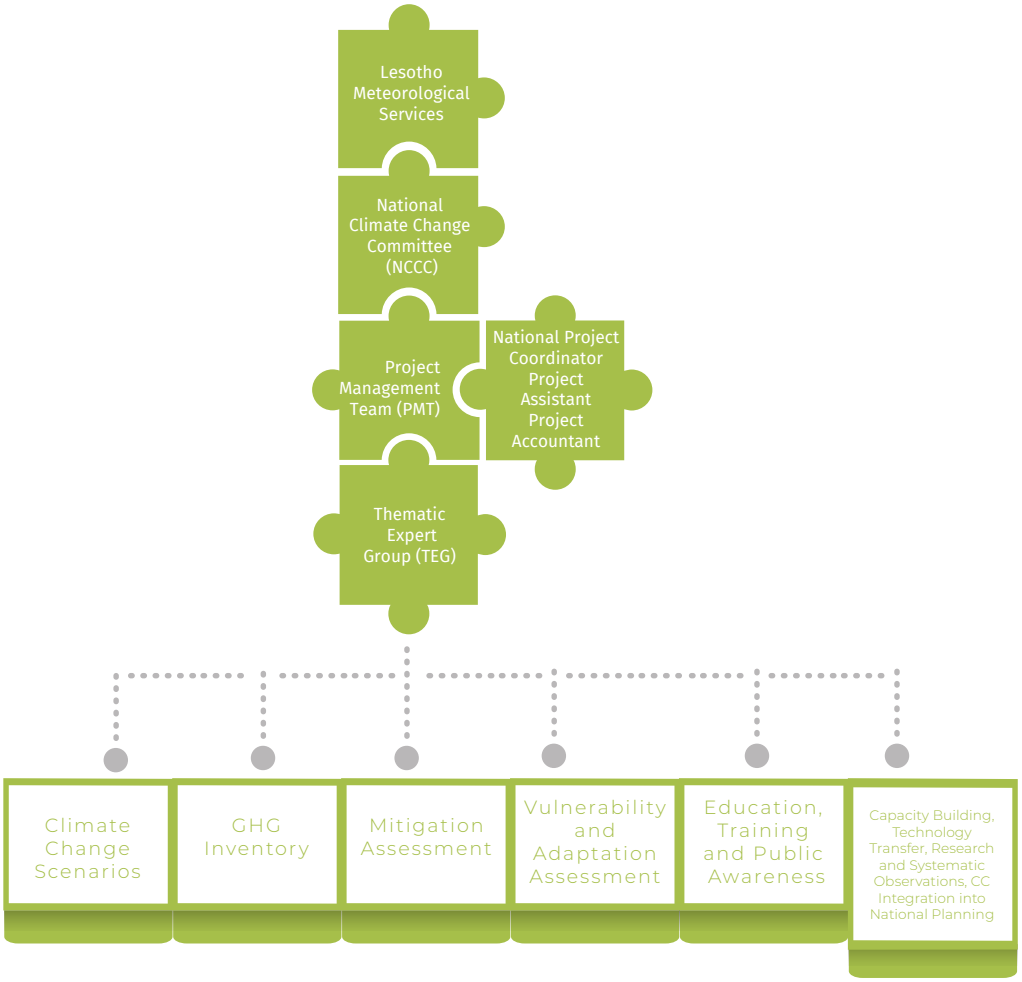


Figure 1-6: Institutional Arrangements for National Communications and BUR

1.12.3 *Institutional arrangements for the GHG Inventory Compilation*

Figure 1-4 below presents the institutional arrangements for compilation of Lesotho's 4th National GHG inventory. LMS is the national inventory agency with the overall responsibility for compiling the national GHG inventories. Other departments and institutions support LMS with data and expert input.

Each sector in the GHG compilation has a number of national departments and institutions that contribute to data-collection. Table 1-3, Table 1-4, Table 1-5 and Table 1-6 present a breakdown of the institutional arrangements and roles per sector.

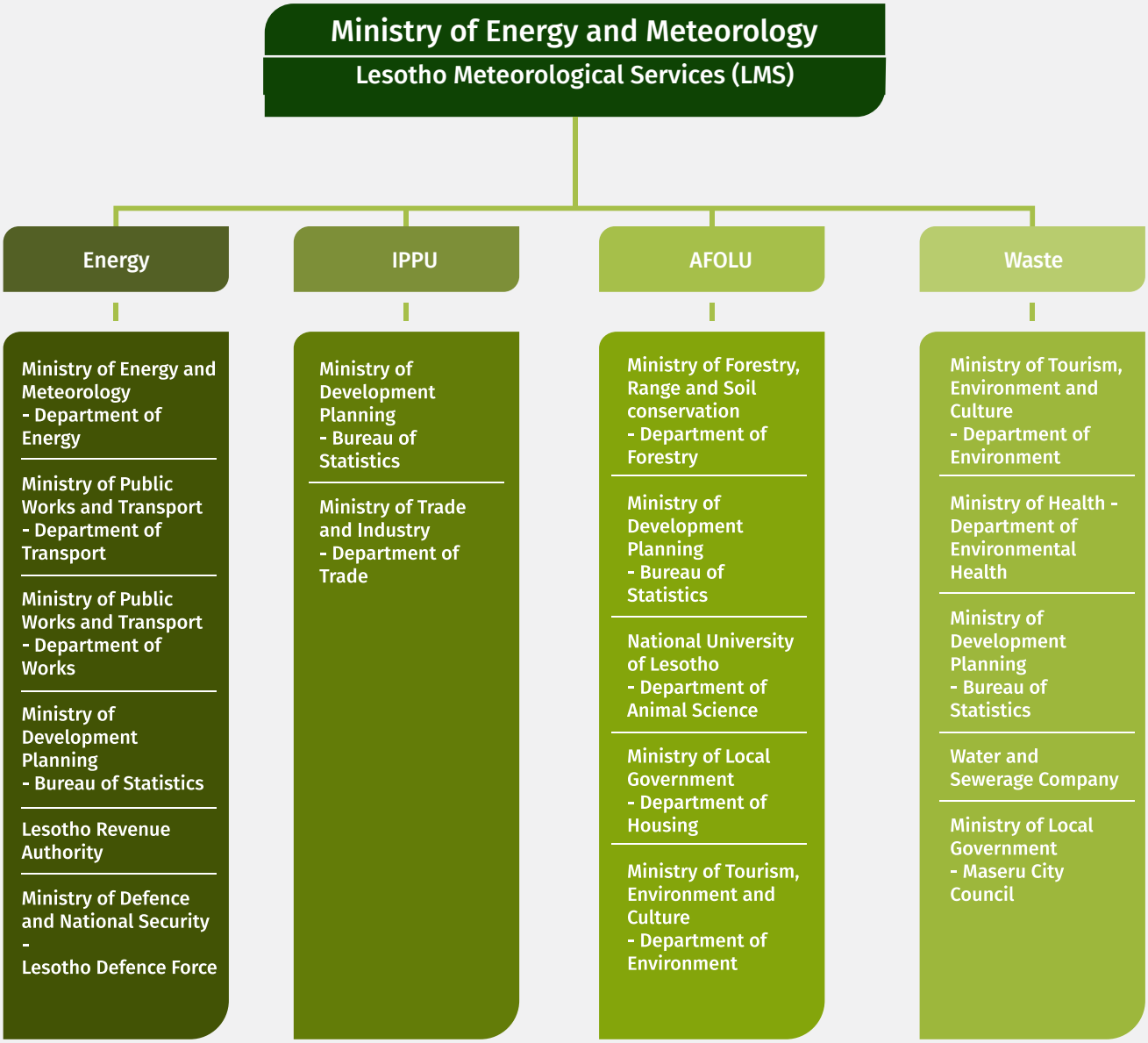


Figure 1-7: Institutional arrangements for the GHG compilation

Table 1-1: Roles of the Institutions in the Energy sector

Ministry / Agency	Role
Department of Energy	Provides: National Energy Balances Imports of petroleum fuels
Bureau of Statistics	Provides information on all fuels consumed
Department of Transport	Provides vehicle statistics
Lesotho Revenue Authority	Provides information on: vehicle imports Imports of all fuels
Ministry of Defence Force	Provides data on fuel consumed by the Ministry

Lesotho Meteorological Services	Collects data on aviation fuel consumed by Non-Governmental Organizations (Mission Aviation Fellowship)

Table 1-2: Roles of the Institutions in the IPPU sector

Ministry / Agency	Role
Lesotho Meteorological Services – Ozone Unit	Provides quantities of HFCs consumed / imported
Bureau of Statistics	Provides refrigeration data
Lesotho Meteorological Services	Collects data on: Ceramics and bricks Beverages

Table 1-3 Roles of the Institutions in the AFOLU sector

Ministry / Agency	Role
Department of Crops	Provides information on: Fertilizer, urea & lime application info; Cultivated area per year; Landcover atlas, Agricultural production survey – crops.
Bureau of Statistics	Provides the Lesotho Agricultural Census Report and Livestock Report
Department of Forestry	Provides forestry and land used data
Department of Environment	Provides data on burnt areas

Table 1-4 Roles of the Institutions in the Waste sector

Ministry / Agency	Role
Department of Environment	Provides information on solid waste per capita for Maseru and Lesotho Provides information on Open Burning of waste
Department of Environmental Health	Provides information on incineration of medical waste
Bureau of Statistics	Provides information on population data and solid waste
Water and Sewerage Company	Provides information on Waste Water Treatment - Domestic Waste

Maseru City Council	Provides information on solid waste per capita for Maseru and Lesotho Provides information on sludge for Ts'oeneng Provides information on open burning of waste

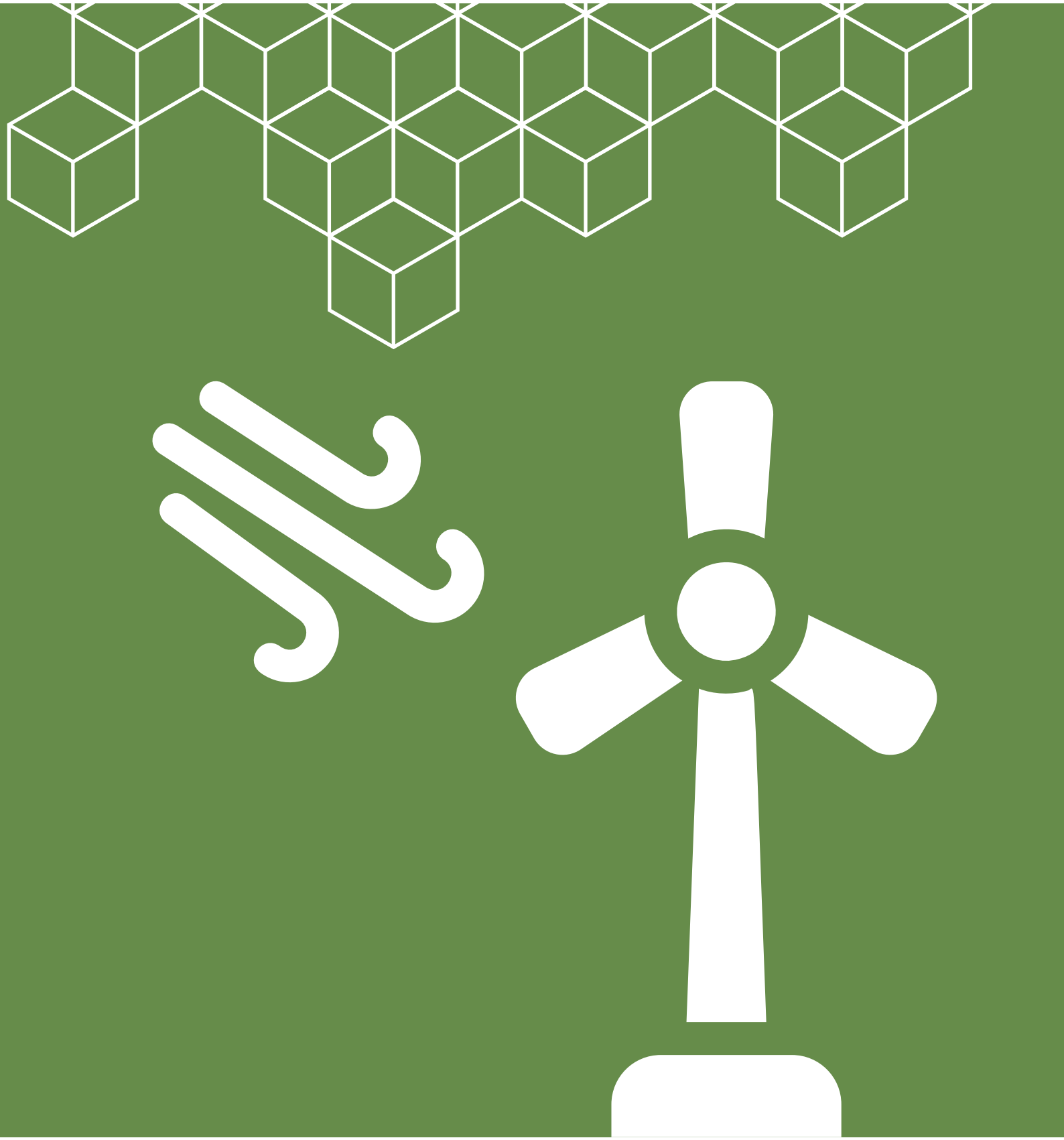
1.12.4 *Building Sustainable Future GHG Inventory Management System*

With the view to enhance a more systematic approach in monitoring GHG inventories and tracking the effectiveness of the climate change mitigation in Lesotho, it is paramount that the country establishes a sustainable national GHG Inventory Management System. The system will ensure a shift of the GHG preparation process from a project-based approach to a more internalized and institutionalized approach which will support the timely delivery of the required information; more efficient use of available resources; and ownership of the GHG inventory process by various institutions. Such a system should address the key elements of the GHG inventory process such as: planning; preparation; reporting; documentation and archiving; as well as inventory improvement strategy.

1.12.5 *Domestic Measurement, Reporting and Verification*

Lesotho has designed the Domestic Measurement, Reporting, and Verification (MRV) System as a fundamental requirement for the country to meet the reporting requirements of the UNFCCC. Aimed at enhancing tracking of: GHG emission levels; the impact of mitigation and adaptation actions; and international, regional and domestic climate finance flows, the system will constitute institutional, regulatory, technical, and sectoral bodies at multi-levels of government, all interacting to track down the quantity of GHG emissions, the quality of GHG inventory and monitoring, the effectiveness of mitigation actions and support received (domestic and international). The system will therefore be premised on national climate change policy, and in line with national plans and programmes. The system will be anchored by Climate Change Monitoring and Evaluation (M & E) Framework. Furthermore, Lesotho's MRV System should be robust enough to effectively deliver the following key outcomes:

- Deliver quality data to help report and evaluate climate change policy and action;
- Promote transparency of GHG reporting;
- Give clear picture of national priorities, strengths and weaknesses which provides clarity on future capacity building needs and financial support;
- Help reporting entities to assess their climate risks and opportunities.



2. NATIONAL GREENHOUSE GAS INVENTORY

NATIONAL GREENHOUSE GAS INVENTORY

2.1 Introduction

Lesotho has submitted its initial, second and third national GHG inventories under the UNFCCC as part of the country's National Communications. Lesotho's 1st National GHG inventory was compiled in 2000 for the year 1994, while the 2nd National GHG inventory was undertaken for the year 2000 and was published in 2013. Both inventories were based on the revised 1996 IPCC guidelines. Lesotho's 3rd National GHG inventory was published in 2018, covering the years 2005 to 2010. The third inventory was based on the 2006 IPCC guidelines.

This chapter presents in details the Lesotho's 4th National Greenhouse Gas (GHG) Inventory, covering the years 2011 to 2017. The inventory was compiled in accordance with the 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines as well as the Global Warming Potentials (GWPs) of the IPCC Second Assessment Report (SAR). Tier 1 methodologies were used. The Chapter further presents the trends in Lesotho's National GHG emissions from 1994 to 2017, based on the published GHG inventory reports.

2.1.1 *Evolution of Lesotho's National GHG Inventory*

Lesotho has submitted its initial, second and third national GHG inventories under the UNFCCC as part of the country's National Communications (NCs).

Lesotho's 1st National GHG inventory was compiled in 2000 for the year 1994, while the 2nd National GHG inventory was undertaken for the year 2000 and published in 2013. Both inventories were based on the revised 1996 IPCC guidelines.

Lesotho's 3rd National GHG inventory was published in 2018, covering the years 2005 to 2010. This inventory (4th GHG Inventory) is based on the 2006 IPCC guidelines. `
The figure below shows an overview of Lesotho's GHG inventory compilations and submissions over the years.

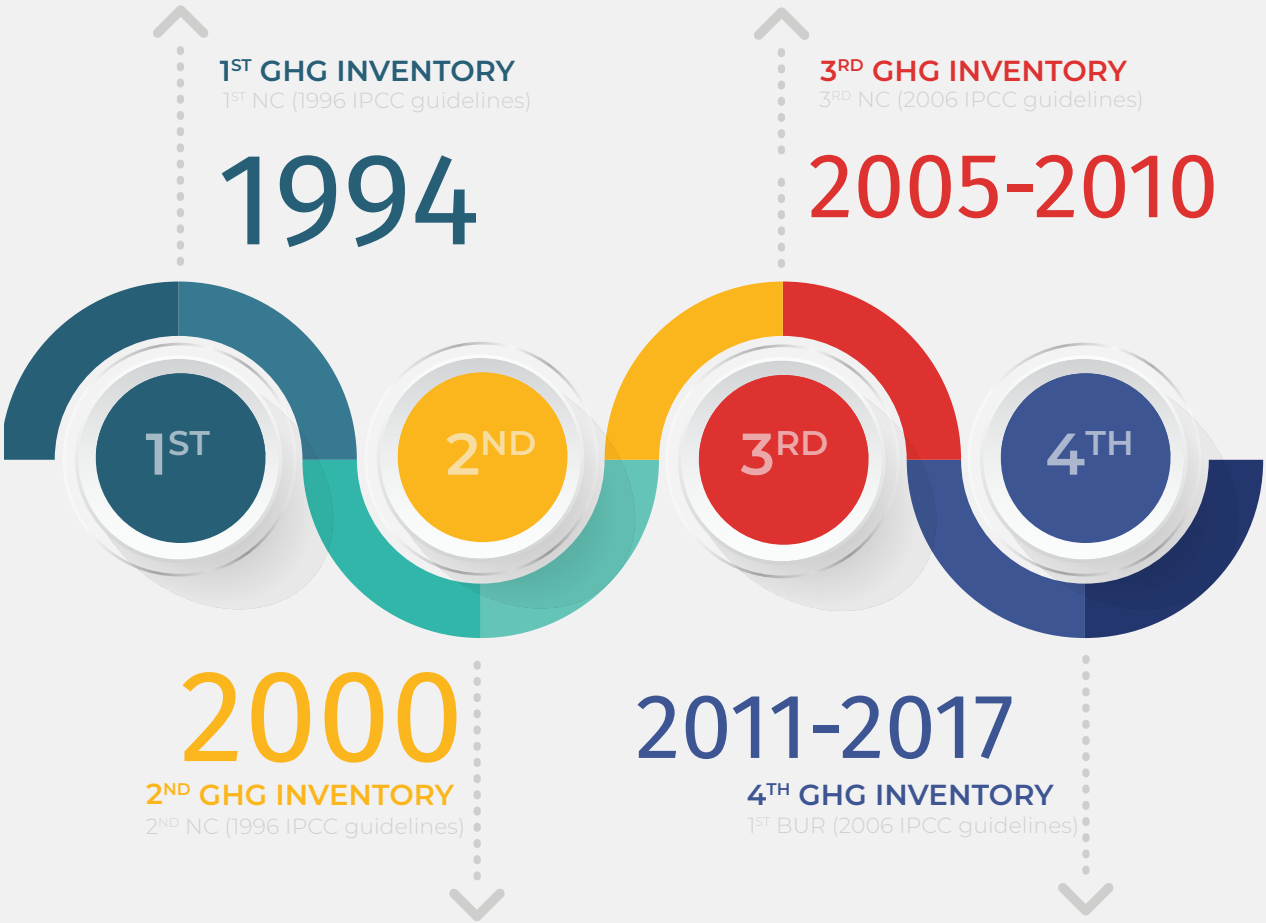


Figure 2-1: Summary of Lesotho's National GHG Inventory submissions

2.1.2 *Preparation of Lesotho's 4th National GHG inventory*

This 4th National GHG Inventory Report was prepared following a nine step process shown in Figure 2-2 below, in line with the recommendations of the Consultative Group of Experts.

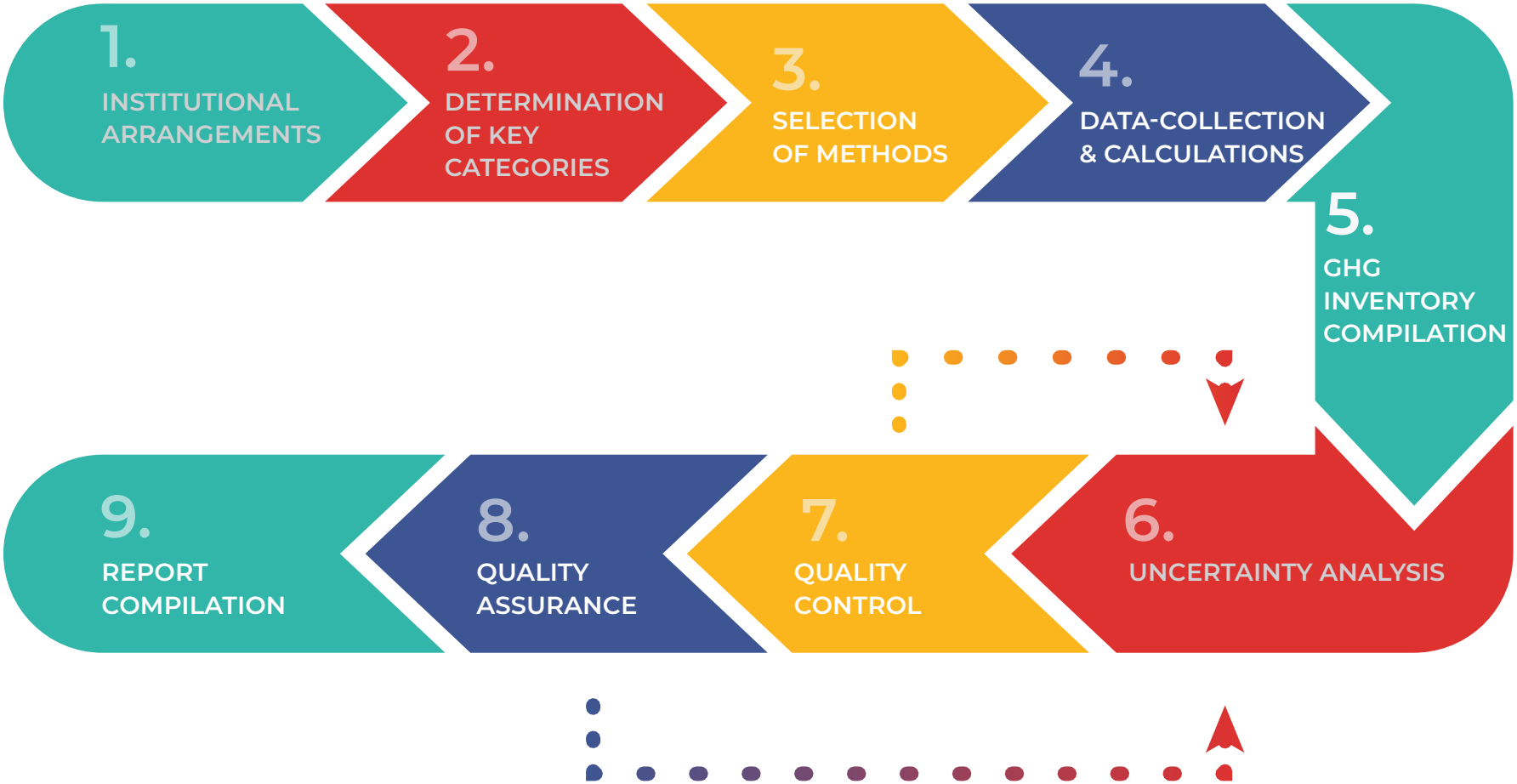


Figure 2-2 Stages followed in compiling the 4th National GHG inventory

The climate crisis is both the easiest and the hardest issue we have ever faced. The easiest because we know what we must do. We must stop the emissions of greenhouse gases. The hardest because our current economics are still totally dependent on burning fossil fuels, and thereby destroying ecosystems in order to create everlasting economic growth.

Institutional arrangements for the GHG Inventory Compilation were confirmed, followed by the determination of the key categories from the 3rd National GHG Inventory. The third, fourth and fifth steps were to select the appropriate methods to be used for calculating the emissions, data-collection and GHG inventory calculation and compilation respectively. The GHG inventory compilers then undertook uncertainty analyses for their respective activities. In the 7th step, quality controllers for each sector carried quality control (QC) checks on the respective sectors and where necessary returned the inventories to the compilers to address any identified issues. Once all issues had been addressed the inventories underwent Quality Assurance (QA) process, which also referred any identified issues to the GHG inventory compilers. Then the sectorial inventories that successfully passed the QC and QA steps were used to compile the 4th National GHG inventory report.
The below sections provide a detailed breakdown of each stage in this GHG inventory compilation process.

2.1.3 *Determination of Key and New Categories*

Generally, this step should entail identification of the Key Categories identified in the Key Category Analyses from the preceding GHG inventory. a level key category analysis was carried out by the 4th GHG inventory team using the results of the 3rd GHG inventory.

2.1.4 *Level Key Categories based on 3rd GHG inventory*

The analysis was performed using the Tier 1 level (L1) method for the 3rd GHG inventory result for the year 2010.The table below (Table 2-1 2010 Level Key Categories from the 3rd GHG Inventory) shows the results of the level key category analysis based on the 2010 GHG inventory.

Table 2-1 2010 Level Key Categories from the 3rd GHG Inventory

Category Code	Category	Gas	2010 Estimate (Gg CO_2e)	2010 Absolute Value	Level Assessment (%)	
1A4b	Residential	CO_2	1 227.51	1 227.51	23.91 %	23.91 %
3A1	Enteric fermentation	CH_4	889.25	889.25	17.32 %	41.22 %
3C4	Direct emissions from agricultural soils	N_2O	601.07	601.07	11.71 %	52.93 %
1A4a	Commercial / Institutional	CO_2	506.07	506.07	9.86 %	62.78 %
3A2	Animal Waste Management Systems	N_2O	461.9	461.90	9.00 %	71.78 %
1A3b	Road transport	CO_2	323.95	323.95	6.31 %	78.09 %
1A4b	Residential	CH_4	261.15	261.15	5.09 %	83.17 %
4D	Waste water treatment and discharge	CH_4	236.00	236.00	4.60 %	87.77 %
3C5	Indirect emissions from agricultural soils	N_2O	171.95	171.95	3.35 %	91.12 %
1A4a	Commercial / Institutional	CH_4	95.58	95.58	1.86 %	92.98 %
3C1	Prescribed burning of savannas	CH_4	76.98	76.98	1.50 %	94.48 %

3C1	Prescribed burning of savannas	N_2O	75.99	75.99	1.48 %	95.96 %

The tables below show a summary of the key categories by level, per sector. There were no key categories from the IPPU sector.

Energy

Table 2-2 Key Categories for Energy Sector

Category Code	Key Category	Greenhouse Gases
1A3b	*Road*	CO_2
1A4a	*Commercial / Institutional*	CO_2
1A4b	*Residential*	CO_2, CH_4

AFOLU

Table 2-3 Key Categories for AFOLU Sector

Category Code	Key Category	Greenhouse Gases
3A1	*Enteric fermentation*	CH_4
3A2	*Animal Waste Management Systems*	N_2O
3C1	*Prescribed burning of savannas*	CH_4, N_2O
3C4	*Direct emissions from agricultural soils*	N_2O
3C5	*Indirect emissions from agricultural soils*	N_2O

Waste

Table 2-4 Key Categories for Waste Sector

Category Code	Key Category	Greenhouse Gases
4D	*Waste water treatment and discharge*	CH_4

2.1.5 *New categories*

The GHG inventory team identified the following new emission categories for this 4th inventory. These were then included in this inventory as part of continuous improvement of the country's national GHG inventory.

The below table (Table 2-5 New Categories for this 4th GHG inventory) shows the additional new categories that were added to the existing 4th GHG inventory after the workshop. However, due to unavailability of activity data, GHG emission calculations for cement production could not be carried out, hence this category was excluded from the final GHG inventory.

Table 2-5 New Categories for this 4th GHG inventory

Category Code	New Category	Greenhouse Gases
IPPU		
2A1	*Cement production (This category was subsequently dropped due to unavailability of information and data)*	*CO_2*
2F1	*Refrigeration and Air Conditioning*	*HFCs*
2H2	*Food and Beverages industry*	*CO_2*

2.1.6 *Data-collection procedures*

For data-collection, LMS as the national inventory agency, set up an internal GHG inventory team. Within that team each sector had a team lead, additional team members (if needed) and quality controllers (see section 2.5.). Hence each team lead and members were responsible for their sector (see authors and contributors). Each sector team coordinated and oversaw the collection of data from the other institutions, the GHG calculations, data documentation and quality control for each sub-sector.

LMS team created a data-requirements list and work plan for each sector aligned with the established institutional arrangements. Thereafter, each LMS team lead was responsible to liaise with the relevant institutions and departments to collect the required data and later to process and do the calculations of that data. Data access and collection of required data was a challenge for this inventory. In some instances, only certain year's data was available, some were only financial years and not calendar years and some of the data received was verbal and not documented.

Table 2-10 below lists all the sources of data for compiling this 4th National GHG inventory.

2.1.7 *Methodologies*

This 4th GHG inventory report used the 2006 IPCC Guidelines for estimating the emissions for Lesotho for the years 2011 until 2017. Tier 1 methodologies possible were used. Sections 2.4 to 2.7 present the detailed breakdown of the methodologies used for each sector and emission category.
The Global Warming Potentials (GWPs) of the Second Assessment Report (SAR) of the Intergovernmental Panel on Climate Change were used consistently throughout this inventory (see Units and factors).

2.1.8 *Units and factors*

Below is a summary of the units and factors that were utilized in this report.

Table 2-6 Units used

Multiplication factor	*Abbreviation*	*Prefix*	*Symbol*
1 000 000 000	109	Giga	G
1 000 000	106	Mega	M
1 000	103	Kilo	K
100	102	Hector	H

Table 2-7 conversion factors used

Unit	*Equivalence*
1 tonne (t)	1 Megagram (Mg)
1 Kilotonne	1 Gigagram (Gg)
1 Megatonne	1 Teragram (Tg)

Table 2-8 Global Warming Potentials (GWP) (Solomon, et al., 2007)

Greenhouse Gas	*Chemical Formula*	*100-year GWP*
Carbon Dioxide	CO_2	1
Methane	CH_4	21
Nitrous Oxide	N_2O	310
HFC – 32	CH_2F_2	650
HFC – 125	CHF_2CF_3	2,800
HFC – 134a	CH_2FCF_3	1,300
HFC – 143a	CF_3CH_3	3,800

Table 2-9 Data sources

Category	*Greenhouse Gases*	Data Sources
1 Energy		
1A Fuel Combustion Activities		
1A2 Manufacturing Industries and Construction	***CO_2 CH_4 N_2O***	■ ***Department of Energy*** ■ ***2015 and 2016 BOS Energy Reports***
1A3 Transport		
1A3a Civil Aviation	***CO_2 CH_4 N_2O***	■ Department of Energy ■ 2015 and 2016 BOS Energy Reports ■ Lesotho's 3rd National GHG Inventory for 2005 - 2010
1A3b Road Transport	***CO_2 CH_4 N_2O***	
1A4 Other Sectors		
1A4a Commercial / Institutional	***CO_2 CH_4 N_2O***	■ Department of Energy ■ 2015 and 2016 BOS Energy Reports ■ Lesotho's 3rd National GHG Inventory for 2005 - 2010;
1A4b Residential	***CO_2 CH_4 N_2O***	
1A4c Agriculture / Forestry / Fishing / Fish Farms	***CO_2 CH_4 N_2O***	
2 IPPU		
2A Mineral Industry		
2A4 Other Process Uses of Carbonates		
2A4a Ceramics	***CO_2***	■ U.S Geological Survey minerals yearbooks (2015 and 2016); ■ Loti Brick
2F Product Uses as Substitutes for Ozone Depleting Substances		
2F1 Refrigeration and Air Conditioning		
2F1a Refrigeration and Stationery Air Conditioning	***HFCs***	■ LMS Ozone Unit
2H Other		
2H2 Food and Beverages industry	***CO_2***	***Maluti Mountain Breweries***
3 AFOLU		
3A Livestock		

3A1 Enteric Fermentation	CH_4	■ Bureau of Statistics; ■ IPCC 2006 Guidelines.
3A2 Manure Management	CH_4 N_2O	■ Bureau of Statistics; ■ Lesotho National GHG Inventory for 2010;
3B Land		
3B1 Forest Land	CO_2	■ Food and Agriculture Organisation; ■ Forest Resource Assessment.
3C Aggregate sources and non-CO2 emissions sources on land		
3C1 Emissions from biomass burning	CH_4 N_2O	■ **Food and Agriculture Organisation**
3C3 Urea Application	CO_2 CH_4 N_2O	■ **Ministry of Food and Agriculture, Department of Crops**
3C4 Direct N_2O emissions from managed soils	N_2O	■ **Ministry of Agriculture and Food Security**
3C5 Indirect N_2O emissions from managed soils	N_2O	■ **Ministry of Agriculture and Food Security**
3C6 Indirect N_2O Emissions from Manure Management	CO_2 CH_4 N_2O	■ **Bureau of Statistics;** ■ **Lesotho's 3rd National GHG Inventory for 2005 - 2010**
4 Waste		
4A Solid Waste Disposal	CH_4	■ **2006 Lesotho Population and Housing survey** ■ **2011 Demographic survey** ■ **2016 Lesotho Population and Housing survey** ■ **2006 Baseline Assessment study for ISWMS for Maseru**
4C Incineration and open burning of waste		
4C Waste Incineration and Open Burning of Waste	CO_2 CH_4 N_2O	■ *2006 Lesotho Population and Housing survey* ■ *2011 Demographic survey* ■ *2016 Lesotho Population and Housing survey* ■ *2006 Baseline Assessment study for ISWMS for Maseru* ■ *COWI Lesotho Healthcare Waste Study Report 2012*
4D Waste water treatment and discharge	CH_4 N_2O	■ **2006 Lesotho Population and Housing survey** ■ **2011 Demographic survey** ■ **2016 Lesotho Population and Housing survey**

2.1.9 *QA / QC Plan*

A QA/QC plan is necessary in order to have transparency, accuracy, completeness, comparability and consistency in a national inventory. That plan must comprise of aspects that include methodologies used, assumptions, uncertainties, data used and formats among other things.
For this inventory a QA/QC plan was developed in order to plan, prepare and manage the inventory activities correctly. With the consideration of available data, resources, expertise and the characteristics of the inventory the existing QA/QC plan was developed. Various activities and procedures were then conducted in order to fulfil that QA/QC plan.

The aspects that were defined in or for the QA/QC plan incorporated:

- Institutional arrangements;
- Detailed work plan and schedule;
- Responsibilities;
- Data requirements;
- Data collection;
- QC activities;
- QA activities;
- Uncertainty assessment;
- Reporting and data storage process.

2.1.10 *Quality Control*

Quality control is the process that is followed while the inventory is being compiled by the team that is compiling the inventory. This is done in order to evaluate and conserve the quality of the inventory by having routine technical activities.

The following QC checks on activities and procedures (Table 2-10 Quality Control) were followed during the compilation of this 4th GHG national inventory.

Table 2-10 Quality Control

QC Activity	*Methods followed / procedures*
Activity data QC	*Check the temporal consistency of the activity data;* *Check the consistency of the units.*
EF data QC	*IPCC default EF:* *Check default EF applicability;* *Check temporal consistency;* *Check the consistency of the units.*

General data QC	• Check the data calculations: • Reproduce a set of emission/removal calculations; • Calculate Implied Emission Factor. • Check any recalculation data; • Check that emission and removal data are correctly aggregated from lower ;reporting levels; • Check that the data is compared to previous estimates; • Check for consistency in the trend; • Check for completeness of each subcategory.
Uncertainty QC	*Check that expert judgement is recorded;* *Check uncertainty calculations.*
Database QC	• Check that the data is in the database; • Check for transcription errors; • Check uncertainty is in the database; • Check for transcription errors in uncertainty data; • Check the correct units have been used in the database; • Check the labels in the database are correct; • Check that data sources / references have been correctly recorded; • Check the correct conversion factors are used; • Check data aggregations are correct; • Check the uncertainty aggregations are correct; • Check that original and supporting documents are attached.
Supporting data	*Check all supporting data and references are stored in the web-based data-collection tool or sector folders.*
Reporting	• Check that the activity and EF data have been added into the report; • Check if there is proper citation of references; • Check that uncertainty data is added in; • Check that completeness is acknowledged; • Check the comparisons and trends with previous estimates; • Check that explanations are provided for any data differences; • Check that the QC/QA procedures have been included.

For some of the above aspects a QC sheet was developed to check and verify data collections, uncertainty and the database as data was being compiled, the full QC sheet is included in Appendix B.

2.1.11 *Quality Assurance*

Quality assurance is conducted by a person / persons (independent third parties) that are not directly involved in the compilation of the inventory. This is done via a system of review procedures once the inventory is complete and has gone through the internal QC process while being compiled.

The review results in

» Ensuring that the inventory represents the best possible estimates of emissions and removals given the current state of scientific knowledge and data availability;

» Verifying that measurable objectives were met;

» Supporting the effectiveness of the QC programme.

The QA process that was followed in this inventory included a two-phase quality assurance process. Quality assurance will be undertaken by an independent third party appointed by LMS. This stage of the QA system will be performed once this inventory is complete.

2.1.12 *Evaluating Uncertainty*

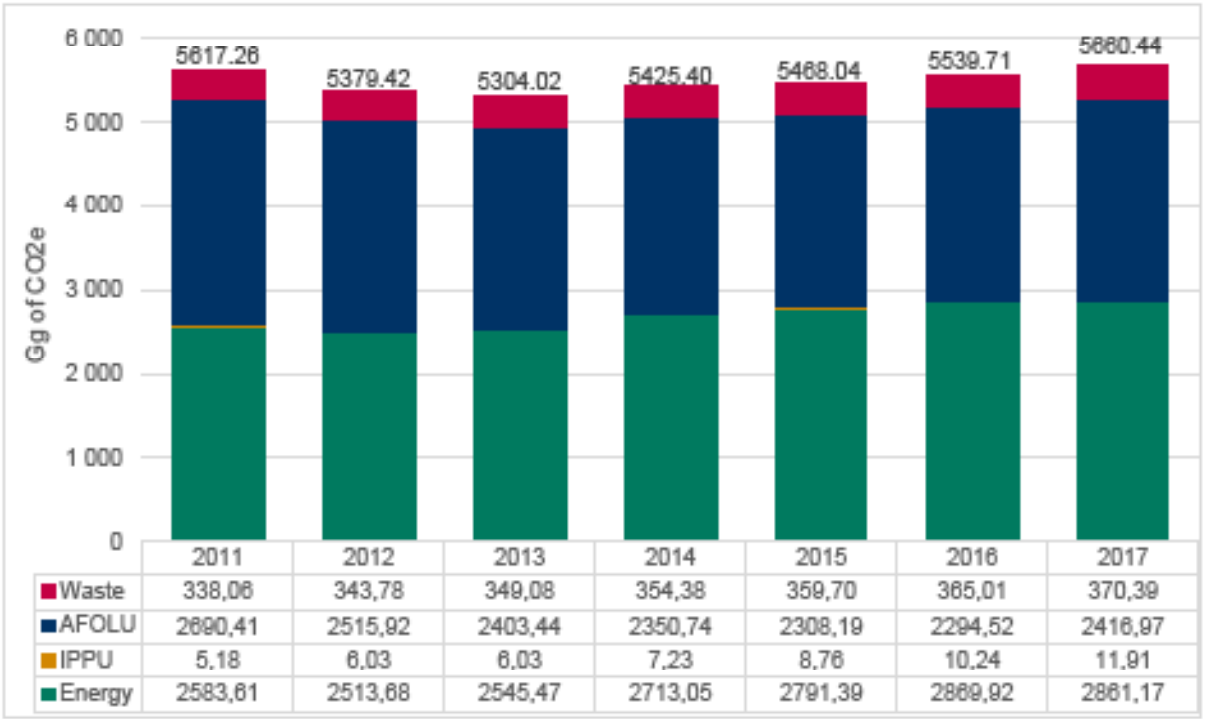
Uncertainty analyses were carried out for each emission category based on the 2006 IPCC Guidelines. Tier 1 uncertainty methods were used. The specific uncertainty analyses methods and approaches used are dependent on each category and have been outlined in detail under each category.
The overall results of the 4th National GHG inventory are presented, followed by a trend analysis of Lesotho's GHG inventories covering the results of all the four GHG inventories for Lesotho.

2.2 Lesotho's 4th Lesotho's GHG Emissions

This section presents the overall results of this 4th National GHG Inventory for Lesotho for the time series of 2011 until 2017. The sections below then present the full details and results of Energy, IPPU, AFOLU and Waste sectors of this 4th GHG inventory respectively.

below presents an overview of the results of the 4th GHG inventory, showing the GHG emissions for each year between 2011 and 2017. The Figure shows that Lesotho's emissions were at 5 617.26 Gg CO_2e in 2011, then declined slightly between 2011 and 2013 to 5 304.02 Gg CO_2e in 2013 before increasing again over the next four years to 5 660.44 in 2017. The decrease in the emissions over the 2011 – 2013 period is due to decrease in energy sector emissions resulting from decreased energy consumption over that period as well as decrease in AFOLU emissions.

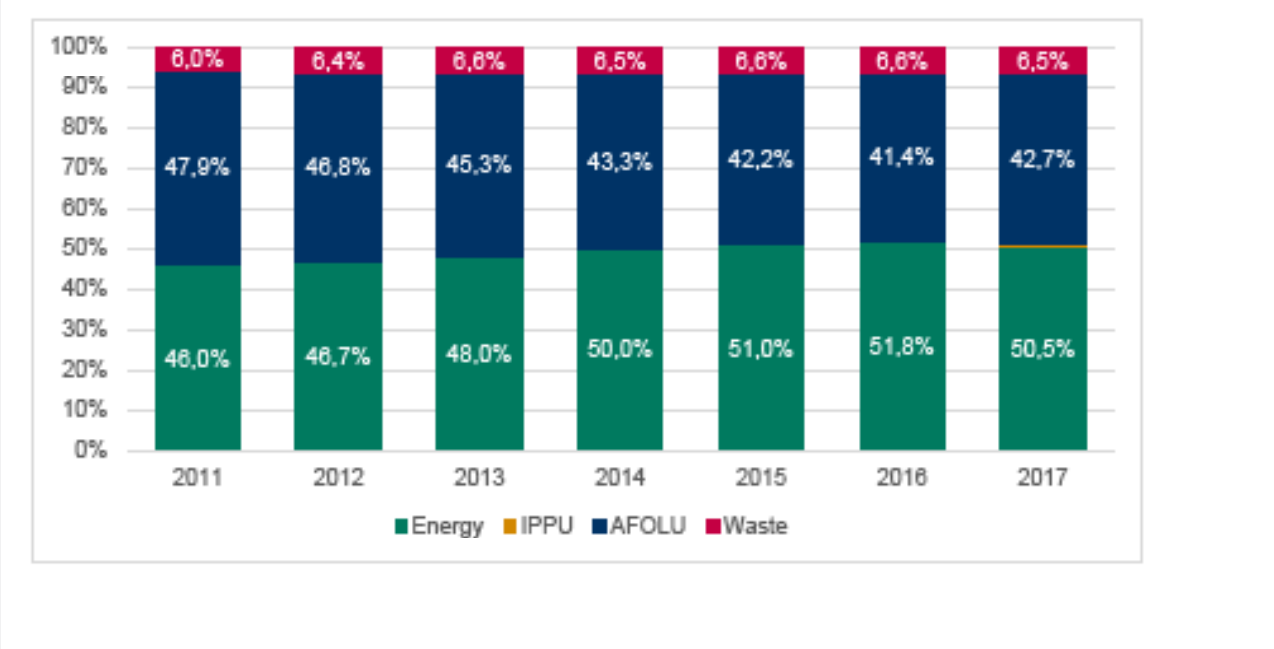
The AFOLU sector was the largest contributor to the national GHG emissions in 2011 at 2 690.41 Gg CO_2e (47.9%), followed by the energy sector at 2 583.61 Gg CO_2e (46%). By 2017 the energy sector had become the largest contributor to the inventory at 2 861.17 Gg CO_2e (50.5%) followed by AFOLU at 2 416.97 Gg CO_2e (42.7%). The waste sector contributed between 6.02% (in 2011) and 6.54% (in 2017), while the IPPU sector was the least contributor throughout the period averaging 0.14%.



	2011	2012	2013	2014	2015	2016	2017
Waste	338,06	343,78	349,08	354,38	359,70	365,01	370,39
AFOLU	2690,41	2515,92	2403,44	2350,74	2308,19	2294,52	2416,97
IPPU	5,18	6,03	6,03	7,23	8,76	10,24	11,91
Energy	2583,61	2513,68	2545,47	2713,05	2791,39	2869,92	2861,17

Figure 2-3: Summary of GHG Emissions

The below figure (Figure 2-4) shows the change in the percentage contribution of the sectors to the national GHG inventory over the period 2011 - 2017. The IPPU sector emissions are very small, ranging between 0.08 and 0.09%.



In terms of greenhouse gas contribution, carbon dioxide has been the most prominent gas in Lesotho's GHG inventories, contributing between 60.6% in 2011 and 64.6% in 2016 Figure 2-5 Changes in gas percentage contribution over time-5). On average, methane and Nitrous oxide have contributed 24.2% and 13.0% respectively over the period 2011 – 2017. HFCs have been the least contributors to the country's GHG inventory throughout the period of the assessment. The collective contribution of HFC-32, HFC-125, HFC-134a and HFC-143a ranged from 0.06% in 2011 to 0.21% by 2017.

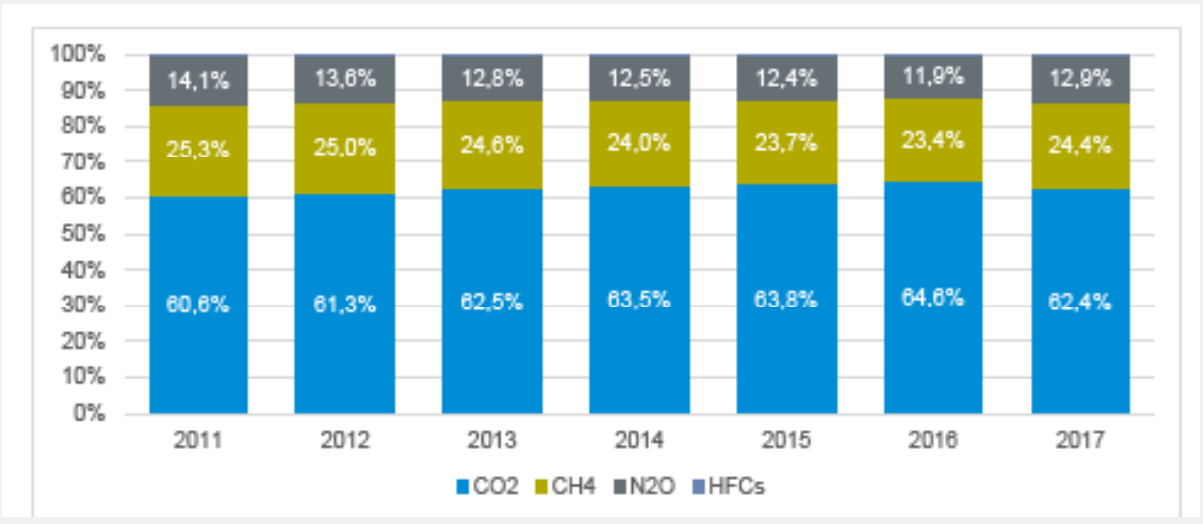
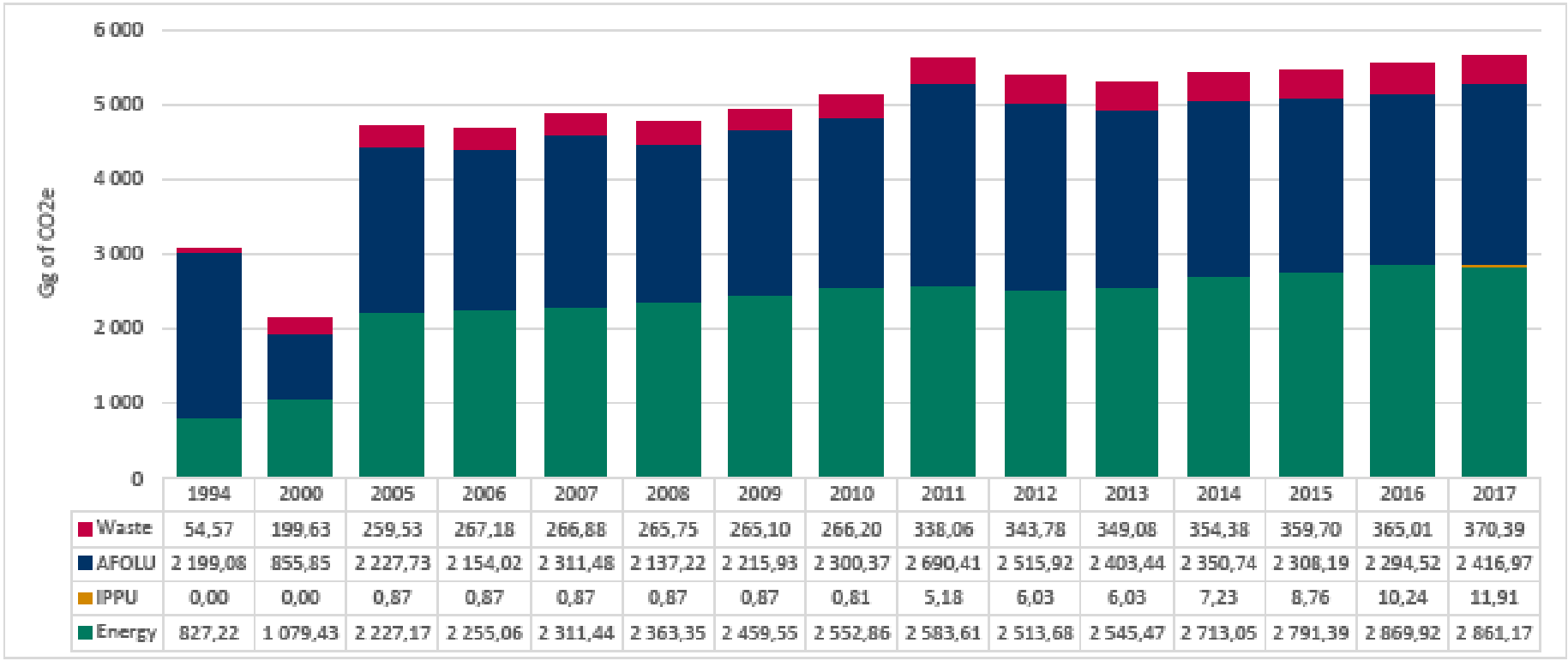


Figure 2-5 Changes in gas percentage contribution over time

The full GHG inventories for each year between 2011 and 2017 can be found in Appendix C.

2.3 Emission trends 1994 – 2017

Figure 2-6 presents the trends in Lesotho's GHG emissions from 1994 to 2017. It is worth noting that the 1994 and 2000 emissions were based on the 1996 IPCC guidelines and were not recalculated due to unavailability of dataset used while compiling the inventory. According to the Figure, the country's GHG emissions have increased by 83.7% from 3 080.7 Gg CO2e in 1994 to 5 660.44 Gg CO2e in 2017. The waste sector emissions have increased by 574.7% while the energy sector ir



	1994	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Waste	54,57	199,63	259,53	267,18	266,88	265,75	265,10	266,20	338,06	343,78	349,08	354,38	359,70	365,01	370,39
AFOLU	2 199,08	855,85	2 227,73	2 154,02	2 311,48	2 137,22	2 215,93	2 300,37	2 690,41	2 515,92	2 403,44	2 350,74	2 308,19	2 294,52	2 416,97
IPPU	0,00	0,00	0,87	0,87	0,87	0,87	0,87	0,81	5,18	6,03	6,03	7,23	8,76	10,24	11,91
Energy	827,22	1 079,43	2 227,17	2 255,06	2 311,44	2 363,35	2 459,55	2 552,86	2 583,61	2 513,68	2 545,47	2 713,05	2 791,39	2 869,92	2 861,17

Figure 2-6 Totals per sector in Gg of CO_2e emissions from 1994 until 2017

Since annual GHG inventories have been compiled (from 2005), a consistent time-series of the GHG inventory has been achieved. Since 2005, Lesotho's GHG emissions have grown by 20.4% from 4 715.30 Gg CO_2e to 5 660.44 Gg CO_2e in 2017. While this growth is primarily due to the growth of the economy, it is also partly due to the improvement in the quality of the country's GHG inventories, in terms of accuracy and completeness, overtime.

In 2005 Lesotho's net GHG emissions per capita were estimated at 2.51 tCO_2e per capita. This value increase by 11.16% over the 12 years to 2.79 tCO_2e per capita 7) On the other hand, 7 shows that the country has achieved a slight decoupling of GHG emissions and economic growth. The carbon intensity of the economy has decreased by more than 60% from 0.44 ktCO_2e per million Maloti in 2005 to 0.16 ktCO_2e per million Maloti in 2017.

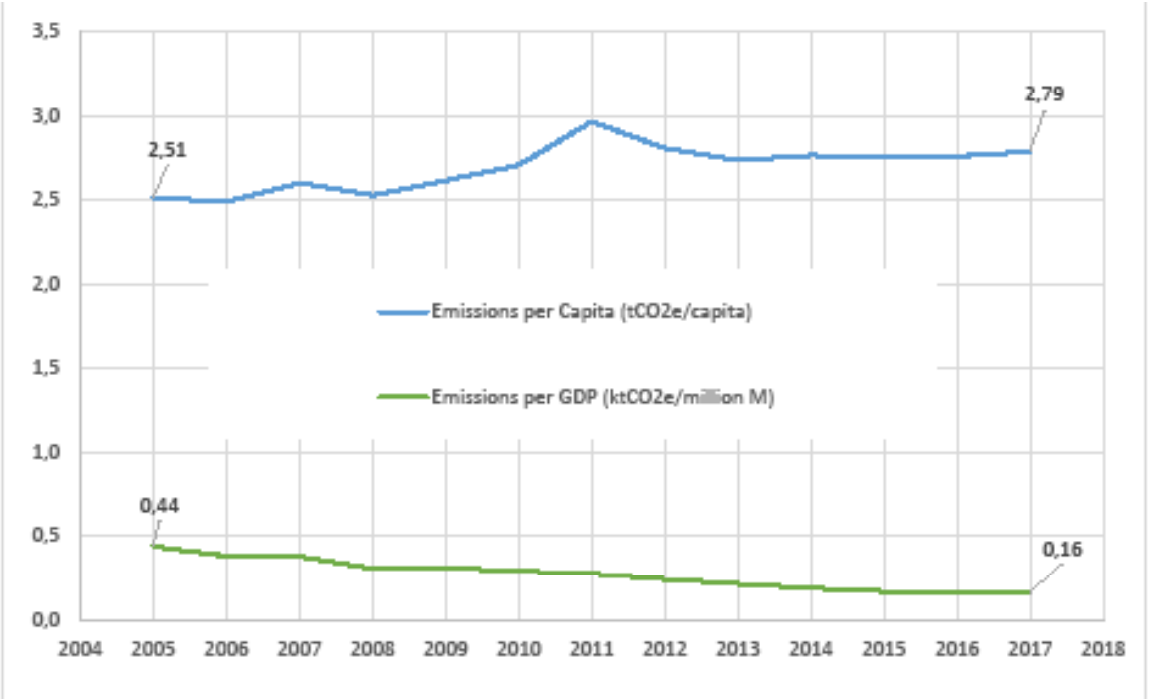


Figure 2-7 Other low carbon indicators

2.3.1 4th GHG Inventory Key Categories

The below table identifies the key categories, by level, from the 2017 GHG Inventory for Lesotho.

Table 2-11: 2017 Level Key Categories from this 4th GHG Inventory

Category Code	*Category*	*Gas*	*2017 Estimate (Gg CO_2e)*	*2017 Absolute Value*	*Level Assessment (%)*	
1A4b	*Residential*	*CO_2*	*1553.25*	*1553.25*	*27.44%*	*27.44%*
3B1	*Forest land*	*CO_2*	*1089.55*	*1089.55*	*19.25%*	*46.69%*
3A1	*Enteric Fermentation*	*CH_4*	*669.65*	*669.65*	*11.83%*	*58.52%*
1A3b	*Road Transport*	*CO_2*	*455.77*	*455.77*	*8.05%*	*66.57%*
3C4	*Direct emissions from managed soils*	*N_2O*	*408.85*	*408.85*	*7.22%*	*73.79%*
1A4a	*Commercial / Institutional*	*CO_2*	*358.75*	*358.75*	*6.34%*	*80.13%*
1A4b	*Residential*	*CH_4*	*300.06*	*300.06*	*5.30%*	*85.43%*
4A	*Solid Waste Disposal*	*CH_4*	*236.61*	*236.61*	*4.18%*	*89.61%*
3C6	*Indirect emissions from managed soils*	*N_2O*	*135.11*	*135.11*	*2.39%*	*92.00%*

3A2	*Manure Management*	*N_2O*	*62.78*	*62.78*	*1.11%*	*93.11%*
1A2	*Manufacturing Industries and Construction*	*CO_2*	*60.82*	*60.82*	*1.07%*	*94.18%*
1A4a	*Commercial / Institutional*	*CH_4*	*51.89*	*51.89*	*0.92%*	*95.10%*

2.4 Energy sector

2.4.1 *An overview of the Energy sector*

Lesotho uses hydro-electricity generated at 'Muela, this is also supplemented with imports from neighbouring countries when there is peak consumption. The consumption of biomass fuel has surpassed its manageable supply, consequently, the population relies on supplementary energy sources that consist of agricultural residues and cattle dung. About 90% of rural households in Lesotho use biomass for thermal energy and cooking. Due to the fact that a large portion of biomass is from the informal sector, this results in poor accurate energy figures for Lesotho. Biomass consumption (wood, agricultural residues and cow dung) is the main source of domestic energy and energy in small-scale commercial sectors.
All the electricity generated in the country comes from hydroelectric plants. Biomass consumption in Lesotho is the main source of domestic energy (Lesotho Review, 2018).

Emission Sources

Lesotho GHG national inventory for the Energy sector is made up of the following sources:

- 1A2 Manufacturing Industries and Construction
- 1A3 Transport
  - 1A3a Civil Aviation
  - 1A3b Road Transport
- 1A4 Other Sectors
  - 1A4a Commercial / Institutional
  - 1A4b Residential
  - 1A4c Agriculture / Forestry / Fishing / Fish Farms

Source Description, Methodological issues and Data sources

DATA SOURCES

The only primary activity data used in the energy sector was the quantities of liquid fuels consumed per year. This data was provided by the Department of energy for all the liquid fuels imported and consumed in the country for each year between 1992 and 2018. But there were numerous gaps and inconsistencies in the data, hence additional data sources were sought, in the form of the 2015 Energy Report, and the 2017 Energy Report (Bureau of Statistics, 2018), which contain data up to 2014 and 2016 respectively. For the 2014, 2015 and 2016, the diesel and petrol data from the energy reports did not match the data from the Department of Energy, and in order to be conservative, the higher value was used in all cases. This was also the case for the 2014 - 2015 aviation fuel consumption values. For 2015 aviation fuel consumption,

the energy reports also provided the ratio between consumption by Mission Aviation Fellowship and the military. This ratio was applied throughout the time series (2011 – 2017) to obtain total aviation fuel consumption in country for that period.
LPG values were only available for 2011 and 2014, hence the values for other years interpolated and extrapolated as necessary. Table 2-12 Litres of liquid fuels consumed in Lesotho from 2011 to 2017 below shows the quantities of liquid fuels used in this GHG inventory for the years 2011 to 2017.

Table 2-12 Litres of liquid fuels consumed in Lesotho from 2011 to 2017

Year	*Petrol*	*Diesel*	*Paraffin*	*LPG*	*Aviation gas*
2011	101 914 000	77 140 000	37 542 000	5 005 000	64 138
2012	77 474 000	69 961 000	28 315 000	6 397 667	179 509
2013	76 345 000	70 795 000	27 240 000	7 790 333	336 269
2014	103 821 621	90 993 357	30 434 000	9 183 000	253 161
2015	115 748 600	97 542 590	28 930 000	10 575 667	280 832
2016	127 157 000	101 389 700	30 871 000	11 968 333	242 345
2017	133 335 000	78 231 000	33 621 000	13 361 000	396 272

The Department of Energy estimate that these fuels have generally been consumed in the various sectors as per below.

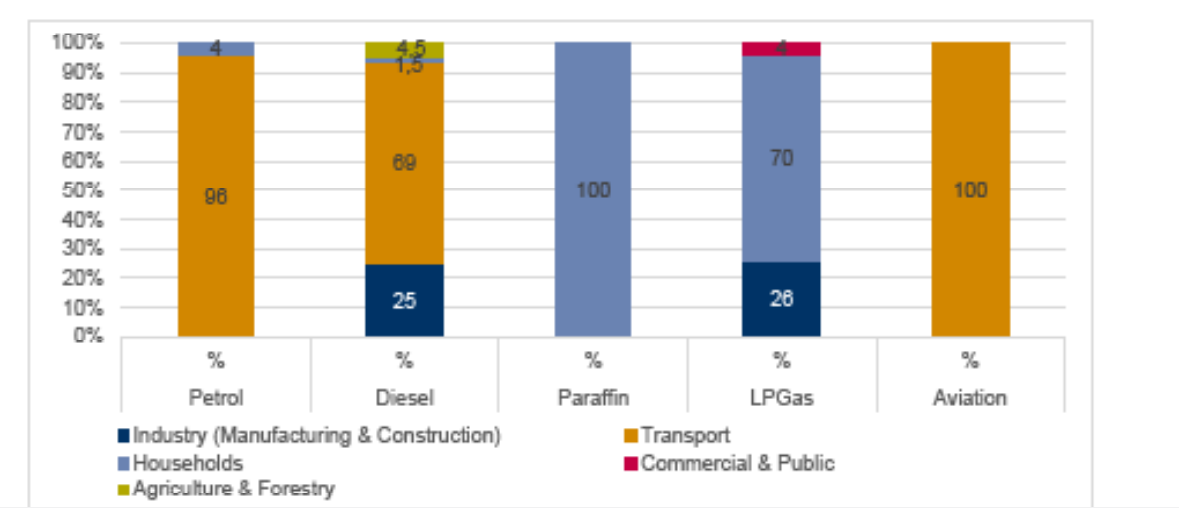


Figure 2-8 Distribution of liquid fuels consumed in Lesotho per sector

There are no statistics of solid fuels consumed in Lesotho, hence for this GHG inventory, these values were extrapolated by linear regression from the 2005 – 2010 consumption estimates made in the 3rd GHG inventory. Table 2-13 Tonnes of solid fuels consumed in Lesotho from 2011 to 2017 presents the estimated tonnes of solid fuels consumed in Lesotho between 2011 and 2017.

Table 2-13 Tonnes of solid fuels consumed in Lesotho from 2011 to 2017

Year	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
Wood	*693 348*	*705 888*	*718 428*	*730 968*	*743 508*	*756 048*	*768 588*

Shrubs	*644 042*	*655 592*	*667 142*	*678 692*	*690 242*	*701 792*	*713 342*
Dung	*630 007*	*641 426*	*652 845*	*664 264*	*675 683*	*687 102*	*698 521*
Crop Residue	*108 111*	*108 974*	*109 836*	*110 699*	*111 562*	*112 424*	*113 287*
Coal	*665 984*	*676 616*	*687 248*	*697 880*	*708 512*	*719 144*	*729 776*

CONVERSIONS AND EMISSION FACTORS

Table 2-14 Net Calorific Values (NCV) used and Table 2-12 below show net calorific values and the emission factors that were used for calculations of emissions in the energy sector respectively.

Table 2-14 Net Calorific Values (NCV) used

Fuel	NCV	Source
Aviation gas	33.9 MJ/L	(Department of Environmental Affairs, 2017)
Motor gasoline	34.2 MJ/L	(Department of Environmental Affairs, 2017)
Gas/Diesel oil	38.1 MJ/L	(Department of Environmental Affairs, 2017)
Other kerosene (paraffin)	37.5 MJ/L	(Department of Environmental Affairs, 2017)
LPG	25.6 MJ/L	(Department of Environmental Affairs, 2017)
Coal (Other bituminous)	24.3 MJ/kg	(Department of Environmental Affairs, 2017)
Fuelwood	19.32 MJ/kg	(Mosiori, et al., 2015)
Shrubs	19.18 MJ/kg	(Klein, 1986)
Crop residue	19,80 MJ/kg	(Klein, 1986)
Animal dung	14.0 MJ/kg	(Klein, 1986)

Table 2-15 Default IPCC Emission Factors used in this inventory (IPCC, 2006)

Type	Input	CO_2 (kg CO_2/TJ)	CH_4 (kg CH_4/TJ)	N_2O (kg N_2O/TJ)
Construction	Motor gasoline	69 300	3	0.6
	Gas/Diesel	74 100	3	0.6
Domestic aviation	Aviation gasoline	70 000	0.5	2
Road transport	Gas/Diesel oil	74 100	3.9	3.9
	Motor gasoline	69 300	33	3.2
Commercial/ Institutional	Motor gasoline	69 300	10	0.6
	Other bituminous coal	94 600	10	1.5
	Liquefied petroleum gas	63 100	5	0.1
	Wood/wood waste	112 000	300	4

Residential	Motor gasoline	69 300	10	0.6
	Other kerosene	71 900	10	0.6
	Other bituminous coal	94 600	300	1.5
	Wood/wood waste	112 000	300	4
	Liquefied petroleum gas	63 100	5	0.1
Off-road vehicles and other machinery	Other primary solid biomass	100 000	300	4

2.4.2 *Energy Industries (1A1)*

The only energy industry in Lesotho is electricity generation. Electricity in Lesotho is generated from Muela's hydroelectric power station (72MW), and two mini hydro power plants in Semonkong and Mantšonyane (Bureau of Statistics, 2018). The rest of the electricity demand for Lesotho is met through purchased electricity from South Africa's Eskom. Therefore, there are no GHG emissions from energy industries.

2.4.3 *Manufacturing Industries and Construction (1A2)*

The three main industrial activities in Lesotho are mining and quarrying, construction and textile manufacturing. According to the Department of Energy, the industry sector in Lesotho primarily uses electricity, complemented by diesel and LPG as shown in .

2.4.4 *Transport (1A3)*

In Lesotho, civil aviation and road transportation are the only two GHG-emitting categories in the transport sector.

2.4.4.1 *Civil Aviation (1A3a)*

Civil aviation in Lesotho can be categorized into three types as follows:

- C**ommercial flights:** There are no longer domestic commercial flights operating in Lesotho. While a number of international airlines operate through Moshoeshoe I International Airport, none of them are fuelled in Lesotho, hence there are neither GHG emissions from domestic commercial flights nor international bunker emissions from international flights.
- **Mission Aviation Fellowship (MAF) flights:** Since 1980, MAF has been operating 5 Cessna 206 aircrafts to transport the Lesotho Flying Doctor Service (LFDS) and other health and aid agencies operating in Lesotho's rural areas. In addition, MAF provides weekly flights to six health clinics operated by Partners-In-Health. In total, MAF serves 12 rural mountain health posts from over 20 dirt airstrips carved into the nation's rugged mountains (MAF website, 2019).
- **The Lesotho Defence Force (LDF) Airwing:** This is located in the north-east of Maseru, and has three fixed-wing aircraft and six helicopters out of Mejametalana Airbase2 (Lesotho Review, 2018)

Emissions in this category come from the aviation gasoline combusted in MAF and LDF aircrafts.

6

Photo taken by Ewa Matuszewska, ERM, 2019.

Figure 2-9 MAF plane taking off from the Mejametalana Airbase in Maseru East

2.4.4.1 *Road Transportation (1A3b)*

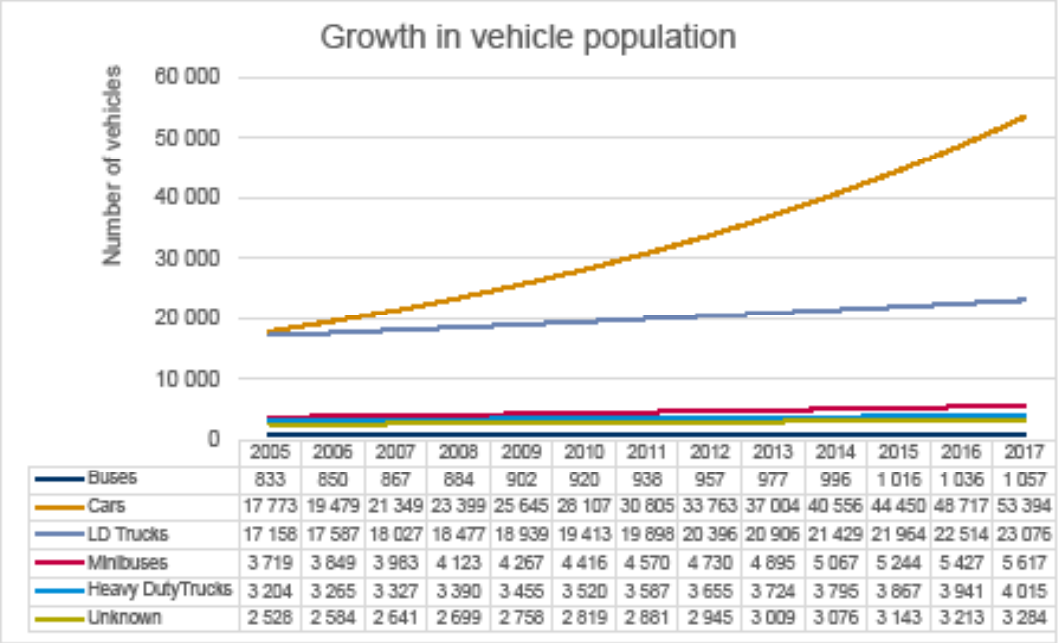
Lesotho's main transport network is road, which makes up 70% of domestic travel needs (Lesotho Review, 2018). The total national road network is in excess of 7,500 km in length, of which 1,526 km is tarred and the rest is gravel (3,036 km), earth (1,170 km), and tracks (132 km) (World bank PID, 2017).

Photo taken by Ewa Matuszewska, ERM, 2019.

Figure 2-10 Photo showing infrastructure in Maseru

GHG emissions from this category are made up of carbon dioxide, methane and nitrous oxide emissions from the combustion of petrol and diesel in vehicles travelling on these roads.

The Department of Transport manages two databases of vehicles in the country, however it is not possible to extract information (numbers and types) on the annual population of vehicles in the country from these databases. As such, annual vehicle population was extrapolated from the 2005 – 2010 estimates made in the 3rd GHG inventory (Lesotho Meteorological Services, 2018), using linear regression (Figure 2-11 Vehicle population between 2005 and 2017).



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Buses	833	850	867	884	902	920	938	957	977	996	1 016	1 036	1 057
Cars	17 773	19 479	21 349	23 399	25 645	28 107	30 805	33 763	37 004	40 556	44 450	48 717	53 394
LD Trucks	17 158	17 587	18 027	18 477	18 939	19 413	19 898	20 396	20 906	21 429	21 964	22 514	23 076
Minibuses	3 719	3 849	3 983	4 123	4 267	4 416	4 570	4 730	4 895	5 067	5 244	5 427	5 617
Heavy DutyTrucks	3 204	3 265	3 327	3 390	3 455	3 520	3 587	3 655	3 724	3 795	3 867	3 941	4 015
Unknown	2 528	2 584	2 641	2 699	2 758	2 819	2 881	2 945	3 009	3 076	3 143	3 213	3 284

Figure 2-11 Vehicle population between 2005 and 2017

The GHG emissions in this category were estimated using Tier 2 approach. For each year the amount of greenhouse gas "g" emitted was calculated as per equation 1 below:

Equation 1:

$$GHG\ emissions_g = \sum (Population_{f,v} * Efficiency_{f,v} * Distance\ travelled_v * NCV_f * Emission\ factor_{f,g})$$

Where:

- $Population_{f,v}$ = annual population of vehicle type "v", consuming fuel type "f"
- $Efficiency_{f,v}$ = fuel efficiency of vehicle type "v", consuming fuel type "f" (litres/100km)
- $Distance\ travelled_v$ = annual average distance travelled by all vehicles of type "v" (km/vehicle)
- NCV_f = Net Calorific Value of fuel type "f" (TJ/litre)
- $Emission\ factor_{f,g}$ = Default IPCC emission factor of gas "*g*" for fuel type "*f*" (Gg/TJ)
- f = fuel type, which is either diesel or petrol.

The average distance travelled per mode of transport was determined based on the diesel and petrol consumption values in the transport sector as per Table 2-12 Litres of liquid fuels consumed in Lesotho from 2011 to 2017 and . Table 2-16 Estimated annual distance travelled per type of vehicle (km)

Table 2-16 Estimated annual distance travelled per type of vehicle (km)

Vehicle type	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
Buses	*26 637*	*20 990*	*20 162*	*25 744*	*27 138*	*27 971*	*21 825*
Cars	*17 645*	*11 429*	*10 230*	*13 165*	*13 755*	*14 242*	*15 515*
LD Trucks	*19 981*	*16 535*	*15 991*	*20 059*	*20 866*	*21 096*	*16 087*
Minibuses	*35 276*	*26 002*	*24 753*	*32 436*	*34 848*	*36 862*	*36 596*
Heavy Duty Trucks	*22 066*	*21 599*	*21 880*	*27 311*	*28 570*	*28 782*	*20 010*
Unknown	*900*	*900*	*900*	*900*	*900*	*900*	*700*

The split between diesel and petrol vehicles for each type of vehicle were broadly based on Tongwane et al. (2015) with minor adjustments based on annual fuel consumption per type of fuel.

2.4.5 *Other Sectors (1A4)*

Commercial / Institutional (1A4a)

This category covers emissions from fuel combustion in commercial and institutional buildings, particularly in commercial offices and public institutions, including government offices, prisons and schools. According to the Department of Energy, commercial and institutional buildings consume about 20% of all the solid fuels consumed in Lesotho and 4% of the LPG consumed in the country.

Photo taken by Ewa Matuszewska, ERM, 2019.

Figure 2-12 Commercial and institutional sectors on the west side of Maseru

Residential (1A4b)

Included in this category are all the emissions from fuel combustion in households. The 2016 Population Census and household survey (Bureau of Statistics, 2018) shows that there were 537,457 households in Lesotho in 2016. The Census further indicates that LPG is the most popular fuel used for cooking in the country's urban areas (49.2%) while wood is the most common in the rural areas, used by 65.1% of rural households.

According to the Department of Energy, 80% of all the solid fuels used in the country are consumed in the residential sector, while the rest is consumed in the commercial and public sectors.

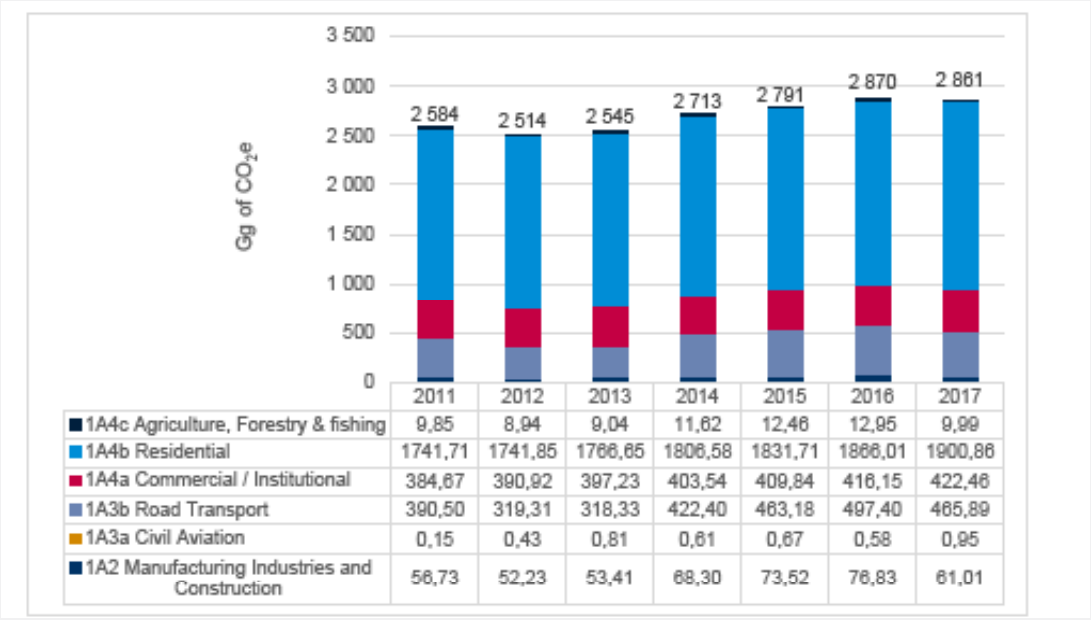
Agriculture / Forestry / Fishing / Fish Farms (1A4c)

This covers the emissions from fuel combustion in agriculture, forestry and fishing industries. It includes stationary combustion emissions from these industries as well as emissions from off-road and traction vehicles used on farm land and in forests (IPCC, 2006). According to the Department of Energy, about 4.5% of the annual diesel consumption in the country is used by the agriculture, forestry and fishing industries.

2.4.6 *Energy Sector GHG Emissions and Trends*

Lesotho's GHG emissions from the energy sector amounted to 2,583.6 GgCO_2e in 2011, and increased to 2,861.2 GgCO_2e by 2017. Reduced consumption of diesel and petrol in 2012 and 2013 led to reduction in GHG emissions to 2,513.7 GgCO_2e and 2,545.5 GgCO_2e respectively. Overall, the emissions from the energy sector increased by 10.74% from 2011 to 2017.

Figure 2-13 Energy Sector GHG emissions: 2011 - 2017 presents the energy sector GHG emissions between 2011 and 2017, disaggregated by category.



	2011	2012	2013	2014	2015	2016	2017
1A4c Agriculture, Forestry & fishing	9,85	8,94	9,04	11,62	12,46	12,95	9,99
1A4b Residential	1741,71	1741,85	1766,65	1806,58	1831,71	1866,01	1900,86
1A4a Commercial / Institutional	384,67	390,92	397,23	403,54	409,84	416,15	422,46
1A3b Road Transport	390,50	319,31	318,33	422,40	463,18	497,40	465,89
1A3a Civil Aviation	0,15	0,43	0,81	0,61	0,67	0,58	0,95
1A2 Manufacturing Industries and Construction	56,73	52,23	53,41	68,30	73,52	76,83	61,01

Figure 2-13 Energy Sector GHG emissions: 2011 - 2017

The residential sector is the largest contributor to Lesotho's energy sector emissions accounting for 65.3% in 2016 (minimum) and 69.7% in 2013 (maximum), while civil aviation is the smallest contributor accounting for between 0.006% (in 2011) and 0.033% (in 2017).

Manufacturing Industries and Construction (1A2)

Table 2-17 Manufacturing Industries and Construction emissions below presents the emissions from the manufacturing industries and construction, disaggregated by gas. The total emissions in this sector amounted to 56.73 Gg CO_2e in 2011 and increased to 61.01 Gg CO_2e by 2017. Due to unavailability of disaggregated energy consumption data for each sector (construction, textile, etc.), it was also not possible to disaggregate the emissions.

Table 2-17 Manufacturing Industries and Construction emissions

Gas	*2011*		*2012*		*2013*		*2014*		*2015*		*2016*		*2017*	
	Gg	*Gg CO_2e*	*Gg*	*Gg CO_2e*	*Gg*	*Gg CO_2e*	*Gg*	*Gg CO_2e*	*Gg*	*Gg CO_2e*	*Gg*	*Gg CO_2e*	*Gg*	*Gg CO_2e*
CO_2	*56.55*	*56.55*	*52.06*	*52.06*	*53.24*	*53.24*			*73.29*	*73.29*	*76.58*	*76.58*		
CH_4	*0.00*	*0.05*	*0.00*	*0.04*	*0.00*	*0.04*	*0.00*	*0.06*	*0.00*	*0.06*	*0.00*	*0.06*	*0.00*	*0.05*
N_2O	*0.00*	*0.14*	*0.00*	*0.13*	*0.00*	*0.13*	*0.00*	*0.16*	*0.00*	*0.17*	*0.00*	*0.18*	*0.00*	*0.14*
Total		*56.73*		*52.23*		*53.41*				*73.52*		*76.83*		*61.01*

Transport (1A3)

Table 4-7 Transport sector emissions for 2011 – 2017, in Gg CO2e show the trends in transport emissions between 2011 and 2017. Transport sector emissions were 390.65 Gg CO_2e in 2011, increasing to 466.85 Gg CO_2e in 2017. Road Transport accounted for over 99% of all the transport emissions throughout that period. Figure 2-15 shows a disaggregation of the road emissions by vehicle type.

Table 4-7 Transport sector emissions for 2011 – 2017, in Gg CO_2e

	2011	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
1A3 Transport	*390.65*	*319.74*	*319.14*	*423.01*	*463.86*	*497.98*	*466.85*

1A3a Civil Aviation	*0.15*	*0.43*	*0.81*	*0.61*	*0.67*	*0.58*	*0.95*
CO_2	*0.15*	*0.43*	*0.80*	*0.60*	*0.67*	*0.58*	*0.94*
CH_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
N_2O	*0.00*	*0.00*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*
1A3b Road Transport	*390.50*	*319.31*	*318.33*	*422.40*	*463.18*	*497.40*	*465.90*
CO_2	*382.15*	*312.56*	*311.61*	*413.48*	*453.37*	*486.82*	*455.77*
CH_4	*2.57*	*2.00*	*1.98*	*2.65*	*2.94*	*3.21*	*3.30*
N_2O	*5.77*	*4.75*	*4.74*	*6.27*	*6.87*	*7.36*	*6.83*

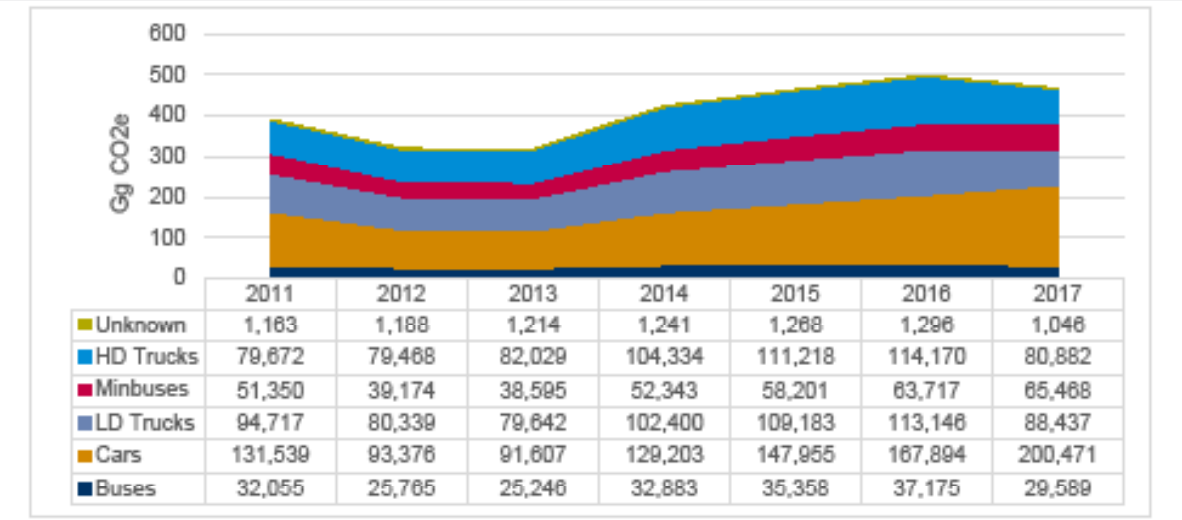


Figure 2-15 Road transport emissions disaggregated by vehicle type

Other Sectors (1A4)

GHG emissions from Other Sectors amounted to 2,126.4 Gg CO_2e in 2011 and 2,323,3 Gg CO_2e in 2017. The biggest contributor to these emissions is the residential sector, which accounts for about 82% of the emissions annually, followed by the commercial / institutional sectors at 18%. Table 216 shows the GHG emissions from the Other Sectors, disaggregated by gas.

Table 2-18 Disaggregation of emissions from Other Sectors, in GgCO_2e

	2011	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
1A4 Other Sectors	*2 126.38*	*2 132.77*	*2 163.88*	*2 210.12*	*2 241.56*	*2 282.17*	*2 323.32*
1A4a Commercial / Institutional	*384.67*	*390.92*	*397.23*	*403.54*	*409.84*	*416.15*	*422.46*
CO_2	*326.93*	*332.23*	*337.53*	*342.84*	*348.14*	*353.45*	*358.75*
CH_4	*46.98*	*47.80*	*48.62*	*49.44*	*50.26*	*51.07*	*51.89*
N_2O	*10.76*	*10.89*	*11.08*	*11.26*	*11.45*	*11.63*	*11.82*
1A4b Residential	*1 741.71*	*1 741.85*	*1 766.65*	*1 806.58*	*1 831.71*	*1 866.01*	*1 900.86*
CO_2	*1 426.22*	*1 421.15*	*1 440.61*	*1 475.11*	*1 494.89*	*1 523.80*	*1 553.25*
CH_4	*272.36*	*276.90*	*281.51*	*286.17*	*290.78*	*295.42*	*300.06*

N_2O	43.14	43.80	44.53	45.30	46.04	46.79	47.55
1A4a Agriculture / Forestry / Fishing	9.85	8.94	9.04	11.62	12.46	12.95	9.99
CO_2	9.80	8.89	8.99	11.56	12.39	12.88	9.94
CH_4	0.03	0.03	0.03	0.03	0.04	0.04	0.03
N_2O	0.02	0.02	0.02	0.03	0.03	0.03	0.02

2.4.7 *Information items*

According to the 2006 IPCC guidelines, emissions of CO_2 from biomass fuels (wood, dung, crop residues and shrubs) are estimated and reported in the AFOLU sector as part of the AFOLU methodology. To avoid double-counting, the CO_2 emissions from biomass fuels calculated in the energy sector are reported as information items only and not included in the sectoral or national totals. Table 2-19 CO2 emissions from biomass fuels, Gg presents the CO_2 emissions from biomass fuels for the period 2011 – 2017. The emissions were 3,585.32 Gg in 2011, reaching 4,233.53 Gg in 2017.

Table 2-19 CO_2 emissions from biomass fuels, Gg

	2011	2012	2013	2014	2015	2016	2017
Wood	1 500.29	1 527.43	1 554.56	1 581.70	1 608.83	1 635.97	1 663.10
Shrubs	988.96	1 257.43	1 279.58	1 301.73	1 323.88	1 346.04	1 368.19
Dung	882.01	898.00	913.98	929.97	945.96	961.94	977.93
Crop Residue	214.06	215.43	217.48	219.18	220.89	222.60	224.31
TOTAL	3 585.32	3 898.28	3 965.60	4 032.58	4 099.56	4 166.55	4 233.53

2.4.8 *Uncertainty assessment*

Uncertainty associated with energy data obtained from reliable energy balances and national energy statistics is about 5%. However, in this case, some of the data provided by the Department of Energy varied significantly with energy data published by the Bureau of Statistics. This increases the uncertainty associated with the petrol, diesel, LPG, illuminating paraffin and aviation data provided by the Department of Energy significantly. Expert judgment puts this uncertainty in the same range as uncertainty associated with energy data obtained through surveys in developing countries, which is 10 – 15%. Because consumption data for biomass fuels (wood, shrubs, dung and crop residues) as well as coal was estimated by extrapolation, it carries uncertainty in the range of 60 – 100% as per 2006 IPCC guidelines.
Combining these activity data uncertainties with uncertainties associated with the default emission factors applied to the different fuels results in the uncertainties presented in the table below:

Table 2-20 Uncertainties associated with energy sector CO_2 emissions per fuel

Fuel	Emission Factor Uncertainty (%)	Activity Data Uncertainty (%)	Combined Uncertainty (%)
Motor Gasoline	2.6 – 5.3	10 – 15	10.33 – 15.92
Aviation Gasoline	3.57 – 4.29	10 – 15	10.62 – 15.60
Other Kerosene	1.53 – 2.50	10 – 15	10.12 – 15.21

Diesel	*0.94 – 2.02*	*10 – 15*	*10.04 – 15.14*
Liquefied Petroleum Gas	*2.38 – 3.94*	*10 – 15*	*10.28 – 15.51*

2.4.9 *Quality Assurance / Quality Control*

Quality control was performed by the Energy team as per QC sheet, while data was being collected, when calculations were being performed and while the data was recorded in excel spreadsheets and the final numbers were added into the IPCC software. The following energy sector-specific QC activities were carried out:

- For liquid fuels, a full time series graph for each fuel, covering data for 1982 – 2017, was plotted to check and correct for data consistency;
- The 2012 – 2016 liquid fuels data obtained from the Department of energy was compared with the corresponding data published in the 2015 Energy Report and the 2017 Energy Report;
- Data and calculation checks were undertaken on the linear extrapolation calculations for vehicle statistics, biomass fuels and coal.
- Checks were also made on the application of fuel percentage splits per sector.

2.4.10 *Methodology and Completeness*

Table 2-22 provides a summary of the methods and types of emission factors used during the compilation of this inventory. All estimates were made using the IPCC 2006 inventory software.

Table 2-21: Summary of methods and types of emissions factors for Energy sector

GHG Source and sink category		CO_2		CH_4		N_2O		
		Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	
A	Energy							
1	Manufacturing industries and construction							
	Construction	T1		DF	T1	DF	T1	DF
	Transport							
	Civil Aviation	T1		DF	T1	DF	T1	DF
	Road Transportation	T1		DF	T1	DF	T1	DF
	Other Sectors							
	Commercial/Institutional	T1		DF	T1	DF	T1	DF
	Residential	T1		DF	T1	DF	T1	DF
	Agriculture/Forestry/Fishing/ Fish Farms	T1		DF	T1	DF	T1	DF

T1 = Tier 1, DF = Default Factor. Categories and sub-categories not listed above were neither not occurring

nor not estimated due to data unavailability.

2.4.11 *Recommendations for future improvements*

There is need for strengthening of energy statistics in Lesotho in order to improve the accuracy of the energy sector GHG inventory. The following are the key recommended improvements:

- The compilation of a consistent accurate annual energy balance is recommended, based on actual energy consumption data
- Improving the accuracy of fossil fuel consumption data: All the fossil fuels used in Lesotho are imported from South Africa, and are by law required to be recorded when they enter the country. If the recording and monitoring procedures for imported fuels can be strengthened at the border gates by the Lesotho Revenue Authority, this would improve the accuracy and reliability of fossil fuel data in the country, and subsequently the accuracy of the GHG inventory.
- Strengthening the QC procedures for energy data management. It was observed that there were instances where the energy data held by the Department of Energy differed significantly with the data published by the Bureau of Statistics in energy reports. It is thus recommended that the quality control procedures as data is shared between different government institutions be strengthened.

2.5 Industrial processes and other product use (IPPU)

2.5.1 *An overview of the IPPU sector*

Industrial activity in Lesotho is dominated by the textile industry which does not undertake activities that release industrial process emissions. The main industrial activity that results in industrial process emissions is the ceramic industry, which comprises of numerous brick-makers, ranging from large companies to individual producers using the large deposits of clay in Lesotho to manufacture bricks. The other, less significant contributor, in this category is the manufacture of beverages by the Maluti Mountain Brewery. The use and disposal of refrigeration and stationery air conditioning equipment is the main source of GHG emissions arising from product use in Lesotho.

2.5.2 *Sources*

IPPU sector emissions in Lesotho come from the following categories:

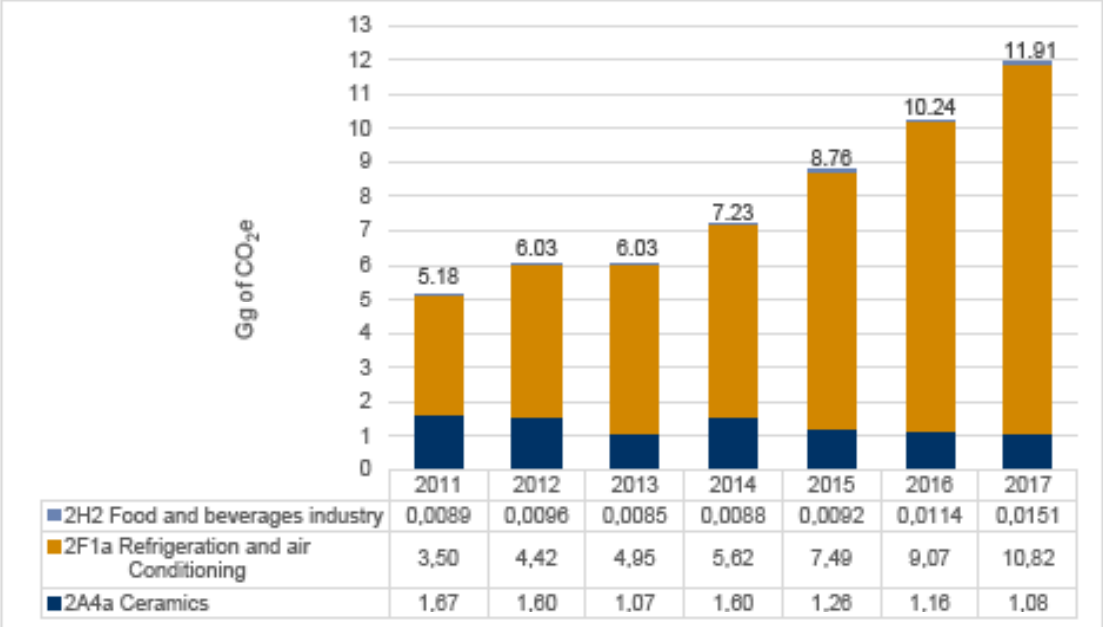
» 2A4 Other Process Uses of Carbonates

» 2A4a Ceramics

» 2F1 Refrigeration and Air Conditioning

2.5.3 *IPPU Sector Emissions and Trends*

below presents the totals and trends in GHG emissions for the IPPU sector for the years 2011 – 2017.



	2011	2012	2013	2014	2015	2016	2017
2H2 Food and beverages industry	0,0089	0,0096	0,0085	0,0088	0,0092	0,0114	0,0151
2F1a Refrigeration and air Conditioning	3,50	4,42	4,95	5,62	7,49	9,07	10,82
2A4a Ceramics	1.67	1.60	1.07	1.60	1.26	1.16	1.08

Figure 2-15 Summary of the IPPU sector emissions for the years 2011 to 2017

Between 2011 and 2017, IPPU sector GHG emissions increased by 130% from 5.18 Gg CO_2e in 2011 to 11.92 Gg CO_2e in 2017. Refrigeration and air conditioning are the largest contributors to emissions in this sector, with contributions ranging between 67.6% in 2011 to 90.8% in 2017. Food and beverages contribute the least to emissions in the IPPU sector, with contributions ranging between 0.1% and 0.2% throughout the period.

2.5.4 *2A4a Ceramics*

2.5.4.1 *Source Description*

The manufacture of ceramics falls within the mineral industry sector, under other process uses of carbonates. This category comprises the production of vitrified clay pipes, expanded clay products, technical ceramics, bricks and roof tiles, table and ornamental ware (household ceramics), refractory products, sanitary ware, wall and floor tiles and inorganic bonded abrasives. The process of calcination of carbonates in the clay and the addition of additives results in the emission of carbon dioxide gas. Ceramic products are primarily made from one or more different types of clay (e.g., shales, fire clay and ball clay).
In Lesotho there are widespread clay deposits all over the country and clay is utilised by small individual plaster brick producers and by local ceramic companies as raw materials for bricks. There is no database of all brick makers in the country.

Photo taken by Ewa Matuszewska, ERM, 2019.

Figure 2-16 Informal fire clay brick-making in Maseru East

Lesotho's bricks are manufactured from fire clay, coal additives are then used for colouring and to achieve the desired characteristics. The carbonates of dolomites and / or calcites are contained in fire clay deposits.

2.5.4.2 *Data sources and Methodological issues*

There are no statistics of clay consumption and brick manufacturing in Lesotho. In the past inventories the United States Geographical Survey (USGS) minerals Yearbooks, which report estimated clay consumption based on the installed capacity of Loti Brick – the largest brick manufacturer in the country. In this inventory, production data was first sources from Loti Brick, which could only provide data for 2015 – 17. This data was then complimented with data from the 2015 and 2016 USGS Yearbooks (USGS, 2016), which contained data from 2012. Clay consumption for 2011 was calculated through linear extrapolation of the available 2012 – 2017 data.

Loti Brick supplied the number of bricks produced per year, together with the average weight 2.70 kg per brick, which is equivalent to the mass of clay used per brick. Hence, the tonnes of clay used per year was determined by multiplying the number of bricks per year with the weight per brick.

Table 2-22 Quantify of clay consumed from 2011 – 2017, by data source below presents the tons of clay consumed between 2011 and 2017, disaggregated by source.
Table 2-22 Quantify of clay consumed from 2011 – 2017, by data source

		2011	2012	2013	2014	2015	2016	2017
Tons of clay consumed		37 475	36 000	24 000	36 000	28 341	25 983	24 227
Data Source	U.S Geological Survey minerals yearbooks		X	X	X			
	Loti brick					X	X	X

To calculate the emissions, a default 10% carbon content of clay was assumed, as well as an 85%:15% split between limestone and dolomite content in the clay as recommended in the 2006 IPCC guidelines. Default Tier 1 emission factors for limestone and dolomite were applied for emission estimates.

2.5.5 *Results and Trends*

below provides the GHG emissions for ceramics for the period 2011 – 2017 in Lesotho.

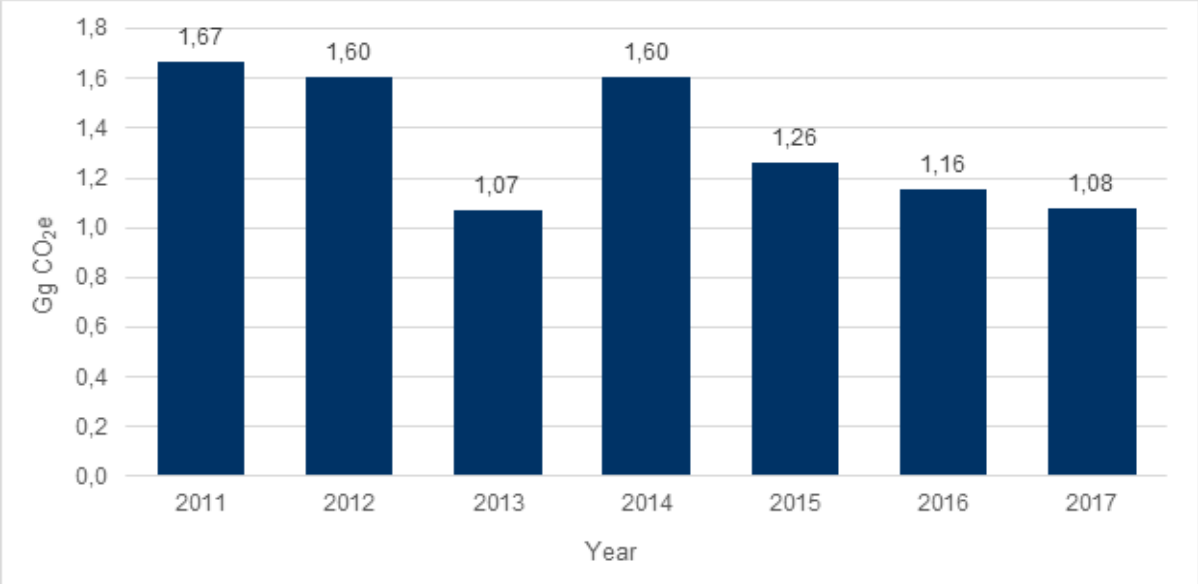


Figure 2-17 Total emissions for ceramics in Lesotho from 2011 to 2017

GHG emissions from the production of ceramics decreased from 1.67 Gg CO_2e in 2011 to 1.08 Gg CO_2e in 2017. This 35.4% decrease in emissions results from the overall reduction in the number of bricks produced. Emissions for the years 2011 – 2014 fluctuated yearly with a decrease of about 33% from 2012 to 2013 and about 50% increase from 2013 to 2014. Between 2014 and 2017 the emissions decreased by about 32%.

2.5.6 *Uncertainty assessment*

The uncertainty in this category lies in the uncertainty of the activity data since the emission factor based on the stoichiometric ratio reflecting the amount of CO_2 released upon calcination of the carbonate. The uncertainty of the activity data obtained from Loti Brick is very low (1 – 3 percent) because it is based on the actual production statistics. On the other hand, the activity data obtained from USGS has a higher uncertainty since it estimated based on historical production values and installed capacity. According to the 2006 IPCC guidelines, the uncertainty associated with the chemical analysis pertaining to carbonate content and identity also is 1-3 percent, while the uncertainty associated with the assumption of a default breakdown of limestone versus dolomite of 85%/15%, varies depending on country specific circumstances. A Lesotho-specific uncertainty analysis of the limestone: dolomite breakdown has not been done.

2.5.7 *Quality assurance / Quality control*

Quality control was performed by the IPPU team while data was being collected, when calculations were being performed and while the data was recorded in excel spreadsheets and the final numbers were added into the IPCC software. Hence, all the relevant points on the QC sheet were followed for emission calculations for ceramics.

2.5.8 *Planned improvements and recommendations*

In order to improve the accuracy of the GHG emissions in this category, the following improvements are recommended:

- Improved data consistency over the entire time series: Currently the activity data over the time series is a combination of actual production data and production estimates based on capacity, and this affects the consistency of the emission estimates. It is thus recommended that a complete dataset of brick production be sourced from Loti brick for the entire time-series.
- Improved completeness: Ceramics in Lesotho are produced by many formal companies as well as companies and individuals in the informal sector. It is best practice to include all the sources of emissions for each category, hence it is recommended that a survey be undertaken to determine the full scale of brick production in the country.

2.5.9 *2F1 Refrigeration and air conditioning*

2.5.9.1 *Source Description*

Within the IPPU sector the product uses of substitutes for ozone depleting substances (ODS) can be broken down into refrigeration and air conditioning, foam blowing agents, fire protection, aerosols, solvents and other applications.
Refrigeration and air conditioning is the most prominent application in Lesotho. The use covers transport refrigeration, domestic refrigeration, stationary air conditioning including, commercial refrigeration and industrial processes including chillers, cold storage, and industrial heat pumps used in the food industry. All refrigeration and stationery air conditioning equipment and refill gases are imported from South Africa. The biggest refrigeration and air conditioning ODS alternatives imported into Lesotho are HFCs. There are 19 main importing companies in Lesotho. There are over 100 different uses for these gases in Lesotho.

2.5.9.2 *Data Sources and Methodological issues*

The data for HFCs consumed in the country between 2012 and 2015 was provided by the Ozone Unit of the Lesotho Meteorological Services. The data comprised consumption of pure HFC–134a and of HFC blends R–404A (44% HFC-125, 52% HFC-143a and 4% HFC-134a) and R–410A (50% HFC-32, 50% HFC-125). HFC consumption for the years 2011, 2016 and 2017 was projected from the 2012 – 2015 data using linear regression.

Figure 2-18 Consumption of pure HFC-134a and HFC blends between 2011 and 2017* below presents the actual and projected consumption of pure HFC-134a for the period 2011 – 2017.

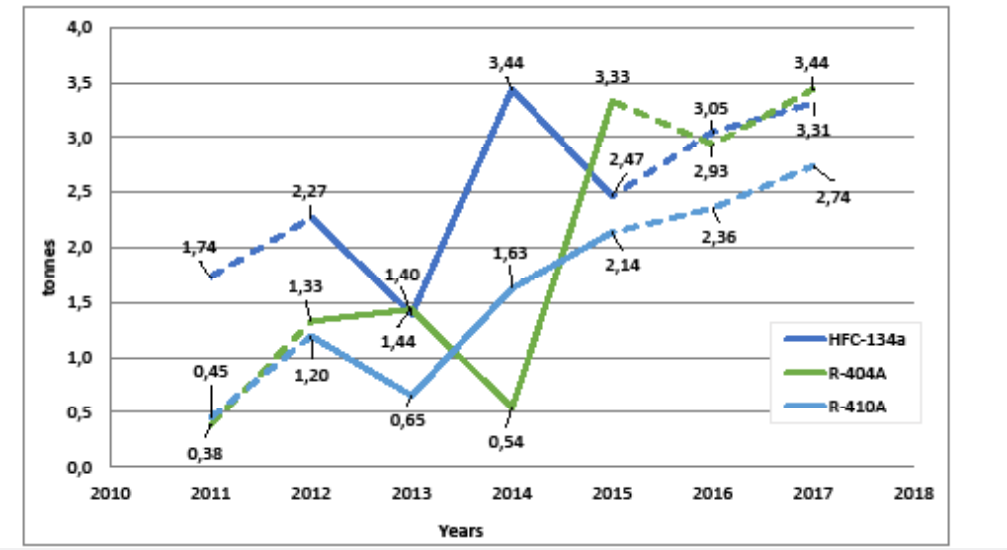


Figure 2-18 Consumption of pure HFC-134a and HFC blends between 2011 and 2017*

**Dotted lines in the graph depict projected data*

The resulting annual consumption of each individual HFC gas for the period 2011 – 2017 is shown in Table 2-23 Quantity of individual HFC gases consumed between 2011 and 2017 below.

Table 2-23 Quantity of individual HFC gases consumed between 2011 and 2017

	2011	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
HFC -134a	*1.75*	*2.32*	*1.45*	*3.46*	*2.60*	*3.17*	*3.45*
HFC - 125	*0.39*	*1.18*	*0.96*	*1.05*	*2.54*	*2.47*	*2.89*
HFC - 143a	*0.20*	*0.69*	*0.75*	*0.28*	*1.73*	*1.53*	*1.79*
HFC - 32	*0.23*	*0.60*	*0.33*	*0.82*	*1.07*	*1.18*	*1.37*

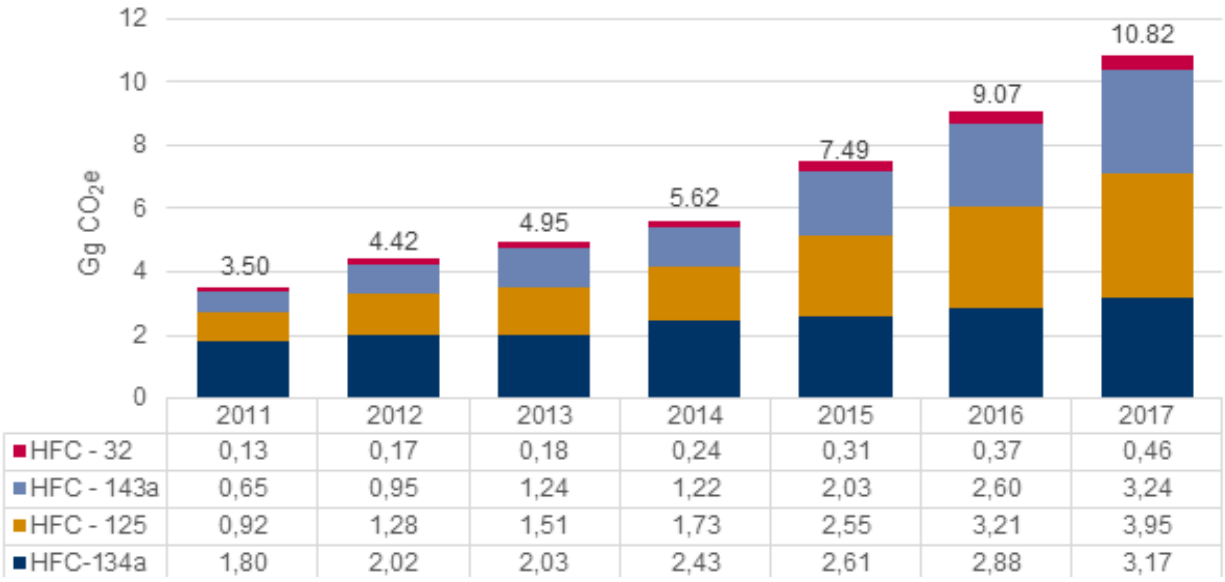
To estimate the annual emissions, the default 2006 IPCC guideline method, with the parameters shown in Table 2-24 Parameters used to estimate annual emissions of HFCs from refrigeration and air conditioning equipment below, was used.

Table 2-24 Parameters used to estimate annual emissions of HFCs from refrigeration and air conditioning equipment

	Introduction year	*Annual growth rate*	*Equipment lifetime*	*Emitted gas %*	*Destroyed gas %*
Value and units	*1993*	*1%*	*15 years*	*15%*	*0%*

2.5.9.3 *Results and Trends*

below provides the annual emission estimates of HFCs from refrigeration and stationery air conditioning for the time series of 2011 to 2017 in Lesotho.



	2011	2012	2013	2014	2015	2016	2017
HFC - 32	0,13	0,17	0,18	0,24	0,31	0,37	0,46
HFC - 143a	0,65	0,95	1,24	1,22	2,03	2,60	3,24
HFC - 125	0,92	1,28	1,51	1,73	2,55	3,21	3,95
HFC-134a	1,80	2,02	2,03	2,43	2,61	2,88	3,17

Figure 2-19 HFC emissions from refrigeration and air conditioning from 2011 to 2017

Refrigeration and stationery air conditioning emissions in Lesotho have increased three-fold between 2011 and 2017, from 3.50 Gg CO_2e in 2011 to 10.82 Gg CO_2e in 2017. In 2011 HFC-134a was the largest contributor of GHG emissions at 51.5%, followed by HFC-125 and HFC-143a with 26.2% and 18.6% respectively. Over the six years, however, emissions of HFC-125 and HFC-143a have been growing faster than those of HFC-134a reaching 36.6% and 29.9% of the total HFC emissions by 2017 respectively. This is as a result of the relatively higher growth in the use of equipment using R-404A and R-410A compared to those using pure HFC-134a.

2.5.9.4 *Uncertainty assessment*

GHG emissions from this category have been estimated for the first time in this 4th GHG inventor, as such it is difficult to quantify the level of uncertainty due to the large number of emission patterns. In general, the uncertainly of the activity data depends on the accuracy with which the quantity of HFCs consumed annually has been determined. If this is data is collected directly from the importers the uncertainly associated with it will be very low. The greatest uncertainly for this category lies in the emission factors, including the annual growth rate, the equipment lifetime and the percentage of gas emitted over time, especially if the activity data has not been disaggregated by sub-application as is the case for this inventory. According to the 2006 IPCC guidelines, equipment lifetime ranges between 6 and 30 years, while emission factor percentages range between 0.2% and 50%. Because the bulk of HFCs in Lesotho are used in domestic refrigeration and stand-alone commercial applications, conservative default values for both equipment lifetime and emission factor percentages have been applied.

2.5.9.5 *Quality assurance/ Quality control*

Quality control was performed by the IPPU team for this category while data was being collected when calculations were being performed and while the data was recorded in excel spreadsheets and the final numbers were added into the IPCC software. Internal QC included checking the units of the HFC activity data as received from the Ozone Unit, ensuring consistent time-series of HFC quantities, checking that the percentages of individual HFCs contained in each of the HFC blends (R-401A and R-410A) have been correctly recorded and applied to the blends, accuracy in transferring the data onto the IPCC software and accuracy in applying the correct emission parameters.
The ERM then reviewed the data, all the calculators and final numbers and assured the overall quality of

the inventory for refrigeration and stationery air conditioning.

2.5.9.6 *Planned improvements and recommendations*

For the refrigeration and air conditioning category, the following improvements are recommend:

- To ensure completeness and a consistent time series, it is recommended that an accurate inventory of all new refrigerators and air condition units imported into the country be kept and included in future inventories. For accuracy of the inventory this data needs to be disaggregated by sub-application (e.g. mobile refrigeration, etc.)
- To ensure a consistent time series going back, it is recommended that BOS assists with surveys and/or collect 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.
- BOS has started including questions related to the use of fridges and air-conditioning systems in their regular planned household surveys; it is recommended that these questions be tailored to ensure that as much data required for the GHG inventory is gathered through these surveys.

2.5.10 *Methodology and completeness*

Table 2-26 provides a summary of methods and types of emission factors used during the compilation of this inventory. All estimates were made using IPCC 2006 inventory software.

Table 2-25: Summary of methods and types of emission factors for IPPU sector

GHG Source and sink category		CO_2		CH_4		HFCs			
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor		
A	IPPU								
1	Mineral Industry								
	Cement Production	T1	DF	NA	NA	NA	NA		
	Product uses as substitutes for Ozone depleting substances								
	Refrigeration and air conditioning	NA	NA	NA	NA	T1	DF		

T1 = Tier 1, DF = Default Factor, NA = Not applicable. Categories and sub-categories not listed above were neither not occurring nor not estimated due to data unavailability.

2.6 Agriculture, forestry and other land use (AFOLU)

2.6.1 *An overview of the AFOLU sector*

In reference to AFOLU, land use and management effect a variety of ecosystem processes that affect greenhouse gas changes, these include: respiration, photosynthesis, decomposition, combustion, enteric fermentation and nitrification/denitrification. These processes comprise transformations of carbon and nitrogen that are driven by the biological and physical processes. The key greenhouse gases in AFOLU are CO_2, N_2O and CH_4.

The GHG emissions from the agriculture, forestry and other land-use (AFOLU) sector often have the highest contribution in developing countries because of their reliance on agriculture. Lesotho, like all other least developed countries, has majority of her population relying on agriculture for livelihood. Agricultural land covers 18.9% of Lesotho, while grasslands cover 49.6% (Figure 2-20 Land cover map and summary of the land cover statistics of Lesotho). Trees and shrubs cover 1.3% and 19.1% respectively.

Figure 2-20 Land cover map and summary of the land cover statistics of Lesotho

Farming is an important livelihood activity for a significant percentage of the population due to the fact that about 70% of Lesotho's people live in rural areas (Lesotho Review, 2018).

2.6.2 *Agriculture in Lesotho*

Agriculture still remains the main source of livelihoods in terms of food and income. The agricultural sector alone is responsible for employing 65% of the population mainly in the rural areas. In terms of

income, 77% of household income was derived from farming in 2014 (Bureau of Statistics, 2014).
Crop production is mainly rain fed, with a few and small irrigation schemes covering about 1 358 hectares of the total arable land countrywide. As a result, Lesotho is more susceptible to drought and desertification. Lesotho's main crops grown by mostly subsistence farmers are maize, wheat, sorghum and drybean (Bureau of Statistics, 2017a) Horticulture in the country is characterized by fruit and vegetable production through homestead gardens, community gardens and backyard fruit trees.

Rangelands cover around 50% of Lesotho and support the large amount of livestock present in Lesotho. National livestock statistics (Bureau of Statistics, 2018a) indicates that there are around 4 million livestock in Lesotho, with approximately 50% of this being sheep and 25% goats. Livestock are reared for production of meat, wool, skins, mohair, hides, manure, drawing carts and ploughing.

Source: SHutterstock

Figure 2-21Photo of cattle used to draw a cart in Lesotho

2.6.3 *Forestry in Lesotho*

Forests account for a very small percentage of Lesotho but indigenous trees and shrubs coverage is more significant (Figure 2-20 Land cover map and summary of the land cover statistics of Lesotho). Lesotho's very small area of tree plantations comprises exotic species, and are of two types. The first category of plantations are those grown primarily for wood production (mainly Government-owned woodlots), and the second comprises those planted by the present and past Governments mainly for erosion stabilisation but self-regenerating and now regularly harvested by rural people for firewood and poles (FAO, 2014). Forestry in Lesotho contributes insignificantly to the official revenue figures in the national economy. The greatest threat by far to forest resources in Lesotho is from the browsing of the re-growth of harvested woody plants by its huge population of freely-grazed domestic livestock (FAO, 2014).

2.6.4 *Key categories*

The key categories for the AFOLU sector from the 2010 key category analysis for all three gases was:

» 3A1 Enteric fermentation;

» 3A2 Animal Waste Management Systems;

» 3C1 Prescribed burning of savannas;

» 3C4 Direct emissions from agricultural soils;

» 3C5 Indirect emissions from agricultural soils.

Completeness

Liming (3C2) was excluded from AFOLU as there was insufficient data on lime consumption to include this category. Data was only available for the year 2013 and it is unclear how reliable this data is.

Sources

This section includes GHG emissions and removals from agriculture as well as land use and forestry. Based on the IPCC 2006 Guidelines, the following categories were included in this inventory:

- Livestock:
  - 3A1 Enteric fermentation;
  - 3A2 Manure management;
- Land:
  - 3B1 Forest land;
- Aggregate sources and non-CO_2 emissions on land:
  - 3C1 Biomass burning;
  - 3C3 Urea application;
  - 3C4 Direct N_2O emission from managed soils;
  - 3C5 Indirect N_2O emission from managed soils;
  - 3C6 Indirect N_2O emission from manure management.

Emissions from fuel combustion in this sector are not included here as these fall under the agriculture/forestry/fisheries subsector in the energy sector. Losses of CO_2 emissions from biomass burning are included under losses due to disturbance in the land section (3B) and not in the biomass burning (3C1) section. Section 3C1 deals with non-CO_2 emissions from biomass burning in all land use types.

Methodology and Completeness

Table 2-26 Summary of methods and emission factors for the AFOLU sector and an assessment of the completeness of the AFOLU sector emissions provides a summary of the methods and types of emission factors used during the compilation of this inventory. All estimates were made via the use of the IPCC 2006 inventory software.

Table 2-26 Summary of methods and emission factors for the AFOLU sector and an assessment of the completeness of the AFOLU sector emissions3

GHG Source and sink category		CO_2	CH_4		N_2O		
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor	
A	Livestock						
1	Enteric fermentation						
	a.i. Dairy cattle	NA		T1	DF	NA	
	a.ii. Other cattle	NA		T1	DF	NA	
	b. Buffalo	NA		NO		NA	
	c. Sheep	NA		T1	DF	NA	
	d. Goats	NA		T1	DF	NA	
	e. Camels	NA		NO		NA	
	f. Horses	NA		T1	DF	NA	
	g. Mules and asses	NA		T1	DF	NA	
	h. Swine	NA		T1	DF	NA	
	j. Other (Game)	NA		NE		NA	
2	Manure management						
	a.i. Dairy cattle	NA		T1	DF	T1	DF
	a.ii. Other cattle	NA		T1	DF	T1	DF
	b. Buffalo	NA		NO		NO	
	c. Sheep	NA		T1	DF	T1	DF
	d. Goats	NA		T1	DF	T1	DF
	e. Camels	NA		NO		NO	
	f. Horses	NA		T1	DF	T1	DF
	g. Mules and asses	NA		T1	DF	T1	DF
	h. Swine	NA		T1	DF	T1	DF
	i. Poultry	NA		T1	DF	T1	DF
	j. Other (Game)	NA		NE		NE	
B	Land						

[7] NA = Not applicable; NE = Not Estimated; NO = Not Occurring; DF = Default Factor; T1 = Tier 1

1	Forest land						
	a. Forest land remaining forest land	Biomass: T1	Biomass: DF	NE		NE	
		DOM: NE					
		Soil: NE					
	b. Land converted to forest land	Biomass: NE		NE		NE	
		DOM: NE					
		Soil: NE					
2	Cropland						
	a. Cropland remaining cropland	Biomass: NE		NE		NE	
		DOM: NE					
		Soil: NE					
	b. Land converted to cropland	Biomass: NE		NE		NE	
		DOM: NE					
		Soil: NE					
3	Grassland						
	a. Grassland remaining grassland	Biomass: NE		NE		NE	
		DOM: NE					
		Soil: NE					
	b. Land converted to grassland	Biomass: NE		NE		NE	
		DOM: NE					
		Soil: NE					
4	Wetland						
	a. Wetland remaining wetland	NE		NE		NE	
	b. Land converted to wetland	NE		NE		NE	

5	Settlements						
	a. Settlements remaining settlements	Biomass: NE		NE		NE	
		DOM: NE					
		Soil: NE					
	b. Land converted to settlements	Biomass: NE		NE		NE	
		DOM: NE					
		Soil: NE					
6	Other land						
	a. Other land remaining other land	Biomass: NE		NE		NE	
		Soil: NE					
	b. Land converted to other land	Biomass: NE		NE		NE	
		Soil: NE					
C	Aggregated sources and non-CO_2 emissions on land						
1	Biomass burning	T1	DF	T1	DF	T1	DF
2	Liming	NE		NA		NA	
3	Urea application	T1	DF	NA		NA	
4	Direct emissions from managed soils						
	Synthetic fertilizers	NA		NA		T1	DF
	Animal waste added to soils	NA		NA		T1	DF
	Other organic fertilizers	NA		NA		T1	DF
	Urine and dung deposited by grazing livestock	NA		NA		T1	DF
	Crop residues	NA		NA		T1	DF
5	Indirect emissions from managed soils						
	Atmospheric deposition	NA		NA		T1	DF
	Nitrogen leaching and runoff	NA		NA		T1	DF
6	Indirect emissions from manure management						
	Volatilization	NA		NA		T1	DF
	Nitrogen leaching and runoff	NA		NA		NE	
7	Rice cultivation	NO		NO		NO	
D	Other						

1	Harvested wood products	NE		NA		NA	

2.6.5 *Results and Trends in AFOLU*

Table 2-25 below demonstrates the totals in Gg of CO_2e emissions for the AFOLU sector for the years 2011 to 2017.

Table 2-27 Summary of the AFOLU sector emissions, in Gg CO_2e, for the years 2011 until 2017

AFOLU Sector	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
3A1 Enteric fermentation	*761.19*	*684.94*	*638.50*	*625.25*	*608.04*	*594.30*	*669.65*
3A2 Manure Management	*90.22*	*89.09*	*75.17*	*76.74*	*81.25*	*78.65*	*87.95*
3B1 Forest land	*1193.64*	*1164.86*	*1156.50*	*1124.71*	*1097.58*	*1117.23*	*1089.55*
3C1 Biomass Burning	*36.65*	*19.05*	*15.60*	*11.98*	*17.66*	*23.73*	*23.73*
3C3 Urea Application	*0.08*	*0.08*	*0.12*	*0.07*	*0.05*	*0.08*	*0.08*
3C4 Direct N_2O Emission from Managed Soils	*465.86*	*423.85*	*394.31*	*390.29*	*382.35*	*364.69*	*408.85*
3C5 Indirect N_2O Emission from Managed Soils	*140.59*	*131.84*	*121.49*	*120.01*	*119.28*	*114.07*	*135.11*
3C6 Indirect N_2O Emissions from Manure Management	*2.18*	*2.21*	*1.76*	*1.68*	*1.99*	*1.77*	*2.05*
Totals	*2690.41*	*2515.92*	*2403.44*	*2350.74*	*2308.19*	*2294.52*	*2416.97*

The below graph (Figure 2-22) provides the illustration of the above graph for the Gg of CO_2e emissions in Lesotho by each sub-sector for the AFOLU sector over the years 2011 to 2017.

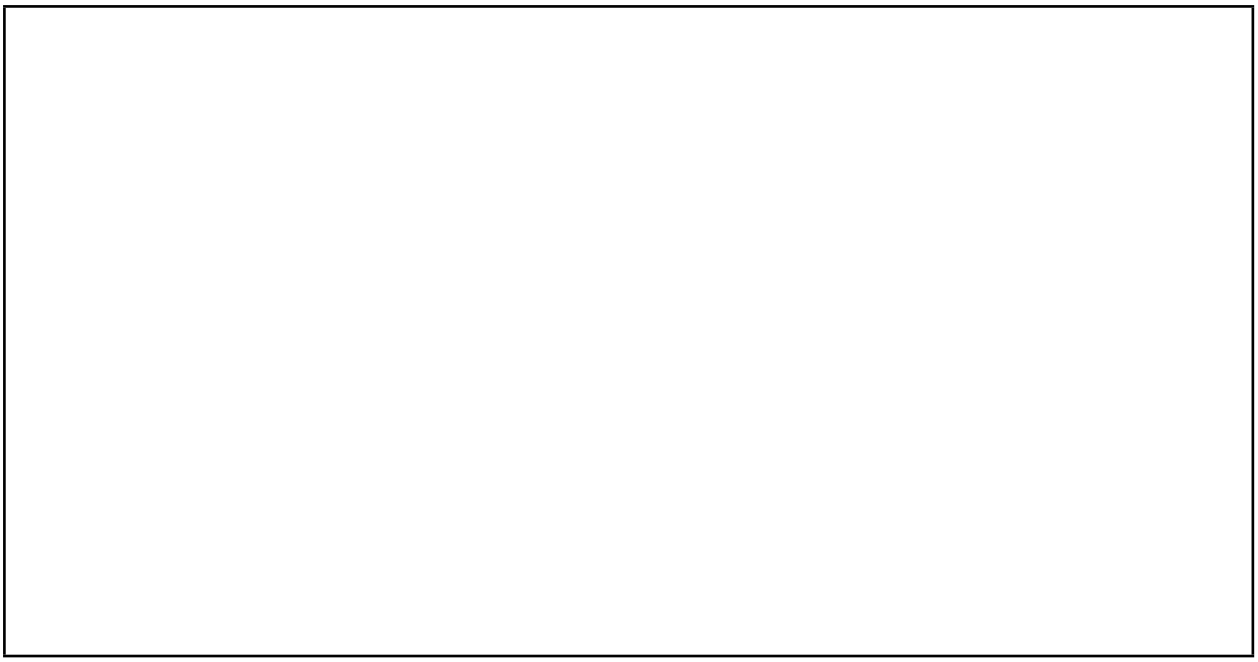


Figure 2-22 Graph showing the AFOLU sector totals by sub-sector

Trends

The AFOLU sector is estimated to produce 2 417 Gg CO_2e in 2017. Emissions declined from 2012 to 2016, and then increased slightly in 2017. The land sector is the largest contributor (45.1%), followed by livestock (Figure 2-23). The emission estimates are higher than what was provided in the previous inventory (2005 to 2010) (LMS, 2018), however there are inconsistencies in the data sources and some methodologies, therefore the change is representative of these changes not actual emission changes. The reason for these inconsistencies as discussed in the sections below.

Figure 2-23 Summary of GHG emission trends in the AFOLU sector

2.6.6 *3A: Livestock*

Emission results and trends

Total livestock emissions are estimated at 758 Gg CO_2e for 2017. Livestock emissions declined between 2011 and 2016, after which there was an increase in 2017 (Figure 2-24). These trends follow the livestock population trend as population number is the main driver in this category. Enteric fermentation is the largest contributor to the emissions in the livestock category, contributing an average of 88.8% between 2011 and 2017.Figure 224 also shows the comparison with the previous inventory for 2005 and 2010. It can be seen that enteric fermentation and CH_4 manure management emissions are very similar between the two sets of data. On the other hand, N_2O emissions from manure management are much reduced compared to the last inventory. The main reason for this change is the discrepancy in the manure management usage systems. This is a highly uncertain data and shows the importance of collecting data to improve the accuracy and reduce uncertainty in this category.

Figure 2-24 Trends in livestock emissions for Lesotho between 2005 and 2017

2.6.7 *3A1 Enteric Fermentation*

Category information

Enteric fermentation emissions are calculated for all livestock, except poultry as IPCC (2006) states that enteric fermentation from poultry is negligible. A lack of data for poultry means no emission factor is provided by IPCC.

Methodological issues

Enteric fermentation emissions were calculated using Tier 1 equations 10.19 and 10.20 from the IPCC 2006 Guidelines. The IPCC 2006 software was utilized to estimate the emissions.

Population data

Livestock population data for the inventory are shown in Table 2-28 Livestock population data (head/yr) used in the inventory. Population data for all livestock was obtained from BOS annual livestock statistics reports (BOS, 2013; 2013a; 2014; 2015b; 2016; 2017; 2018).

A total cattle number is supplied in these reports (Table 3.1 in BOS reports), therefore this number had to be split into dairy and other cattle. To determine the number of dairy cattle the fraction of cattle reared for milk purposes (see Table 3.2 in BOS report) was multiplied by the total number of cattle. The total number of other cows was therefore calculated as the total number of cattle minus the dairy cattle. The total number of cows, number of bulls and percentage of cows reared for milk were obtained from BOS annual livestock statistical reports (Table 3.1 and 3.1 in the report).

Swine population is also provided as a total, but this was split into market and breeding swine using the IPCC default assumption of 90% market swine and 10% breeding swine. This division was done as IPCC 2006 Guidelines provides different factors for market and breeding swine.

Table 2-28 Livestock population data (head/yr) used in the inventory

Type	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
Dairy cattle	*6 905*	*5 772*	*3 836*	*8 102*	*4 575*	*2 470*	*6 924*
Other cattle	*683 982*	*571 400*	*544 205*	*532 031*	*503 769*	*491 537*	*454 649*
Sheep	*1 552 241*	*1 556 188*	*1 410 013*	*1 346 596*	*1 356 485*	*1 432 065*	*2 041 479*
Goats	*814 018*	*886 340*	*838 650*	*824 968*	*813 850*	*700 509*	*972 701*
Horses	*77 089*	*63 656*	*59 731*	*55 397*	*59 704*	*59 875*	*64 410*
Mules & asses	*148 220*	*122 133*	*102 124*	*103 859*	*113 778*	*113 988*	*124 788*
Swine	*66 548*	*91 951*	*41 040*	*63 416*	*90 368*	*83 190*	*38 689*
Poultry	*535 793*	*509 489*	*366 584*	*453 083*	*443 364*	*292 024*	*432 976*

Emission factors

IPCC 2006 default emission factors for Africa (Table 10.11 for cattle; Table 10.10 for other livestock) were applied (Table 2-29 Enteric fermentation emission factors for the various livestock).

Table 2-29 Enteric fermentation emission factors for the various livestock

Livestock category	*CH_4 emission factor ($kgCH_4$ head-1 yr-1)*
Dairy cattle	*40*
Other cattle	*31*
Sheep	*5*
Goats	*5*
Horses	*18*
Mules & asses	*10*
Swine	*1*

Data sources

Table 2-30 Table of data sources for enteric fermentation provides the activity data required for the enteric fermentation emission estimates and where the data was obtained from.
Table 2-30 Table of data sources for enteric fermentation

Activity data	*Data source*
Population data	*BOS: Lesotho livestock reports for 2010/11 to 2016/17 (BOS, 2013; 2013a; 2014; 2015b; 2016; 2017; 2018)*
Fraction of dairy cows	*BOS: Lesotho livestock reports for 2010/11 to 2016/17 (BOS, 2013; 2013a; 2014; 2015b; 2016; 2017; 2018)*

Uncertainty

Country specific uncertainty data was not supplied, however IPCC 2006 Guidelines indicate that livestock population data usually has an uncertainty of ±20%, while emission factors have a ±30%-50% uncertainty.

Quality Assurance / Quality Control

All the general QA/QC activities (Appendix B) were undertaken, and for enteric fermentation the population data was checked against FAO data. These data sets were found to be consistent.

Planned improvements and recommendations

There are no planned improvements for this category.

2.6.8 *3A2 Manure Management*

Category information

Manure management emissions, for both CH_4 and N_2O are calculated for all livestock, including poultry.

Methodological issues

Population data as discussed under enteric fermentation was applied. In addition, chicken numbers from BOS reports (BOS, 2013; 2013a; 2014; 2015b; 2016; 2017; 2018) were included under manure management. Broilers were separated from all other chickens (layers and other chickens grouped together) due to the different weights and emission factors associated with broiler chickens. IPCC 2006 Guideline default TAM weights (Table 10A4 – 10A8) were used. Enteric fermentation emissions were determined using equation 10.19 and 10.20 in the IPCC 2006 Guidelines.

Manure management data is an important component of the N_2O emission estimates and there is often a lack of data in this area. The manure management data usage applied in this inventory was derived from various sources (Table 2-31 Fraction of manure managed in each manure management system for all livestock types.) and are shown in Table 2-30 Table of data sources for enteric fermentation. The manure management is assumed to remain constant for all the years (2011 to 2017). Manure management emissions were determined with a Tier 1 approach in the IPCC 2006 software, which makes use of equations 10.22 (CH_4) and 10.25 (N_2O) in the IPCC 2006 Guidelines.

Table 2-31 Fraction of manure managed in each manure management system for all livestock types

Livestock	PRP	Daily spread	Solid storage	Dry lot	Burned for fuel	Cattle & swine deep bedding	Pit storage below animal confinement	Liquid slurry	Poultry manure without litter	Poultry manure with litter
Dairy cattle	0.83	0.05	0.01	0	0.06	0.05	0	0	0	0
Other cattle	0.95	0.01	0	0.01	0.03	0	0	0	0	0
Sheep	0.8	0	0.05	0.1	0.05	0	0	0	0	0
Goats	0.8	0	0.05	0.1	0.05	0	0	0	0	0
Horses	0.75	0	0	0.25	0	0	0	0	0	0
Mules and asses	0.75	0	0	0.25	0	0	0	0	0	0
Swine	0	0	0.06	0.87	0	0	0.01	0.06	0	0
Poultry	0	0	0.1	0	0	0	0	0	0.45	0.45

Emission factors

The IPCC 2006 default manure management CH_4 emission factors for developing countries (Table 10.15) were applied. IPCC 2006 default nitrogen extraction rates for Africa (Table 10.19) along with the direct N_2O emission factors for the manure management systems (EF3, Table 10.21) were used for estimating manure management N_2O emissions.

Data sources

The activity data for the manure management emission estimates, along with their data sources, are provided in Table 2-32 Data sources for enteric fermentation and manure management emissions.

Table 2-32 Data sources for enteric fermentation and manure management emissions

Activity data	*Data source*
Livestock typical animal mass (TAM)	*IPCC 2006 Guidelines (Tables 10A-4 to 10A-9)*
Manure management data	*Lesotho National GHG Inventory for 2010 for sheep, goats, horses, mules & asses, poultry (LMS, 2018);* *IPCC 2006 Guidelines (Tables 10A-4 to 10A-9) for cattle and swine.*
N excretion rates	*IPCC 2006 Guidelines (Table 10.19)*

Uncertainty

Uncertainty on livestock population, as mentioned under enteric fermentation, is estimated to be ±20%, while the uncertainty on the manure management usage is not known but it is very high. It is estimated to be around ±50%. The uncertainty on the CH_4 manure management emission factor is ±30% and for nitrogen

excretion rates it is ±50% (IPCC 2006 Guidelines). The N_2O emission factors for manure management systems (EF3) all have an uncertainty of a factor of 2.

Time series consistency

The time series is consistent for all the data for 2011 to 2017, however there are inconsistencies in the manure management data between this inventory and the previous inventory years (2005, 2010) (LMS, 2018). Data was obtained from the previous inventory, but the source of data was not documented. For cattle and swine the manure management data from the previous inventory was replaced by IPCC default values, while the data for other livestock was taken from the previous inventory as there was no other data source for the information.

QA/QC

All the general QA/QC activities (Appendix B) were undertaken, and for manure management emissions the population data was checked against FAOStat (FAO, 2019) data. These data sets were found to be consistent. No other source specific checks were undertaken.

Planned improvements and recommendations

In order to improve the N_2O emission estimates from manure management it is recommended that data be collected on the various manure management systems used for the various livestock.

2.6.9 ***3B: Land***

Emission results and trends

The land sector for Lesotho was found to be a source of 1 090 Gg CO_2 in 2017(Figure 2-25). This category is, however, not complete as it only included estimates from forest land remaining forest land and also only includes changes in biomass. Emissions from most of the sub-categories have not been estimated due to a lack of data. No land use change area was available therefore all forest land was incorporated into forest land remaining forest land category. The forest land remaining forest land is shown to be a source of CO_2 because of the large amount of wood that is being removed as fuel wood. The drivers in this category therefore are the land areas, and the wood removals. For cropland remaining croplands in this inventory the area was indicated to be annual crops and the Tier 1 assumption for annual crops is that the increase in biomass stocks in a single year is equal to biomass losses from harvest and mortality in the same year, therefore there is no net accumulation of biomass carbon stocks.
There is a large discrepancy between this inventory and the previous inventory because of differences in data sources and methodologies. In the previous inventory only changes due to soil carbon were incorporated for both forest lands and croplands. The data from the previous inventory was not available and not well documented making it difficult to replicate.

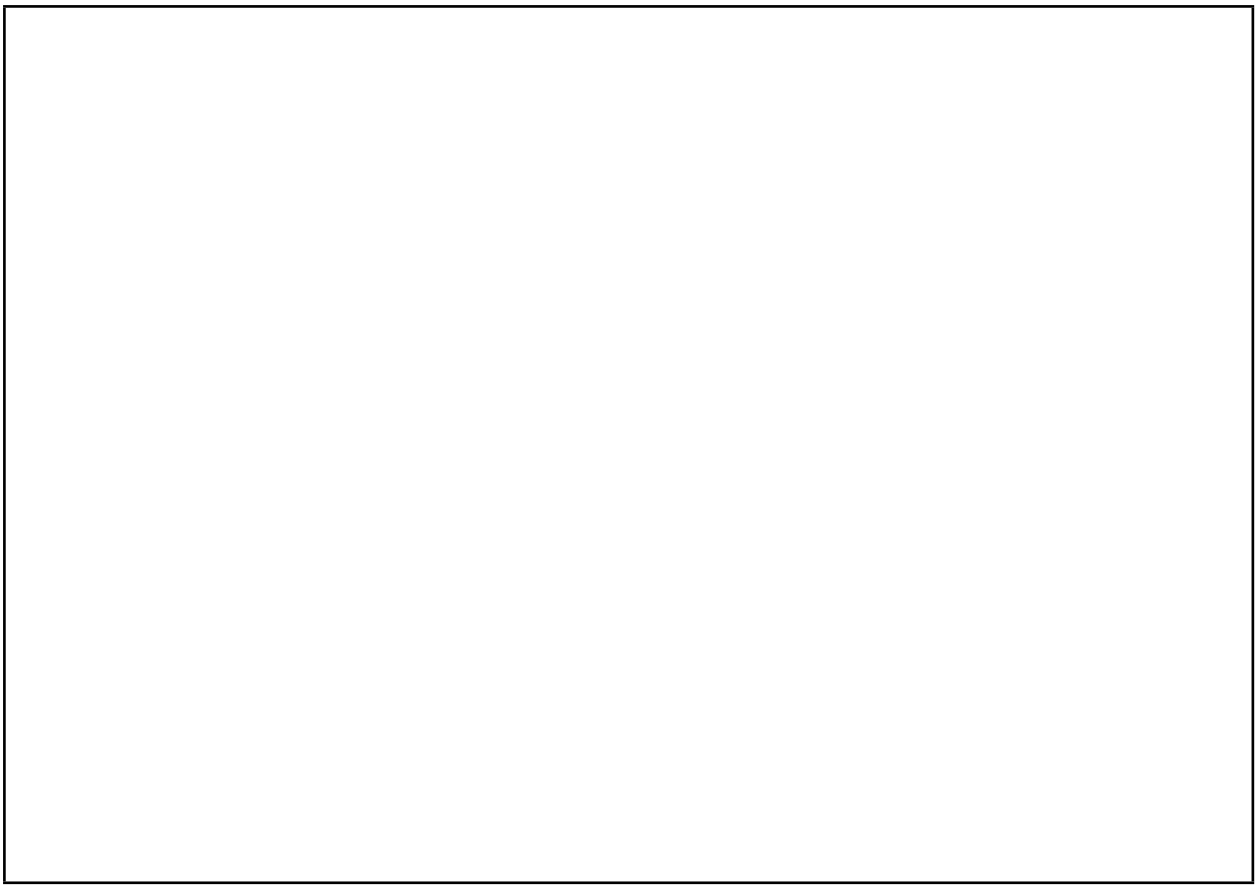


Figure 2-25 Trends in the land emissions (Gg CO_2e) for Lesotho

2.6.10 *3B1 Forest land*

Category information

Forest land category includes forest land remaining forest land and land converted to forest land, however no and change data was available. Therefore all the forest land area was included under forest land remaining forest land. Emission estimates were provided for biomass only as land use change, dead organic matter and soil data were not available. As in the FRA (FAO, 2010; 2014), the forest land area was divided into plantations, naturally regenerating forests and other wooded lands. CO_2 emissions from biomass burning were included here as a disturbance loss and not under biomass burning.
Croplands were investigated but since there is no land and because of the equivalence rule applies to annual croplands there is no accumulation of biomass carbon for croplands.

Methodological issues

Emissions from changes in biomass in forest land remaining forest land were estimated using the gain-loss method (Equation 2.4 of IPCC 2006 Guidelines). Estimates were made through the assistance of the IPCC 2006 inventory software. The forest areas were obtained from FAOStat (2019a) data. This data was also checked against the Forest Resource Assessment (FRA) for Lesotho (FAO, 2010; 2014). The biomass stocks, root to shoot ratios, and above ground biomass data for forests was obtained from the FRA reports (FAO, 2010; 2014). The factors used to characterize each forest are provided in Table 2-23.

Table 2-33 Carbon factors applied to characterize the forest types

	Plantation forest	*Naturally regenerating forest*	*Other wooded land*	*Data source*
Age class (yrs)	*>20*	*>20*	*>20*	
Growing stock level (m3/ha)	*41-80*	*41-80*	*<20*	*FRA (2010; 2015)*
Ratio of below ground to above-ground biomass	*0.24*	*0.24*	*0.24*	*FRA (2010; 2015)*
BCEFr (t/m3 wood volume)	*0.67*	*0.89*	*5.55*	*IPCC 2006 default*
Above ground biomass (t dm/ha)	*90*	*50*	*14.2*	*FRA (2010, 2015)*
Above ground biomass growth (t dm/ha/yr)	*10*	*1.5*	*1.25*	*IPCC 2006 default*
Wood density (t/m3)	*0.42*	*0.42*	*0.58*	*FRA (2015)*

Disturbance losses due to fire were included, with burnt area being determined as discussed in section 2.6.9.2 on biomass burning. No harvest data was available, but the FRA indicated all wood removals were for fuel wood use. Fuel wood removal data for 2000 to 2011 was taken from FRA (FAO, 2010; 2014) and extrapolated (linear extrapolation) to 2017. This data was under bark data, so were adjusted to include bark by multiplying by the default factor 1.15. It was not indicated which forest type the wood was removed from, however the FRA report seems to indicate that fuel wood is removed from plantations and naturally regenerating forests. In order to split the fuel wood removals between these two forest types and area weighting was applied. It was also assumed that all fuel wood was removed as tree parts and not as whole trees.

Data sources
Data sources for the land sector are shown in Data sources below.
Table 2-34 Activity data sources for the land sector

	Activity data	*Data source*
Carbon gains	*Forest land areas*	*FAOStat (2019b)*
	Growth factors	*See table 6.7*
Carbon losses	*Burnt area*	*FAOStat (2019c)*
	Fuel wood removals	*FRA for Lesotho (FAO, 2014)*

Uncertainty

Uncertainty on the area data is not provided, but uncertainty on emission and removal factors are estimated at: basic wood density (40%); annual increment (20%); growing stock (30%) and fuelwood removals (30%).

Time series consistency

The time series between 2011 and 2017 is consistent, however this data is not consistent with the previous inventory. In the previous inventory only soil organic carbon changes were included, whereas in this

inventory only changes in biomass were included. Data from the previous inventory was not available, therefore could not be included in this inventory.

QA/QC

All the regular QA/QC checks were completed (Appendix B), and checks were done between the FRA data, extrapolated fuel wood data and the FAO data and were all found to be consistent.

Planned improvements and recommendations

A new forest resource assessment with updated data is currently being developed, but the data could not be incorporated as it is still in the review phase. It is recommended that this data be included in the next inventory. In terms of the SOC data it would be important to try and obtain the data from the previous inventory and include it in the inventory going forward.
Further in the future, and if resources are made available, it would be recommended to develop another land cover map so that changes in land use can be determined. This would allow for the incorporation of data on land conversions.

2.6.11 *3C: Aggregated non-CO_2 emission sources on land*

Emission results and trends

Total emissions for aggregated and non-CO_2 emission sources on land were estimated at 570 Gg CO_2e in 2017. As with livestock emissions, the aggregated and non-CO_2 emissions also decline slowly between 2011 and 2016 after which they increase (Figure 2-26 Emission trends (Gg CO2e) for aggregated and non-CO2 emission sources from land). This trend closely follows that of enteric fermentation as well as livestock population numbers. This is because most of the inputs to the managed soil are from livestock (i.e. manure from manure management, or urine and dung inputs from livestock kept in pasture, range and paddock). Therefore, livestock population is again the major driver of these emissions. Direct N_2O emissions is the largest contributor to emissions in this category, contributing 71.8% in 2017. The inputs due to fertilizers is very small, as is the contribution from indirect N_2O from managed manure. Direct and indirect N_2O emissions are in a similar range to the values estimated in the previous inventory, although the direct N_2O emissions are slightly lower. The difference is due to the difference in the manure management system usage data that was discussed in .

Biomass burning emissions are estimated at 24 Gg CO_2e in 2017 (Figure 2-26 Emission trends (Gg CO2e) for aggregated and non-CO2 emission sources from land), with grasslands contributing 92.3% to these emissions. Biomass burning emissions decline slightly between 2001 and 2014 after which there is a slight increase. Burnt area data is the driver of emission estimates in this category. Biomass burning emissions are very much lower than was estimated in the previous inventory for 2005 and 2010. It is difficult to determine the exact reason for this change as the data sources for the previous inventory were not provided, but it is assumed that there is a difference in the source of the burnt area data.

Figure 2-26 Emission trends (Gg CO_2e) for aggregated and non-CO_2 emission sources from land

2.6.12 *2.6.12 3C1 Biomass burning*

Category information

Emissions of CO_2, CH_4, N_2O, NOx and CO from biomass burning are included in this category. The CO_2, CH_4 and N_2O emissions are included in the total GHG emissions for the country, while CO and NOx area reported as indirect emissions and are not converted to Gg CO_2e.

CO_2 emissions for forest burning are included under disturbances in the land category (category 3B1) and are not reported in this biomass burning section. CO_2 emissions for grasslands remaining grasslands are also not included as there is a Tier 1 assumption of equivalence, i.e. all gains and losses in annual grasslands are equal therefore not included.

Biomass burning emissions were only reported for forest lands and grasslands as these are the only land types that are seen to burn. In the previous inventory (LMS, 2018) the IPCC 1996 Guidelines were used and emissions from burning of agricultural residue was determined. This is, however not a specific category in the IPCC 2006 Guidelines. There was also insufficient data on the amount of crop residues that were burnt, therefore crop residue burning was not included in this inventory.

Methodological issues

Biomass burning emissions were determined, through the use of the IPCC 2006 inventory software, with equation 2.27 in the IPCC 2006 Guidelines, The activity data for this category is burnt area. Biomass burning emissions are to be determined for each of the 6 IPCC categories. The burnt area for Lesotho is reported as

total bunt area and not per land category (AMESD, 2013; 2015). Only reports for the years 2012 to 2015 were available. Furthermore, the burnt area reports did not cover a full year, only the supposed burning season and the period report for each year varied, i.e April to September for 2012/2013 and June to August for 2014/2015. Due to these inconsistencies in the activity data the FAO data (FAOStat, 2019c) was used instead. The FAO data did not match the country data however the areas were within the range of the AMESD (2013, 2015) reports.

FAO data (FAOStat, 2019c) provided burnt area data for forests for 2012, 2014 and 2015. These numbers were constant; therefore, a constant burnt area was applied to all years for forests. Lesotho forest are divided into forest plantations and naturally regenerating forests. To divide the forest burnt area into these two categories an area weighted average was applied. FAO data also provided burnt areas for other wooded lands and grasslands for the years 2011 to 2016. Burnt area is very variable, so for 2017 a 5-year average burnt area was assumed. This can be corrected in the next inventory when more up-to-date data becomes available. Burnt area data is shown in (Table 2-35 Burnt area (ha) data for Lesotho between 2011 and 2017). The mass of fuel available was determined from values provided in the IPCC 2006 Guidelines (Table 2.4) and is provided in Table 2-35 Burnt area (ha) data for Lesotho between 2011 and 2017 below with an explanation of which values were chosen.

Table 2-35 Burnt area (ha) data for Lesotho between 2011 and 2017

Land type	2011	2012	2013	2014	2015	2016	2017
Forest plantation	5.60	6.10	6.59	7.05	7.49	7.92	8.33
Naturally regenerating forest	15.87	15.37	14.88	14.42	13.98	13.55	13.14
Other wooded land	2 640.30	2 103.66	2 447.11	2 253.92	3 627.73	4 507.83	2 988.05
Grassland	101 469.16	51 904.47	41 751.11	31 640.69	46 495.07	62 937.93	62 937.93

EMISSION FACTORS

The emission factors and the source are provided in Table 2-36 Mass of fuel available (Mb) for burning and emission factors for the various gases.
Table 2-36 Mass of fuel available (Mb) for burning and emission factors for the various gases

Land type	Mb*Cf (ton dm ha-1)	CH_4 (g kg-1 dm burnt)	N_2O (g kg-1 dm burnt)	CO (g kg-1 dm burnt)	NOx (g kg-1 dm burnt)
Forest plantation	53 (Eucalyptus forest – wildfire)	4.7	0.26	107	3
Naturally regenerating forest	19,8 (Other temperature forests – wildfire)	4.7	0.26	107	3

Other wooded land	2.9 (average of early and late season burn data for savanna woodlands)	2.3	0.21	65	3.9
Grassland	3.1 (average of early and late season burn – grassland)	2.3	0.21	65	3.9

Data sources

Burnt area data was obtained from FAOStat (2019c).

Uncertainty

Uncertainty on the activity data is not provided. Emission factors have an uncertainty of ±30%.

Time series consistency

Time series was consistent for the period 2011 to 2017. Data indicates that there are inconsistencies between this and the previous inventory years (2005, 2010) (LMS, 2018) inventory. Previous inventory data sources were not provided making it difficult to assess the consistency.

QA/QC

All the general QA/QC activities (Appendix B) were undertaken, and burnt area data was checked against the AMESD 2013 and 2015 reports. These data sets were found to provide data in a similar range. No other source specific checks were undertaken.

Planned improvements and recommendations

It is recommended that the inconsistencies in the country burnt area data be investigated so that actual burnt area data can be incorporated. It is also suggested that the burnt area be overlaid with vegetation type to determine the amount of burnt area in each land type.

2.6.13 *2.6.12 3C2: Liming*

2.6.12.1 Category information

CO_2 emissions from liming are included in this category.

Methodological issues

There was insufficient data on lime consumption to include this category. Data was only available for the year 2013 and it is unclear how reliable this data is. This category was therefore excluded.

Planned improvements and recommendations

It is recommended that the current lime consumption figure be verified and further data is sought for the other years.

2.6.14 *3C3 Urea application*

Category information

Adding urea to soils leads to a loss of CO_2 that was fixed in the industrial production process. Emissions from urea application were not estimated in the last inventory, therefore it is a new category for the inventory.

Methodological issues

Urea consumption was determined from the subsidy seeds spreadsheet provided by the Ministry of Food and Agriculture (MAFS, 2017), Department of Crops. The data provided the amount of 50kg pockets that are in stock and the number distributed. For this inventory, it was assumed that the amount that was distributed was all applied to agricultural soils in that year.
Data was provided for 2013/2014/2015. The other years there was no urea data entry. It is not clear if this is because no urea was used or if the data was just missing. In this inventory it was assumed the data was missing and an average value (for the three data points) was applied to the other years.

In 2015 there is only the amount distributed to lowlands and not the total distribution. In the previous 2 years lowland distribution was 0.84 and 0.94 % of total distribution. Therefore, an average fraction of 0.89 was used to estimate the total urea distribution.

Emissions were determined with a Tier 1 methodology using IPCC 2006 inventory software (which applies IPCC equation 11.13).

Emission factors

IPCC 2006 default factor of 0.2 ton of C (ton of urea)-1 was applied.

Data sources

Urea consumption data was obtained from the subsidy seeds spreadsheet provided by the Ministry of Food and Agriculture, Department of Crops (MAFS, 2017).

Uncertainty

Uncertainty in the urea consumption data is not known, but it is thought to be high since direct data on the amount of urea applied to agricultural soils is not provided. Using the Tier 1 method it is assumed that all C in the urea is lost as CO_2 from the atmosphere. This is a conservative approach, and the default emission factors are considered certain.

Time series consistency

The data was extrapolated for the years where data was missing in order to obtain a consistent time series. There was no data in the previous inventory for this category so no comparisons were made for this data set.

QA/QC

All the general QA/QC checks were completed, but no category specific checks were undertaken.

Planned improvements and recommendations

It is recommended that urea consumption data for the full times series is sought in order to present a consistent time series. Furthermore, it would be useful to determine an uncertainty for the urea consumption data.

2.6.15 *3C4 Direct N_2O from managed soils*

Category information

This category includes N_2O emissions from nitrogen inputs into agricultural soils. The nitrogen inputs include synthetic nitrogen fertilizers, animal manure application, other organic nitrogen inputs (such as compost and sewage sludge), crop residues and nitrogen from urine and dung. In this inventory all inputs except other organic inputs were included.

Methodological issues

Synthetic fertilizer emissions are calculated from N fertilizer consumption data and an emission factor. The amount of N consumed was obtained from the Seed subsidy spreadsheet provided by Ministry of Agriculture and Food Security (MAFS, 2017). It was assumed that the amount distributed was all applied to agricultural fields in that year. These values were further adjusted for the amount of N in each fertilizer type based on the nutrient ratios in the various pockets. Data was available for the years 2013 – 2017, and a straight-line extrapolation was applied to estimate the amount consumed in 2011 and 2012. The amount of fertilizer N was used as input to the IPCC software.

The amount of animal manure N applied is determined by adjusting the amount of manure N available (see equation 10.34 of IPCC 2006 Guidelines) for the amount of manure used for feed, burnt for fuel or used for construction. This was done within the IPCC 2006 inventory software. The urine and dung N inputs are the amount of N deposited on pasture, range and paddock by grazing animals and the amount of manure daily spread applied. In other words, it is all the manure that is managed in PRP and daily spread.

The amount of crop residue N available for application was determined following equation 11.6 of the IPCC 2006 software. Crop area, production and yield data was obtained from Agricultural Situation Report (2017). IPCC default factors for fraction of total area under crop that is renewed annually, ratio of above-ground residues dry matter to harvest yield, N content of above-ground residues, the fraction of above-ground residues removed annually, ratio of below-ground residues to harvest yield, and N content of below-ground residues (IPCC, 2006; Table 11.2) were applied to each crop type. Crop residue inputs were not included in the previous inventory, so is a new sub-category to the inventory.
N_2O emissions from the mineralization of N associated with loss of soil C in organic soils due to land use change is not estimated due to a lack of data.
All emissions were determined using the Tier 1 approach with the assistance of the IPCC 2006 inventory software.

EMISSION FACTORS

Emissions were determined using the IPCC 2006 default emission factors (IPCC, 2006; Table 11.1).

Data sources

The activity data for direct N_2O emissions from managed soils are shown in Table 2-37 Activity data sources for direct N2O emissions from managed soils.

Table 2-37 Activity data sources for direct N_2O emissions from managed soils

Sub-category	*Activity data*	*Data source*
Synthetic fertilizers	*Total N fertilizer consumption*	*Seed subsidy spreadsheet (MAFS, 2017)*

Organic fertilizers (animal waste)	*Amount of animal waste N available for application to fields*	*Data from animal manure emissions section*
Crop residues	*Crop area, crop production, crop yield*	*Agricultural Situation Report (MAFS, 2016)*

Uncertainty

Uncertainty ranges for the IPCC 2006 default emission factors are provided in the IPCC 2006 Guidelines in table 11.1 and are around -50% to 100%. Uncertainty ranges for the default excretion rates are estimated at about ±50%, as is the uncertainty on the default N retention values.

Time series consistency

Synthetic fertilizer N available was extrapolated for the years 2011 and 2012 in order to present a consistent time-series. There is an inconsistency in the organic fertilizer emissions between this time series (2011 and 2017) and the previous inventory (LMS, 2018). This is because of the difference in the manure management data between the two data sets. The source of the manure management data in the previous inventory was unclear, so where possible IPCC default values were applied instead.

QA/QC

All the general QA/QC checks were completed (Appendix B), as well as some category specific checks. The crop production and yield data was checked against FAO data and the two data sets were found to be the same. There was no fertilizer data in FAO for Lesotho so no further comparisons could be made.

Planned improvements and recommendations

As mentioned in the animal manure emissions section, it is very important to obtain country specific data on livestock manure management, as this data sets affects direct and indirect N_2O emissions as well as manure emissions.

2.6.16 *3C5 Indirect N_2O emissions from managed soils*

Category information

Indirect N_2O emissions can occur through two pathways, namely (a) volatilization of N as NH3 and NOx and the depositing of these gases and their products onto soil, and (b) the leaching and runoff from land of N from N additions and mineralization of N associated with loss of soil C in organic soils though land use change. In this inventory the indirect emissions from the latter process are not estimated because of a lack of data.

Figure 2-27 Photo of agricultural land in Lesotho

Methodological issues

Indirect N_2O emissions were determined using the N available for application to soils (from synthetic and organic fertilizers, urine and dung inputs and crop residue inputs) as calculated in the previous section and multiplying it with emission factors (see equation 11.9 of IPCC 2006 Guidelines). This is a Tier 1 methodology and estimates were produced through the assistance of the IPCC 2006 inventory software.

EMISSION FACTORS

IPCC 2006 default emission factors (Table 11.3 in the guidelines) were applied.

Data sources

All data is taken from other sections of the inventory, therefore activity data is detailed in the relevant sections.

Uncertainty

Uncertainties on indirect N_2O emission factors are provided in the IPCC 2006 Guidelines in Table 11.3. Uncertainties on the activity data are discussed in the other relevant sections (section and section).

Time series consistency

The time series for the period 2011 to 2017 is consistent, however there are inconsistencies in the activity data for indirect N_2O from animal waste and urine and dung inputs between this inventory and the previous inventory years of 2005 and 2010 (LMS, 2018) data. This is because of the change in manure management data.

QA/QC

All the general QA/QC checks were completed (Appendix B), and no category specific checks were undertaken.

Planned improvements and recommendations

There are no planned improvements for this section.

2.6.17 *3C6 Indirect N_2O emissions from manure management*

Category information

Indirect N_2O from manure management result from volatile nitrogen losses that occur primarily in the forms of ammonia and NOx. Nitrogen losses begin at the point of excretion and continue through on-site management in storage and treatment systems. Nitrogen is also lost through runoff and leaching into the soils from solid storage of manure.

Methodological issues

Indirect N_2O emissions from manure were calculated using the IPCC 2006 inventory software and follow a Tier 1 approach. It is determined by multiplying the amount of nitrogen excreted from livestock and managed in each manure management system by a fraction of volatilized nitrogen (IPCC 2006, equation 10.26).

Emission factors

IPCC default emission factors were applied.

Data sources

The activity data for this section is described in the manure management emissions section (section).

Uncertainty

The uncertainty ranges for default N losses due to volatilization of NH3 and NOx and total losses from manure management systems is given in Table 10.22 and 10.23 of the IPCC 2006 Guidelines. The uncertainty associated with default emission factors for nitrogen volatilization and re-deposition, as well as for leaching and runoff, are given in Table 11.3 of the IPCC 2006 Guidelines. Activity data uncertainties are discussed in the relevant sections above.

Time series consistency

The time series between 2011 and 2017 is consistent, however there are inconsistencies between this inventory and the previous inventory. This is due to a change in the manure management system data, as described in .

QA/QC

All the general QA/QC checks were completed, and no category specific checks were undertaken.

Planned improvements and recommendations

There are no planned improvements for this category.

2.7 Waste sector

2.7.1 *An overview of the Waste sector*

Waste sector emissions can arise from the disposal of solid waste, incineration and open burning of waste, biological treatment of waste as well as wastewater treatment and discharge. Lesotho's waste treatment facilities are few and generally in poor condition. The main and largest landfill site is T'sosane landfill site, which is located in the city of Maseru. There is generally poor or no municipal waste management in the rest of the country, and thus residents and industries mostly resort to burning or illegal waste dumping. Some medical facilities are equipped with waste incineration facilities for treatment of their clinical waste.

Although there is no treatment of general municipal waste in Lesotho, there are a number of recovery centres in the country, which collect and recover scrap metal, cans, plastic, white paper and cardboard. However, there are no statistics on the amount of solid waste generated, recycled and disposed of in the country.
Similarly, wastewater management is very limited in Lesotho, with three proper wastewater treatment facilities in Maseru and only evaporation ponds in the other smaller towns around the country. The majority of the residents in the country use VIP toilets and pit latrines.

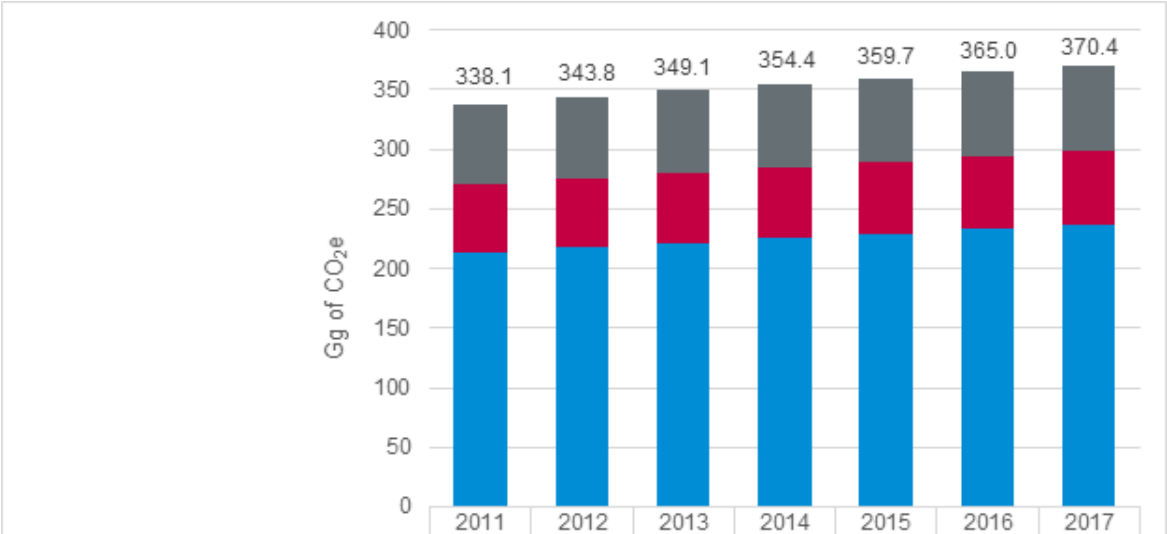
2.7.1.1 *Sources*

4th national GHG inventory for the Waste sector is made up of the following sources:

» 4A	Solid Waste Disposal
» 4C	Incineration and open burning of waste
» 4D	Wastewater treatment and discharge

2.7.2 *Results and Trends in the Waste Sector*

GHG emissions in the waste sector were estimate at 338.1 Gg CO_2e and 370.4 Gg CO_2e in 2011 and 2017 respectively (Figure 2-29). This is a 9.56% increase over a period of six years. The largest contributor to waste sector emissions is the disposal of solid waste at 63.2% and 63.9% in 2011 and 2017 respectively. Incineration and open burning of waste is the smallest contributor of GHG emissions in the waste sector with an average contribution of 16.7% over the entire time period.



	2011	2012	2013	2014	2015	2016	2017
4D Wastewater Treatment and Discharge	67,20	68,42	69,22	70,02	70,82	71,62	72,42
4C Incineration and open burning of waste	57,27	57,95	58,63	59,32	60,00	60,68	61,37
4A Solid Waste Disposal	213,59	217,40	221,22	225,04	228,87	232,71	236,61

Figure 2-28 Graph showing the waste sector emissions from 2011 to 2017, in Gg CO_2e

2.7.3 *4A Solid Waste Disposal*

2.7.3.1 *Description of sources*

The main solid waste disposal site in Maseru is the Tšosane landfill site. The other much smaller dumpsite is at T'soeneng, where industries mostly dump sludge from industrial processes. While there are no statistics on the amount of solid waste generated, recycled and disposed of in Lesotho, two survey studies were comissioned in 2002 and 2006 to investigate urban poverty reduction through municipal solid waste particularly in Maseru and Maputsoe, and to undertake a baseline assessment of waste management with the city of Maseru respectively. The latter study found that 78% of the waste generated in the city does not reach the landfill site, but ends up in dongas, by the road side and/or in open spaces (Thamae, Phomane, Koaleli, & Lombard, 2006).

2.7.3.2 *Data sources and Methodological Issues*

Tier 1 approach was used to estimate GHG emissions from solid waste disposal in Lesotho. A time series of population growth was generated based on three published censuses and household surveys, namely the 2006 Lesotho Population and Housing Census (Bureau of Statistics, 2006) the 2011 Lesotho Demographic Survey (Bureau of Statistics, 2018) and the 2016 Lesotho Population and Housing Census (Bureau of Statistics, 2018). The 2006 Population and Housing Census also contained a summary of the data from the 1976 and 1986 Population Censuses. The population for the years between these censuses and surveys were estimated by linear interpolation. below presents a time-series of the country's population between 1976 and 2017.

Figure 2-29 Lesotho's population between 1976 and 2017

To estimate the average waste generation per capita, the results of the two survey studies by Mvuma and Thamae et al were utilized. This involved extrapolation of waste generation in Maseru for the entire country. According to the surveys, the total waste generated in Maseru was 161 141 tons in 2002 and 244 832 tons in 2006 Table 2-38 Maseru waste generation for 2002 and 20067).

Table 2-38 Maseru waste generation for 2002 and 2006

Waste Source	*2002 Waste generation, in tons per year (Mvuma, 2002)*	*2006 Waste generation, in tons per year (Thamae, Phomane, Koaleli, & Lombard, 2006)*
Residential	*20 676*	*32 900*
Industries	*4 038*	*17 878*
Commercial outlets	*112 838*	*187 701*
Schools	*4 038*	*900*
Hospitals, clinics & administrative institutions	*3 589**	*5 453*
TOTAL	*161 141*	*244 832*

*Value estimated by authors of this 4th GHG inventory

The amount of residential waste generated in the country in 2006 was estimated based on the 2011 ratio of Maseru residents to Lesotho residents, while the waste generated by the other sources was estimated by assuming that Maseru generates a third of the country's waste from those sources.

Once the 2006 national waste generation was determined, the same ratio of waste generated in Maseru in 2006 to waste generated nationally in 2006 was used to determine the amount of waste generated in Lesotho in 2002 from the results of the Mvuma survey study. From these national waste generation figures for 2002 and 2006, waste per capita generation for each of these years was then calculated to be 268.13 and 406.14 kg of waste per capita respectively. An average of these two values (337.13 kg waste per capita) was applied throughout the time series in order to estimate emissions from solid waste disposal (Table 2-39 Determination of average waste per capita).

Table 2-39 Determination of average waste per capita

Year	*Estimated National waste generation (tons)*	*Kg of waste per capita*	*Average Kg of waste / capita*
2002	*501 639*	*268.13*	*337.13*
2006	*762 173*	*406.14*	

Solid waste in Lesotho is primarily disposed of in shallow dumpsites or burnt. To determine the ratio of waste dumped to waste burnt by households, the 2011 Lesotho Demographic Survey was used. The survey shows that 0.94% of households in Lesotho burnt their waste in 2011. For waste generated in other sectors of the economy, it was assumed that 60% of waste is burnt. Overall, it was determined that about 49.8% of the waste generated in the country ends up in solid waste disposal sites, while the rest is burnt.

The Maseru City Council (MCC) provided the quantities of sludge dumped at T'soeneng between 2016 and 2018, while the 2006 quantities were obtained from the Assessment report for the development of an integrated waste management system for Maseru City (Thamae et al, 2006). The sludge quantities for the entire period was then determined by linear interpolation of the 2006, 2016, 2017 and 2018 data as shown in Table 2-40 Quantity of Sludge dumped at T'soeneng (tons) below.

Table 2-40 Quantity of Sludge dumped at T'soeneng (tons)

Year	*2006*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
Sludge	*2 073.0*	*2 215.5*	*2 244.0*	*2 272.5*	*2 301.0*	*2 329.5*	*8 116.3*	*6 132.0*

Default waste fractions and methane generation factors for shallow solid waste disposal sites were assumed for emission calculations.

2.7.3.3 *Solid Waste Emissions and trends*

Table 2-41 Methane emissions from Solid Waste Disposal in Lesotho from 2011 to 2017, in Gg CO2e below shows the methane emissions from the easily biodegradable waste as well as from carbon stored in the paper and wood wastes. In total, methane emissions from solid waste disposal amounted to 213.59 GgCO_2e in 2011 and then grew by 10.8% to 236.61 Gg CO_2e in 2017.

Table 2-41 Methane emissions from Solid Waste Disposal in Lesotho from 2011 to 2017, in Gg CO_2e

4 Waste	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
4A Solid Waste Disposal	*213.59*	*217.40*	*221.22*	*225.04*	*228.87*	*232.71*	*236.61*
Easily biodegradable CH_4	*120.23*	*122.30*	*124.38*	*126.46*	*128.55*	*130.64*	*132.79*
Stored carbon CH_4 – paper	*65.62*	*66.71*	*67.81*	*68.90*	*70.00*	*71.09*	*72.19*
Stored carbon CH_4 - wood	*27.74*	*28.38*	*29.03*	*29.68*	*30.33*	*30.98*	*31.63*

2.7.3.4 *Uncertainty assessment*

The biggest uncertainty for this category lies in the activity data because there are no national statistics of solid waste in the country. According the 2006 IPCC guidelines, the uncertainty associated with the type of data used in this inventory is at least 60%.

Uncertainties associated with various elements of the default emission factors and methodology are as follows:

- Methane correction factor calculated for this inventory was 4.2, which carries and uncertainty of 30%
- Default fraction of CH_4 generated in landfills carries 5% uncertainty
- Uncertainty associated with the estimated half-life is in the range of 14% - 21%.
- Overall, the emission estimates in this category carry uncertainties in the range of 60%.

2.7.3.5 *Quality assurance/ Quality control*

Quality control was performed by the Waste team as per QC sheet in Appendix B, while data was being collected, when calculations were being performed and while the data was recoded in excel spreadsheets and the final numbers were added into the IPCC software. Specific solid waste QC activities included checking that population data was properly interpolated and recorded, checking the calculations for estimating the average waste generation per capita, checking the interpolation calculations for sludge and checking the calculations for percentage of waste that ends up in solid waste disposal sites.

2.7.3.6 *Planned improvements and recommendations*

To improve the solid waste disposal emissions inventory the following improvements are recommended:
Improved estimates of national waste generation: It is recommended that a survey be undertaken at national level to determine the amount and composition of waste generated nationally. This can be complimented by frequent surveys for the city of Maseru.

Improved estimates of waste going to T'sosane landfill site: It is recommended that weigh bridges be utilized at the landfill site to record the quantities of waste that are disposed of at that landfill site. This can be complimented by visual determination of waste composition in each truck load.

2.7.4 *4C Incineration and Open Burning of Waste*

2.7.4.1 *Description of sources*

About 44% of the health care facilities in Lesotho use incinerators to treat their medical and clinical waste, while the rest use open pit burning (Thamae, Phomane, Koaleli, & Lombard, 2006)). Section 2.7.3.2 shows that about 50.2% of all municipal waste is openly burnt in Lesotho.

2.7.4.2 *Data Sources and Methodological issues*

Incineration of medical waste – The quantity of medical waste incinerated in 2012 was obtained from a 2012 Lesotho Healthcare Waste Study Report 2012 from a study undertaken by COWI Consultants (COWI Consulting, 2012). This report estimates the annual clinical waste incinerated in the country at 156,500 Kg/ year. This value was applied throughout the entire time series. Default dry matter content, fossil carbon content and total carbon content factors were used for emission calculations.
Open Burning of waste – It was calculated based on the estimation that 50.2% of the total waste generated in the country is burnt (See section 2.7.3.2). Default emission factors were used for emission calculations.

2.7.4.3 *Results and Trends*

Table 2-42 Emissions in Gg CO2e from incineration and open burning of waste in Lesotho from 2011 to 2017, disaggregated by gas and Figure 2-30 below present the CO_2e emission from incineration of clinical waste

and open burning of waste for the time series of 2011 – 2017 in Lesotho. The emissions in the category vary from 57.27 Gg CO_2e in 2011 to 61.37 Gg in 2017. Emissions from open burning of waste account for 99.9% of the emissions yearly.

Table 2-42 Emissions in Gg CO_2e from incineration and open burning of waste in Lesotho from 2011 to 2017, disaggregated by gas

4 Waste	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
4C Incineration and Open Burning of Waste	*57.27*	*57.95*	*58.63*	*59.32*	*60.00*	*60.68*	*61.37*
4C1 Waste Incineration	*0.041*	*0.041*	*0.041*	*0.041*	*0.041*	*0.041*	*0.041*
CO_2	*0.037*	*0.037*	*0.037*	*0.037*	*0.037*	*0.037*	*0.037*
CH_4	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
N_2O	*0.003*	*0.003*	*0.003*	*0.003*	*0.003*	*0.003*	*0.003*
4C2 Open Burning of Waste	*57.23*	*57.91*	*58.59*	*59.28*	*59.96*	*60.64*	*61.32*
CO_2	*4.974*	*5.033*	*5.093*	*5.152*	*5.212*	*5.271*	*5.330*
CH_4	*43.759*	*44.281*	*44.803*	*45.325*	*45.847*	*46.369*	*46.890*
N_2O	*8.497*	*8.599*	*8.699*	*8.801*	*8.903*	*9.002*	*9.105*

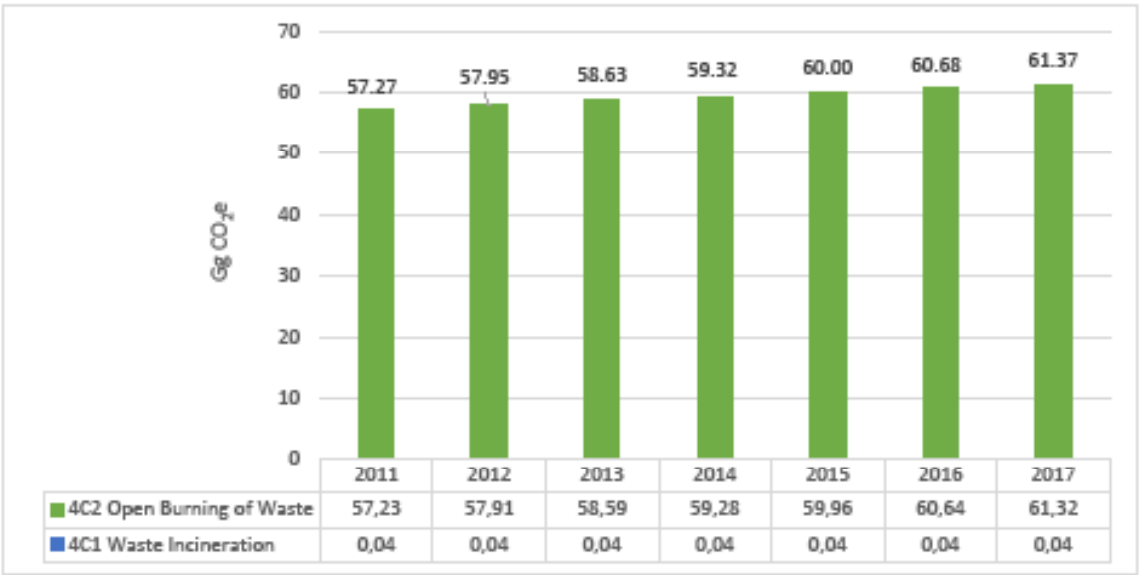


Figure 2-30 Incineration and open burning of waste emissions from 2011 to 2017

2.7.4.4 *Uncertainty assessment*

The activity data used for estimating emissions from open burning of waste, which make up 99.9% of the emissions in this category, is the same as that used for estimating emissions from solid waste disposal, hence the uncertainty is also the same at 60%.

2.7.4.5 *Quality assurance/ Quality control*

Quality control was performed by the Waste team as per QC sheet in Appendix B while data was being collected, when calculations were being performed and while the data was recoded in excel spreadsheets and the final numbers were added into the IPCC software. ERM then checked the quality of the inventory for incineration and open burning of waste and all the calculators and final numbers, and made updates

and adjustments as necessary.

2.7.4.6 *Planned improvements and recommendations*

In addition to the recommendations for improving the emissions from solid waste disposal, it is recommended that surveys of the quantity of clinical waste incinerated in medical healthcare facilities be undertaken more frequently.

2.7.5 *4D Waste Water Treatment and Discharge*

2.7.5.1 *Description of sources*

Other than the small evaporation ponds located in all the towns across the country, there are three fully-equipped wastewater treatment facilities in Lesotho, all located in Maseru. The Ratjomose wastewater treatment works (WWTW) is the largest wastewater treatment facility Lesotho, serving approximately 41 200 residents (WASCO, 2019). The Plant makes use of both the conventional and waste stabilization pond methods to treat or purify sewage. It is located on the South West of Maseru on the banks of the Mohokare (Caledon). The Agric and Masooe wastewater treatment facilities combined serve a population of 35 722 per year.

Photo taken by Ewa Matuszewska, ERM, 2019

Figure 2-31 View of the Ratjomose wastewater treatment plant from Mpilo hill

2.7.5.2 *Data Sources and Methodological issues*

The default 2006 IPCC method based on population was used to calculate emissions for this category. The categorization of wastewater treatment was based on the 2011 Household survey results as shown in Table 2-43 Household Wastewater treatment in Lesotho (Bureau of Statistics, 2014) below. Over 80% of the urban population uses VIP and pit latrine toilets, while 9.3% have not toilet facilities. In the rural areas the two are matched at about 50% each.

Table 2-43 Household Wastewater treatment in Lesotho (Bureau of Statistics, 2014)

	Rural %	*Urban %*
Population	*76.3%*	*23.7%*
Toilet facility		
No toilet	*49.7%*	*9.3%*
Water sewage system	*0.7%*	*6.1%*
Septic tank and conservancy tank	*0.5%*	*1.6%*
VIP, pit latrine and public toilet	*49.1%*	*83.0%*

A 3-year average protein supply value of 32 g/capita/day from FAO (FAO, 2019) was used to estimate the

N_2O emissions from wastewater treatment and discharge.

2.7.5.3 *Results and Trends*

Table 2-44 CO2e emissions in Gg for waste water treatment and discharge in Lesotho from 2011 t0 2017, disaggregated by gas and Figure 232 present the CO_2e emissions from wastewater treatment and discharge for the time series of 2011 to 2017 in Lesotho. The emissions were 67.20 Gg CO_2e in 2011, growing to 72.42Gg CO_2e by 2017.

Table 2-44 CO_2e emissions in Gg for waste water treatment and discharge in Lesotho from 2011 t0 2017, disaggregated by gas

4 Waste 4D Waste Water Treatment and Discharge	2011	2012	2013	2014	2015	2016	2017
4D1 Domestic Waste Water Treatment and Discharge	67.20	68.42	69.22	70.02	70.82	71.62	72.42
CH_4	34.71	35.55	35.97	36.38	36.79	37.20	37.61
N_2O	32.48	32.87	33.26	33.64	34.03	34.42	34.81

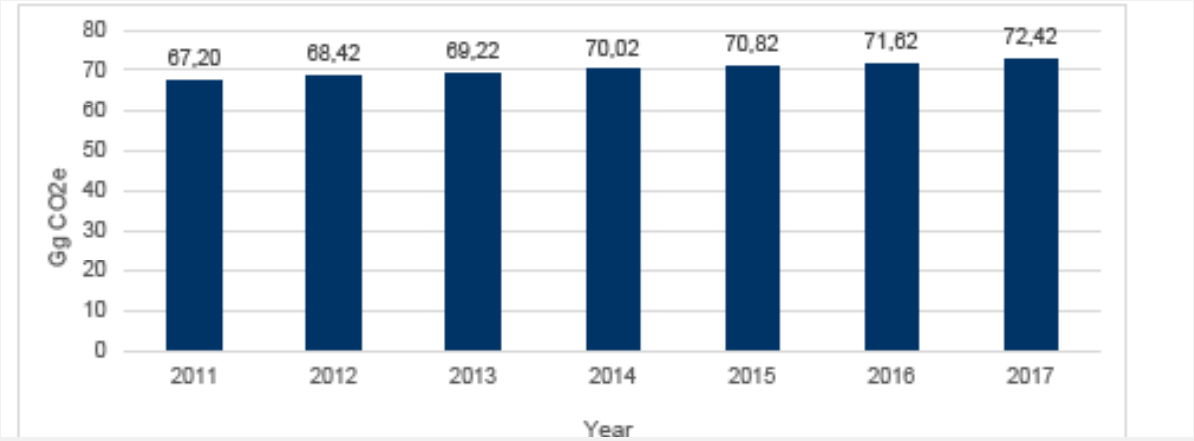


Figure 2-32 Waste water treatment and discharge emissions from 2011 to 2017

2.7.5.4 *Uncertainty assessment*

Uncertainty associated with the default emission factor for methane emissions is about 58.3%, while the activity data used carries a combined uncertainty of 64%. Thus the combined uncertainty is about 86.6%. The activity data used for estimating N_2O emissions in this category has uncertainty in the range of 6 – 20%. The default emission factors for N_2O from effluent carry large uncertainties, ranging from 10% to 5000%. Thus the combined uncertainty associated with N_2O emission is about 5000%.

2.7.5.5 *Quality assurance/ Quality control*

Quality control was performed by the Waste team, as per QC sheet in Appendix B, while data was being collected, when calculations were being performed and while the data was recoded in excel spreadsheets and the final numbers were added into the IPCC software. Hence, all the relevant points on the QC sheet were followed for emission calculations for waste water treatment and discharge.

2.7.5.6 *Planned improvements and recommendations*

In order to improve the quality of the wastewater emissions inventory, it is recommended that:

» Accurate monitoring of wastewater flows going to all WWTW and evaporation ponds around the country be done.

2.7.6 *Methodology and Completeness*

Table 2-46 provides a summary of methods and types of emission factors used during the compilation of this inventory. All estimates were made using the IPCC 2006 inventory software.

Table 2-45: Summary of methods and emission factors for the Waste sector and an assessment of the completeness of the Waste sector emissions

	GHG Source and sink category	CO_2		CH_4		N_2O	
		Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
A	Waste						
	Solid Waste Disposal						
1	a. Unmanaged Solid waste disposal	NA	NA	T1	DF	NA	NA
	Incineration and open burning of waste						
	a. Open burning of waste	T1	DF	T1	DF	T1	DF
	b. Waste incineration	T1	DF	T1	DF	T1	DF
	Wastewater treatment and Discharge						
	a. Domestic wastewater treatment and discharge	NA	NA	T1	DF	T1	DF

T1 = Tier 1, DF = Default Factor, NA = Not applicable. Categories and sub-categories not listed above were neither not occurring nor not estimated due to data unavailability.

2.8 GHG improvement plan

The Table below outlines the proposed GHG improvement plan to be implemented by the national inventory agency (LMS), in partnership with relevant institutions and other government departments.

Table 2-46 Proposed GHG Inventory Improvement Plan for Lesotho

GENERAL	Design and implement a National Measurement, Reporting and Verification (MRV) System	All stakeholders that are part of the National Climate Change Committee	Implemented National MRV System	2019 - 2023
ENERGY	Compile a disaggregated, consistent and accurate annual energy balance, based on actual energy consumption data	Department of Energy Bureau of Statistics	Disaggregated annual energy balances	Annually from 2019
	Strengthen the recording and monitoring procedures for imported fuels at the ports of entry	Lesotho Revenue Authority	Complete and accurate annual statistics of imported fuels	Annually from 2019
	Develop or strengthen the Quality Control (QC) and Quality Assurance (QA) procedures for energy data management between Department of Energy, Bureau of Statistics, Lesotho Revenue Authority and LMS.	Department of Energy Bureau of Statistics Lesotho Revenue Authority	New or updated QC and QA procedures developed and documented	By December 2019

IPPU	Conduct a national survey to determine the full scale of brick and ceramic production in the country	Bureau of Statistics Department of Trade and Industry	Database of brick and ceramic manufactures and their production quantities	By December 2019 and at least every 5 years thereafter
	Sign Memoranda of Understanding (MOUs) with major brick and ceramic manufacturers (making up 90% of national production as informed by the survey), to share annual production data. Then use the MoUs to collect all previous years' data up to 2017 for recalculations.		Signed MOUs with major brick and ceramic manufacturers Activity data for historical years up to 2017	Before compilation of next GHG inventory
	Put together a complete and accurate database of all refrigerators, air-conditioning units and HFC gases in the country, dis-aggregated by sub-application, name of HFC gas, quantity of gas, year of introduction and year of import. Existing units and gases can be collected through surveys (including existing household surveys by BOS), while new ones can be tracked through the border gates.	Bureau of Statistics Department of Trade and Industry Lesotho Revenue Authority	Complete and accurate database of refrigerators, air-conditioning units and HFC gases in the country	By December 2019
	Identify all key data-providers in the food and beverages industry and sign Memoranda of Understanding with them before the next GHG inventory is compiled. Then use the MoUs to collect all previous years' data up to 2017 for recalculations.		Signed MOUs with data providers Food and beverages activity data for historical years up to 2017	Before compilation of next GHG inventory

AFOLU	Include data-collection of manure management systems information for various livestock types in the data-collection process for compiling annual Lesotho Livestock Statistical Reports and Agricultural	Bureau of Statistics Agricultural Research Department of Livestock	Annual accurate data on manure management systems	From 2020
	Include data from the newly undertaken forest resource assessment in the next GHG inventory	Department of Forestry	Up to date forestry activity data	In the next GHG inventory
	Develop new land cover maps every five years so that changes in land use and land conversions can be determined.	Food and Agricultural Organization Lands Administration Authority	Up to date land cover maps	2019 and every five years thereafter
	Develop or strengthen the QC and QA procedures for fertilizer, urea and lime consumption data	Department of Crops	New or updated QC and QA procedures developed and documented	By December 2019
	Include data-collection of urea consumption information in the data-collection process for compiling annual Agricultural Production Survey Statistical Reports.	Bureau of Statistics Agricultural Research Department of Crops	Annual accurate data on urea consumption	From 2020

WASTE	Undertake a national survey to determine the amount and composition of solid waste generated nationally. This can be complimented by frequent surveys for the city of Maseru.	Department of Environment Maseru City Council	Complete national dataset of solid waste generation and management	Before the next GHG inventory
	Installed and utilize weigh bridges at the T'sosane landfill site to record the quantities of waste that are disposed of at that landfill site. This can be complimented by visual determination of waste composition in each truck load	Department of Environment Maseru City Council	Accurate annual data on quantities and categories of waste disposed of at T'sosane landfill site	Weigh bridges to be installed by December 2019
	Conduct frequent surveys of the quantity of clinical waste incinerated in medical healthcare facilities. Ideally surveys to be done at least every five years.	Ministry of Health Maseru City Council Department of Environment	Up-to-date activity data on clinical waste incineration	From 2020
	Accurately monitor wastewater flows going to all WWTWs and evaporation ponds around the country be done	Water and Sewage Company Department of Environment	Up-to-date activity data on wastewater flows	From January 2020

3. MITIGATION ACTIONS AND THEIR EFFECTS

MITIGATION EFFECTS AND THEIR EFFECTS

The Kingdom of Lesotho's approach to climate change mitigation is enshrined in the National Climate Change Policy (NCCP) 2017-2027 which envisions "to build climate change resilience and low-carbon societies including a prosperous economic environment in the country". The Policy underscores the implementation of concrete climate change adaptation and mitigation measures, advancing low-carbon development pathways and building more sustainable development outcomes that consider on-going and future climate-related impacts.

In addition, the Policy emphasizes the need to ensure active participation of all stakeholders in the social, environmental, and economic sectors. This endorses climate-smart agriculture, renewable energy sources and energy efficiency, best practice for forestry and rangelands as well as low-carbon transport systems; which are identified as sectors with mitigation potential4.

In pursuit of the above aspirations, Lesotho is guided by relevant international, regional and national guidelines and principles. One of the main guiding principles is to develop and implement cost-effective integrated mitigation solutions, which have environmental and socio-economic benefits. Furthermore, Nationally Determined Contribution (NDC) has identified 10% unconditional and 25% conditional target reduction in Greenhouse gas (GHG) emissions compared to business as usual (BAU) by 2030; Lesotho has set an ambitious, fair and responsible contribution to global efforts towards meeting the objective of the United Nations Framework Convention on Climate Change (UNFCCC) and the goal of limiting global average temperature rise to below 2.0°C5 aligning with the set emission targets under the Paris Agreement.

[1] LMS 2017. Lesotho's National Climate Change Policy. Ministry of Energy and Meteorology, Lesotho.
[2] LMS 2017. Lesotho Nationally Determined Contributions Under the United Nations Framework Convention on Climate Change. Ministry of Energy and Meteorology, Lesotho

3.1 Mitigation policies and strategies

3.1.1 *International Agreements*

Lesotho cooperates with other Member States, at both the regional and international spheres to address climate change. As thus, the country adheres to regionally and internationally endorsed climate change protocols as outlined below.

3.1.1.1 *United Nations Framework Convention on Climate Change*

Lesotho signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and acceded to it in 1995. The country participates in global efforts to curb GHGs emissions as set out in the Convention. To the effect, pursuant to Article 4, paragraph 1, and Article 12, paragraph 1 of the Convention, Lesotho prepared and submitted the First and the Second National Communication (SNC) to the Conference of Parties (COP), communicating, information on policies and measures undertaken to implement the Convention. Of particular relevance to the report are efforts to climate change mitigation strategies in the residential, commercial and institutional; transport and industrial sectors.6

3.1.1.2 *Kyoto Protocol.*

Lesotho ratified the Kyoto Protocol (KP) on 06 September 2000. As signatory to the Kyoto Protocol, the country has the responsibility to, formulate, where relevant and to the extent possible, cost-effective national and, where appropriate, regional programmes to improve the quality of local emission factors, activity data and/or models which reflect the country's socio-economic conditions for the preparation and periodic updating of national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol. In observing the stipulations of the KP Lesotho is guided by the principle of common but differentiated responsibilities and specific national and regional development priorities, objectives and circumstances.

3.1.1.3 *The Paris Agreement*

Lesotho ratified the Paris Agreement on 17th January 2017, and in line with Article 4 of the Paris Agreement and Decision1/CP.21 Lesotho communicated the country's Nationally Determined Contributions (NDC) in December 2017. This agreement aims at enhancing the implementation of the Convention including its objective of strengthening global response to the threat of climate change in the context of sustainable development including efforts to eradicate poverty. Specifically, the Agreement aims to "hold increase in the global temperature to well below 2°C while pursuing efforts to limit the temp to 1.5°C below the preindustrial levels"7. The aim is to increase the ability of countries to adapt to the adverse impacts of climate change and foster climate resilience and low GHG emissions development in the manner that does not threaten food production. The NDC outlines the country's strategy to address climate change mitigation and adaptation in the context of sustainable development and efforts to eradicate poverty8.

3.1.1.4 *The United Nations Convention to Combat Desertification*

The Government of the Kingdom of Lesotho has committed to the Land Degradation Neutrality – Target Settling Programme (LDN–TSP), a programme established by the Global Mechanism in collaboration with the United Nations Convention to Combat Desertification (UNCCD). The Agriculture, Forestry and Other Land

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[1] LMS 2a0132013. Lesotho's Second National Communication under the United Nations Framework Convention on Climate Change. Lesotho Meteorological Services, Lesotho.
[2] Paris Agreement-1/CP.21
[3] LMS 2017. Lesotho Nationally Determined Contributions Under the United Nations Framework Convention on Climate Change. Ministry of Energy and Meteorology, Lesotho.

Use (AFOLU) sectors are responsible for 43% of the total greenhouse gas emissions of the country (second largest emitting sector)9. This commitment marks a crucial step through which land is positioned as a key point of intervention for climate change mitigation due to the role of terrestrial ecosystems as a source and sink of emissions, and adaptation as reflected in Lesotho's Nationally Determined Contributions (NDC). The 2017 Land Degradation Neutrality – Target Settling Programme (LDN –TSP) outlines specific targets to reverse land degradation in Lesotho and improve land by 5% in 2030 compared to 2015 baseline. The specific targets are[1]:

i.	To avoid, minimize and reverse land degradation productivity and Soil Organic Carbon stocks to 1% in all land classes by 2030 as compared to 2015,
ii.	Rehabilitate 600,000 hectares of degraded land to functionality by 2030 and convert 135,600 ha of brush land back to rangeland by 2030 as compared to 2015,
iii. Halt the conversion of forests and wetlands to other land cover classes by 2022,	
iv.	Increase forest cover by 61,325 ha by 2030 as compared to 2015, and
v.	Reduce the rate of soil erosion and sealing (conversion to artificial land cover) by 20% by 2030 as compared to 2015.

3.1.2 *Regional Protocols and Cooperation Frameworks*

Regionally, Lesotho subscribes to the aspiration of the African Union Strategy on Climate Change which stipulates the Continent's common position in relation to Nationally Appropriate Mitigation Actions (NAMAs) under the UNFCCC, Reducing Emissions from Deforestation and Forest Degradation (REDD), as well as Mitigation and Climate-Proofing Development. The country also endorsed the Southern African Development Community (SADC) Draft Regional Strategy and Plan of Action which institute mitigation actions that also build economic and social resilience for present and future generations. Of equal importance is the Programme on Climate Change Adaptation and Mitigation in the Eastern and Southern Africa (COMESA-EAC-SADC) region the purpose of which was to enable Member States to increase investments in climate resilience and carbon efficient agriculture and its linkages to forestry, land use and energy practices by 2016.

3.1.3 *National Commitments*

At the national level, Lesotho has established legislative, regulatory and institutional frameworks, including policies, strategies, plans and programmes to advance low-carbon development in the context of sustainable development and poverty eradication.

3.1.3.1 *Nationally Determined Contributions*

The Nationally Determined Contributions (NDC) presents Lesotho's two- fold strategy for climate change action. The country's primary focus is on activities which enhance the country's adaptive capacity and build the resilience to the impacts of climate change. Secondly, in order to reduce the GHG emissions, Lesotho focuses on transitioning to low-carbon development pathways. In this regard, the country mitigation targets consider emissions reductions in 5 sectors, namely: Energy, Industrial Processes and Product Use, Agriculture, Agriculture Forestry and Other Land Uses (AFOLU) and Waste. Lesotho's plan to mitigate GHG emissions is built on some of the following pillars:

» Adoption of climate-smart agricultural practices for greater food security and higher famers' income

[4] Global Mechanism of the UNCCD, 2018. Country Profile of Lesotho. Investing in Land Degradation Neutrality: Making the Case. An Overview of Indicators and Assessments. Bonn, Germany.

- Increased carbon sequestration in forestry, i.e., afforestation, reforestation and protecting forests for their economic and ecosystem services.
- Energy efficiency measures, deployment of renewable energy sources in power generation (hydro, solar and wind), promotion and dissemination of clean energy technologies (efficient cook-stoves and LPGs) to reduce overreliance on fuel wood.
- Adoption of modern, efficient and advanced technologies in industry, transport and buildings.
- Sustainable waste management systems: solid waste management, wastewater recycling, composting of biodegradable waste and possible methane recovery from landfills [10]

3.1.3.2 *National Climate Change Policy 2017-2027*

The vision of National Climate Change Policy 2017-2027 (NCCP) is to build climate change resilient and low-carbon society, a prosperous economy and environment in Lesotho. The mission of the Policy is to increase climate change resilience and improve the well-being of Basotho through mainstreaming and implementing concrete measures for adaptation and climate risk reduction, mitigation and low-carbon development in the context of sustainable development. The Policy advocates for active participation of all stakeholders in respective social, environmental and economic sectors. The vision and the mission of the NCCP 2017-2027 are premised on government's commitment to poverty reduction and sustainable development as echoed in the National Vision 2020. The Policy, therefore, articulates the national strategic response to climate change within the context of Lesotho's broader national development plans as outlined in the National Strategic Development Plans (NSDP I and II).

The Policy calls for prioritization and implementation of adaptation and climate risk reduction measures as well as mitigation and low-carbon development pathways. The Policy further identifies water, agriculture, energy, mining, industrial manufacturing, tourism, forestry, rangelands, biophysical environment, health, transport, human settlements and infrastructure as key socio – economic sectors within which climate change mitigation and adaptation should be mainstreamed11. Objectives.

3.1.3.3 *National Climate Change Policy Implementation Strategy*

The National Climate Change Implementation Strategy (NCCPIS) of 2017 outlines action guidelines to build a climate resilient society and promote green development pathways by mainstreaming and integrating climate change into key national socio – economic and environmental sectors. To this effect, the NCCPIS identifies exploring low-carbon development opportunities, nationally and internationally, in order to promote the sustainable use of resources as one of its strategic objective. Furthermore, the Strategy recognizes Lesotho's potential to mitigate climate change through low- carbon development pathways in the context of sustainable development and eradication of poverty12.

3.1.3.4 *The National Strategic Development Plan*

The National Strategic Development Plan (NSDP) II 2018/19-2022/23 identifies climate change as one of the key challenges hindering Lesotho's development, which, as such, should be responded to in a strategic manner using appropriate approaches. The strategy recognizes the needs for Lesotho to promote green economy during its development trajectory and embraces clean energy and green technologies as one of

[1] MFRSC 2017. Measures to Achieve national LDN targets. Ministry of Forestry, Range and Soil Conservation.
[2] LMS 2017. Lesotho Nationally Determined Contributions Under the United Nations Framework Convention on Climate Change. Ministry of Energy and Meteorology, Lesotho.
[3] LMS 2017. Lesotho National Climate Change Policy. Ministry of Energy and Meteorology, Lesotho.
[4] LMS 2017. Lesotho's National Climate Change Implementation Strategy. Ministry of EnergyEnerg y and Meteorology, Lesotho.
[1] LMS 2017. Lesotho's National Climate Change Implementation Strategy. Ministry of EnergyEnerg y and Meteorology, Lesotho.

the mechanisms thereto.

The Government will, as thus, promote private and public investment to harness the country's renewable energy potential, appropriate technologies to reduce biomass and fuel consumption to maintain low carbon emissions, reduce pollution while preventing loss of biodiversity and ecosystems. Furthermore, Lesotho plans to explore the potential to export renewable power to the SADC region.

Investments in green energy technologies will reverse the trends in deforestation and soil erosion and enhance the use of more efficient technologies for space heating and cooking. Adoption of green technologies will likely rebuild Lesotho's natural capital as a critical economic asset and source of livelihoods especially for the poor people whose livelihoods and food security depend on nature.

3.1.3.5 *The Energy Policy 2015-2025*

The objective of the Policy is to, among others, improve the country's energy security situation by reducing reliance on fossil fuels and imported electricity and reduce GHG emissions from the energy sector. The Policy proposes energy sector development path that is consistent with the three pillars of the United Nations initiative on Sustainable Energy for All (SE4ALL), namely: access to modern energy, energy efficiency and renewable sources of energy. In this respect, the Policy envisions to ensure that energy is universally accessible and affordable in a sustainable manner, with minimal negative impact on the environment13.

3.1.3.6 *Sustainable Energy Strategy*

Consistent with the three major objectives of SE4All that advocates for universal access to modern energy, increased energy efficiency and doubling the renewable energy sources in the total energy mix, the main objective of the strategy is to promote renewable energy sources and energy efficiency with the view to increase the share of cleaner fuels in the energy supply mix while reducing the share of non-sustainable forms of energy. The strategy identifies security of energy supply, energy efficiency and demand side management efforts, response to environment, women and climate change as the key pillars with substantial potential of reducing GHG emissions14.

3.1.3.7 *Other Sectoral Policies, Strategies and Plans*

Various socio-economic subdivisions have formulated policies, strategies, and are consequently implementing climate change mitigation actions. Such include the National Forestry Policy 2008; Agriculture Sector Strategy 2003, National Conservation Agriculture Strategy Framework 2012 – 2017, Climate Smart Investment Plan, Lesotho Food Security Policy 2005, as well as the National Action Plan for Food Security 2007 – 2017. In addition, the Transport Policy 2006, National Range Resources Management Policy 2013 and National Range Action Plan 2015 as well as the National Environment Policy 1998 and the Environment Act 2008 are taking robust sector specific mitigation actions in line with macro-economic policies and national priorities.

3.2 Implementation of mitigation actions in Lesotho

3.2.1 *Summary of how mitigation has been implemented*

Lesotho has accessed funds from the Global Environment Facility (GEF), and the Least Developed Countries

[2] Government of Lesotho, 2015. The Energy Policy 2015-2025. Ministry of Energy and Meteorology. Lesotho.
[3]Government of Lesotho, 2017. National Sustainable Energy Strategy. Ministry of Energy and Meteorology. Lesotho

Fund (LDCF) to implement mitigation actions in the water, Energy and biodiversity sectors15. Other mitigation measures have been implemented through technical and financial support from bilateral and multilateral financing mechanisms. Initiatives including sustainable land management, reforestation and afforestation as well as Integrated Watershed Management (IWM) have been implemented through the national budget support. In addition, mitigation actions have been implemented through a broad diversity of institutions including, government agencies, civil society organizations, private sector companies, research institutions to implement projects and programmes (Lesotho Meteorological Services, 2017)16.

3.2.2 *Barriers in Implementing Mitigation Actions*

There are several barriers to effective implementation of mitigation measures in Lesotho. Among others are; limited human resources capacity in terms of number, skill range and depth; low level of awareness; low level of involvement and participation of the private sector and civil society; unavailability of data; Nationally Appropriate Mitigation Actions registry and Measuring Reporting Verification (MRV) System. Other overarching critical issues comprise economic barriers including high investment cost associated with mitigation actions as well as limited financial resources for sustainable funding of climate change research and programmes. In addition, insufficient mainstreaming of climate change mitigation agenda into national and sectoral policies and planning processes hinder progress.

3.2.3 *Opportunities for Implementing Mitigation Actions*

The implementation of policies such as the Energy Policy 2015-2025, The Forestry Policy 2008, the National Climate Change Policy and mitigation measures spelled out therein continues to yield several socio-economic and environmental benefits. The measures not only reduce greenhouse gases but also enable a range of co-benefits as outlined in Table 41 below

Table 3-1: Co-benefits of GHG Mitigation Measures

Category	Examples of co-benefits
Economic Benefits	• Support for sustainable development • Provision and maintenance of infrastructure • Increase in productivity • Generation of new national and regional business and trade opportunities that come with the diffusion and adoption of clean technologies • Introduction of new technologies – Invention, innovation and diffusion • Enhanced research and development • Technology enhancement and transfer
Social Benefits	• Creation of employment and income generation opportunities • Improvement of public health • Improvement of education and public awareness • Improvement of local living conditions
Environmental Benefits	• Improvement of air and water quality • Avoidance of soil pollution • Conservation and sustainable use of resources • Use of appropriate and environmentally friendly technologies

[1] https://www.thegef.org/country/lesotho

3.3 Assessment OF PAST AND Current MITIGATION measures

3.3.2 *Individual Measures Per Sector*

3.3.1.1 *Energy Sector*

Table 3-2: Energy Sector Mitigation Measures

Name of Policy/ Instrument/ Strategy/ Plan	Primary Objective(s) and Progress	GHGs affected	Type of Instrument and status	Administering government agency/ Actors	Time Horizon	Cumulative GHG impact (Tons CO_2e)	Co-benefits	
Development of Cornerstone Public Policies and Institutional Capacities to accelerate Sustainable Energy for All (SE4All) Progress	To catalyse investments in renewable energy-based mini-grids and Energy Centres to reduce GHG emissions and contribute to the achievement of Lesotho's Vision 2020 and SE4All goals.	CO_2, CH_4, N20	Strategy	Department of Energy, UNDP	2016-2021	N/A	Healthier environment for the rural population Opportunities for income-generating activities Improved natural resource management. Promote gender equality and women's empowerment	
Lesotho Energy Policy: 2015-2025	To improve people's livelihoods by promoting the utilisation of renewable energy with the aim of providing basic electricity services to the rural areas in Lesotho starting in the Mokhotlong, Thaba-Tseka and Qacha's Nek districts, thus reducing the country's dependency on fossil fuels	CO_2, CH_4, N20	Policy	Department of Energy	2015	N/A	Enhanced private sector participation	
National Sustainable Energy Strategy	To increase energy access. To promote availability of up-to-date energy resources information. Contribution to government revenue. • To explore environmentally friendly energy sources and technologies. To improve Departmental service delivery. Ensuring security of energy supply.	CO_2, CH_4, N20	Policy	Department of Energy	2016-2018	N/A		

Name of Policy/ Instrument/ Strategy/ Plan	Primary Objective(s) and Progress	GHGs affected	Type of Instrument and status	Administering government agency/ Actors	Time Horizon	Cumulative GHG impact (Tons CO_2e)	Co-benefits	
Lesotho Renewable Energy-Based Rural Electrification Project (LREBRE)	• To improve people's livelihoods by promoting the utilization of renewable energy to provide basic electricity services to the rural areas in Lesotho starting in the Mokhotlong, Thaba-Tseka and Qacha's Nek districts, thus reducing the country's dependency on fossil fuels. Delivering household PV systems to rural customers at reduced prices and credit terms. • 951 solar PV systems distributed between 2008 and 2010	CO_2, CH_4, N20	Physical Mitigation action, completed	DoE, REU, UNDP,	2008 -2017	1,249	Reduced indoor air pollution reduced expenditure on dry cell batteries reduction of the use of fossil fuels increased market of PVs	
Dissemination of Energy efficient cookstoves for conservation of biomass	• To conserve biomass reduction of emissions from the unsustainable use of wood • 1,138 stoves distributed to households and schools between 2005 and 2014	CO_2, CH_4, N20	Physical Mitigation action, completed	Technologies for Economic Development (TED)	2005-2017	18,283	Reduced indoor air pollution reduction of the use of fossil fuels	
Biogas Technology and Decentralized Wastewater Treatment Systems (DEWATS)	• To treat wastewater in an environmentally friendly manner in which Biogas produced is used for cooking reducing emissions of greenhouse gases, especially methane gas from escaping to the atmosphere but also for utilizing treated effluent as soil conditioner to prevent pollution of water bodies • 229 biogas digesters installed between 2005 and 2018, generating about 524,786 MJ of biogas over the period	CO_2, CH_4, N20	Physical Mitigation action, completed	TED	2005-2018	111	Increased public health New business / investment opportunities Reduction of waste Energy security	
(SREP) Scaling up Renewable Energy and Energy Efficiency Programme in Lesotho Investment plan	To increase access to modern and clean energy to Basotho as well as promoting private sector involvement in energy sector. Rural electrification through mini grids will enable women and children to spend less time collecting biomass, will increase economic activities in off-grid villages and reduce dependency on more costly energy sources, increasing household safety and extend study hours for students.	CO_2, CH_4, N20	Policy, Completed	Ministry of Energy and Meteorology	2016 -2017	N/A	Opportunities for income-generating activities Increase in social services and infrastructure Improved natural resource management and land use Improved local air pollution Financial and time-saving	

Name of Policy/ Instrument/ Strategy/ Plan	Primary Objective(s) and Progress	GHGs affected	Type of Instrument and status	Administering government agency/ Actors	Time Horizon	Cumulative GHG impact (Tons CO_2e)	Co-benefits	
Efficient Wood Fuel Stove-Cooking-Sets, Lesotho (Save80 Cookstoves) CDM	Dissemination of efficient fuel wood stoves and heat retaining polypropylene boxes in several polypropylene boxes in several districts of Lesotho, at subsidized prices. Users are households who previously used inefficient, traditional fireplaces.	CO_2, CH_4, N20	Physical Mitigation action, Ongoing	Solar Lights, atmosfair GmbH, Deutsche Post AG	2012 -2017	124,458	Reduced wood consumption to a sustainable level to allow natural recovery of forests and/or reforestation to take place. Reduction of indoor air pollution from wood smoke and avoid its harmful health consequences. Reduction of fuel wood bill or wood collection time for households. Contribution to the preservation of wood resources to avoid inter-community conflict over resources. Financially empowerment of participating community groups (majority women) in villages through financial incentives by including them in project activities.	
Introduction of Clean Energy by Solar Electricity Generation System	To enhance power generation capacity, diversify energy sources and increase awareness among the people of Lesotho on the utilization of renewable energy by procurement and installation of grid-connected Photovoltaic (PV) system as well as capacity building of engineers in the Moshoeshoe I International Airport (MIA).	CO_2, CH_4, N20	Physical Mitigation action, completed	Department of Energy	2014 -2016	0	Reduced importation of the coal based electricity	

3.3.1.2 *AFOLU Sector*

Table 3-3: AFOLU Sector Mitigation Measures

Name of Policy/ Instrument/ Strategy/ Plan	Primary Objective(s) and Progress	GHGs affected	Type of Instrument and status	Administering government agency/ Actors	Time Horizon	GHG impact (Tons CO_2e)	Co-benefits
• Forestry policy 2008		CO_2	Policy, Completed				

• National Tree Planting Initiative (Forest Trees)	To increase land cover through tree planting mainly focusing on increasing carbon sequestration potential by expanding the carbon sink area thus achieving low carbon emissions mitigation	CO_2	Physical Mitigation	Department of Forestry	2005-2018	23,443	Improvement of biodiversity/ natural resources Reduction of loss of top soil Employment and job creation

3.3.1.3 *Waste Sector*

Table 4: Waste Sector Mitigation Measures

Name of Policy/ Instrument/ Strategy/ Plan	Primary Objective(s) and Progress	GHGs affected	Type of Instrument and status	Administering government agency/ Actors	Time Horizon	GHG impact (Mt CO_2e)	Co-benefits (name: impact)
• The baseline assessment for the development of an Integrated Solid Waste Management System (ISWMS) for Maseru City	To carry out a baseline assessment of waste management in Maseru City through (i) carrying out an inventory of waste infrastructure and waste sources (ii) mapping sources of waste generation and current waste treatment infrastructure (iii) collecting data on population, number of households, commercial, industrial, administrative, and hospital establishments in Maseru City (iv) collecting data on quantities and composition of solid waste generation for different sources in Maseru City	CO_2, CH_4, N20	Research	MCC, Department of Environment	2005-2018	N/A	To provide policy direction on issues of solid waste management

3.3.2 *Impact of current & implemented mitigation Measures*

Figure 31 below presents the combined annual GHG mitigation impact of the main implemented mitigation measures as outlined in the preceding section.

The Figure shows that between 2005 and 2017 the implemented actions reduced between 279 tCO_2e in 2005 and 32,304 tCO_2e in 2017 of annual GHG emissions. A total of 166,460 tCO_2e have been mitigated over the entire period, with the largest contribution coming from the efficient wood fuel stove – Cooking sets (Save 80 cookstoves) project accounting for 75% of the emission reductions.

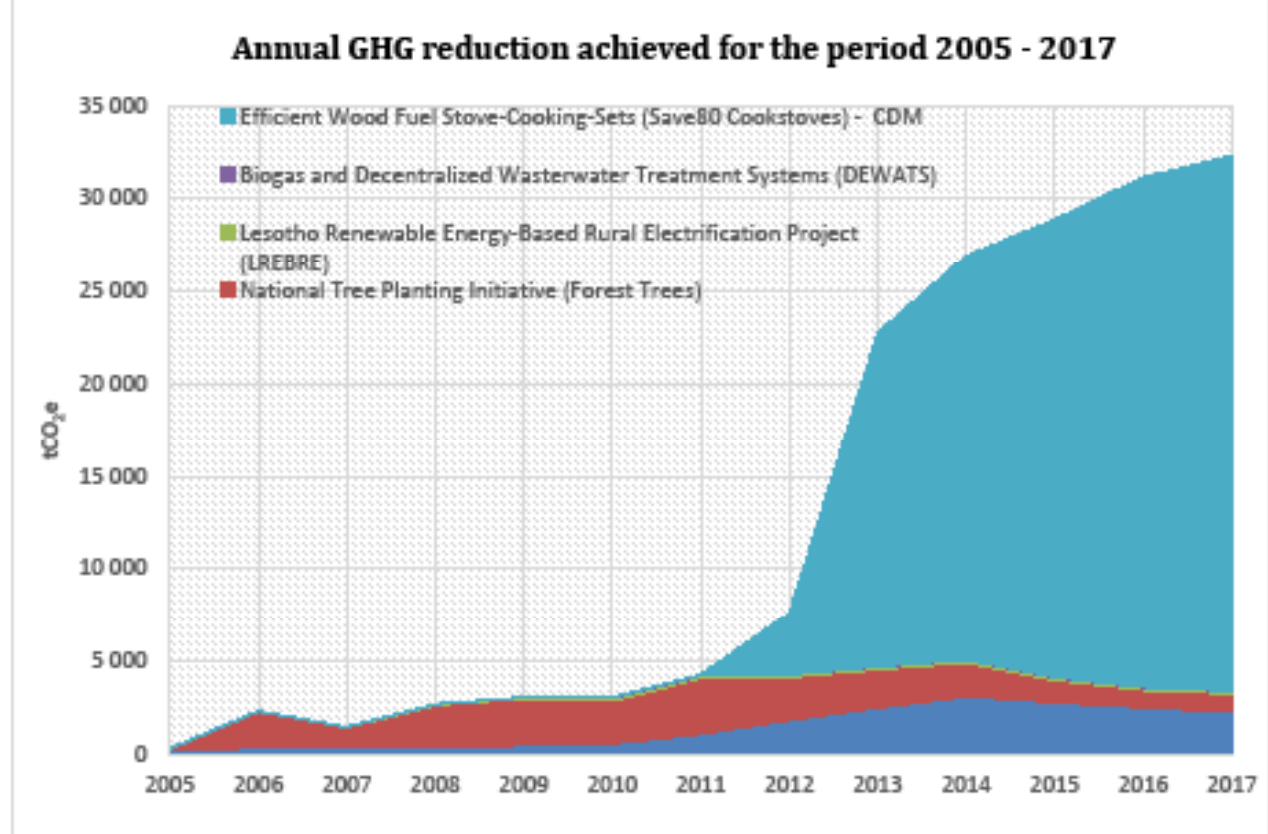


Figure 3-1: Annual combined GHG reductions achieved between 2005 and 2017

Lessons learnt from implementing these mitigation actions have been used to inform the development of new Nationally Appropriate Mitigation Actions as outlined in the next section.

3.4 Nationally appropriate mitigation actions (NAMAs)

3.4.1 *Development of New NAMAs*

Based on the ongoing mitigation projects and programmes presented in the preceding section as well as key GHG emitting sectors identified from the GHG inventory, five focus areas for Nationally Appropriate Mitigation Actions (NAMAs) were identified as shown in the Figure 2 below:

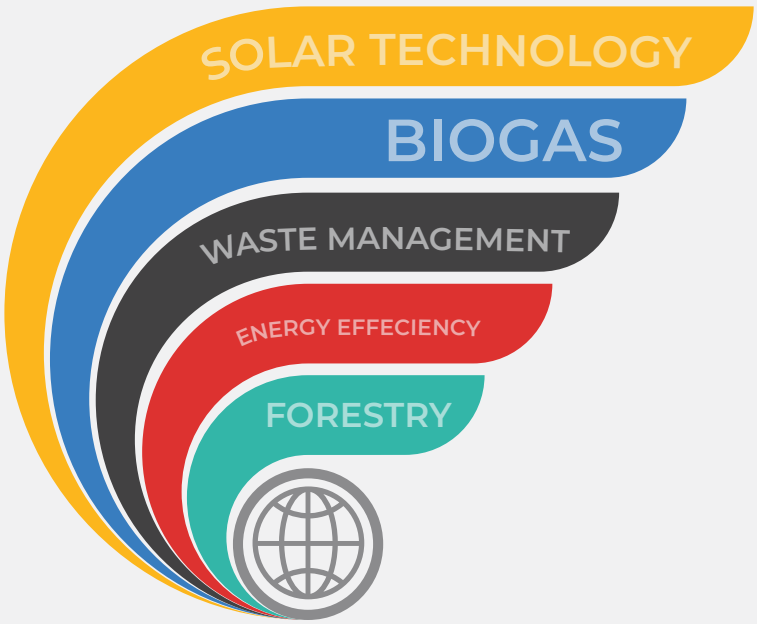


Figure 3-2 Focus areas identified for NAMA development

Through a national stakeholder's workshop, the above five themes were then packaged into the following five NAMAs that are aimed at scaling up existing action and accelerating GHG reduction in Lesotho:

- » Biogas Programme of activities in Public Institutions
- » Scaled-up dissemination of efficient cooking devices
- » Solar Technologies Programme of activities
- » National Forestation/ Reforestation Programme
- » Alternative Solid Waste Management Programme

Each NAMA was then developed and elaborated following a six-step process as shown in Figure 3-3: Summary of NAMA development steps.

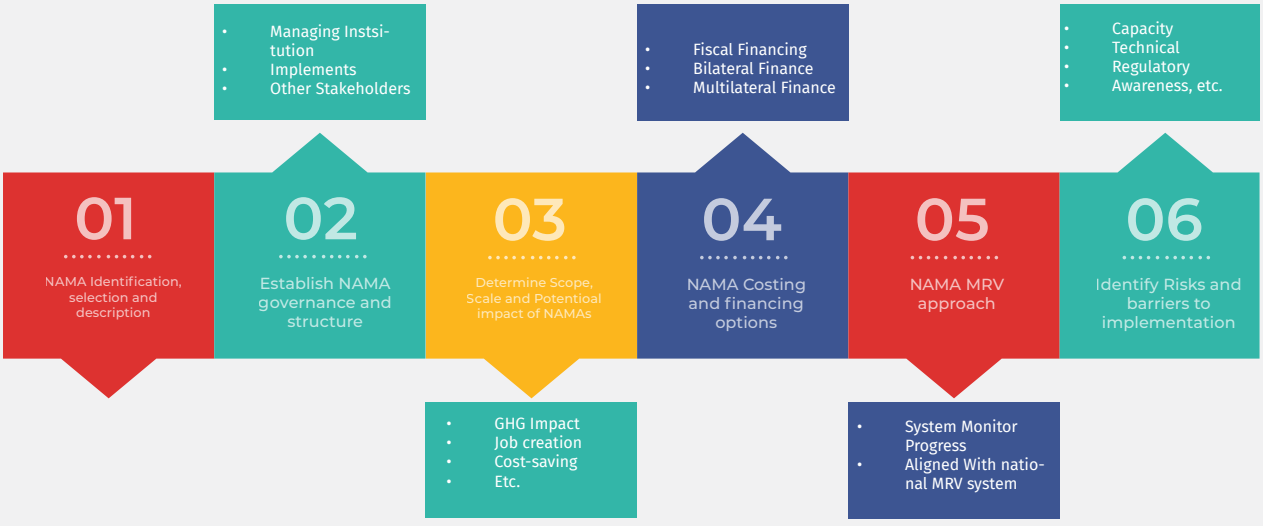


Figure 3-3: Summary of NAMA development steps

Sections 1 to v below present each of the NAMAs in detail, including descriptions, scale, scope, activities, governance arrangements, anticipated GHG impact, co-benefits, MRV requirements, estimated initial cost of establishing the NAMAs as well as possible risks and barriers to implementation.

1. 1st NAMA – Biogas Programme of Activities in Public Institutions

Table 5: 1st NAMA- Biogas Programme of Activities in Public Institutions

		DETAILS
Title		Biogas Programme of Activities in Public Institutions
Description of the NAMA		Installation of centralized and decentralized biogas digesters in public institutions to reduce energy costs and GHG emissions. Emission reductions to be realized in two areas, namely: • Wastewater treatment because of burning the CH_4 in the biogas and converting it to CO_2, and • Using biogas to supply the energy needs of those institutions, replacing fossil based energy sources.
Components, Activities and scale		• Components: • Centralized biogas production programme in all municipal wastewater treatment works (WWTWs) facilities. Biogas to be used in public institutions for cooking and heating • Installation of biogas digesters for cooking and heating in all prisons, hospitals and schools
Governance	Managing institution	• Ministry Responsible for Energy
	Implementers and their roles	• Ministry of Public Works and Transport - Responsible for public buildings infrastructure. • Appropriate Technologies Services- Responsible for technological Innovation • Water and Sewage Company (WASCO) – Co-ownership of WWTW projects • Private Sector – Construction of biogas digesters • Non-Governmental Organizations (NGOs) and CSO's – Advocacy and Awareness Raising. • Prisons – Co-ownership of the digesters, operation of the digester and utilization of biogas • Hospitals – Co-ownership of the digesters, operation of the digester and utilization of biogas • Schools – Co-ownership of the digesters, operation of the digester and utilization of biogas
	Other stakeholders	• National Climate Change Committee (NCCC) • Academia (Energy Research Centre – National University of Lesotho) – Research. • Ministries of Education, Health and Correctional Services

Impact	Anticipated GHG emission reduction	• Centralized biogas production (from 4% of national wastewater) = 9,012 tons CO_2e per annum • Decentralized biogas from schools, hospitals and prisons17 = 4,097 tons CO_2e per annum • TOTAL: = 13,109 tons CO_2e per annum
	Anticipated job-creation	• Job creation in: • construction of the biogas plants • operation of the biogas plants
	Other co-benefits expected	• Renewable Energy generation ≈ 35,400 GJ per annum • Food security. • Soil conditioning (fertilizer). • Waste management. • Cost reduction on water, electricity, fertilizers. • Pollution reduction. • Biodiversity.
Finance	Estimated capital cost	• Centralized biogas production (from 4% of national wastewater) = M 326,000,000 • Decentralized biogas from schools, hospitals and prisons = M 244,000,000 • TOTAL ESTIMATE: = M 570,000,000 (US$ 33,537,000)
	Financing options	• Government of Lesotho. • Green Climate Fund. • Energy and Environment Partnership Trust Fund (EEP Africa). • Global Environment Facility, • Development Partners. • Private Investors
MRV approach	MRV description (including indicators, data to be collected and frequency of monitoring)	• To monitor and evaluate the implementation and performance of this NAMA, the following indicators need to be tracked: • Number and sizes of biogas digesters installed – implementation (annually) • Quantify of biogas produced in each digester, through installed meters – performance (monthly) • Destination and use of the biogas produced – performance (monthly) • Number of part-time and fulltime jobs created – performance (annually) • Quantity and destination of water discharged – performance (monthly)

[1] Based on number of pupils, hospital beds and prisoners obtained from the following resources respectively: http://www.ibe.unesco.org/fileadmin/user_upload/Publications/WDE/2010/pdf-versions/Lesotho.pdf , https://trading-economics.com/lesotho/hospital-beds-per-1-000-people-wb-data.html and https://www.prisonstudies.org/country/lesotho

Risks and barriers	Risks and Barriers to implementation	• Lack of information. • Lack of funding. • Lack of ownership/regulation. • Affordability. • Operation and maintenance.
	How risks and barriers will be mitigated	• Involve NGO's and CBO's for advocacy and sensitization. • Do sensitization to align with national commitments. • Apply for international funding to support implementation

1. 2nd NAMA – Scaled-Up Dissemination of Efficient Cookers

Table 6: 2nd NAMA- Scaled-Up Dissemination of Efficient Cookers

		DETAILS
Title		Scaled-up dissemination of efficient cooking devices
Description of the NAMA		Dissemination and subsidy of efficient cooking devices to households across the country
Components and Activities		• Components: • Distribution of efficient fuel wood stoves (Nkokonono rocket stove) to 10,000 households countrywide (To rural and urban households that use inefficient traditional biomass fire) • 50% subsidy of slow cookers (wonderbags / Liphehisi tsa mohlolo) for 100,000 households.
Governance	Managing institution	• Department of Energy.
	Implementers and their roles	• NGO's (Technologies for Economic Development (TED) and other energy related NGO's – Distribution, education, improvement of technology and adaptation. • Private Sector – Manufacturing, assembling, retailing and distribution. • Bureau of Statistics – Monitoring and data collection. • Appropriate Technology Services (ATS) – Research, Monitoring and data collection.
	Other stakeholders	• National Climate Change Committee (NCCC) • Ministries of Local government, development planning, small businesses, trade and industry.

Impact	Anticipated GHG impact	• 10,000 household size rocket wood stoves = 33,812 tons CO_2e per annum • 50% subsidy of 100,000 wonderbags* = 66,600 tons CO_2e per annum • **TOTAL: = 100,413 tons CO_2e per annum** • *50% usage of the wonderbags assumed.
	Anticipated job-creation	• Manufacturing /Assembly labour. • Marketers/Sales workforce. • Trainers. • Drivers. • Data collectors, monitoring and evaluation officers.
	Other co-benefits expected	• Conservation of the environment. • Reduced energy costs for households. • Reduced indoor air pollution and improved health. • Improved safety for women who are mainly wood collectors. • Saved time for women who are mainly wood collectors. • Reduced risk of open fires.
Finance	Estimated cost	• 10,000 household size rocket wood stoves = M 3,000,000 • 50% subsidy of 100,000 wonderbags = M 24,000,000 • **TOTAL ESTIMATE: = M 27,000,000 (US$ 1,588,000)**
	Financing options	• Government subsidy. • Green Climate Fund. • Global Environment Facility (Small Grants Programme). • Development Partners. • Private Sector. • Carbon Credits under the Paris Agreement.
MRV approach	MRV description (including indicators, data to be collected and frequency of monitoring)	• To monitor and evaluate the implementation and performance of this NAMA, the following indicators need to be tracked: • Number, sizes and types of stoves and cookers distributed – implementation (annually) • Frequency at which the stoves and cookers are used – performance (annual surveys) • Number of part-time and fulltime jobs created – performance (annually)

Risks and barriers	Risks and Barriers to implementation	• People not keen to use new technologies (due various reasons including that new technologies do not generate enough heat generated, does not accommodate traditional pots). • Unaffordability even with subsidy. • Costs and importation of pellets. • Lack of information.
	How risks and barriers will be mitigated	• More education and awareness. • Develop the technology to align with traditional practices. • Increase subsidy.
Opportunities & enablers	Available opportunities & enabling environment	• Existence of Energy Policy. • Existence of Sustainable Energy Strategy. • Energy stakeholder Forum (Energy Sector Coordination Forum). • Existence of institutions, NGO's and private sector active in this field.

1. 3rd NAMA – Solar Technologies Programme of Activities

Table 7: 3rd NAMA- Solar Technologies Programme of Activities

	DETAILS
Title	Solar Technologies Programme Of Activities
Description of the NAMA	Deployment of three solar technologies in rural and urban communities: Photovoltaic, concentrated solar and solar water heating technologies.
Components and Activities	• Components: • Rural Electrification through Photovoltaic (PV) Solar Home Systems (SHS): Installation of 10,000 PV SHS systems in non-electrified rural households across the country. This is scaling up of the UNDP/GEF-supported Lesotho Renewable Energy-Based Rural Electrification (LREBRE) Project • Dissemination of parabolic solar bread ovens in all orphanages across the country. • Household solar water heater (SWH) Programme for urban areas: Dissemination of low pressure SWHs in 10,000 low income urban households without electric geysers across the country

Governance	Managing institution	• Department of Energy (Ministry responsible for energy)
	Implementers and their roles	• Private Sector – manufacturing, distribution and installation • Bethel Business and Community Development Centre (BBCDC) – Design and production of solar trough bread ovens; training of private sector to manufacture • NGOs – training, awareness creation, monitoring and evaluation • Bureau of statistics – monitoring and evaluation
	Other stakeholders	• National University of Lesotho. – Capacity building and training • Technical Institutions - Capacity building and training • Appropriate Technology Services – Training of manufacturers • Lesotho Solar Energy Society (LESES) • Ministries of small business development, trade and industry and local government
Impact	Anticipated GHG impact	• 10,000 PV SHS for rural electrification = 2,336 tons CO_2e per annum • Parabolic solar bread oven in orphanages = 24,373 tons CO_2e per annum • 100,000 Solar water heaters for urban areas = 10,898 tons CO_2e per annum • **TOTAL: = 37,607 tons CO_2e per annum**
	Anticipated job-creation	• In manufacturing and Installation. • In maintenance. • In monitoring and verification
	Other co-benefits expected	• Renewable energy generation ≈ 365,768 GJ per annum • Reduced indoor air pollution and improved health. • Improved safety for women who are mainly wood collectors. • Saved time for women who are mainly wood collectors. • Reduced risk of open fires (safety) • Savings on energy costs, including charging of cell phones • Improved lighting.

Finance	Estimated cost	• 5,000 PV SHS for rural electrification = M 150,000,000 • Parabolic solar bread oven in orphanages = M 10,630,000 • 100,000 Solar water heaters for urban areas = M 150,000,000 • **TOTAL ESTIMATE: = M 310,630,000 (US$ 18,272,000)**
	Financing options	• Government of Lesotho. • Development partners. • Green Climate Fund. • United Nations Agencies. • Private Sector.
MRV approach	MRV description (including indicators, data to be collected and frequency of monitoring)	• Indicators to be tracked to monitor and evaluate the implementation and performance of this NAMA: • Number, sizes and types of PV systems, bread ovens and solar water heaters installed – implementation (annually) • Quantity of energy and bread produced from each technology – performance (monthly) • Frequency and habits of using the solar water heaters (annual surveys) • Number of part-time and fulltime jobs created – performance (annually) • Number of orphans served /fed (annual surveys)
Risks and barriers	Risks and Barriers to implementation	• Costs • Standards. • Affordability. • Maintenance. • Private Sector bye in.
	How risks and barriers will be managed	• Government subsidy. • Independent /semi-autonomous body.
Opportunities & enablers	Available opportunities & enabling environment	• Existence of a national rural electrification programme • Existence of Energy Policy. • Existence of Sustainable Energy Strategy. • Energy stakeholder Forum (Energy Sector Coordination Forum). • Existence of institutions, NGO's and private sector active in this field.

4th NAMA – National (Re)Forestation Programme

Table 8: 4th NAMA- National (Re)ForestationProgramme

		DETAILS
Title		National (Re)Forestation Programme
Description of the NAMA (including scope and scale)		The objective is to support the National Forestry Strategic plan by increasing tree cover from 1.63% (49,478ha) to 5.4% of the total land area (Based on Forestry Strategic Plan 2014 -2017 target). This implies an increase of forest cover by 114,437 ha.
Components and Activities		• Activities: • Planting indigenous trees, including Pinus, Eucalyptus, Boleikatle and Cheche. • Planting fruit trees.
Governance	Managing institution	• Ministry of Forestry, Range and Soil Conservation- strategic framing, inventories.
	Implementers and their roles	• Local Government – Land allocation and protection of trees. • Private Nursery Owners – Production of seedlings. • Communities – Planting and caring for trees. • NGO's, CSO's, Churches, Schools, Individuals – Planting and caring for tree; advocacy and awareness raising.
	Other stakeholders	• UN Agencies. • Development Partners. • Government Departments and institutions. • Private Companies.
Impact	Anticipated GHG impact	• (Re)Forestation of 114,437 ha (indigenous & fruit trees) = 126,460 tons CO_2e per annum
	Anticipated job-creation	• Seed harvesting. • Soil collection and potting. • Care and tending of seedlings. • Pitting. • Tree Planting. • Care and tending of trees.
	Other co-benefits expected	• Enhance biodiversity. • Aesthetic purpose. • Land rehabilitation. • Air purification. • Cooling.

Finance	Estimated cost	• (Re)Forestation of 57,370 ha estimated cost = M 105,891,000 (US$ 6,229,000)
	Financing options	• Government. • REDD+ • GEF. • GCF. • Development Banks. • IFAD.
MRV approach	MRV description (including indicators, data to be collected and frequency of monitoring)	• Indicators to be tracked to monitor and evaluate the implementation and performance of this NAMA: • Number and type of trees planted – implementation (annually) • Number and type of surviving trees – performance (annually) • Number of part-time and fulltime jobs directly created – performance (annually)
Risks and barriers	Risks and Barriers to implementation	• Land tenure system. • Lack of political will. • Lack of law enforcement. • Shortage of qualifies human resources. • Climate risks. • Fire. • grazing of Animals at the identified forestation sites.
	How risks and barriers will be managed	• Awareness raising • Law enforcement. • Capacity building. • Recruitment of technically qualified staff. • Assessment of climate risks. • Mapping of fire prone areas.
Opportunities & enablers	Available opportunities & enabling environment	• Existence of the National Forestry Policy. • Existence of the National Forestry Strategic plan • Government is already running the forestation program that can be up-scaled to enhance the achievement of this NAMA. • National Institutions produce people with the required skills. • Varying topography and climate is conducive for variety of tree species.

1. *5th NAMA – Alternative Solid Waste Management Programme*

Table 9: 5th NAMA- Alternative Solid Waste Management Programme

		DETAILS
Title		Alternative Solid Waste Management Programme
Description of the NAMA (including scope and scale)		Minimizing the quantity of landfilled solid waste at 3 landfill sites within Maseru district through separation at source, diversion of recyclables and energy generation from non-recyclables
Components		• Components: • Separation of solid waste at source and recycling the recyclables • Recovery of recyclable waste material through material recovery facilities (MRFs) at 3 landfill sites and recycling • Biogas energy generation from residual non-recyclable biodegradable wet waste
Supporting activities		• Education and public awareness regarding separation at source • Enforcement of laws
Governance	Managing institution	• Ministry of Local Government and Chieftainship.
	Implementers and their roles	• Department of Energy – Energy Regulation • Department of Environment – Regulatory body on environmental issues. • Maseru City Council – co-ownership and management of the facilities, collection of waste, manage usage of the energy produced • Waste recycling companies – recycling of the waste • NGOs – information dissemination, awareness creation, M&E and training to households • Private sector – manufacture, supply and construction of MRFs and biogas digesters
	Other stakeholders	• Ministry of Health. • Communities – separation of waste at source • Meteorology

impact	Anticipated GHG impact	• Material recovery at source and in a landfill facility in Maseru = 28,751 tons CO_2e per annum • Biogas generation from biodegradable residual waste = 54,298 tons CO_2e per annum • TOTAL: = 83,049 tons CO_2e per annum
	Anticipated job-creation	• Job creation in: • Recycling • Waste collection • Operating the MRFs • Construction of biogas digesters • Operation of biogas digesters • Biogas distribution
	Other co-benefits expected	• Renewable Energy generation ≈ 120,350 GJ per annum • Capacity building intensified through training. • Attract more funding from development partners. • Reduced local air pollution and respiratory illnesses • Improvement in Private Sector development.
Finance	Estimated cost	• Material recovery at source & in MRFs in Maseru = M 132,458,000 • Biogas generation from biodegradable residual waste = M 4,854,254,000 • TOTAL ESTIMATE: = M 4,986,712,000 (US$ 293,336,000)
	Financing options	• Government of Lesotho. • United Nations Industrial Development Organization. • Green Climate Fund.
MRV approach	MRV description (including indicators, data to be collected and frequency of monitoring)	• Indicators to be tracked to monitor and evaluate the implementation and performance of this NAMA: • Quantity and sizes of material recovery facilities established – implementation (annually) • Quantity and types of waste separated, collected and recycled – performance (monthly) • Quantify of biogas produced in each digester, through installed meters – performance (monthly) • Destination and use of the biogas produced – performance (monthly) • Number of part-time and fulltime jobs directly created – performance (annually) • Quantity and destination of water discharged – performance (monthly)
Risks and barriers	Risks and Barriers to implementation	• Cultural barriers. • Exposure to waste. • Lack of training plan
	How risks and barriers will be managed	• Develop emergency and preparedness plan.

3.4.2 *Combined Impact and Cost of the NAMAs*

3.4.2.1 Anticipated impact

Figure 3-4: Total annual GHG impact of the NAMAs below compares GHG mitigation impact of the individual NAMAs and also shows the collective annual GHG impact envisaged from all the five NAMAs. The national (Re)Forestation NAMA is expected to have the largest GHG abatement impact by sequestering about 126,000 tonnes of carbon dioxide annually. When fully implemented, the NAMAs are expected to collectively reduce the country's annual GHG emissions by 360,636 tonnes of CO_2e. This is about 6.37% of the country's 2017 emissions.

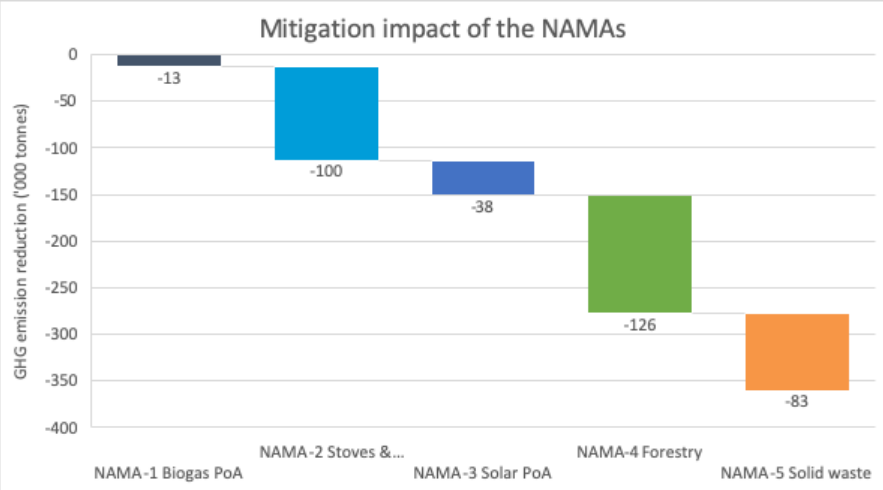


Figure 3-4: Total annual GHG impact of the NAMAs

In addition to GHG abatement impact, the NAMAs are expected to have numerous co-benefits including renewable energy generation of about 521,553 GJ per annum, of which 70% is solar energy from the Solar Programme of Activities NAMA (see Figure 3-6: Contribution of different NAMAs to annual renewable energy generation)

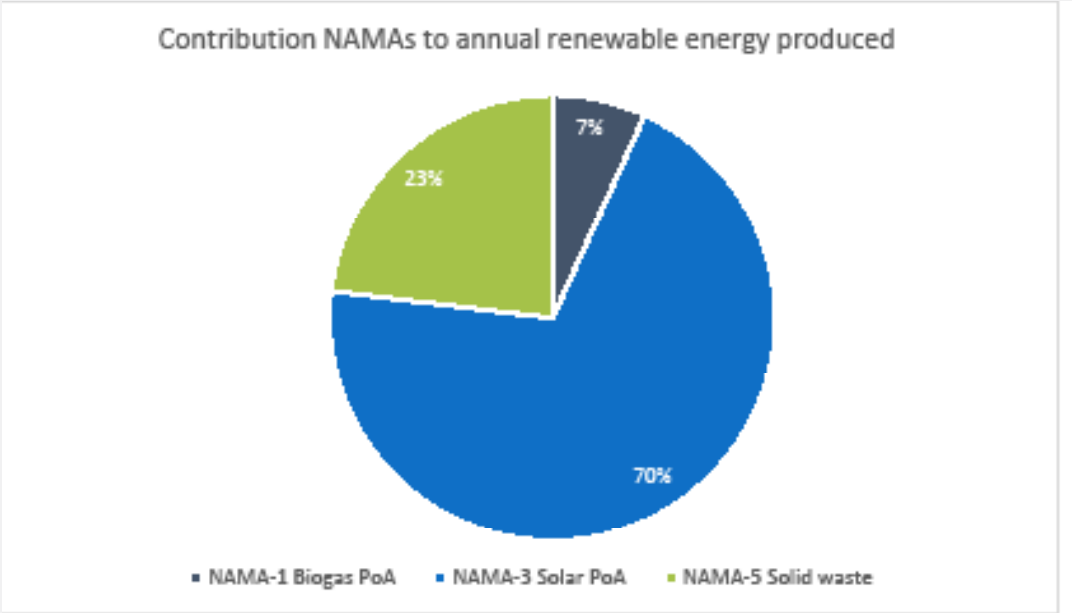


Figure 3-6: ***Contribution of different NAMAs to annual renewable energy generation***

3.4.3 *Estimated NAMA initiation cost*

It is estimated that the initial capital costs of implementing these NAMAs will be in the order of $352,955,000, disaggregated as shown in the Figure 3-7: Estimated NAMA initiation implementation costs below.

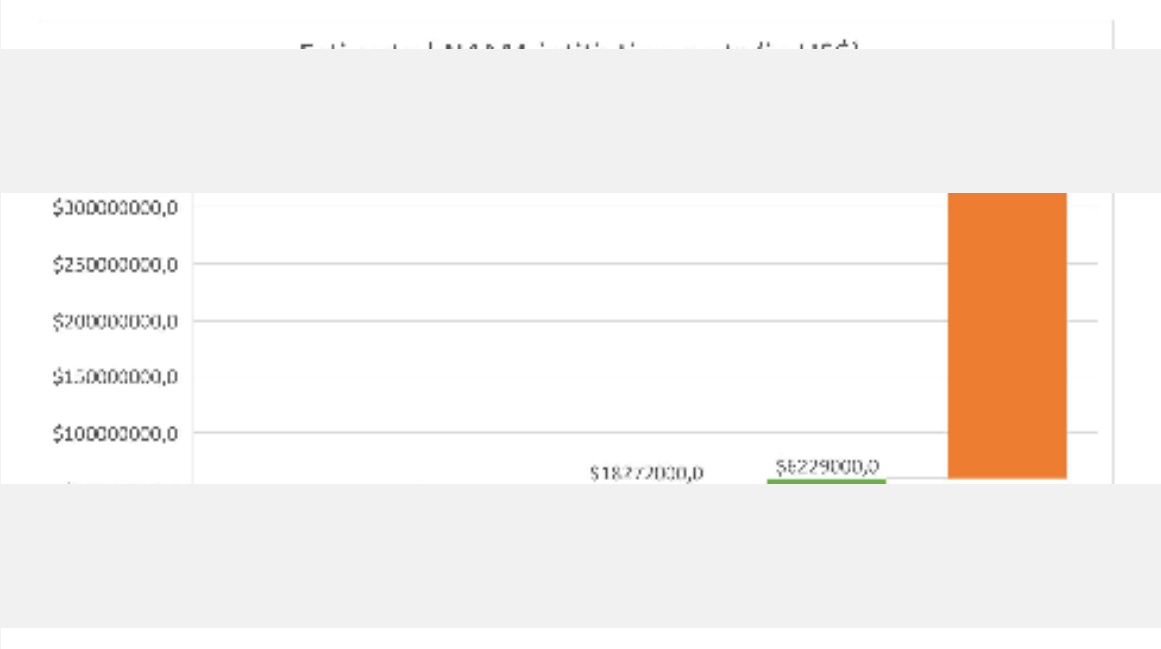


Figure 3-7: Estimated NAMA initiation implementation costs

4. DOMESTIC MEASURING REPORTING AND VERIFICATION

DOMESTIC MEASURING REPORTING AND VERIFICATION

4.1. Introduction

The Kingdom of Lesotho, through the Ministry of Energy and Meteorology Lesotho Meteorological Services, has developed a climate change monitoring, reporting and verification (MRV) framework for reporting to the United Nations Framework Convention on Climate Change (UNFCCC). The MRV framework is specific to the compilation of Biennial Update Reports (BURs). Further to meeting the requirements for international reporting on climate change matters, the development of an MRV framework will support the Kingdom in developing an MRV system in the future, which can assist Lesotho collect, manage, store and report on the country's climate change data.

Monitoring and evaluating climate change data on a systematic and regular basis will assist Lesotho in tracking and reporting progress related to the Kingdom's climate change goals. In addition to meeting international climate change transparency commitments, a climate change MRV system has domestic benefits. Such a system may facilitate the identification of policy misalignment or gaps in implementation of climate actions, which may then be addressed.

4.2. The development of the MRV Framework design

Lesotho is well positioned to develop a climate MRV system for the purpose of assisting the Kingdom compile international reports. The specific BUR requirements for an MRV system include three main components, which form part of the MRV system design:

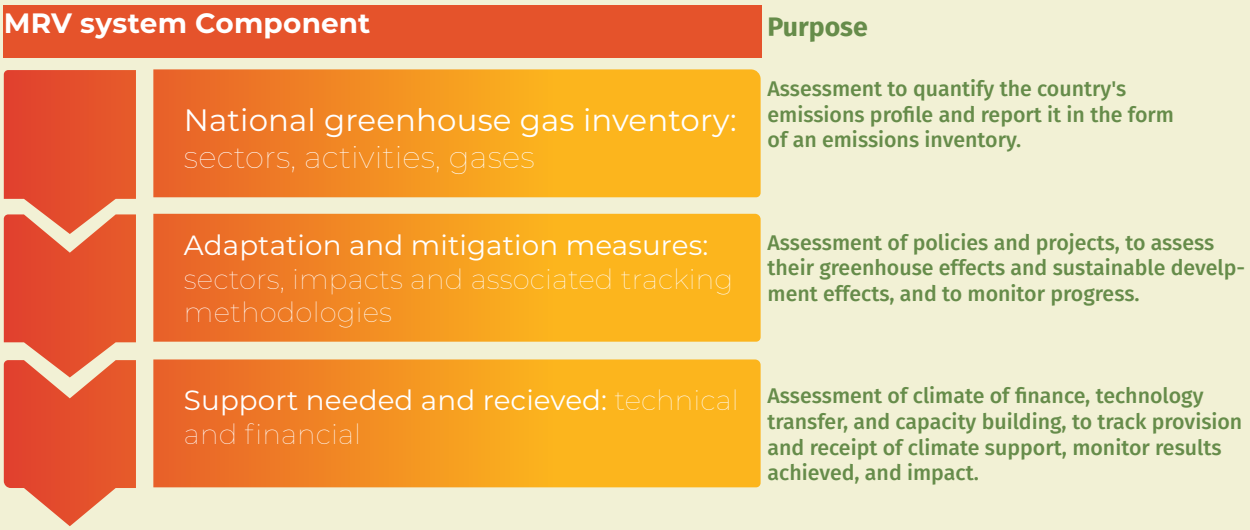


Figure 4-1: BUR MRV system components and purpose

The following conceptual framework is proposed for Lesotho's BUR MRV system.

Figure 4-2: Proposed framework for Lesotho's BUR MRV system

4.3. Institutional arrangements for the Domestic MRV

The formalisation of institutional arrangements, through memoranda of understanding or other such contracts, is critical for the success of the system. Formalizing these arrangements will assist define responsibilities, types and formats of data to be collected as well as the frequency of measurements and reporting.

The following institutional arrangements are therefore proposed for the BUR purposes (Figure 43), which

mirror the approach taken in developing the latest national greenhouse gas inventory (and therefore leverage existing systems and arrangements):

Figure 4-4: Proposed BUR institutional arrangements

Notably, Lesotho's Bureau of Statistics is potentially a key source of data. Overcoming the capacity and mandate challenges facing the institution will assist Lesotho in climate MRV of mitigation actions and other components required for domestic and international reporting.

Lesotho's proposed climate change Monitoring and Evaluation System, mandated by the National Climate Change Policy, envisages that key sectors will be required to provide data on a biannual basis. The implementation of the Monitoring and Evaluation System, coupled with clearly defined and agreed institutional arrangements for data collection and management, will assist in improving Lesotho's data collection and measurement processes. Data collection and measurement methods should be appropriate to the data being monitored (e.g. emissions from cattle production and emissions from power generation will require different approaches). In some instances, Lesotho will be required to balance the costs related to data collection against the benefit of higher accuracy. Starting with simplified approaches and less accurate data and improving over time is a typical approach. Monitoring approaches should always be documented and contain a high level of detail. This will ensure that the same approaches are used over time, thus facilitating comparability of data over time.

Lesotho has identified various adaptation and mitigation actions required to enable the Kingdom to transition to a climate resilient and low-carbon economy. Lesotho's national circumstances, particularly high levels of poverty, favour the pursuit of measures that have sustainable development co-benefits. The implementation and fulfilment of Lesotho's adaptation goals are therefore highly prioritised by the country.

Lesotho has identified a large range of indicators which may be used to track progress of its climate measures (greenhouse gas inventory as well as adaptation and mitigation actions). Collecting and

managing the full spectrum of indicators is not likely to be practical or economically feasible. Lesotho will need to consider options to prioritise the collection and management of key indicators.

Lesotho could reassess the priority of identified climate actions by considering which indicators are practically and economically feasible to monitor. High quality indicators are those that meet the SMART (specific, measurable, achievable, relevant and time-bond) principles. In addition, Lesotho could consider using the five prioritised principles developed by the United States National Academy of Sciences Committee on Metrics18 as a way of refining the list of actions and related indicators for regular monitoring and evaluation. High priority climate actions and indicators should meet all of the following principles:

- A **good strategic plan** must precede the development of metrics. Such a plan includes well-articulated goals against which to measure progress and a sense of priorities.
- Good metrics should **promote strategic analysis**. Demands for higher levels of accuracy and specificity, more frequent reporting, and larger numbers of measures than are needed to improve performance can result in fewer quality results and escalating costs.
- The development and application of meaningful metrics will require **significant human, financial, and computational resources**. A deliberative process of selecting the few most appropriate metrics, collecting the necessary information, and carrying out the evaluation will be required. The frequency of measurement will depend on the context.
- **Metrics must evolve** to keep pace with scientific progress and programme objectives. Adjustments to the measures will be required as programme managers gain experience and the programme itself matures and evolves.

Lesotho has the opportunity to design an MRV database, in which to store and manage data indicators. An accompanying data management system will be required, in order to articulate and document the roles and responsibilities of the managing and contributing entities. The data management system should also be the repository of the standard operating procedures required to operate the MRV database. These operating procedures will range from backup plans, to file and data management practices, archiving procedures and the access of information in the database.

4.3.1 *Greenhouse gas inventory: MRV framework*

Lesotho has a good understanding of the implementation and reporting requirements related to tracking the country's greenhouse gas emissions and sinks. The drafting of the fourth inventory builds on existing processes and systems and demonstrates the country's process of learning in this regard. Lesotho can build on the existing arrangements and data collection systems to systematically refine and improve the national greenhouse gas inventories going forward.
Lesotho's MRV system ultimately needs to provide high-level national inventory information. The following table provides an indication of the required national inventory framework, which includes high-level results and proposed format for reporting in BURs.

[23] Cited in UNFCCC. 2015. *Monitoring and assessing progress, effectiveness and gaps under the process to formulate and implement National Adaptation Plans: The PEG M&E tool*. Page 12.

Table 4-1: MRV framework for national inventory component

Greenhouse gas source and sink sector	Emissions (Gg CO_2e)		Difference (Gg CO_2e)	Change (%)
	[Base year]	[Reporting year]	[Difference between the base year emissions and the reporting year emissions]	
Total net emissions (including FOLU)	[results]	[results]	[results]	[results]
Total gross emissions (excluding FOLU)	[results]	[results]	[results]	[results]
1. ENERGY	[results]	[results]	[results]	[results]
2. IPPU	[results]	[results]	[results]	[results]
3. AFOLU (excluding FOLU)	[results]	[results]	[results]	[results]
3. AFOLU (including FOLU)	[results]	[results]	[results]	[results]
4. WASTE	[results]	[results]	[results]	[results]

The MRV framework for reporting on the greenhouse gas inventory should also include information on the methodologies/monitoring approaches employed, as well as the support (financial, technology transfer, capacity building) received during the reporting period, and support required in future.

4.3.2 *Climate actions: MRV framework*

Lesotho's MRV system is required to provide high-level information on the impacts and needs of the country's prioritised adaptation and mitigation actions. The following table provides an indication of the framework required for the MRV of climate actions.

Table 4-2: MRV framework for climate actions component

Framework components	*Adaptation action*	*Mitigation action*
Name and description of action, including information on the nature of the action, coverage, quantitative and/or qualitative goals and process indicators	*[results]*	*[results]*
Sector	*[results]*	*[results]*
Methodologies and assumptions used to monitor the action	*[results]*	*[results]*

Objectives of the action and steps taken or envisaged to achieve that action	*[results]*	*[results]*
Progress of implementation of the actions and results achieved against baseline	*[results]*	*[results]*
Domestic MRV processes	*[results]*	*[results]*
Monitoring timelines	*[results]*	*[results]*
International market mechanisms (mitigation only)		*[results]*
Support received and needed	*[results]*	*[results]*

The BUR reporting team will be required to consolidate the information provided, per action, in the respective BURs.

4.3.3 *Domestic MRV framework*

Lesotho requires an adequate number of trained technical staff, financial resources and an institutional framework to implement an effective MRV system. Lesotho has the opportunity integrate national-level monitoring and evaluation of adaptation measures with monitoring and evaluations requirements of different global initiatives. Different international reporting platforms present opportunities for linking mechanisms at the national and institutional levels, to link mitigation and adaptation actions with MRV-related activities on a sustained basis, based on international best practices. For example, adaptation measures are required to be monitored under the Paris Agreement, the 2030 Sustainable Development Agenda and the Sendai Framework for Disaster Risk Reduction. While each of these international mechanisms has its own specific focus, they all share similar elements which is a result of the cross-cutting nature of climate change.

Where the MRV systems use the same data, Lesotho has the opportunity to reduce MRV efforts by aligning the MRV approaches, for example, with regards to data collection or reporting. Often the same or similar data sets are required at differing levels of aggregation. Streamlining reporting across these global initiatives, where complementary activities exist, will enhance the quality of data that results from the continuous learning that occurs where monitoring and evaluation activities are undertaken on a standardised and frequent basis.

4.4. General recommendations

The following high-level recommendations are made with regards to finalizing Lesotho's BUR MRV framework, with a view to initiating work to design a functional climate MRV system and database:

» Formalize institutional arrangements for the monitoring, collection, management and reporting of climate information. This includes information related to the national greenhouse gas inventory, climate actions (for both adaptation and mitigation) and support (financial, technical and capacity building) received and required. Identify gaps and develop costed action plans to remediate gaps.

» Implement the requirement for biannual reporting of information by key sectors within the Monitoring and Evaluation System, as envisaged in Lesotho's National Climate Change Policy.

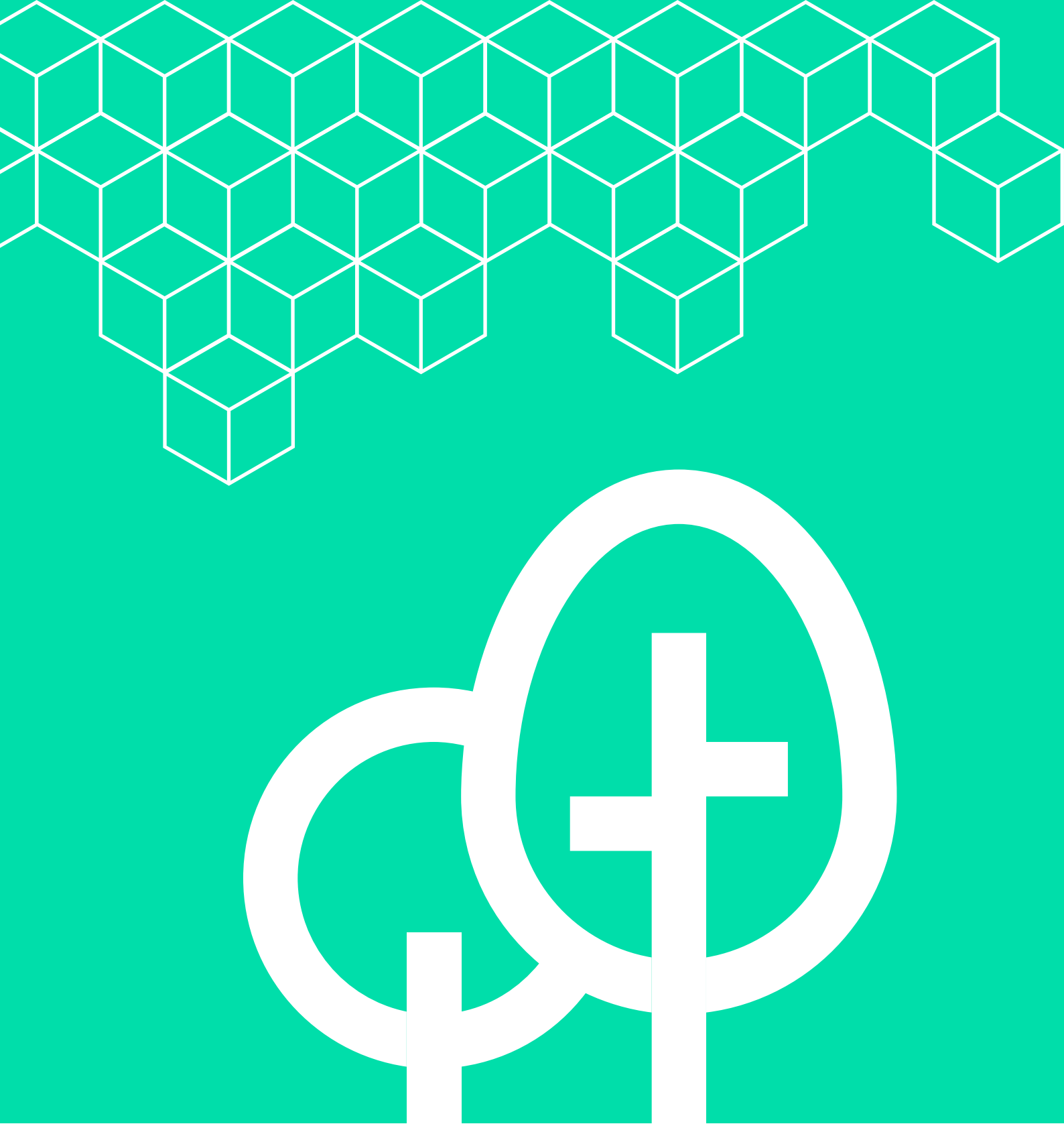
» Reassess and prioritise the actions and indicators for MRV with the aim of balancing the costs related to data collection against the benefits of higher accuracy. Lesotho could consider starting with

simplified approaches and less accurate data, with a view to and improving over time.

» Reduce reporting effort and resources by combining reporting activities across international initiatives where there are synergies.

» Consider the use of an IT-based system (MRV database) for data evaluation and storage.

» Use the monitored data to inform future needs and the use of climate finance,



5. CONSTRAINTS AND GAPS, AND RELATED FINANCIAL, TECHNICAL AND CAPACITY NEEDS, INCLUDING A DESCRIPTION OF SUPPORT NEEDED AND RECEIVED

CONSTRAINTS AND GAPS, AND RELATED FINANCIAL, TECHNICAL AND CAPACITY NEEDS, INCLUDING A DESCRIPTION OF SUPPORT NEEDED AND RECEIVED

5.1. INTRODUCTION

According to decision 2/CP.17, non-Annex I Parties should provide updated information on constraints and gaps, and related financial, technical, and capacity-building needs. Also, they should provide updated information on financial resources, technology transfer, capacity building, and technical support received from the Global Environment Facility. Concerning the development and transfer of technology, non-Annex I Parties should provide information on technology needs, which must be nationally determined, and on technology support received. For Lesotho to fulfil the reporting obligations arising from the 2/CP.17, further support is needed to build technical and institutional capacities and to continue the efforts of integrating climate change into national policies, plans, and programs.

As a Least Developed Country, Lesotho faces challenges related to poverty eradication and other socio-economic issues. While Lesotho recognises the support received from bilateral and multilateral partners to address climate change, it is evident that the level of support received to-date has not been sufficient for the country to meet its reporting obligations and implement its climate actions to the level it requires. Lesotho is highly vulnerable, and the priority has been to invest available resources in addressing adaptation needs rather than mitigation to guarantee the safety and wellbeing of the majority of the population, including vulnerable groups.

5.1.1 *Constraints and Gaps on Compilation of GHG Inventories*

The United Nations Framework Convention on Climate Change (UNFCCC) objective is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. For this objective to be achieved, countries must monitor the levels of greenhouse gas (GHG) emissions and removals. Lesotho has been compiling and reporting its GHG inventories since the First National Communication. The country is committed to implementing low carbon development strategies, and this commitment requires high-quality GHG inventories that are sustainable and consistent with the Intergovernmental Panel on Climate Change (IPCC) sectors and methodologies. However, there are three main constraints related to achieving such a quality inventory namely activity data, emission factors and capacity.

Capacity is the most limiting factor in achieving the high quality GHG inventory. There is a need to develop training courses to cover the various aspects of the GHG inventory process, such as IPCC guideline methodologies for all four sectors, quality assurance and quality control (QA/QC) process and methods, uncertainty analysis, key category analysis and even general coordination and management of the GHG inventory update process. These courses could be developed as short courses to support immediate needs and as part of post graduate university courses.

Activity data and Country specific emission factors- research programs or projects generating information on country specific emission factors in all sectors need to be supported. There are several challenges and data gaps in Agriculture, Forestry and Land-Use (AFOLU), Waste, transport and Industrial Processes and Product Use (IPPU). Constrains and gaps in these sectors include the following:

- Lack of good quality and consistent activity data: Data quality, completeness, and accuracy are the main concerns.
- Limited technical capacity in applying the national data and proxy data to generate the required data for GHG inventory.
- Lack of historical data – particularly for the land use, land use change and forestry, waste, industrial processes and energy sectors.
- Lack of GHG inventory management system with robust institutional arrangements for sustainable production of inventories.
- Lack of a pool of national experts able to compute GHG inventories at sectoral and national level.
- Lack of country-specific emission factors constrained the inventory compilers to the use of Tier 1 methods.

5.1.2 *Constraints and Gaps on Implementation of Greenhouse gas mitigation measures*

Lesotho is transitioning to low-carbon development pathways by leveraging on opportunities presented by green economy. The sectors such as energy, transport, agriculture, forestry, waste, land use and land use change have been identified as catalytic in propelling the transition to low-carbon development and green economy. The country is currently participating in a number of renewable energy projects to meet its energy demands and has identified and reported clear mitigation opportunities in its Nationally Determined Contributions (NDC) and National Climate Change Policy (NCCP). However, Lesotho as a least developed country, requires sustainable funding and technological support in order to make meaningful

contribution towards global efforts to reduce greenhouse gas concentrations in the atmosphere. Funding is required for research programmes and policy formulation. Of critical importance is support to build capacity around tracking of mitigation policies and measures as well as assessment of mitigation policies and measures (ex-post and ex-ante). There is also a need to develop short term training programmes to address capacity challenges associated with GHG mitigation measures. In addition to the aforementioned challenges, it is noted that when preparing the section on 'Mitigation Action and Their Effects as well as Nationally Appropriate Mitigation Actions (NAMAs) for this first Biennial Update Report (BUR), the gaps and constraints listed below were identified:

- Information on mitigation actions and their effects is very scarce and limited. Available information only contains the basic details like programme name, implementation agency, and objective, with little to no information to facilitate the assessment of the effects of the mitigation actions and emissions avoided.
- Limited in-country expertise to run models and undertake mitigation assessments.

5.1.3 *Constraints and Gaps on Domestic Measuring, Reporting and Verification (MRV) System*

The term Measuring, Reporting and Verification (MRV) originated from the Bali Action Plan which states that Greenhouse Gas (GHG) emissions reduction – shall be implemented in a "measurable (M), reportable (R) and verifiable (V)" manner. The key function of MRV system is enhancing transparency through the tracking of national GHG emissions, tracking of the impact of mitigation actions and tracking of climate finance flows received as well as capacity and technologies received. Moreover, MRV facilitates sharing of information and lessons learnt and allow assessing whether set targets have been achieved. A good MRV systems, is essential to track progress towards the implementation of the UNFCCC and achieving Nationally Determined Contributions (NDCs).

There is an opportunity to integrate the domestic Measuring, Reporting and Verification (MRV) system into the existing national-level monitoring and evaluation frameworks. MRV system needs to be institutionalised for its effectiveness. Currently, Lesotho's measurements and reporting are being done on an ad-hoc basis for specific projects. This ad-hoc based approach had rendered the process unsustainable. The country suffers from weak or absence of regular documentation and archiving, which is critical for an effective MRV system.

The fundamental step to establishing a systematic climate MRV system include the identification, formalisation and implementation of the relevant institutional frameworks and coordination mechanisms required to implement the actual MRV system. This step requires the allocation of enough human, technical, and technological resources. Within the framework of reporting for the first BUR, Lesotho developed the MRV Framework, which is the basis for the development of the functional MRV system for Lesotho. Capacity building of sufficient national experts remains a critical barrier in developing functional MRV system and should be prioritised. The development and implementation of this system depends on external financial and technical support.

5.2. Needs and support received

Lesotho has limited financial resources to implement climate change initiatives. Many adaptation and mitigation actions are limited by the cost and suitability of appropriate technologies. Slow payback of the investment in climate change adaptation actions, and low public investment and private participation in the adaptation actions are other limiting factors to addressing issues of climate change in the country. In addition, there is no proper collection/tracking of information on financial resources available to implement activities, including measures and programmes that have multiple uses or climate change co-benefits.

Another challenge is lack of technical knowledge on how (technical knowhow) to collect, manage and store data on climate change finance. Challenges in accessing or mobilizing financial support such as creating a domestic enabling environment and addressing human resource constraints have also been identified.

Despite the challenges, Lesotho is committed to mobilising resources that are necessary to overcome risks post by climate change, building resilience of the Basotho Nation and driving the country towards a low

carbon development pathway. In addition, Lesotho has developed a national Monitoring and Evaluation Framework to track the country's progress in meeting its climate goals and targets. The Framework is also expected to enable Lesotho to track climate financial flows, support on technology transfer and capacity building.

Table 1: Needs identified, Support needed, Specific type of support requested and time Support needed

Need identified	Support needed	Specific type of support requested [technology transfer, capacity building, financial support]	When is support needed?
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	Financial support, capacity building	As soon as possible
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	Financial support	2021
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	Capacity building	As soon as possible

Need identified	Support needed	Specific type of support requested [technology transfer, capacity building, financial support]	When is support needed?
Develop emission factor for road transport, solid waste and waste water.	Research programme with the university	Financial support, Technical Support	2023
Monitor waste water flows going to all Waste Water Treatment Works (WWTW) and evaporation ponds around the country.	Sanitary and industrial sewer flow measurement	Financial support, technology transfer	As soon as possible
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
Need for improved estimates of waste going to the Landfill at Ha Tsosane	Installation of weighbridges at Ha Tsosane Landfill. Recruitment of 8 extra personnel at the landfill for determination of waste composition in each truck load	Financial support	2021
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

Need identified	Support needed	Specific type of support requested [technology transfer, capacity building, financial support]	When is support needed?
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
Expertise on 2006 IPCC Guidelines	Online short-courses	Financial support, Technical Support	As soon as possible
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
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
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
There is need to monitor/ track, evaluate and document information on mitigation actions and their effects	Develop national monitoring and evaluation	Technical	As soon as possible

Need identified	Support needed	Specific type of support requested [technology transfer, capacity building, financial support]	When is support needed?
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
Promote renewable energy/ energy efficient technologies	Introduce RE energy tariffs, RE/ develop energy efficiency legislation	Technical and financial	As soon as possible
Accelerate research and development of renewable energy/ and energy efficient technologies	Research programmes with Universities	Technical and financial	As soon as possible
Promote climate smart agriculture	Implement country's Climate Smart Agriculture Investment Plan	Financial	2021
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
Strengthen existing institutional frameworks including sustainable GHG Inventory Management system, MRV system and NAMA coordination	Legalise National Climate Change Committee	Technical assistance	2021
Reduce emissions from the industry sector, manufacturing	Adopt green technologies in manufacturing industries	Technology transfer, technical, financial	2023

Need identified	Support needed	Specific type of support requested [technology transfer, capacity building, financial support]	When is support needed?
Need to track financial resources from donors	Implement MRV System	Capacity building	As soon as possible
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 to strengthen climate change data archiving system	Missing info	Financial	2021

5.3. Support Received

Lesotho has received financial and technical support from the bilateral and multilateral agencies. Most of the financial support received was from Global Environmental Facility (GEF) and Least Developed Countries Fund (LDCF) for the implementation of adaptation priorities identified under the National Adaptation Programme of Action (NAPA). The country also received financial support from GEF for capacity building to enable implementation of obligations under the Convention. Table 51details the support received from various multilateral and bilateral agreements and table 3 outlines non-monetized support received.

Table 5-1: Summary of bilateral and multilateral financial flows including GEF

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

LDCF- GEF	Strengthening Capacity for Climate Change Adaptation through Support to Integrated Watershed Management Programme in	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	Adaptation of Small-scale Agriculture (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	Energy	Mitigation	2016-2021	ongoing	19,267,837	3,500,000
IFAD	Wool and Mohair Promotion Project (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	Ongoing	Ongoing	N/A	7,500,000

5.4. Information on non-monetized Support Received

Table 5-2: Summary Information on non-monetized Support Received Presents summary of technical support received.

Table 5-2: Summary Information on non-monetized Support Received

Type of support [Capacity building, technology transfer]	Support Activity	Year of receipt (might be several years)	Status (ongoing, finalized)	Focus (mitigation, adaptation, unspecified)	Source of support
Policy formulation, Technical Support	Support to Climate Change Response Strategy	2016-2018	Finalised	Mitigation, Adaptation,	GCCA/GCCA+
Technology Transfer	Programme for the improvement of capabilities to cope with natural disasters caused by climate change	2010- 2012	Finalised	Adaptation,	Government of Japan
Technology Transfer	Project for the introduction of clean energy by solar Electricity generation system	2011-2013	Finalised	Adaptation	Government of Japan
Policy	Lesotho Scaling Renewable Energy Program (SREP) Investment Plan (IP)	2016-2019	Finalised	Mitigation	World Bank
Policy, Technical Support	Lesotho Climate Smart Agriculture Investment Plan	2017-2019	Finalised	Adaptation, Mitigation	World Bank

Policy formulation, Technical Support	Support to Reform in the Energy Sector	2018 - 2021	Ongoing	Mitigation	EU- GCCA
Technical Support	Climate Change Vulnerability, Risk Assessment, Adaptation and Mitigation	2016-2021	Ongoing	Mitigation, Adaptation	Italian Government
Technical Support	Technical Support to the COMESA-EAC-SADC Programme on Climate Change Adaptation and Mitigation at national level	2015-2021	Ongoing	Mitigation, Adaptation	FAO
Technical Support	SADC THEMA in Monitoring for Environment and Security in Africa (MESA)	August 2013 - August 2017	Finalised	Adaptation	EU

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APPENDICES

APPENDIX A - KEY CATEGORY ANALYSES (2010 & 2017)

A1 - Level assessment of the 2010 GHG Inventory year

Category Code	Category	Gas	2010 Estimate (Gg CO_2e)	2010 Absolute Value	Level Assessment (%)	Cumulative Total (%)
1A4b	Residential	CO_2	1227.51	1227.51	23.91	23.91
3A1	Enteric fermentation	CH_4	889.25	889.25	17.32	41.22
3C4	Direct emissions from agricultural soils	N_2O	601.07	601.07	11.71	52.93
1A4a	Commercial / Institutional	CO_2	506.07	506.07	9.86	62.7
3A2	Animal Waste Management Systems	N_2O	461.9	461.90	9.00	71.78
1A3b	Road	CO_2	323.95	323.95	6.31	78.09
1A4b	Residential	CH_4	261.15	261.15	5.09	83.17
4D	Waste water treatment and discharge	CH_4	236.00	236.00	4.60	87.77
3C5	Indirect emissions from agricultural soils	N_2O	171.95	171.95	3.35	91.12
1A4a	Commercial / Institutional	CH_4	95.58	95.58	1.86	92.98
3C1	Prescribed burning of savannas	CH_4	76.98	76.98	1.50	94.48
3C1	Prescribed burning of savannas	N_2O	75.99	75.99	1.48	95.96
1A2	Manufacturing Industries and Construction	CO_2	72.34	72.34	1.41	97.37
1A4b	Residential	N_2O	33.44	33.44	0.65	98.02
3A2	Animal Waste Management Systems	CH_4	30.63	30.63	0.60	98.62
1A4a	Commercial / Institutional	N_2O	17.25	17.25	0.34	98.95
4D	Waste water treatment and discharge	N_2O	14.6	14.60	0.28	99.24
4A	Solid waste disposal	CH_4	12.00	12.00	0.23	99.47
1A4c	Off-road vehicles and machinery	CO_2	6.72	6.72	0.13	99.60
3B1a	Forest – Forest	CO_2	-4.87	4.87	0.09	99.69
1A3b	Road	N_2O	4.74	4.74	0.09	99.79
4C2	Open burning of waste	CH_4	2.75	2.75	0.05	99.84
3B2a	Cropland - Cropland	CO_2	-2.62	2.62	0.05	99.89
1A3b	Road	CH_4	2.3	2.30	0.04	99.94
1A3a	Domestic aviation	CO_2	1.52	1.52	0.03	99.97

2A	Mineral industry	CO_2	0.81	0.81	0.02	99.98
4C2	Open burning of waste	CO_2	0.33	0.33	0.01	99.99
4C2	Open burning of waste	N_2O	0.3	0.30	0.01	99.99
1A2	Manufacturing Industries and Construction	N_2O	0.18	0.18	0.00	100.00
1A2	Manufacturing Industries and Construction	CH_4	0.07	0.07	0.00	100.00
1A4c	Off-road vehicles and machinery	CH_4	0.02	0.02	0.00	100.00
1A4c	Off-road vehicles and machinery	N_2O	0.02	0.02	0.00	100.00
1A3a	Domestic aviation	N_2O	0.01	0.01	0.00	100.00
	Totals:		5119.94	5134.92		

A2 - Level assessment of the 2017 GHG Inventory year

Category Code	Category	Gas	2017 Estimate (Gg CO_2e)	2017 Absolute Value	Level Assessment (%)	Cumulative Total (%)
1A4b	Residential	CO_2	1553.25	1553.25	27.44%	27.44%
3B1	Forest land	CO_2	1089.55	1089.55	19.25%	46.69%
3A1	Enteric Fermentation	CH_4	669.65	669.65	11.83%	58.52%
1A3b	Road Transport	CO_2	455.77	455.77	8.05%	66.57%
3C4	Direct emissions from managed soils	N_2O	408.85	408.85	7.22%	73.79%
1A4a	Commercial / Institutional	CO_2	358.75	358.75	6.34%	80.13%
1A4b	Residential	CH_4	300.06	300.06	5.30%	85.43%
4A	Solid Waste Disposal	CH_4	236.61	236.61	4.18%	89.61%
3C6	Indirect emissions from managed soils	N_2O	135.11	135.11	2.39%	92.00%
3A2	Manure Management	N_2O	62.78	62.78	1.11%	93.11%
1A2	Manufacturing Industries and Construction	CO_2	60.82	60.82	1.07%	94.18%
1A4a	Commercial / Institutional	CH_4	51.89	51.89	0.92%	95.10%
	Residential	N_2O	47.550	47.550	0.84%	95.94%
	Open Burning of Waste	CH_4	46.890	46.890	0.83%	96.77%
	Wastewater Treatment and discharge	CH_4	37.612	37.612	0.66%	97.43%
	Wastewater Treatment and discharge	N_2O	34.806	34.806	0.61%	98.05%
	Manure Management	CH_4	25.167	25.167	0.44%	98.49%

Category Code	Category	Gas	2017 Estimate (Gg CO_2e)	2017 Absolute Value	Level Assessment (%)	Cumulative Total (%)
	Emissions from biomass burning	N_2O	13.609	13.609	0.24%	98.73%
	Commercial / Institutional	N_2O	11.817	11.817	0.21%	98.94%
	Emissions from biomass burning	CH_4	10.124	10.124	0.18%	99.12%
	Agric, Forestry, fishing	CO_2	9.939	9.939	0.18%	99.30%
	Open Burning of Waste	N_2O	9.105	9.105	0.16%	99.46%
	Road Transport	N_2O	6.829	6.829	0.12%	99.58%
	Open Burning of Waste	CO_2	5.330	5.330	0.09%	99.67%
	Refrigeration and airconditioning	HFC - 125	3.954	3.954	0.07%	99.74%
	Road Transport	CH_4	3.297	3.297	0.06%	99.80%
	Refrigeration and airconditioning	HFC - 143a	3.237	3.237	0.06%	99.86%
	Refrigeration and airconditioning	HFC-134a	3.171	3.171	0.06%	99.91%
	Indirect N_2O Emissions from Manure Management	N_2O	2.055	2.055	0.04%	99.95%
	Ceramics	CO_2	1.079	1.079	0.02%	99.97%
	Civil Aviation	CO_2	0.940	0.940	0.02%	99.99%
	Refrigeration and air-conditioning	HFC - 32	0.456	0.456	0.01%	99.99%
	Manufacturing Industries and Construction	N_2O	0.141	0.141	0.00%	100.00%
	Urea Application	CO	0.080	0.080	0.00%	100.00%
	Manufacturing Industries and Construction	CH_4	0.049	0.049	0.00%	100.00%
	Waste Incineration	CO_2	0.037	0.037	0.00%	100.00%
	Agric, Forestry, fishing	CH_4	0.028	0.028	0.00%	100.00%
	Agric, Forestry, fishing	N_2O	0.025	0.025	0.00%	100.00%
	Civil Aviation	N_2O	0.008	0.008	0.00%	100.00%
	Waste Incineration	N_2O	0.003	0.003	0.00%	100.00%
	Waste Incineration	CH_4	0.000	0.000	0.00%	100.00%
	Civil Aviation	CH_4	0.000	0.000	0.84%	95.94%
	TOTAL		5 660.43			

APPENDIX B - QUALITY CONTROL SHEET

Sector: _____

Name of Sector compiler: _____

Name of Quality controller: _____

Date: _____

QC Activity	Procedures	Quality Control	
		Done? Tick	Comments
Activity data QC	Check the temporal consistency of the activity data; Check the consistency of the units		
EF data QC	IPCC default EF: Check default EF applicability Check temporal consistency Check the consistency of the units		
General data QC	Check the data calculations Reproduce a set of emission/removal calculations Calculate Implied Emission Factor		
	Check any recalculation data		
	Check that emission and removal data are correctly aggregated from lower reporting levels		
	Check that the data is compared to previous estimates		
	Check for consistency in the trend		
	Check for completeness of each subcategory		
Uncertainty QC	Check that expert judgement is recorded Check uncertainty calculations		
Database QC	Check that the data is in the database		
	Check for transcription errors		
	Check uncertainty is in the database		
	Check for transcription errors in uncertainty data		
	Check the correct units have been used in the database		
	Check the labels in the database are correct		
	Check that data sources / references have been correctly recorded		
	Check the correct conversion factors are used		
	Check data aggregations are correct		
	Check the uncertainty aggregations are correct		
	Check that original and supporting documents are attached		

APPENDIX C - NATIONAL GHG INVENTORY TABLES 2011 - 2017

Table 7-1 Results of the 2011 National GHG Inventory, in Gg CO_2e

Code	Category	2011						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1. ENERGY		2201.79	321.99	59.83				
1A	Fuel Combustion Activities	2201.79	321.99	59.83				
1A2	Manufacturing Industries and Construction	56.55	0.05	0.14				
1A3	Transport	382.30	2.57	5.77				
1A3a	Civil Aviation	0.15	0.00	0.00				
1A3a	Road Transport	382.15	2.57	5.77				
1A4	Other Sectors	1762.94	319.37	53.92				
1A4a	Commercial / Institutional	326.93	46.98	10.76				
1A4b	Residential	1426.22	272.36	43.14				
1A4c	Agric. / Forestry / fish	9.80	0.03	0.02				
2. IPPU*		1.67			0.13	0.92	1.80	0.65
2A	Mineral Industry	1.67						
2A4	Other Process Uses of Carbonates	1.67						
2A4a	Ceramics	1.67						
2F	Product Uses as Substitutes for ODS				0.13	0.92	1.80	0.65
2F1	Refrigeration and Air Conditioning				0.13	0.92	1.80	0.65
2F1a	Refrigeration and Stationery AC				0.13	0.92	1.80	0.65

Code	Category	2011						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
3. AFOLU		1193.72	806.19	690.49				
3A	Livestock		790.57	60.83				
3A1	Enteric Fermentation		761.19					
3A2	Manure Management		29.38	60.83				
3B	Land	1193.64						
3B1	Forest land	1193.64						
3C	Aggregate sources and non-CO_2 emissions sources on land	0.08	15.62	629.66				
3C1	Emissions from biomass burning		15.62	21.03				
3C3	Urea Application	0.08						
3C4	Direct N_2O emission from managed soils			465.86				
3C5	Indirect N_2O emission from managed soils			140.59				
3C6	Indirect N_2O Emissions from Manure Management			2.18				
4. WASTE		5.01	292.07	40.98				
4A	Solid Waste Disposal		213.59					
4C	Incineration and open burning of waste	5.01	43.76	8.50				
4C1	Waste Incineration	0.04	0.00	0.00				
4C2	Open Burning of Waste	4.97	43.76	8.50				

Code	Category	2011						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
4D	Wastewater Treatment and discharge		34.71	32.48				
TOTAL 2011 INVENTORY (Gg CO_2e)		3402.20	1420.25	791.30	0.13	0.92	1.80	0.65

*2H2: Food and Beverage industry emitted 0.0089 Gg of NMVOC in 2011.

Table 7-2 Results of the 2012 National GHG Inventory, in Gg CO_2e

	Category	2012						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1. ENERGY		2127.32	326.77	59.60				
1A	Fuel Combustion Activities	2127.32	326.77	59.60				
1A2	Manufacturing Industries and Construction	52.06	0.04	0.13				
1A3	Transport	312.99	2.01	4.75				
	Civil Aviation	0.43	0.00	0.00				
	Road Transport	312.56	2.01	4.75				
1A4	Other Sectors	1162.27	324.70	54.72				
	Commercial / Institutional	332.23	47.80	10.89				
	Residential	1421.15	276.90	43.80				
	Agric. / Forestry / fish	8.89	0.03	0.02				
2. IPPU*		1.60			0.17	1.28	2.02	0.95
2A	Mineral Industry	1.60						
2A4	Other Process Uses of Carbonates	1.60						
	Ceramics	1.60						

	Category	2012						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
2F	Product Uses as Substitutes for ODS				0.17	1.28	2.02	0.95
2F1	Refrigeration and Air Conditioning				0.17	1.28	2.02	0.95
2F1a	Refrigeration and Stationery AC				0.17	1.28	2.02	0.95
3. AFOLU		1164.94	719.90	631.09				
3A	Livestock		711.77	62.26				
3A1	Enteric Fermentation		684.94					
3A2	Manure Management		26.83	62.26				
3B	Land	1164.86						
3B1	Forest land	1164.86						
3C	Aggregate sources and non-CO_2 emissions sources on land	0.08	8.13	568.83				
3C1	Emissions from biomass burning		8.13	10.92				
3C3	Urea Application	0.08						
3C4	Direct N_2O emission from managed soils			423.85				
3C5	Indirect N_2O emission from managed soils			131.84				
3C6	Indirect N_2O Emissions from Manure Management			2.21				
4. WASTE		5.07	297.24	41.47				

	Category	2012						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
4A	Solid Waste Disposal		217.40					
4C	Incineration and open burning of waste	5.07	44.28	8.60				
4C1	Waste Incineration	0.04	0.00	0.00				
4C2	Open Burning of Waste	5.03	44.28	8.60				
4D	Wastewater Treatment and discharge		35.55	32.87				
TOTAL 2012 INVENTORY (Gg CO_2e)		3298.93	1343.90	732.15	0.17	1.28	2.02	0.95

*2H2: Food and Beverage industry emitted 0.0096 Gg of NMVOC in 2012.

Table 7-3: Results of the 2013 National GHG Inventory, in Gg CO_2e

	Category	2013						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1. ENERGY		2152.79	332.18	60.51				
1A	Fuel Combustion Activities	2152.79	332.18	60.51				
1A2	Manufacturing Industries and Construction	53.24	0.04	0.13				
1A3	Transport	312.41	1.98	4.75				
	Civil Aviation	0.80	0.00	0.01				
	Road Transport	311.61	1.98	4.74				
1A4	Other Sectors	1787.14	330.15	55.64				
	Commercial / Institutional	337.53	48.62	11.08				
	Residential	1440.61	281.51	44.53				

	Category	2013						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
	Agric. / Forestry / fish	8.99	0.03	0.02				
2. IPPU*		1.07			0.18	1.51	2.03	1.24
2A	Mineral Industry	1.07						
2A4	Other Process Uses of Carbonates	1.07						
	Ceramics	1.07						
2F	Product Uses as Substitutes for ODS				0.18	1.51	2.03	1.24
2F1	Refrigeration and Air Conditioning				0.18	1.51	2.03	1.24
2F1a	Refrigeration and Stationery AC				0.18	1.51	2.03	1.24
3. AFOLU		1156.62	669.10	577.72				
3A	Livestock		662.44	51.22				
3A1	Enteric Fermentation		638.50					
3A2	Manure Management		23.95	51.22				
3B	Land	1156.50						
3B1	Forest land	1156.60						
3C	Aggregate sources and non-CO_2 emissions sources on land	0.12	6.66	526.50				
3C1	Emissions from biomass burning		6.66	8.94				
3C3	Urea Application	0.12						
3C4	Direct N_2O emission from managed soils			394.31				

	Category	2013						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
3C5	Indirect N_2O emission from managed soils			121.49				
3C6	Indirect N_2O Emissions from Manure Management			1.76				
4. WASTE		5.13	301.99	41.96				
4A	Solid Waste Disposal		221.22					
4C	Incineration and open burning of waste	5.13	44.80	8.70				
4C1	Waste Incineration	0.04	0.00	0.00				
4C2	Open Burning of Waste	5.09	44.80	8.70				
4D	Wastewater Treatment and discharge		35.97	33.26				
TOTAL 2013 INVENTORY (Gg CO_2e)		3315.60	1303.27	680.19	0.18	1.51	2.03	1.21

*2H2: Food and Beverage industry emitted 0.0085 Gg of NMVOC in 2013.

Table 9-4: Results of the 2014 National GHG Inventory, in Gg CO_2e

	Category	2014						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1. ENERGY		2311.66	338.35	63.04				
1A	Fuel Combustion Activities	2311.66	338.35	63.04				
1A2	Manufacturing Industries and Construction	68.08	0.06	0.16				

	Category	2014						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1A3	Transport	414.08	2.65	6.28				
	Civil Aviation	0.60	0.00	0.01				
	Road Transport	413.48	2.65	6.27				
1A4	Other Sectors	1829.51	335.64	56.60				
	Commercial / Institutional	342.84	49.44	11.26				
	Residential	1475.11	286.17	45.30				
	Agric. / Forestry / fish	11.56	0.03	0.03				
2. IPPU*		1.60			0.24	1.73	2.43	1.22
2A	Mineral Industry	1.60						
2A4	Other Process Uses of Carbonates	1.60						
	Ceramics	1.60						
2F	Product Uses as Substitutes for ODS				0.24	1.73	2.43	1.22
2F1	Refrigeration and Air Conditioning				0.24	1.73	2.43	1.22
2F1a	Refrigeration and Stationery AC				0.24	1.73	2.43	1.22
3. AFOLU		1124.79	654.31	571.65				
3A	Livestock		649.19	52.80				
3A1	Enteric Fermentation		625.25					
3A2	Manure Management		23.94	52.80				
3B	Land	1124.71						
3B1	Forest land	1124.71						

	Category	2014						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
3C	Aggregate sources and non-CO_2 emissions sources on land	0.07	5.12	518.84				
3C1	Emissions from biomass burning		5.12	6.86				
3C3	Urea Application	0.07						
3C4	Direct N_2O emission from managed soils			390.29				
3C5	Indirect N_2O emission from managed soils			120.01				
3C6	Indirect N_2O Emissions from Manure Management			1.68				
4. WASTE		5.19	306.75	42.45				
4A	Solid Waste Disposal		225.04					
4C	Incineration and open burning of waste	5.19	45.33	8.80				
4C1	Waste Incineration	0.04	0.00	0.00				
4C2	Open Burning of Waste	5.15	45.33	8.80				
4D	Wastewater Treatment and discharge		36.38	33.64				
TOTAL 2014 INVENTORY (Gg CO_2e)		3443.25	1299.40	677.13	0.24	1.73	2.43	1.22

Table 9-5 Results of the 2015 National GHG Inventory, in Gg CO_2e

Code	Category	2015						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1. ENERGY		2382.80	344.07	64.57				
1A	Fuel Combustion Activities	2382.75	344.07	64.57				
1A2	Manufacturing Industries and Construction	73.29	0.06	0.17				
1A3	Transport	454.04	2.94	6.88				
1A3a	Civil Aviation	0.67	0.00	0.01				
1A3a	Road Transport	453.37	2.94	6.87				
1A4	Other Sectors	155.43	341.04	57.52				
1A4a	Commercial / Institutional	348.14	50.26	11.45				
1A4b	Residential	1494.89	290.78	46.04				
1A4b	Agric. / Forestry / fish	12.39	0.04	0.03				
2. IPPU*		1.26			0.31	2.55	2.61	2.03
2A	Mineral Industry	1.26						
2A4	Other Process Uses of Carbonates	1.26						
2A4a	Ceramics	1.26						
2F	Product Uses as Substitutes for ODS				0.31	2.55	2.61	2.03
2F1	Refrigeration and Air Conditioning				0.31	2.55	2.61	2.03
2F1a	Refrigeration and Stationery AC				0.31	2.55	2.61	2.03
3. AFOLU		1097.63	639.72	570.84				
3A	Livestock		632.18	57.10				
3A1	Enteric Fermentation		608.04					

Code	Category	2015						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
3A2	Manure Management		24.14	57.10				
3B	Land	1097.58						
3B1	Forest land	1097.58						
3C	Aggregate sources and non-CO_2 emissions sources on land	0.05	7.54	513.74				
3C1	Emissions from biomass burning		7.54	10.12				
3C3	Urea Application	0.05						
3C4	Direct N_2O emission from managed soils			382.35				
3C5	Indirect N_2O emission from managed soils			119.28				
3C6	Indirect N_2O Emissions from Manure Management			1.99				
4. WASTE		5.25	345.54	8.91				
4A	Solid Waste Disposal		228.87					
4C	Incineration and open burning of waste	5.25	45.85	8.91				
4C1	Waste Incineration	0.04	0.00	0.00				
4C2	Open Burning of Waste	5.21	45.85	8.90				
4D	Wastewater Treatment and discharge		36.79	34.03				

Code	Category	2015						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
TOTAL 2015 INVENTORY (Gg CO_2e)		3486.89	1295.30	678.35	0.31	2.55	2.61	2.03

*2H2: Food and Beverage industry emitted 0.009 Gg of NMVOC in 2015.

Table 9-6: Results of the 2016 National GHG Inventory, in Gg CO_2e

Code	Category	2016						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1. ENERGY		2454.11	349.81	66.01				
1A	Fuel Combustion Activities	2454.11	349.81	66.01				
1A2	Manufacturing Industries and Construction	76.58	0.06	0.18				
1A3	Transport	487.38	3.21	7.37				
1A3a	Civil Aviation	0.58	0.00	0.01				
1A3a	Road Transport	486.82	3.21	7.36				
1A4	Other Sectors	1890.13	346.53	58.46				
1A4a	Commercial / Institutional	353.45	51.07	11.63				
1A4b	Residential	1523.80	295.42	46.79				
1A4b	Agric. / Forestry / fish	12.88	0.04	0.03				
2. IPPU*		1.16			0.37	3.21	2.88	2.60
2A	Mineral Industry	1.16						
2A4	Other Process Uses of Carbonates	1.16						
2A4a	Ceramics	1.16						
2F	Product Uses as Substitutes for ODS				0.37	3.21	2.88	2.60
2F1	Refrigeration and Air Conditioning				0.37	3.21	2.88	2.60
2F1a	Refrigeration and Stationery AC				0.37	3.21	2.88	2.60

Code	Category	2016						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
3. AFOLU		1117.31	627.90	549.32				
3A	Livestock		617.78	55.18				
3A1	Enteric Fermentation		594.30					
3A2	Manure Management		23.47	55.18				
3B	Land	1117.23						
3B1	Forest land	1117.23						
3C	Aggregate sources and non-CO_2 emissions sources on land	0.08	10.12	494.13				
3C1	Emissions from biomass burning		10.12	13.61				
3C3	Urea Application	0.08						
3C4	Direct N_2O emission from managed soils			364.69				
3C5	Indirect N_2O emission from managed soils			114.07				
3C6	Indirect N_2O Emissions from Manure Management			1.77				
4. WASTE		5.31	16.28	43.42				
4A	Solid Waste Disposal		232.71					
4C	Incineration and open burning of waste	5.31	43.37	9.01				
4C1	Waste Incineration	0.04	0.00	0.00				
4C2	Open Burning of Waste	5.27	46.37	9.00				

Code	Category	2016						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
4D	Wastewater Treatment and discharge		37.20	34.42				
TOTAL 2016 INVENTORY (Gg CO_2e)		3576.73	1293.99	658.75	0.37	3.21	2.88	2.60

*2H2t: Food and Beverage industry emitted 0.0114 Gg of NMVOC in 2016.

Table 9-7Results of the 2017 National GHG Inventory, in Gg CO_2e

Code	Category	2017						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1. ENERGY		2439.47	355.33	66.37				
1A	Fuel Combustion Activities	2439.47	355.33	66.37				
1A2	Manufacturing Industries and Construction	60.82	0.05	0.14				
1A3	Transport	456.71	3.30	6.84				
1A3a	Civil Aviation	0.58	0.00	0.01				
1A3a	Road Transport	455.77	3.30	6.83				
1A4	Other Sectors	1912.94	351.98	59.39				
1A4a	Commercial / Institutional	358.75	51.89	11.82				
1A4b	Residential	1523.25	300.06	47.55				
1A4b	Agric. / Forestry / fish	9.94	0.03	0.02				
2. IPPU*		1.08			0.46	3.95	3.17	3.24
2A	Mineral Industry	1.08						
2A4	Other Process Uses of Carbonates	1.08						
2A4a	Ceramics	1.08						

Code	Category	2017						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
2F	Product Uses as Substitutes for ODS				0.46	3.95	3.17	3.24
2F1	Refrigeration and Air Conditioning				0.46	3.95	3.17	3.24
2F1a	Refrigeration and Stationery AC				0.46	3.95	3.17	3.24
3. AFOLU			704.94	622.40				
3A	Livestock		694.81	62.78				
3A1	Enteric Fermentation		669.65					
3A2	Manure Management		25.17	62.78				
3B	Land							
3B1	Forest land							
3C	Aggregate sources and non-CO_2 emissions sources on land	0.08	10.12	599.62				
3C1	Emissions from biomass burning		10.12	13.61				
3C3	Urea Application	0.08						
3C4	Direct N_2O emission from managed soils			408.85				
3C5	Indirect N_2O emission from managed soils			135.11				
3C6	Indirect N_2O Emissions from Manure Management			2.05				
4. WASTE		5.37	321.11	43.91				
4A	Solid Waste Disposal		236.61					

Code	Category	2017						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
4C	Incineration and open burning of waste	5.37	46.89	9.11				
4C1	Waste Incineration	0.04	0.00	0.00				
4C2	Open Burning of Waste	5.33	46.89	9.11				
4D	Wastewater Treatment and discharge		37.61	34.81				
TOTAL 2017 INVENTORY (Gg CO_2e)		3534.47	1381.38	732.69	0.46	3.95	3.17	3.24

*2H2: Food and Beverage industry emitted 0.0151 Gg of NMVOC in 2017.

Table 9-8 Results of the 2011 National GHG Inventory, in Gg

Code	Category	2011						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1. ENERGY		2201.79	15.21	0.20				
1A	Fuel Combustion Activities	2201.79	15.21	0.17				
1A2	Manufacturing Industries and Construction	56.55	0.00	0.00				
1A3	Transport	382.30	0.12	0.02				
1A3a	Civil Aviation	0.15	0.00	0.00				
1A3a	Road Transport	382.15	0.12	0.02				
1A4	Other Sectors	1762.94	15.21	0.17				
1A4a	Commercial / Institutional	326.93	2.24	0.03				
1A4b	Residential	1426.22	12.97	0.14				
1A4b	Agric. / Forestry / fish	9.80	0.00	0.00				
2. IPPU*		1.67			0.00	0.00	0.00	0.00
2A	Mineral Industry	1.67						

Code	Category	2011						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
2A4	Other Process Uses of Carbonates	1.67						
2A4a	Ceramics	1.67						
2F	Product Uses as Substitutes for ODS				0.00	0.00	0.00	0.00
2F1	Refrigeration and Air Conditioning				0.00	0.00	0.00	0.00
2F1a	Refrigeration and Stationery AC				0.00	0.00	0.00	0.00
3. AFOLU		1193.72	38.39	2.23				
3A	Livestock		37.65	0.20				
3A1	Enteric Fermentation		36.25					
3A2	Manure Management		1.40	0.20				
3B	Land	1193.64						
3B1	Forest land	1193.64						
3C	Aggregate sources and non-CO_2 emissions sources on land	0.08	0.74	2.03				
3C1	Emissions from biomass burning		0.74	0.07				
3C3	Urea Application	0.08						
3C4	Direct N_2O emission from managed soils			1.50				
3C5	Indirect N_2O emission from managed soils			0.45				
3C6	Indirect N_2O Emissions from Manure Management			0.01				

Code	Category	2011						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
4. WASTE		5.01	12.25	0.03				
4A	Solid Waste Disposal		10.17					
4C	Incineration and open burning of waste	5.01	2.08	0.03				
4C1	Waste Incineration	0.04	0.00	0.00				
4C2	Open Burning of Waste	4.97	2.08	0.03				
4D	Wastewater Treatment and discharge		1.65	0.10				

Table 9-9: Results of the 2012 National GHG Inventory, in Gg

Code	Category	2012						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1. ENERGY		2127.32	15.50	0.20				
1A	Fuel Combustion Activities	2127.32	15.46	0.17				
1A2	Manufacturing Industries and Construction	52.06	0.00	0.00				
1A3	Transport	312.99	0.10	0.02				
1A3a	Civil Aviation	0.43	0.00	0.00				
1A3a	Road Transport	312.56	0.10	0.02				
1A4	Other Sectors	1162.27	15.46	0.18				
1A4a	Commercial / Institutional	332.23	2.28	0.04				
1A4b	Residential	1421.15	13.19	0.14				
1A4b	Agric. / Forestry / fish	8.89	0.00	0.00				

Code	Category	2012						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
2. IPPU*		1.60			0.00	0.00	0.00	0.00
2A	Mineral Industry	1.60						
2A4	Other Process Uses of Carbonates	1.60						
2A4a	Ceramics	1.60						
2F	Product Uses as Substitutes for ODS				0.00	0.00	0.00	0.00
2F1	Refrigeration and Air Conditioning				0.00	0.00	0.00	0.00
2F1a	Refrigeration and Stationery AC				0.00	0.00	0.00	0.00
3. AFOLU		1164.94	34.29	2.03				
3A	Livestock		33.90	0.20				
3A1	Enteric Fermentation		32.62					
3A2	Manure Management		1.28	0.20				
3B	Land	1164.86						
3B1	Forest land	1164.86						
3C	Aggregate sources and non-CO_2 emissions sources on land	0.08	0.39	1.83				
3C1	Emissions from biomass burning		0.39	0.04				
3C3	Urea Application	0.08						
3C4	Direct N_2O emission from managed soils			1.37				
3C5	Indirect N_2O emission from managed soils			0.43				

Code	Category	2012						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
3C6	Indirect N_2O Emissions from Manure Management			0.01				
4. WASTE		5.07	12.46	0.03				
4A	Solid Waste Disposal		10.35					
4C	Incineration and open burning of waste	5.07	2.11	0.03				
4C1	Waste Incineration	0.04	0.00	0.00				
4C2	Open Burning of Waste	5.03	2.11	0.03				
4D	Wastewater Treatment and discharge		1.69	0.11				

Table 9-10 Results of the 2013 National GHG Inventory, in Gg

Code	Category	2013						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1. ENERGY		2152.79	2152.79	0.20				
1A	Fuel Combustion Activities	2152.79	15.72	0.20				
1A2	Manufacturing Industries and Construction	53.24	0.00	0.00				
1A3	Transport	312.41	0.09	0.02				
1A3a	Civil Aviation	0.80	0.00	0.00				
1A3a	Road Transport	311.61	0.09	0.02				
1A4	Other Sectors	1787.14	15.72	0.18				
1A4a	Commercial / Institutional	337.53	2.32	0.04				

Code	Category	2013						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1A4b	Residential	1440.61	13.41	0.14				
1A4b	Agric. / Forestry / fish	8.99	0.00	0.00				
2. IPPU*		1.07			0.00	0.00	0.00	0.00
2A	Mineral Industry	1.07						
2A4	Other Process Uses of Carbonates	1.07						
2A4a	Ceramics	1.07						
2F	Product Uses as Substitutes for ODS				0.00	0.00	0.00	0.00
2F1	Refrigeration and Air Conditioning				0.00	0.00	0.00	0.00
2F1a	Refrigeration and Stationery AC				0.00	0.00	0.00	0.00
3. AFOLU		1156.62	31.86	1.87				
3A	Livestock		31.54	0.17				
3A1	Enteric Fermentation		30.40					
3A2	Manure Management		1.14	0.17				
3B	Land	1156.50						
3B1	Forest land							
3C	Aggregate sources and non-CO_2 emissions sources on land	0.12	0.32	1.70				
3C1	Emissions from biomass burning		0.32	0.03				
3C3	Urea Application	0.12						
3C4	Direct N_2O emission from managed soils			1.27				

Code	Category	2013						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
3C5	Indirect N_2O emission from managed soils			0.39				
3C6	Indirect N_2O Emissions from Manure Management			0.01				
4. WASTE		5.13	12.67	0.03				
4A	Solid Waste Disposal		10.53					
4C	Incineration and open burning of waste	5.13	2.13	0.03				
4C1	Waste Incineration	0.04	0.00	0.00				
4C2	Open Burning of Waste	5.09	2.13	0.03				
4D	Wastewater Treatment and discharge		1.71	0.11				

Table 9-11 Results of the 2014 National GHG Inventory, in Gg

Code	Category	2014						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1. ENERGY		2311.66	2311.66	0.20				
1A	Fuel Combustion Activities	2311.66	15.98	0.18				
1A2	Manufacturing Industries and Construction	68.08	0.00	0.00				
1A3	Transport	414.08	0.13	0.02				
1A3a	Civil Aviation	0.60	0.00	0.00				
1A3a	Road Transport	413.48	0.13	0.02				
1A4	Other Sectors	1829.51	15.98	0.19				

Code	Category	2014						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1A4a	Commercial / Institutional	342.84	2.35	0.04				
1A4b	Residential	1475.11	13.63	0.15				
1A4b	Agric. / Forestry / fish	11.56	0.00	0.00				
2. IPPU*		1.60			0.00	0.00	0.00	0.00
2A	Mineral Industry	1.60						
2A4	Other Process Uses of Carbonates	1.60						
2A4a	Ceramics	1.60						
2F	Product Uses as Substitutes for ODS				0.00	0.00	0.00	0.00
2F1	Refrigeration and Air Conditioning				0.00	0.00	0.00	0.00
2F1a	Refrigeration and Stationery AC				0.00	0.00	0.00	0.00
3. AFOLU		1124.78	31.15	1.84				
3A	Livestock		30.91	0.17				
3A1	Enteric Fermentation		29.77					
3A2	Manure Management		1.14	0.17				
3B	Land	1124.71						
3B1	Forest land	1124.71						
3C	Aggregate sources and non-CO_2 emissions sources on land	0.07	0.24	1.67				
3C1	Emissions from biomass burning		0.24	0.02				
3C3	Urea Application	0.07						

Code	Category	2014						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
3C4	Direct N_2O emission from managed soils			1.26				
3C5	Indirect N_2O emission from managed soils			0.39				
3C6	Indirect N_2O Emissions from Manure Management			0.01				
4. WASTE		5.19	12.87	0.03				
4A	Solid Waste Disposal		10.72					
4C	Incineration and open burning of waste	5.19	2.16	0.03				
4C1	Waste Incineration	0.04	0.00	0.00				
4C2	Open Burning of Waste	5.15	2.16	0.03				
4D	Wastewater Treatment and discharge		1.73	0.11				

Table 9-12 Results of the 2015 National GHG Inventory, in Gg

Code	Category	2015						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1. ENERGY		2382.75	16.24	0.20				
1A	Fuel Combustion Activities	2382.75	16.24	0.19				
1A2	Manufacturing Industries and Construction	73.29	0.00	0.00				
1A3	Transport	454.04	0.14	0.02				
1A3a	Civil Aviation	0.67	0.00	0.00				

Code	Category	2015						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1A3a	Road Transport	453.37	0.14	0.02				
1A4	Other Sectors	155.43	16.24	0.19				
1A4a	Commercial / Institutional	348.14	2.39	0.04				
1A4b	Residential		13.85	0.15				
1A4b	Agric. / Forestry / fish	12.39	0.00	0.00				
2. IPPU*		1.26			0.00	0.00	0.00	0.00
2A	Mineral Industry	1.26						
2A4	Other Process Uses of Carbonates	1.26						
2A4a	Ceramics	1.26						
2F	Product Uses as Substitutes for ODS				0.00	0.00	0.00	0.00
2F1	Refrigeration and Air Conditioning				0.00	0.00	0.00	0.00
2F1a	Refrigeration and Stationery AC				0.00	0.00	0.00	0.00
3. AFOLU		1097.63	30.46	1.84				
3A	Livestock		30.10	0.18				
3A1	Enteric Fermentation		28.95					
3A2	Manure Management		1.15	0.18				
3B	Land	1097.58						
3B1	Forest land	1097.58						
3C	Aggregate sources and non-CO_2 emissions sources on land	0.05	0.36	1.66				
3C1	Emissions from biomass burning		0.36	0.03				
3C3	Urea Application	0.05						

Code	Category	2015						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
3C4	Direct N_2O emission from managed soils			1.23				
3C5	Indirect N_2O emission from managed soils			0.38				
3C6	Indirect N_2O Emissions from Manure Management			0.01				
4. WASTE		5.25	13.08	0.03				
4A	Solid Waste Disposal		10.90					
4C	Incineration and open burning of waste	5.25	2.18	0.03				
4C1	Waste Incineration	0.04	0.00	0.00				
4C2	Open Burning of Waste	5.21	2.18	0.03				
4D	Wastewater Treatment and discharge		1.75	0.11				

Table 9-13 Results of the 2016 National GHG Inventory, in Gg

Code	Category	2016						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1. ENERGY		2454.11	16.50	0.20				
1A	Fuel Combustion Activities	2454.11	16.50	0.20				
1A2	Manufacturing Industries and Construction	76.58	0.00	0.00				
1A3	Transport	487.38	0.15	0.02				
1A3a	Civil Aviation	0.58	0.00	0.00				
1A3a	Road Transport	486.82	0.15	0.02				

Code	Category	2016						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1A4	Other Sectors	1890.13	16.50	0.19				
1A4a	Commercial / Institutional	353.45	2.43	0.04				
1A4b	Residential	1523.80	14.07	0.15				
1A4b	Agric. / Forestry / fish	12.88	0.00	0.00				
2. IPPU*		1.16			0.00	0.00	0.00	0.00
2A	Mineral Industry	1.16						
2A4	Other Process Uses of Carbonates	1.16						
2A4a	Ceramics	1.16						
2F	Product Uses as Substitutes for ODS				0.00	0.00	0.00	0.00
2F1	Refrigeration and Air Conditioning				0.00	0.00	0.00	0.00
2F1a	Refrigeration and Stationery AC				0.00	0.00	0.00	0.00
3. AFOLU		1117.31	29.90	1.77				
3A	Livestock		29.42	0.18				
3A1	Enteric Fermentation		28.30					
3A2	Manure Management		1.12	0.18				
3B	Land	1117.23						
3B1	Forest land	1117.23						
3C	Aggregate sources and non-CO_2 emissions sources on land	0.08	0.48	1.59				
3C1	Emissions from biomass burning		0.48	0.04				
3C3	Urea Application	0.08						

Code	Category	2016						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
3C4	Direct N_2O emission from managed soils			1.18				
3C5	Indirect N_2O emission from managed soils			0.37				
3C6	Indirect N_2O Emissions from Manure Management			0.01				
4. WASTE		5.31	13.29	0.03				
4A	Solid Waste Disposal		11.08					
4C	Incineration and open burning of waste	5.31	2.21	0.03				
4C1	Waste Incineration	0.04	0.00	0.00				
4C2	Open Burning of Waste	5.27	2.21	0.03				
4D	Wastewater Treatment and discharge		1.77	0.11				

Table 9-14 Results of the 2017 National GHG Inventory, in Gg

Code	Category	2017						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1. ENERGY		2439.47	16.76	0.19				
1A	Fuel Combustion Activities	2439.47	16.76	0.19				
1A2	Manufacturing Industries and Construction	60.82	0.00	0.00				
1A3	Transport	456.71	0.16	0.02				
1A3a	Civil Aviation	0.58	0.00	0.00				

Code	Category	2017						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
1A3a	Road Transport	455.77	0.16	0.02				
1A4	Other Sectors	1912.94	16.76	0.19				
1A4a	Commercial / Institutional	358.75	2.47	0.04				
1A4b	Residential	1523.25	14.29	0.15				
1A4b	Agric. / Forestry / fish	9.94	0.00	0.00				
2. IPPU*		1.08			0.00	0.00	0.00	0.00
2A	Mineral Industry	1.08						
2A4	Other Process Uses of Carbonates	1.08						
2A4a	Ceramics	1.08						
2F	Product Uses as Substitutes for ODS				0.00	0.00	0.00	0.00
2F1	Refrigeration and Air Conditioning				0.00	0.00	0.00	0.00
2F1a	Refrigeration and Stationery AC				0.00	0.00	0.00	0.00
3. AFOLU		1089.63	33.57	2.01				
3A	Livestock		33.09	0.20				
3A1	Enteric Fermentation		31.89					
3A2	Manure Management		1.20	0.20				
3B	Land	1089.55						
3B1	Forest land	1089.55						
3C	Aggregate sources and non-CO_2 emissions sources on land	0.08	0.48	1.81				
3C1	Emissions from biomass burning		0.48	0.04				

Code	Category	2017						
		CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
3C3	Urea Application	0.08						
3C4	Direct N_2O emission from managed soils			1.32				
3C5	Indirect N_2O emission from managed soils			0.44				
3C6	Indirect N_2O Emissions from Manure Management			0.01				
4. WASTE		5.37	13.50	0.03				
4A	Solid Waste Disposal		11.27					
4C	Incineration and open burning of waste	5.37	2.23	0.03				
4C1	Waste Incineration	0.04	0.00	0.00				
4C2	Open Burning of Waste	5.33	2.23	0.03				
4D	Wastewater Treatment and discharge		1.79	0.11				

APPENDIX D - REFERENCE APPROACH

The below table (Table 7-4 2011 and 2017 Reference approach emissions, Gg CO2) shows reference approach emissions for the energy sector for 2011 and 2017.

Table 7-4 2011 and 2017 Reference approach emissions, Gg CO_2

Fuel	2011			2017		
	Imports (TJ)	Apparent	Emissions (Gg CO_2)	Imports (TJ)	Apparent	Emissions (Gg CO_2)
Crude Oil			0			0
Orimulsion			0			0
Natural Gas Liquids			0			0
Motor Gasoline	3 485	3 485	241.511	4 560	4 560	316.008
Aviation Gasoline	2.17	2.17	6.732	13.43	13.43	0.941
Jet Gasoline			0			0
Jet Kerosene			0	0	0	0
Other Kerosene	1 408	1 408	101.188	1 261	1 261	90.624
Shale Oil			0			0
Gas/Diesel Oil	2 939	2 939	217.681	2 981	2 981	220.793
Residual Fuel Oil			0			0
Liquefied Petroleum Gases	128.06	128.06	8.076	341.85	341.85	21.559
Ethane			0			0
Naphtha			0			0
Bitumen			0			0
Lubricants			0			0
Petroleum Coke			0			0
Refinery Feedstocks			0			0
Refinery Gas			0			0
Paraffin Waxes			0			0
White Spirit and SBP			0			0
Other Petroleum Products			0			0
Anthracite			0			0
Coking Coal			0			0
Other Bituminous Coal	17 262.31	17 262.31	1 633.015	18 915.79	18 915.79	1 789.434
Sub-Bituminous Coal			0			0

Fuel	2011			2017		
	Imports (TJ)	Apparent	Emissions (Gg CO_2)	Imports (TJ)	Apparent	Emissions (Gg CO_2)
Lignite			0			0
Oil Shale / Tar Sands			0			0
Brown Coal Briquettes			0			0
Patent Fuel			0			0
Coke Oven Coke / Lignite Coke			0			0
Gas Coke			0			0
Coal Tar			0			0
Natural Gas (Dry)			0			0
Municipal Wastes (nonbiomass fraction)			0			0
Industrial Wastes			0			0
Waste Oils			0			0
Peat			0			0
TOTAL			2 208.204			2 439.358

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