GOVERNMENT
OF THE
REPUBLIC OF
ZAMBIA

# ZAMBIA

# THIRD NATIONAL COMMUNICATION

**TO THE**

**UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)**

**©SEPTEMBER, 2020**

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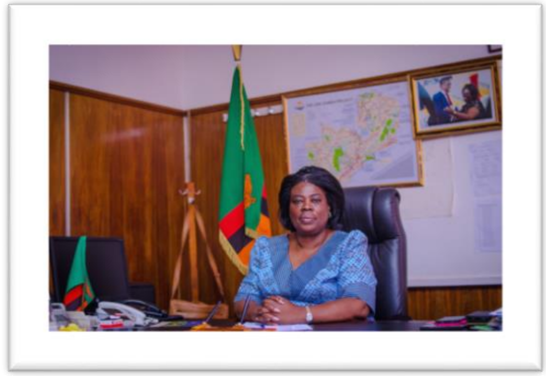
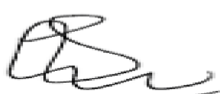
## FOREWORD



The Government of the Republic of Zambia (GRZ) is cognisant of the effects of climate change and the need to contribute to the global efforts in addressing it. As a Party to the United Nations Framework Convention on Climate Change (UNFCCC) and in fulfilling its obligation to the Convention and the Paris Agreement, Zambia has prepared this Third National Communication (TNC) in order to share its efforts to address climate change with the global community. The TNC builds on climate change activities reported in the country's Second National Communication (SNC) submitted in 2014 and provides key developments and other on-going national processes that have since taken place.

Since Zambia submitted its Second National Communication, the country continues to experience a number of climate hazards which include droughts, extreme temperatures, dry spells as well as seasonal and flash floods. These have adversely impacted food and water security, infrastructure, energy, health and livelihoods of rural communities and the overall socio-economic development of the country. It is for this reason that Zambia has integrated climate change in its development planning process to create a diversified and resilient economy for sustained growth and socio-economic transformation.

This report was compiled through a broad stakeholder consultation process involving government departments, private sector, cooperating partners, Civil Society Organisations (CSO) and academia, among others. It highlights the country's (i) anthropogenic Greenhouse Gas (GHG) emission sources and sinks for the years 2005 and 2010; (ii) emission drivers and measures to abate GHG emissions (iii) vulnerability status to climate change, policies, programmes and plans to enhance resilience and adaptation actions; (iv) Financial, technical and capacity needs including support needed and received; and (v) other measures considered relevant to meeting the objectives of the Convention. Government remains confident that the recommendations on addressing emissions and actions on adaptation contained in the TNC will be implemented by all stakeholders in a coordinated manner to ensure that the country remains on course to achieving a climate resilient and low carbon development pathway as envisaged in the Vision 2030 and the Seventh National Development Plan (7NDP). Government will remain committed to providing a conducive environment and support for its implementation in a transparent, inclusive, accurate, complete and comparable manner.



Hon. Jean Kapata MP
**MINISTER OF LANDS AND NATURAL RESOURCES**

**ACKNOWLEDGEMENT**

The Third National Communication (TNC) aims to communicate Government's effort to address climate change in Zambia. The TNC was prepared through a consultative approach comprising various Government ministries, Cooperating Partners Civil Society Organisations (CSO), academia and the media, among others. The country received support in various forms and from different institutions and individuals during the process of preparing the TNC.

The Ministry of Lands and Natural Resources wishes to thank the Global Environmental Facility (GEF) through the United Nations Environment Programme (UNEP) for providing financial resources which made this whole exercise possible. The Ministry further wishes to thank the UNEP/UNDP Global Support Programme team and the German Agency for International Cooperation (GIZ) for the technical support during the preparation of the TNC.

Further, commendation goes to the Zambia Environmental Management Agency (ZEMA) for their coordination role and the leadership demonstrated in the process. The Ministry would also like to thank various Government line ministries, Civil Society Organisations, the academia, local communities and individuals for their input into the TNC. Gratitude is also extended to the Technical Working Group for providing editorial oversight.

Lastly, but not the least, the Ministry extends gratitude to all individuals, institutions and organizations that played a role which is not specifically mentioned here. The Ministry wishes to encourage all stakeholders to continue contributing their respective roles to ensure that the country can effectively address the challenge of climate change.

Ndashe L. Yumba
**PERMANENT SECREATRY**
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## EXECUTIVE SUMMARY

### Background

The Third National Communication (TNC) for Zambia has been prepared in accordance with the United Nations Framework Convention on Climate Change (UNFCCC) guidelines on national communications for Non-Annex I Parties. The TNC builds on climate change activities reported in the Second National Communication (SNC) and provides information on the socio- economics of the country, gives an insight into the country's emission and mitigation status, and vulnerability to impacts of climate change, including other information relevant to meeting the objectives of the Convention.

### National Circumstances

Zambia covers a total surface area of 752,614 $km^2$ out of 99 percent is land area and 1percent is covered by water. The population of Zambia in 2010 was estimated at 13,092,666, representing a 32.5 percent increase compared to 9,885,591 in 2000 (CSO, 2012). Approximately 60.5 percent of the population lives in rural areas and 39.5 percent in urban areas. The population growth rate was approximately 2.8 percent.

The country is endowed with abundant natural resources that contribute significantly to the national economy. Primary resources include minerals, forests, water, wildlife, fisheries and land. Mining has been a key driver of the Zambian economy for many years. Government however, continued to diversify the economy to focus on other key economic sectors such as agriculture, energy, transport, construction, manufacturing and tourism. In 2010, the Real Gross Domestic Product (GDP) grew by 7.6 percent compared to 3.5 percent in 2000. This economic growth rate was largely driven by agriculture, infrastructure developments including increased metal production following a rebound in copper prices on international markets and provision of various tax incentives in the agricultural and mining sectors. 2010 also recorded increased investments in the transport and communications, forestry and fisheries sectors. The annual inflation slowed down to 7.9 percent in 2010 compared to 9.9 percent in 2000 (MoF, 2010).

Economic growth in the agriculture, livestock and fisheries sectors slowed down and their contribution to GDP declined from 24 percent in 2000 to 13.9 percent in 2010 (MoA, 2017, MOF, 2010). The decline was attributed to the unfavourable performance in the fisheries sub-sector. However, growth in the agricultural sub-sector increased to 13.9 percent in 2010 resulting from increased output of crops such as maize, rice, cassava, sorghum, mixed beans, sweet potatoes and groundnuts. The rise in crop production was largely due to favourable weather conditions and an increase in the number of beneficiaries under the Farmer Input Support Programme (FISP). Further, favourable producer prices by the Food Reserve Agency (FRA) contributed to increased output of food crops, such as maize and rice. Zambia's agricultural sector however is the socio-economic backbone of the rural population, with 60 percent being dependent on the sector as the main source of income and livelihood. Many of them however, are poor and engage in low-productivity rain-fed subsistence farming resulting from inadequate resources for the purchase of inputs, use of inappropriate farming practices and failure to fully develop the irrigation potential. These challenges are exacerbated by increased frequency of extreme weather events such as rainfall variation, floods and droughts caused by climate change.

About one sixth of the rural population depend heavily on forests and non-forest resources for their livelihood and contribute approximately 20 percent to rural household incomes. Both indirect and direct values of forests are estimated to make a GDP contribution of about 4.7 percent if well managed. However, unsustainable charcoal and fuel wood production including the unsustainable clearance of forest land for agriculture and settlement expansion has resulted in high rates of deforestation and increased greenhouse gas emissions. The country's annual deforestation rate was estimated at 276,021 hectares per annum which amounts to a potential loss of about 10 million hectares of forests in the next 30 years, posing a threat to the forestry sector. For the period 2000 to 2010, the deforestation rate stood at 0.5 percent; losing approximately 250,003 ha on an annual basis. (Shakacite, et.al, 2016).

Climate change impacts could slow the development process of the country and could cost Zambia approximately USD $13.8 billion loss in GDP. In order to prevent economic losses resulting from impacts of climate change, the Government of Zambia (GRZ) has integrated climate change concerns in its policies, programmes, plans and strategies to support a low carbon and climate-resilient development pathway and the attainment of the middle-income status envisioned in the country's Vision 2030.

**Greenhouse Gas Inventory**

The country's emission levels were estimated for the years 2010 and 2005 and recalculations made for the years 2000 and 1994 using the 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines. The recalculations were necessitated by a change in methodology from IPCC guidelines of 1996, collection of additional activity data across all sectors and the migration to higher tiers in the Forestry sector emanating from the robust data availability from Integrated Land Use Assessments (ILUA). Total emissions for the 2010 were compared with the 1994 (recalculated figures) base year.

Zambia's emission levels for 2005 and 2010 revealed that the country was a net sink. The total GHG emissions by source were estimated at 120,507.7 Gg $CO_2$ eq and 106,967.1 Gg CO2 eq in 2010 and 2005 respectively. The total GHG removals were 137,322.9 Gg $CO_2$ eq and -138, 259 Gg $CO_2$ eq in 2010 and 2005 respectively. Total emissions from Agriculture, Forestry and other Land Use (AFOLU) were 106,967.1 Gg $CO_2$ eq. in 2005 and 120,507.7 Gg $CO_2$ eq. in 2010. The total emissions without AFOLU was 3,791.7 Gg $CO_2$ eq. and 5,082.7 Gg $CO_2$ eq giving a net sink of -16,815.2 and -31,292 Gg $CO_2$ eq in 2010 and 2005 respectively. The net sink however, reduced by 70 percent from -57,124.0 Gg $CO_2$ eq estimated in 1994 to -16,815.2 Gg $CO_2$ eq in 2010. The total emissions by source increased from 85,805.1 Gg $CO_2$ eq. to 120,507.7 Gg $CO_2$ eq in 1994 and 2010 respectively, representing a total emissions growth of 40 percent. Total emissions with AFOLU were 85,805.1 Gg $CO_2$ eq. in 1994 base year and 120,507.7 Gg $CO_2$ eq. in 2010. Total emissions without AFOLU were 2,815.0 Gg $CO_2$ eq. in 1994 base year and 5,082.7 Gg $CO_2$ eq. in 2010. The total removals however, declined by 4 percent from -142,929.2 Gg $CO_2$ eq.in 1994 to -137,322.9 Gg $CO_2$ eq. in 2010.

In the energy sector, emissions increased from 2,534.5 Gg $CO_2$ eq. in 1994 to 4,048.6 Gg $CO_2$ eq in 2010. This was as a result of increased consumption of petroleum products in the manufacturing, construction and transport sectors. Emissions from the Industrial Processes and Product Use (IPPU) sector increased by 91.3 percent from 431.2 Gg $CO_2$ eq. in 1994 base year to 1,621.0 Gg $CO_2$ eq in 2010. This increase in emissions was attributed to increased cement and lime production triggered by growth in the construction industry. Emissions in the Waste sector increased by 49.6 percent from the 1994 base year of 204.5 Gg $CO_2$ eq. to 305.9 Gg $CO_2$ eq. in 2010 with Waste Water Treatment and Discharge contributing 75 percent and Solid Waste Disposal 25 percent of the total emissions from the waste sector.

In 2010, the AFOLU sector contributed 95.75 percent of the total emissions with 2.62 percent from Energy, 1.35 percent IPPU and 0.25 percent from the waste sector. The trend was similar for all the time series where emissions were highest in AFOLU followed by energy, IPPU and waste. Over half (55.2percent) of emissions in the AFOLU sector were attributed to wood removals for commercial timber and fuelwood and about 21.3 percent emissions were from forestland conversions into cropland. Land conversions to settlements contributed 8.28 percent emissions, biomass burning 8.63 percent while enteric fermentation emission contribution stood at 1.85 percent.

The highest emission sinks were predominantly in the forest woodland (Miombo) and other wooded land. About 88.4 percent emissions by gas was $CO_2$, 7.9 percent. $CH_4$, 3.6 percent $N_2O$ and 0.1 percent of both HFC and $SF_6$. The total emissions indicated an increasing emission trend and decreasing emission removals across all sectors over the years 1994, 2000, 2005 and 2010. The total emissions indicated an increasing emission trend across all sectors over the years 1994, 2000, 2005 and 2010. Emission removals have been reducing over the same period.

The recalculated figures for energy, IPPU and Waste sectors were lower than those submitted in the Second National Communication (SNC) for the years 1994 and 2000. Zambia's total emissions estimated in the TNC were however two times higher than was reported in the SNC and the Initial National Communication because of availability of additional data from ILUA II.

## Vulnerability, Climate Change Impacts and Adaptation Measures

### Current and Future Climate Projections

Zambia has continued to experience climate change and climate variability. Studies undertaken reveal that the country's mean annual temperature increased by 1.3$^{o}$C since 1960, an average of 0.29$^{o}$C per decade (NAPA, 2007). Historical climate data analysis showed an increase in maximum temperatures with an increase in the number of hot days and warm nights and a decrease in minimum temperatures and decrease in extreme cold days and nights. The annual number of days experiencing higher temperatures and occurrences of heat stress has been increasing (Fumpa-Makano 2011). Temperature extremes in Zambia indicated patterns of warming from 1961 to 2000 and increases in annual daily maximum temperature and mean Temperature which were higher in Agro-ecological Region (AER) I and lower in AER II. Downscaled 30-year annual mean minimum temperature projected smaller minimum temperatures increases for AER III and larger values for AER I.

Rainfall records have shown that southern Zambia had experienced below average rainfall in the period 1886 to 1925 and above average rainfall between 1926 to 1970. A decline of 6 percent in annual precipitation from 1971 to 2005, relative to 1940 to 1970 was also recorded. The south-western region was reported to be the most severely affected with rainfall seasons becoming critically shorter. The assemblage of models however, reveals that annual mean total precipitation (mm) is expected to increase in future in AER I and decrease in AER II and AER III. Information from the Vulnerability Assessment points to an increased inter-annual variability in the frequency and distribution of rainfall, with extremely wet periods and more intense droughts in future.

### Climate sector impacts and adaptation measures in key economic sectors

Since 2000, the country has experienced more frequent and intense droughts, dry spells, floods and flash floods that have impacted negatively on key economic sectors leading to significant economic and livelihoods losses. Changes in temperatures and precipitation has led to high disease incidences in crops and livestock, reduced crop yields and increased water stress (NAPA, 2007). Climate change is projected to reduce water availability by about 13 percent by 2100 in Zambia impacting on hydropower generation, agriculture and industrial production and domestic use. Since the submission of the SNC, a number of adaptation actions have been undertaken to address current and future climate hazards and associated losses and damage experienced in the past. These actions are aimed at enhancing the country's adaptive capacity and resilience to climate shocks in the key economic sectors.

In the Agriculture sector, a number of programmes were undertaken and actions proposed to strengthen the adoption of Climate Smart Agriculture (CSA) practices that offer an opportunity for increased productivity, enhanced resilience and climate change mitigation co-benefits.

The adoption rates of CSA were still low, due to high labour demand, poor access to critical labor-saving equipment, and limited knowledge and capacity.

Measures to address climate change impacts on the water sector included the promotion of water harvesting structures and wastewater recycling technologies and implementation of energy efficient and alternative renewable energy sources. In addition, the promotion of research and development of inter-basin water transfer, integrated watershed and land-use management and protection of groundwater aquifers must be undertaken.

Measures and strategies developed to help address climate change impacts in the health sector included strengthening of surveillance systems and emergency responses to disease outbreaks, updating and improving compliance (enforcement) of existing Laws on public health, along with improving access to clean water, sanitation and strong public awareness programmes to promote hygiene (HNAP, 2019).

**Greenhouse Gas Emission Projections, Mitigation Options and Policies**

The mitigation assessment conducted for the TNC revealed that Zambia's total GHG emissions are projected to grow by 42 percent from 120,785.2 Gg $CO_2$ eq. in 2010 to 171,532.1Gg $CO_2$ eq. in 2050. The total removals or sinks are projected to decrease by 25 percent from -137,322.9Gg $CO_2$ eq. in 2010 to -103,684.3 Gg $CO_2$ eq. in 2050. The net emissions however will increase from -16,538.2Gg $CO_2$ eq to 67,843.0 Gg $CO_2$ eq. in 2050.

Analysis of projected emissions showed that Zambia will transition from net sink to net source in 2018 under the business as usual scenario. This is attributed to increasing emissions from opening up new land for settlements and agriculture, wood removals for firewood, charcoal and commercial timber, fertilisers on agriculture land and increased usage of fossil fuels. Further, the emissions will be driven by population and economic growth, urbanization and changes in production and consumption patterns among others. If all the mitigation policy recommendations in the Seventh National Development Plan (7NDP) and other national strategies are implemented, total emissions mitigation potential are projected to decrease from 120,784.8 Gg $CO_2$ eq. in 2010 to 42,468.6 Gg $CO_2$ eq. in 2050.

Furthermore, the net sink will be retained during the same period. Mitigation options include promotion of renewable energy and energy efficiency; sustainable Forest Management, Conservation and CSA. A total of 4,328.1Gg $CO_2$ eq is projected to be reduced in 2019, representing 11 percent progress against the 2030 Nationally Determined Contribution (NDC) target. The achievement is largely attributed to greater ambitions and projects that are under implementation in the renewable energy and energy efficiency sub-sector and mitigation actions in other sectors such as agriculture and forestry.

Tracking emission reductions under this scenario will enable Zambia to attain emissions reduction of 137,409.7 Gg $CO_2$ eq. and achieve the NDC target by 2030.

Zambia is taking steps to maintain its net sink status and reduce emissions in the various sectors in order to meet its emission reduction target articulated in the country's NDC. Efforts have been made to increase energy efficiency and reduce GHG. Various strategies and policies to mitigate GHG across key economic sectors were formulated and are under implementation. These strategies are aimed at increasing carbon sinks, promoting CSA and up scaling renewable energy and energy efficiency. Implementation of these programmes will minimise emissions from the country's key emitting sectors.

**Other Information Relevant to the Convention**

Zambia has made progress in creating an enabling environment to support a climate resilient and low carbon development pathway for sustainable development. The country has developed various policies, plans, strategies and programmes and has an established long-term institutional framework to provide for a coordinated approach to the implementation of climate change programmes. Further, a national Measuring Reporting and Verification (MRV) system to track emissions, mitigation actions and support received is being developed to support enhanced transparency.

The country has established a National Designated Entity (NDE) and a National Designated Authority (NDA) for Environmentally Sound Technologies (ESTs) and Green Climate Fund (GCF) respectively. There have been some efforts in the area of systematic observations through the deployment of early warning systems. The country has also received support through the Climate Change Capacity Development under United Nations Institute for Training and Research (UNITAR) to facilitate climate change learning as a tool to create awareness in climate change. In order to enhance the attainment of a low carbon development in the country, support towards research and systematic observations, technology transfer, capacity building and awareness is needed.

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## ACRONYMS

| | |
|---|---|
| 7NDP | Seventh National Development Plan |
| AD | Activity Data |
| AfDB | Africa Development Bank |
| AFOLU | Agriculture Forestry and Other Land Uses |
| APMEP | Agriculture Productivity and Market Enhancement Project |
| AU | African Union |
| AWF | African Water Facility |
| BoZ | Bank of Zambia |
| BUR | Biennial Update Report |
| CASU | Conservation Agricultural Scaling UP |
| CBA | Cost-Benefit Analysis |
| CBU | Copperbelt University |
| ccGAP | Climate Change Gender Action Plan |
| CCS | Carbon Capture and Storage |
| CDD | Consecutive Dry Days |
| CDO | Climate Data Operations |
| CEEEZ | Centre for Energy, Environment and Engineering Zambia |
| CIF | Cost, Insurance and Freight |
| CMIPS | Coupled Multi-Inter-comparison Project Phase 5 |
| CO2eq | Carbon Dioxide equivalent |
| COMACO | Community Market for Conservation |
| COMESA | Common Market for Eastern and Southern Africa |
| DRC | Democratic Republic of Congo |
| COP | Conference of the Parties |
| CORDEX | Coordinated Regional Climate Down-Scaling Experiment |
| CRBs | Community Resource Boards |
| CRU | Climate Research Unit |
| CSA | Climate Smart Agriculture |
| CSO | Central Statistical Office |
| CTCN | Climate Technology Centre and Network |
| DBZ | Development Bank of Zambia |
| EAF | Electric Arc Furnace |
| EC | European Commission |
| EF | Emission Factor |
| EIZ | Engineering Institute of Zambia |
| ENSO | E1 Nino/ Southern Oscillation |
| ESTs | Environmentally Sound Technologies |
| ESMAP | Energy Sector Management Assistance Programme |

| | |
|---|---|
| EUMETSAT | European Meteorological Satellites organizations |
| FAO | Food and Agriculture Organisation |
| FOB | Freight on Board |
| FISP | Farmer Input Support Programme |
| FNB | First National Bank |
| FNDP | Fifth National Development Plan |
| FRA | Food Reserve Agency |
| FRs | Forest Reserves |
| GAFSP | Global Agriculture and Food Security Programme |
| GART | Golden Valley Agricultural Research Trust |
| GCF | Green Climate Fund |
| GDP | Gross Domestic Product |
| GEF | Global Environmental Facility |
| GETFiT | Global Energy Transfer Feed-in Tariff |
| Gg | Giga grams |
| GHGi | Greenhouse Gas Inventory |
| GHGs | Greenhouse Gases |
| GMAs | Game Management Areas |
| GNI | Gross National Income |
| GRZ | Government of the Republic of Zambia |
| HDI | Human Development Index |
| HFO | Residual Fuel Oil |
| HIV | Human Immuno Virus |
| HNAP | Health National Adaptation Plan |
| IAPRI | Indaba Agriculture Policy Research Institute |
| IDC | Industrial Development Corporation |
| IFAD | International Fund for Agricultural Development |
| IFC | International Financing Corporation |
| ILUA | Integrated Land Use Assessment |
| INC | Initial National Communication |
| INDC | Intended Nationally Determined Contribution |
| NDC | Nationally Determined Contribution |
| IPP | Independent Power Producer |
| IPCC | Intergovernmental Panel on Climate Change |
| IPPU | Industrial Processes and Product Use |
| IWRM | Integrated Water Resources Management |
| JICA | Japan International Cooperation Agency |
| KCM | Konkola Copper Mines |
| LCMS | Living Conditions Monitoring Survey |
| LECB | Low Emission Capacity Building |

| | |
|---|---|
| LFs | Local Forests |
| LPG | Liquefied Petroleum Gas |
| LRC | Luangwa River Catchment |
| MAC | Marginal Abatement Cost |
| MLGH | Ministry of Local Government and Housing |
| MLNR | Ministry of Lands and Natural Resources |
| MLNREP | Ministry of Lands Natural Resources and Environmental Protection |
| MNDP | Ministry of National Development Planning |
| MTA | Ministry of Tourism and Arts |
| MTENR | Ministry of Tourism Environment and Natural Resources |
| MW | Mega Watts |
| NAMAs | Nationally Appropriate Mitigation Actions |
| NAPA | National Adaptation Programme of Action |
| NC | National Communication |
| NCCRS | National Climate Change Response Strategy |
| NCSA | National Capacity Self-Assessment |
| NDA | National Designated Authority |
| NDC | Nationally Determined Contribution |
| NDE | National Designated Entity |
| NDF | Nordic Development Fund |
| NEP | National Energy Policy |
| NEPAD | New Partnership for Africa's Development |
| NFs | National Forests |
| NGOs | Non-governmental Organisations |
| NISIR | National Institute for Scientific and Industrial Research |
| NPs | National Parks |
| NPCC | National Policy on Climate Change |
| NRGI | Natural Resource Governance Institute |
| NWASCO | National Water and Sanitation Council |
| ODU | Oxidised During Use |
| OPPPI | Office for Promoting Private Power Investment |
| OWL | Other Wooded Land |
| PFC | Perfluorocarbons |
| PPCR | Pilot Programme for Climate Resilience |
| PPPs | Policies Plans and Programmes |
| PSF | Private Sector Facility. |
| QA/QC | Quality Assurance/ Quality Control |
| r6NDP | Revised Sixth National Development Plan |
| RDA | Road Development Agency |
| REA | Rural Electrification Authority |

| | |
|---|---|
| REDD+ | Reduced Emissions from Deforestation and forest Degradation |
| REFiT | Renewable Energy Feed in Tariff |
| SASSCAL | Southern African Science Service Centre for Climate and Adaptive Land Management |
| SD | Sustainable Development |
| SDGs | Sustainable Development Goals |
| SFM | Sustainable Forest Management |
| SAHIMS | Southern Africa Humanitarian Information Network |
| SANWATCHE | Southern African Network of Water Centres of Excellence |
| SIP | Small-scale Irrigation Project |
| SNC | Second National Communication |
| SNV | Netherlands Development Organisation |
| TNA | Technology Needs Assessment |
| TNC | Third National Communication |
| UN REDD+ | United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation |
| UN | United Nations |
| UNCBD | United Nations Convention on Biological Diversity |
| UNCCD | United Nations Convention to Combat Desertification |
| UNDP | United Nations Development Programme |
| UNECA | United Nations Economic Commission for Africa |
| UNEP | United Nations Environment Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UNIDO | United Nations Industrial Development Organisation |
| UNZA | University of Zambia |
| USAID | United States Agency for International Development |
| USIP | Upscaling Smallholder Irrigation Project |
| V&A | Vulnerability and Adaptation |
| WARMA | Water Resources Management Authority |
| WUA | Water User Associations |
| ZACCI | Zambia Chamber of Commerce and Industry |
| ZANACO | Zambia National Commercial Bank |
| ZARI | Zambia Agricultural Research Institute |
| ZAWA | Zambia Wildlife Authority |
| ZCCN | Zambia Climate Change Network |
| ZDA | Zambia Development Agency |
| ZEMA | Zambia Environmental Management Agency |
| ZEO | Zambia Environment Outlook |
| ZIEM | Zambia Institute of Environmental Management |
| ZILFP | Zambia Integrated Forest Landscape Project |

| | |
|---|---|
| ZMD | Zambia Meteorological Department |
| ZNFU | Zambia National Farmers Union |
| ZRA | Zambia Revenue Authority |

# 1.0 INTRODUCTION

Zambia is Party to the United Nations Framework Convention on Climate Change (UNFCCC). The country signed and ratified the Convention on 11th June 1992 and 28th of May 1993 respectively. Following the ratification process, Zambia embarked on a development agenda that aspires to a low carbon development pathway and is committed to report on the status of climate change activities in the country to the UNFCCC. Consequently, the country prepared and submitted its Initial and Second National Communications to UNFCCC, in 2004 and 2014 respectively.

The preparation of the Third National Communication (TNC) was based on climate change activities reported in the Second National Communication (SNC), the National Adaptation Plan of Action (NAPA) and other ongoing national processes such as the National Adaptation Plan (NAP). The TNC preparation process started with a self-assessment which identified the country's technical and institutional capacity gaps and highlighted the country's priority areas of action.

The TNC was further informed by UNFCCC methodologies and guidelines that included (i) an assessment of national circumstances, institutional arrangements for the preparation of national communications on a continuous basis; (ii) compilation of national inventory of anthropogenic emissions by sources and removal by sinks of all greenhouse gases (GHGs) for the years 2005 and 2010 (iii) an assessment of the country's vulnerability to climate change and programmes and plans on adaptation actions taken; (iv) an assessment of mitigation actions and their effects; (v) financial, technical and capacity needs including support needed and received; and (vi) an assessment of other measures considered relevant to the achievement of the objective of the Convention.

The TNC presents the country's efforts in addressing climate change issues and the future capacity requirements in order to meet national and global climate change obligations as enshrined in the Convention and the Paris Agreement.

The country received financial support for preparation of the TNC from the Global Environment Facility (GEF) through the United Nations Environment Programme (UNEP). Further, technical support was provided by the UNEP/UNDP Global Support Programme team and German Agency for Technical Cooperation (GIZ).

## 2.0 NATIONAL CIRCUMSTANCES

This section provides an update of the changing national circumstances that are relevant to climate change in Zambia. It also gives the country's socio-economic development perspectives and priorities including policy, legal framework and institutional arrangement relevant to climate change.

### 2.1 Geographical Location

Zambia lies between the latitudes 10° and 18° South of the equator and longitudes 22° and 33° East of Greenwich Meridian. The country shares borders with eight countries namely; Angola, Botswana, Democratic Republic of Congo, Malawi, Mozambique, Namibia, Tanzania and Zimbabwe (Figure2.1).


**Figure 2.1 Location Map of Zambia.** Source: Zambia Atlas, 2013

The country covers a total surface area of 752,614 km$^2$ comprising an area of 5,078 km$^2$ covered by water bodies and land area of 747,536 km$^2$ (GRZ, 2016). Approximately 40% of Zambia's total surface area is covered by protected areas which include national forests, national parks, game management areas and wetlands.

It consists for the most part of a high plateau, with an average height of between 1060 and 1363 meters above sea level and isolated mountain ridges that rise to more than 1,829 meters with an occasional peak above 2,134 meters on the eastern border, called Nyika Plateau.

## 2.2 Climate

Zambia's climate is tropical but varies according to elevation and latitude. Mean annual temperatures vary from 18 to 20$^{O}$c. According to the Koppen-Geiger climate classification system (Figure 2.2), the major part of the country is classified as humid subtropical or tropical wet and dry, with small stretches of semi-arid climate in the south-west, along the Zambezi valley.

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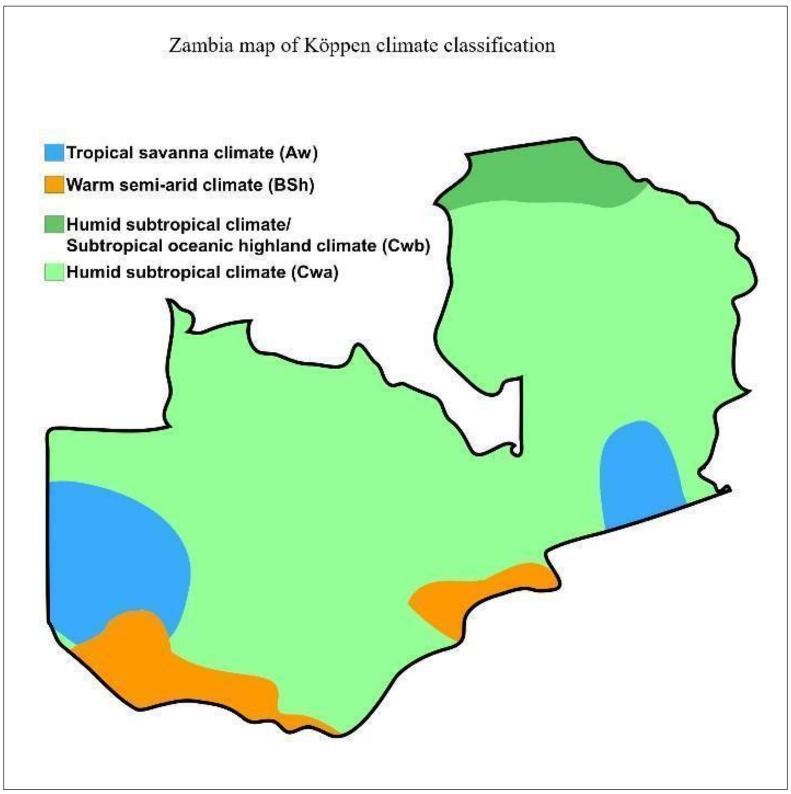


*Figure 1.2*: Koppen climate classification of Zambia, Source: Southern African Humanitarian Network, 2005

Zambia experiences a predominantly sub-tropical climate characterised by three distinct seasons, namely a hot and dry season (mid-August to mid-November), a wet rainy season (mid-November to April) and a cool dry season (May to mid-August). Rainfall is strongly influenced by the movement of the Inter-Tropical Convergence Zone (ITCZ) as well as the El Nino/Southern Oscillation (ENSO) phenomenon and varies from an annual average of 600 mm in the lower south up to 1,300 mm in the upper north of the country. Based on the variation in rainfall and broad ecological patterns, the country is divided into three Agro-ecological Regions (AERs) I, II and III.

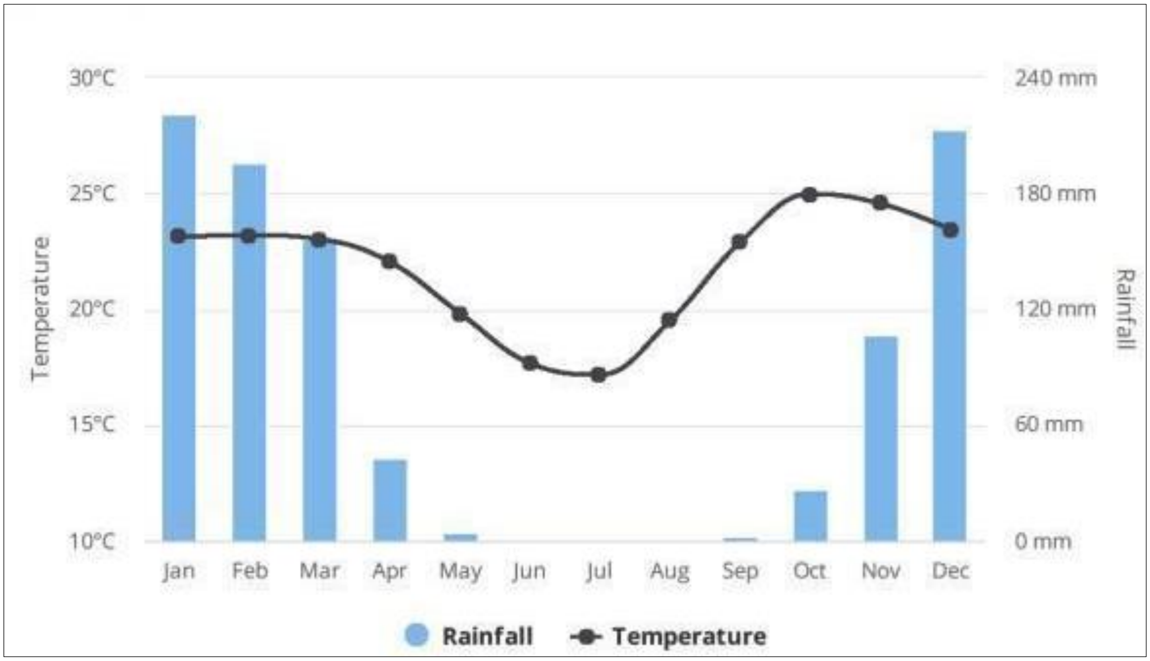


**Figure 2.3Average Temperature and Rainfall of Zambia for 1901 to 2016** *Source: CRU TS 3.21. University of East Anglia, 2013*

AER I receives less than 800 mm of rainfall annually. It generally consists of loamy to clayey soils on the valley floor and coarse to fine loamy shallow soils on the escarpment. It covers parts of Southern, Eastern and Western Provinces. AER I has been experiencing low, unpredictable and poorly distributed rainfall over the last 20 years. AER I has a growing season spanning between 80 and 120 days. Observed meteorological data indicates that it is currently drought-prone and the driest region in Zambia limiting its potential for crop production.

AER II receives between 800 mm to 1,000 mm of annual rainfall with a growing season that ranges between 100 and 140 days. AER IIa covers Central, Lusaka and parts of Southern and Eastern provinces. The region generally has inherent fertile soils while most soils in Zambia are inherently poor and degraded and have a low potential to supply and retain nutrients. Permanent settled (sedentary) systems of agriculture are practiced in the Region.  AER IIb covers the aggraded Western plateau characterised by infertile, sandy soils.

AER III: This AER receives between 1,000 mm and 1,500 mm of rainfall annually and constitutes 46 percent of the country's total land area comprising the Copperbelt, Luapula, Northern, and

North-western Provinces. The Region is generally characterized by highly leached, acidic soils. AER III has a growing season that ranges from 130 to 160 days.

## 2.3 Population and Human Development

### 2.3.1 Population

The 2010 Census of Population and Housing of Zambia estimated the population at 13,092,666, representing a 32.5 percent increase compared to the 2000 population (CSO, 2010). The 2010 population was projected to grow at an average of 2.4 percent per annum in rural areas during the projection period 2011 to 2035, while the urban population was expected to grow at about 3.5 percent per annum during the same period (CSO, 2010). In 2010, the proportion of the population living in rural areas accounted for 60.5 percent as compared to the urban population which stood at 39.5 percent. The population density for Zambia increased from 13.1 persons per square kilometer in 2000 to 17.3 in 2010. The population and projections up to 2035 are shown in Table 2.1 and 2.2.

**Table 2.1: Population Size by Rural/Urban, Zambia 1990-2010.**

| Rural/Urban | 1990 Population | 2000 Population | Percentage change | 2010 Population | Percentage change |
|---|---|---|---|---|---|
| Zambia | 7,383,097 | 9,885,591 | 33.9 | 13,092,666 | 32.4 |
| Rural | 4,477,814 | 6,458,729 | 44.2 | 7,919,216 | 22.6 |
| Urban | 2,905,283 | 3,426,862 | 17.9 | 5,173,450 | 51.0 |

*Sources: Censuses of Population and Housing, 1990, 2000 and 2010*

**Table 2.2: Zambia, Population Projection (2011-2035)**

| Year | 2011 | 2015 | 2020 | 2025 | 2030 | 2035 |
|---|---|---|---|---|---|---|
| Population Zambia | 13,718,722 | 15,473,905 | 17,885,422 | 20,574,138 | 23,576,214 | 26,923,658 |

*Source: Zambia Population and Demographic Projections, 2011-2035*

### 2.3.2 Zambia Governance

Zambia is a multi-party democracy with a distinct separation of powers between the three arms of Government; the Executive, Legislature and Judiciary. The Executive is headed by the President of the Republic, the Legislature by the Speaker of the National Assembly while the Judiciary is headed by the Chief Justice. The Legislature makes laws, the Executive enforces them and the Judiciary applies them to specific cases arising out of breach of laws.

The Central Government operates through sub national structures at provincial, district and ward levels. Each Province is headed by a Provincial Minister, while the Permanent Secretary is the administrative head. In the districts, the District Commissioner is the administrative head. At ward level, the government is headed by a Councilor (National Assembly of Zambia, 2018). It is worth noting that the provincial and district coordination committees are the established structures through which the Central Government governs the country at provincial and district levels.

## 2.4 National Development Priorities

Zambia remains committed to socio-economic development planning as reflected in the Seventh National Development Plan (7NDP) for the period 2017- 2021. The 7NDP is aimed at attaining the long-term objectives outlined in Zambia's Vision 2030 of becoming a "prosperous middle-income country by 2030". The Vision 2030 articulates long-term alternative development policy scenarios aimed at contributing to the attainment of the desirable socio-economic status, operationalised through the five-year development plans.

The 7NDP takes an integrated development planning approach under the theme "Accelerating development efforts towards the Vision 2030 without leaving anyone behind". The goal of the 7NDP is to create a diversified and resilient economy for sustained growth and socio-economic transformation driven, among others, by agriculture, tourism, manufacturing and mining. Furthermore, this Plan responds to the Smart Zambia transformation agenda 2064 and embeds in it the economic stabilisation and growth necessary for the actualisation of a Smart Zambia. This is in support of the UN 2030 Agenda for Sustainable Development and the African Union Agenda 2063.

The country's development agenda focuses on five pillars to realize the goal of the 7NDP namely:

1. Economic Diversification and Job Creation;
2. Poverty and Vulnerability Reduction;
3. Reducing Developmental Inequalities;
4. Enhancing Human Development; and
5. Creating a Conducive Governance Environment for a Diversified and Inclusive Economy.

The TNC was prepared within the frameworks of the Fifth National Development Plan (FNDP), Sixth National Development Plan (SNDP) and the 7NDP and responds to Pillar 2 of the 7NDP namely, Poverty and Vulnerability Reduction. Further, the National Policy on Climate Change (NPCC) which provides a framework for coordinated response to climate change in Zambia informed the preparation of the TNC. Some of the key strategies and plans considered included the National Climate Change Response Strategy, REDD+ strategy, the ReFit strategy, National Investment Plan for REDD +, the Nationally Determined Contributions, among others.

At regional level, relevant strategies and programmes were considered in the preparation of the TNC. The purpose was to ensure that regional priority strategies and programmes that have direct impact on Zambia's climate change agenda are well documented. For example, the Southern African Power Pool (SAPP) is a regional initiative that Provides for a stable interconnected electrical system in the Southern African region. Further, SAPP provides for the development of the regional grid emission factor necessary for estimating emission reduction in the energy sector. In addition, the Southern African Development Community Climate Services Center (SADC-CSC) and the Africa Center for Meteorological Applications for development (ACMAD) have been instrumental in preparing the regional statistical models and dissemination of data and information sharing on climate services. Zambia has benefited from the services provided by SADC-CSC such as climatic data and information for early warning systems and capacity building. This data was utilized in the assessment of the country's vulnerability, hazards and risks.

## 2.5 Economy

In the period under review, Zambia's economy was predominantly dependent on mining. However, the Government continued to diversify the economy to other key economic sectors such as agriculture, energy, transport, construction, manufacturing and tourism. Zambia's economy has been expanding as evidenced by the growth in Gross Domestic Product (GDP) from 3.5 percent to 7.6 percent in 2000 and 2010, respectively. This economic growth rate was largely driven by agriculture, infrastructure developments including increased metal production following a rebound in copper prices on international markets and provision of various tax incentives in the agricultural and mining sectors. The year 2010 also recorded increased investments in the transport and communications, forestry, wildlife and fisheries sectors. Utilization of these resources has helped to transform the economy and achieved a positive GDP growth of more than 6 percent in the time period of 2000 to 2013 whilst it remained relatively stable over 2016, 2017 and 2018 with growth rates between 3 and 4 percent.

The annual inflation slowed down to 7.9 percent in 2010 compared to 9.9 percent in 2000 (MoF, 2010). For the years 2011, 2012 and 2013 the real GDP was 6.8, 7.3 and 6.4 percent respectively, with annual inflation rate of 8.7 for 2011, 6.6 for 2012 and 7.1 percent for 2013. This growth was driven by transport and communications, construction, agriculture, wholesale and retail trade, and manufacturing sectors.

### 2.5.1 Agriculture

Government has identified agriculture as the key driver of economic growth, wealth creation and poverty reduction. The sector is critical for achieving diversification in order to complement mining which has been the largest contributor of foreign exchange earnings and national revenue (FNDP, 2006-2010, rSNDP, 2013-2016, 7NDP, 2017-2021). Of the 752,614 $km^2$ total land area of Zambia, about 43 Million hectares (58 percent) is classified as arable land (ZDA, 2014), of which 14 percent is utilized. Economic growth in the agriculture sector slowed down and contribution to GDP declined from 24 percent in 2000 to 13.9 percent in 2010 (MoA, 2017, MOF, 2010). The decline was attributed to the unfavorable performance in the fishing sub-sector. However, growth in the agricultural sub-sector increased in 2010 resulting from increased output of crops such as maize, rice, cassava, sorghum, mixed beans, sweet potatoes and groundnuts etc. The average yield of the staple maize crop among small scale farmers increased from 1.2 to 1.9 tonnes per hectare resulting in a net increase in maize production (GRZ, 2016). The rise in crop production was largely due to favourable weather conditions and an increase in the number of beneficiaries under the Farmer Input Support Programme (FISP) to 500,000 from 200,000 that was covered in the previous season. Further, favourable producer prices by the Food Reserve Agency (FRA) contributed to increased output of food crops, such as maize and rice. Zambia's agricultural sector however is the socio-economic backbone of the rural population, 60 percent of whom depends on the sector as the main source of income and livelihood. Many of them however, are poor and locked into low-productivity rain-fed subsistence farming resulting from inadequate resources for the purchase of inputs, use of inappropriate farming practices that lead to soil degradation, and the failure to fully develop the irrigation potential. These challenges are exacerbated by increased frequency of extreme weather events such as rainfall variation, floods and droughts caused by climate change.

Agricultural systems in Zambia comprise commercial, medium and small scale. Agriculture generates between 16 and 20 percent of the GDP and provides livelihood for more than 70 percent of the population. The sector absorbs about 67 percent of the labour force and remains the main source of income and employment for both rural women and men (GRZ 2016). The country has the potential to expand agricultural production given the vast resource endowment in terms of land, water and labour.

The country developed the Second National Agriculture Policy (SNAP) of 2016 which provides for an efficient, competitive and sustainable agriculture sector, which assures food and nutrition security, increased employment opportunities and incomes. The agricultural sector during this period has registered some positive gains in the areas of an increase in crop production, capture fisheries and aquaculture production as well as livestock population.

The livestock sub-sector, contributes to provide draught power, organic fertilizer and its by-products such as hides and skins. Livestock population has been increasing mainly due to decreases in livestock diseases of national economic importance. Cattle population increased from 2,375,453 in 2004 to 4,319,277 in 2014 while goats increased from 1,002,376 in 2004 to 3,538,785 in the same year. The increase in livestock population contributes to GHG emissions through manure management and enteric fermentation. This has been achieved through the Government prioritizing the establishment of livestock breeding centers, infrastructure development and rehabilitation, surveillance and research, and the development of livestock standards and grades.

Given that Zambia has abundant water resources and land, the country has the potential to increase fish production including aquaculture to meet the ever-increasing demand for fish protein. The sub-sector is estimated to have the potential to increase production from 70, 000 to about 150, 000 metric tonnes of fish annually on a sustainable basis (GRZ, 2016).

Production levels have continued to be low especially among most small scales farmers who usually depend on rain fed agriculture and have limited equipment. This has resulted in expansion of agricultural land thereby contributing to forest degradation and deforestation.

**2.5.2 Energy**

Energy is a critical input in the socio-economic development of the country as outlined in the country's Energy Policy. The National Energy Policy of 2019 is aimed at guiding the energy sector in the development of electricity generation, transmission and distribution capacity. Further, the Policy promotes security of energy supply through diversification of energy sources and cost reflective pricing which will promote new investments in the sector leading to scaling up access to energy services in rural and urban areas.

The major primary sources of energy in Zambia are hydro power, biomass, coal, renewable and petroleum, which contribute to the national energy demand. The country has experienced an increase in demand for energy services which is driven by population growth. Its central location in the region, gives it wider markets for the commodity, making Zambia a potential energy hub.

Hydro power is the most developed form of energy in the country and contributes 80.8 percent to the total electricity generation, followed by coal at 10 percent. Petroleum products contribute 9.4 percent to the total national energy demand while solar contributes 3 percent (GRZ,2019). Biomass is the predominant source of energy in Zambia accounting for more than 70 percent of total primary energy supply. The main forms and products of biomass include wood fuel (charcoal and firewood), biogas, pellets, briquettes, biofuels and gel fuel mainly used as a household fuel for cooking and heating. The high dependence on wood fuel is due to low access and also unreliable electricity supply, high cost of efficient alternatives.

Zambia's demand for electricity stood at 1,949 megawatts (MW) in 2015. However, the sector was only able to produce 1,281 MW thus giving a deficit of 668 MW. This situation resulted from limited investment over the years, which was also compounded by non-cost-reflective tariffs. Further, the deficit was exacerbated by the effects of climate change on the availability of water, considering that Zambia was highly dependent on hydro-power. The current projections indicate that growth in demand will increase by 150 MW to 200 MW per annum. The demand for electricity in the country is projected at 3,000 MW by 2020.

As at 2016, the country's installed capacity stood at 2,493 MW of which 97 percent was from hydro and 3 percent from other sources. It was envisaged that other sources of energy which included geothermal, wind, solar and coal would grow to about 15 percent by 2030. To increase supply, there was a need for additional investment in hydro, geothermal, wind and solar energy generation.

The national consumption of petroleum products increased from 429,309 metric tons in 2005 to 753,652 metric tons in 2010. The total consumption in 2010 of Low Sulphur Diesel, Unleaded Petrol (ULP) and Kerosene increased by 24.6 percent, 8.2 percent, 5.6 percent and 11.3 percent respectively. However, consumption of Heavy Fuel Oil (HFO), Liquified Petroleum Gas (LPG), Avgas and JetA1 declined by 22.0 percent, 11.9 percent, 12.4 percent and 1.8 percent respectively.

### 2.5.3 Mining

Mining has been a major driver of the Zambian economy contributing significantly to the country's GDP. The total contribution of mining to GDP averaged 12.9 percent in 2006 to 26 percent in 2015. The sector also provided direct employment for 56,227 persons in 2005 which increased to 82,725 in 2014. The major minerals produced include copper, cobalt, coal and gemstone. Generally, the mineral output in the sector has not been at optimum due to inadequate investments and repeated power outages.

In 2015, the output of copper which is the country's major export commodity was estimated at 710,560 Metric Tonnes (MT) below the Government forecast of 800,000 MT (7NDP). However, it is worth mentioning that cobalt, coal and gemstone production has great potential that has yet to be fully realized.

### 2.5.4 Manufacturing

The manufacturing sector is considered as one of the leading sectors for the revitalization of the economy in the strategy for Zambia's socio-economic development and poverty reduction. The manufacturing sector accounted for about 7.8 percent of the country's GDP and an average annual growth rate of 3 percent from 2006 to 2015. The growth in the sector for the period 2010 to 2012 was mainly driven by the following subsectors namely; food, beverages and tobacco (11.2 percent), wood and wood products (3.7 percent), paper and paper products (16.2 percent), chemicals, rubber and plastic products (12.8 percent), non-metallic mineral products (16.9 percent), basic metal products (12 percent) and fabricated metal products (7.7 percent) (BOZ, 2013).

The sector has great potential for both income generation and job creation due to its forward and backward linkages to other sectors of the economy, particularly agriculture and mining. The key linkage between the manufacturing sub-sectors and other sectors is seen to operate through the main channels of expansion in output, job creation, growth of household incomes, widened tax base and increased foreign exchange earnings.

In this sector, the construction industry played an integral part in the development of the economy and was one of the important catalysts for its growth. Activities in the sub-sector were driven by public and private projects, such as roads, stadia, hospitals, schools, and residential and commercial property.

### 2.5.5 Transport

The transport sector in Zambia consists of roads, railways, aviation and maritime. The increase in fuel consumption was due to the growth in the transportation sector largely attributed to the continued importation of motor vehicles. The number of motor vehicles increased from 183,701 in 2006, 337,513 in 2010 and 663,529 in 2015 as shown in Figure 2.4.

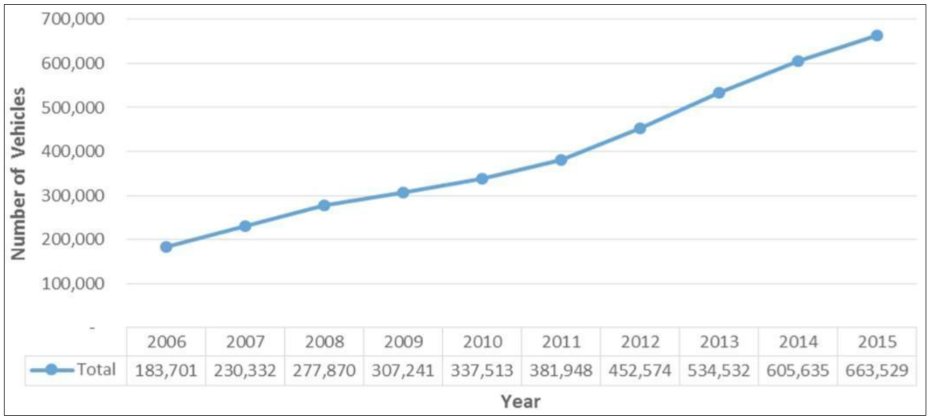


**Figure 2.4. Number of Vehicles from 2006-2015** *Source: ZEMA, 2017*

The increase in motor vehicle population was attributed to economic and population growth which has had a bearing on increased fossil fuel consumption, GHG emissions and congestion.

## 2.6 Natural Resources

### 2.6.1 Forestry

The total forest cover is 49.9 million hectares representing 66.4 percent of the country's land surface area. Out of this, 7.4 million hectares is under protection in approximately 480 forest reserves. About 42 percent of the forest cover is Miombo, comprising *Brachystegia longifolia* (Mubombo), *Julbernardia paniculata* and *Brachystegia speciformis*. Forests and woodlands cover about 535,000 km2, or about 70 percent of the total national land area. Zambian woody vegetation can be divided into five forest types, namely the Dry evergreen, Dry deciduous, Montane, Swamp and Riparian Forests, and five woodland types – the Miombo, Kalahari, Mopane, Munga and Termitaria, and the Grasslands. Under the Integrated Land Use Assessment (ILUA-1), the national vegetation classes were re-classified into global classes as follows:

a) Miombo woodlands (plateau and hills) to semi evergreen forests;
b) Baikiaea forests, Munga, Mopane and Kalahari woodlands to Deciduous forests;
c) Riparian, Swamp, Parinari, Itigi and the lake basin Chipya forests to evergreen forests;
d) Termitary associated bushes to shrub thickets; and
e) Treeless areas comprising riverines, plains, dambos to either grasslands or wooded grasslands.

The results from the Zambia Forests and Natural Resources Inventory from the ILUA study are summarised in Table 2.3

**Table 2.3:ZAMBIA FORESTS AND NATURAL RESOURCES INVENTORIES RESULTS**

| | **Information set** | **Findings** |
|---|---|---|
| 1 | Tree Species (density) Abundance | 1. More than 2,500 different tree species were found;<br>2. The 2 most dominant species were the *Entandrophragma delevoyi* (Mofu) and *Brachystegia longifolia* (Muombo);<br>3. *Julbernardia paniculata* (Mutondo) and *Brachystegia speciformis* (Kaputu) were the most abundant species recorded;<br>4. There are about 11.4 billion trees (trees measuring ≥ 10cm diameter at breast height) and an estimated 10.9 billion saplings (trees measuring ≥ 5cm and < 10cm diameter at breast height across the country for different tree species; and<br>5. On average there are 154 tree stems/ha and 148 stems for saplings per hectare in forested areas. |
| 2 | Tree species regeneration | Forests in Muchinga have higher regeneration potential than forests in Southern and Copperbelt Provinces. |
| 3 | The commercial timber species | 1. Commercial timber species accounts for 6.4 billion stems representing 29percent of the total tree count;<br>2. *Colophospermum mopane* (Mupani) is the most abundant (though lesser-used) species accounting for 10.57 percent, followed by the most commonly processed *Pterocarpus angolensis* (Mukwa) which is estimated at 8.74 percent, *Guilbortia coloesperma* (Rose-wood) is at 2.7 percent, *Afzelia quanzensis* (Mupapa) 1.3 percent, *Baikiaea pulrijuga* (Mukusi) 2.1 percent, and *Pterocarpus chrysothrix* (Mukula); and<br>3. Mukwa is more abundant in Western Province representing 2.01percent and in North-western Province it is estimated at 1.84percent, while in Northern and Luapula provinces it is estimated at 1.62percent and 1.53percent respectively. Traditionally *Baikiaea plurijuga* which is the most sought after for durable sawn |

| | | |
|---|---|---|
| | | timber production is only available in Western and Southern provinces estimated at 1.62percent and 0.47percent respectively. |
| 4 | Tree volumes | The total tree (for trees measuring ≥ 10 cm dbh) volume for the growing stock was estimated at 3,178 million m3 the majority of this volume, 2,602 million m3, is contained in forest woodlands, while the saplings (for trees measuring ≥ 5 and < 10 cm dbh) volume is estimated to be 154.4 million m3. |
| 5 | Biomass stock | Total biomass in the standing trees (dbh > 10 cm) was estimated at 2.74 billion tons, while for the saplings (dbh 5 - 9.9 cm) it was estimated at 220.9 million tons. Biomass from the stumps and lying dead wood was estimated at 68.4 million tons and 107.4 million tons respectively. |
| 6 | Carbon stock: | Total carbon from standing trees (dbh > 10 cm) was estimated at 1.34 billion tons, 108.3 million tons from saplings, 33.5 million tons from stumps and 52.6 million tons from dead wood. |
| 7 | Forest cover | The total forest cover (based on the 2014 remote sensing data) is estimated to be 45.9 million ha and represents 61.04 percent of the country's land surface area. |
| 8 | Drivers of deforestation | The direct drivers of forest cover loss based on the land cover maps are mainly attributed to agriculture, settlement expansion, conversion of land to other-land, and wetland (especially water development). Other-land and wetland (water development) was mainly attributed to the opening up of new mines and related infrastructure development |
| 9 | Forests and livelihood | Overall, 21 percent of households in Zambia depend on crop production as the main livelihood activity, followed by fuelwood collection (16percent). Non-wood forest products such as edible wild foods (i.e. fruits, roots, tubers and bulbs), plant medicines and mushrooms were among the top ten forest products contributing to household incomes |

*Source: ILUA II, 2016*

The Country has 480 Forest Reserves (FRs) comprising 175 National Forests (NFs) and 305 Local Forests (LFs) with an estimated combined total area of 74,361 km2. However, the country is experiencing deforestation at the rate of 271,021 hectare per annum which amounts to a potential loss of about 10 million hectares of forests in the next 30 years, posing a threat to the forestry sector. For the period 2000 to 2010, the deforestation rate stood at 0.5 percent, losing approximately 250,003 hectares on an annual basis. (Shakacite, et.al, 2016. The direct drivers of forest cover loss are mainly attributed to conversion of forest land to other land uses such as agriculture, settlement expansion, urban and industrial development and charcoal production, which presents the major source of GHG emissions.

About one sixth of the rural population depend heavily on forests and non-forest resources for their livelihood and contribute approximately 20 percent to rural household incomes. Both indirect and direct values of forests are estimated to make a GDP contribution of about 4.7 percent if well managed. However, unsustainable charcoal and fuel wood production including the unsustainable clearance of forest land for agriculture and settlement expansion has resulted in high rates of deforestation and increased greenhouse gas emissions. In addition, bush fires have contributed to loss of forest cover contributing to emission of GHGs to the atmosphere. Every year, during the dry season, forest fires occur in most parts of Zambia. Early burning starts from April to July while late burning occurs between August and November. In 2005, approximately 21,204,441 hectares of land was burnt compared to 18,146,973 hectares in 2010. Figures 2.5 and Figures 2.6 show the extent and distribution of bushfires for the years 2005 and 2010.

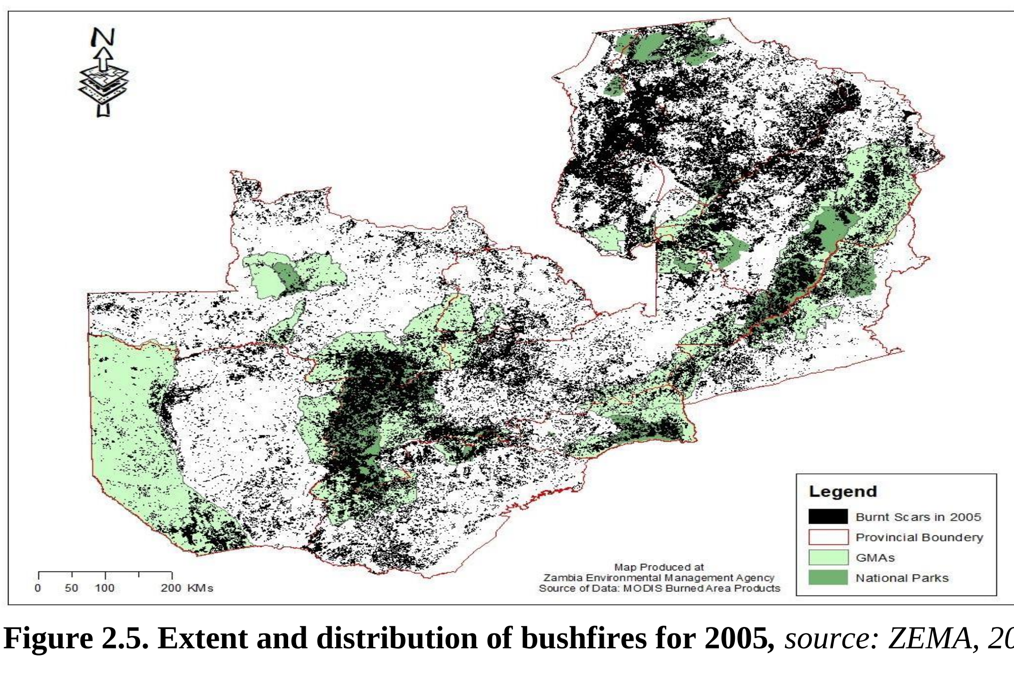


**Figure 2.5. Extent and distribution of bushfires for 2005,** *source: ZEMA, 2020*

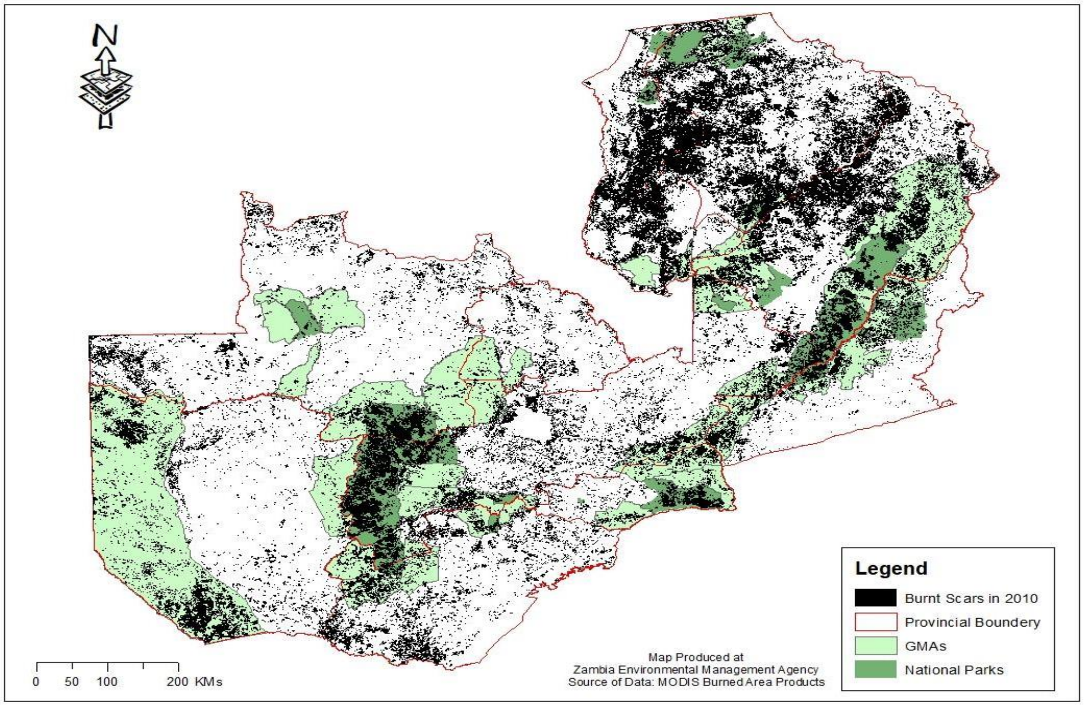


**Figure 2.6. Extent and distribution of bushfires for 2010,** *source: ZEMA, 2020*

### 2.6.2 National Parks and Game Management Areas

Zambia's wildlife is managed through National Parks (NPs) and Game Management Areas (GMAs). There are currently 20 NPs and 36 GMAs covering a total area of about 6.36 million ha (8.5 percent of total land area) and 16.6 million km$^2$ or (22 percent of the country) respectively (ZAWA, 2016).

The NPs and GMAs are inhabited by diverse wildlife which contributes to the socio-economic development of the country, through the tourism sector, job and wealth creation. The NPs and GMAs have however, been encroached by local communities resulting in degradation due to activities such as poaching. Figure 2.7 shows the areas covered by these NPs and GMAs.

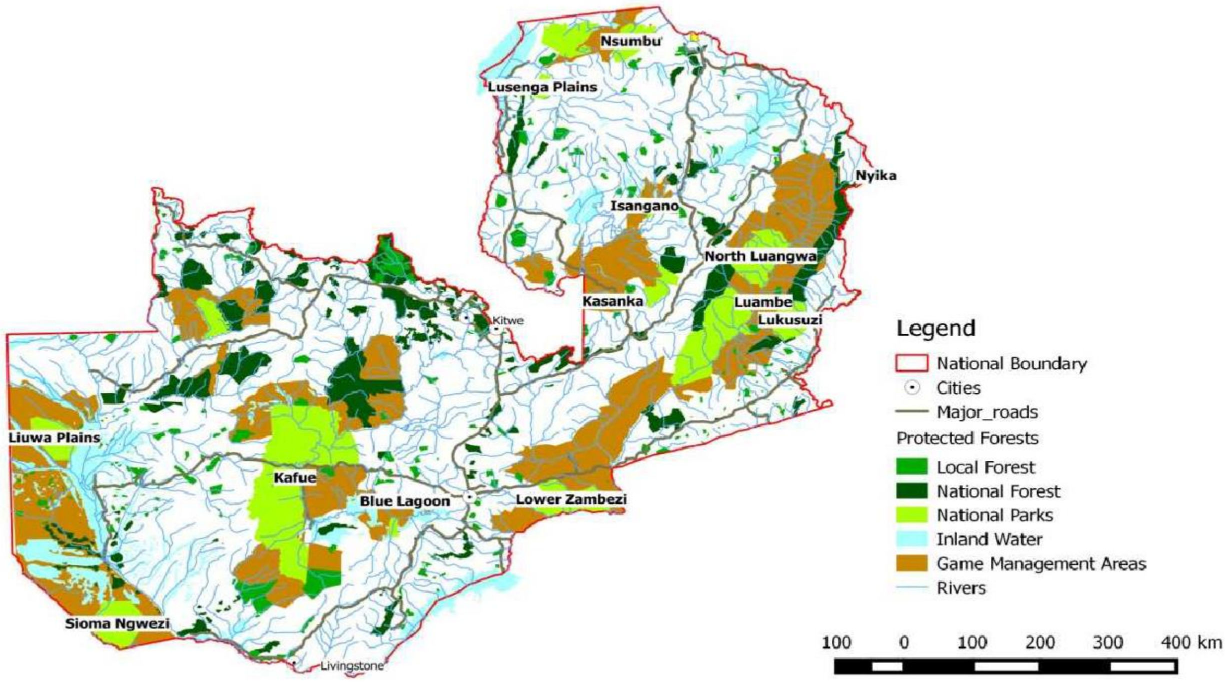


**Figure 2.7. National Parks, Game Management Areas and Forest Reserves in Zambia.** *Source: NBSAP 2015*

### 2.6.3 Wetlands

Zambia's wetlands cover about 14 to 19 percent of the total land area of the country and contributes to economic development through supporting various sectors such as tourism, agriculture, fisheries and forestry among others (GRZ 2018). They also support livelihoods and provide ecosystem services such as reducing the impacts from storm damage and flooding, maintaining good water quality in rivers, recharging groundwater, storage of carbon and nutrient cycling, thereby helping to control pests and stabilise climatic conditions.

#### 2.6.3.1 Wetlands of International Importance

The country has eight Ramsar sites with a combined total area of 40,305 km$^2$. These wetlands are habitats of several important fauna and flora species including some endemic and endangered. Recent assessment of the state and trends in these wetlands (ZAWA, 2015) indicates improved status of the Lukanga and Bangweulu Swamps and Liuwa Plains and attributes the improvement to the attention some of these wetlands have received from private sector engagement in their conservation regimes. Apart from their global significance, these wetlands are also important at national level including others (e.g., Kariba, Itezhi-tezhi and Lower Zambezi) as they comprise the major fisheries of the country.  Table 2.4 shows the Ramsar sites in Zambia.

**Table 2.4: Ramsar sites in Zambia**

| Name of Ramsar Site | Area (km2) |
|---|---|
| Bangweulu Swamps | 11,000 |
| Busanga Swamp | 2,000 |
| Kafue Flats (includes Lochinvar & Blue Lagoon NPs) | 6,005 |
| Lake Tanganyika (portion in Zambia | 2,300 |
| Luangwa Floodplains | 2,500 |
| Lukanga Swamp | 2,600 |
| Mweru-Wantipa Swamps | 4,900 |
| Barotse Floodplain | 9,000 |
| Total | 40,305 |

*Source: https://rsis.ramsar.org/*

## 2.7 Institutional Arrangements

This chapter describes institutional arrangements relevant to the preparation of the national communications on a continuous basis. Examined are: (i) distribution of responsibilities within government departments, universities, research institutions, and others; (ii) national climate change committees or other relevant coordinating bodies (establishment, funding, membership); (iii) involvement and participation of other stakeholders; and (iv) technical/expert groups or teams (inventory, vulnerability and adaptation assessment, mitigation and any other team relevant to the work on climate change).

### 2.7.1 Overall Institutional Arrangement for Climate Change Coordination

The National Policy on Climate Change (NPCC) defines the climate change coordination structure in the country. The Council of Ministers is the supreme decision-making body for overseeing climate change interventions in the country. The Chairperson of the Council is the Vice President while the Secretariat is provided by the Ministry of National Development Planning which also chairs the Steering Committee of Permanent Secretaries. The Steering Committee is the main advisory body to the Council of Ministers on policy and programme coordination and implementation. The Secretariat to the Steering Committee is provided by the Ministry of Lands and Natural Resources. The Ministry of Lands and Natural Resources (MLNR) is the Chair of the Technical Committee on Climate Change and is also the UNFCCC focal point. The MLNR has delegated the functions of coordinating the compilation of Zambia's National Communications on climate change to the Zambia Environmental Management Agency (ZEMA). The institutional arrangement is shown in Figure 2.8.

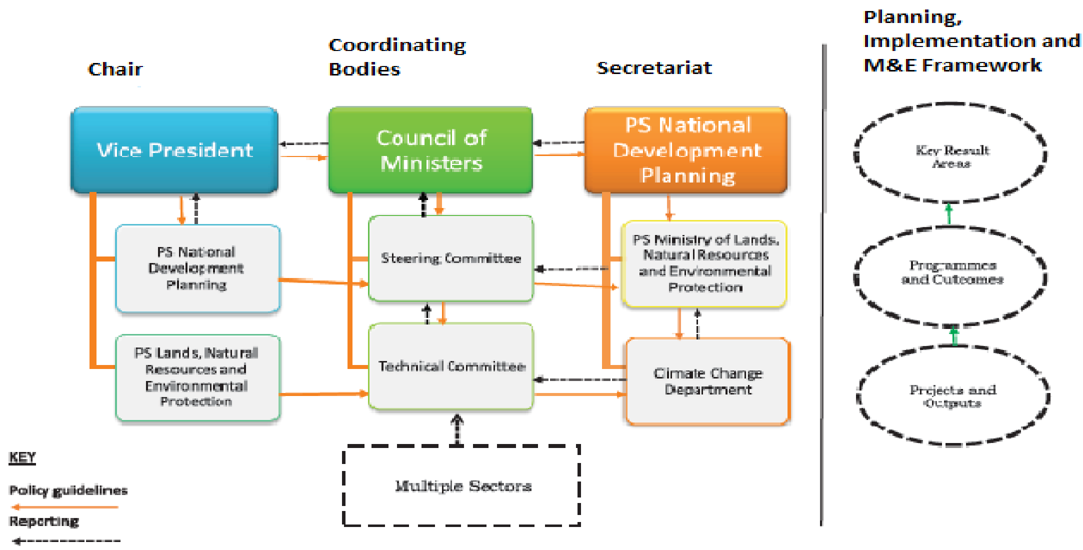


**Figure 2.8 Structure for Climate Change Implementation.** *Source: National Policy on Climate Change, 2016*

### 2.7.2 Institutional Arrangements for Preparation of the National Communication

The institutional arrangement for preparation of the TNC utilized the structures established under the National Policy of Climate Change. A structure for preparation of climate change national communications is shown in Figure 2.9.

The GHG Inventory System was developed to address challenges that were identified from past GHG inventories including, (i) Lack of documented procedures; (ii) Limited data storage and sharing systems; (iii) Lack of quality control and quality assurance (QA/QC) system to ensure routine and consistent checks required for data integrity, correctness and completeness from different data sources; and (iv) Lack of in-country capacity for GHG inventory management.

Strategies used to address the challenges were: (i) Building a sustainable GHG management system; and (ii) Building national systems and tools for data collection, processing, analysis, archiving and data sharing for Inventory development.

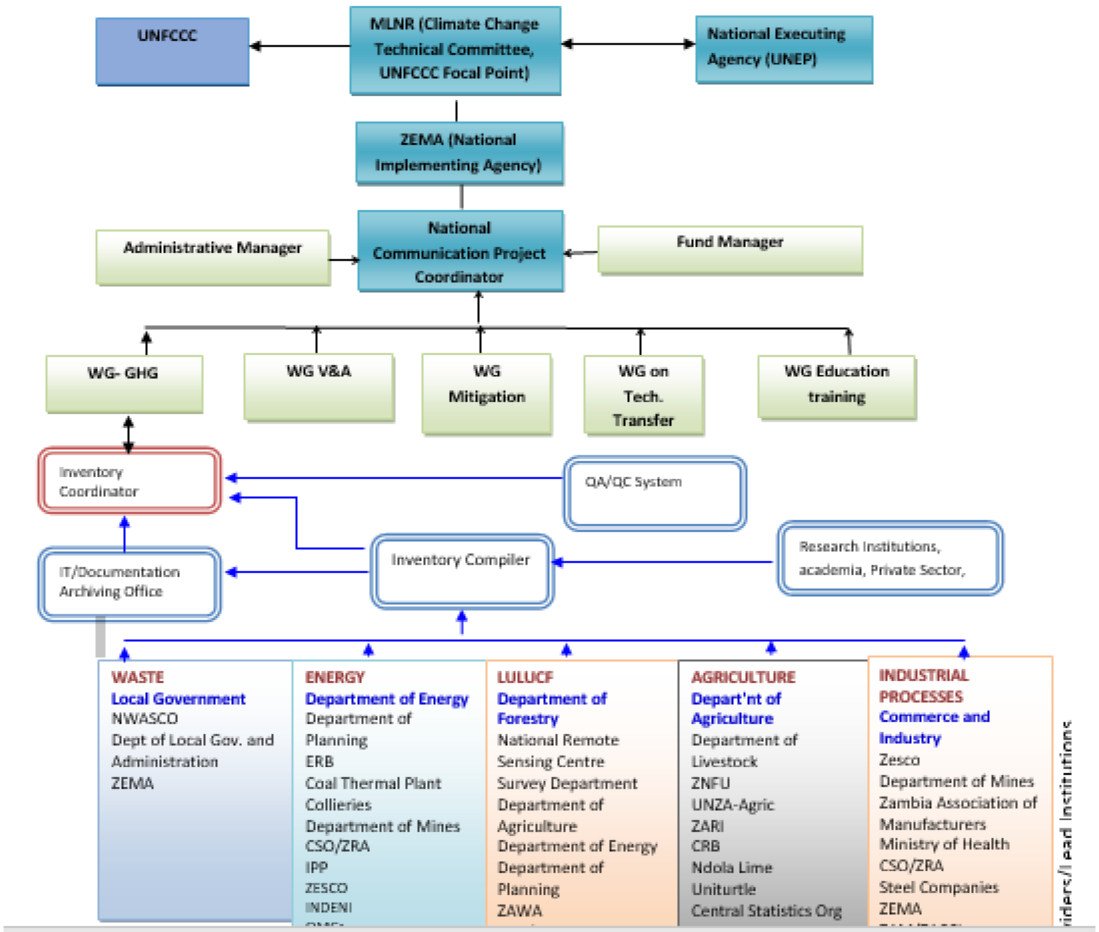


**Figure 2.9. Structure for the preparation of the Third National Communication,** *Source: ZEMA, 2018*

## 3.0 NATIONAL GREENHOUSE GAS INVENTORY

The Greenhouse Gas Inventory (GHGi) was prepared in accordance with the requirements of the UNFCCC using the Intergovernmental Panel on Climate Change (IPCC) guidelines. The Inventory used the 2006 IPCC guidelines for National GHG Inventories and 2006 IPCC software Version 2.54.6396.19217 released on 6$^{th}$ July, 2017. Further, Emission Factor Database (EFDB) Version 2.7 of November 2017 was used. The GHGi assessed the following sectors: Energy, Industrial Processes and Product Use, Agriculture, Forestry and Other Land Use and Waste. The GHGs covered in the Inventory included the following[1]:

a) Carbon dioxide ($CO_2$)
b) Methane ($CH_4$)
c) Nitrous oxide ($N_2O$)
d) Hydrofluorocarbons (HFCs)
e) Sulphur hexafluoride ($SF_6$)

The Global Warming Potential used to estimate the emissions were obtained from the IPCC Second Assessment Report (SAR). The objective of the GHGi was to determine Zambia's emission levels for the years 2005 and 2010 and recalculate emissions for 1994 and 2000 using the updated 2006 IPCC Guidelines methodologies.

### 3.1 GHG Inventory Management System

The GHG Inventory Management System was developed to address challenges that were identified from past GHG inventories including, (i) Lack of documented procedures; (ii) Limited data storage and sharing systems; (iii) Lack of quality control and quality assurance (QA/QC) system to ensure routine and consistent checks required for data integrity, correctness and completeness from different data sources; and (iv) Lack of in-country capacity for GHG inventory management.

In 2013, a robust GHG management system was established through a stakeholder consultative process to address the identified challenges. Memoranda of Understanding were signed with government institutions identified as Sector Lead institutions and capacity building on inventory preparation was provided.

GHG Management Tools were developed and these included an Inventory Management Plan, Data Collection Protocols and a Platform for Data Storage and Sharing.

[1] Gases other than those listed in the inventory were not assessed because they are non-occurring in the country.

The National GHG Inventory Management System and tools that were developed are envisaged to achieve the following:

a. Continuous collection of quality data for preparation of GHG inventories;
b. Generation of data to inform planning, mitigation actions and policies;
c. Tracking efficiency of mitigation actions and progress towards meeting country's emissions reduction goals;
d. Leveraging resources for mitigation actions; and
e. Facilitating future Inventory improvements.

## 3.2 Process of GHG Inventory Preparation

The inventory preparation process involved data collection from institutions such as government, private sector, Civil Society Organisations (CSO) and academia, sorting and documentation. The data documentation involved provision of source and sink category information, methodological choices and description, listing of activity data, identification of emission factors and uncertainty estimates. Additional information and recommendations for future improvements were also documented. Quality Control (QC) was undertaken at every stage of the inventory preparation process for all activity data and emission factors to evaluate for completeness and accuracy. The 2006 IPCC software was used to generate GHG estimates and all data and documentation were archived in the GHG Inventory Management System. The tools used in the GHG inventory preparation process included spreadsheets, IPCC 2006 Guidelines, IPCC Software and ZEMA GHG Inventory Management Plan (adapted from the US EPA guidelines). Figure 3.1 illustrates the GHGi preparation process.

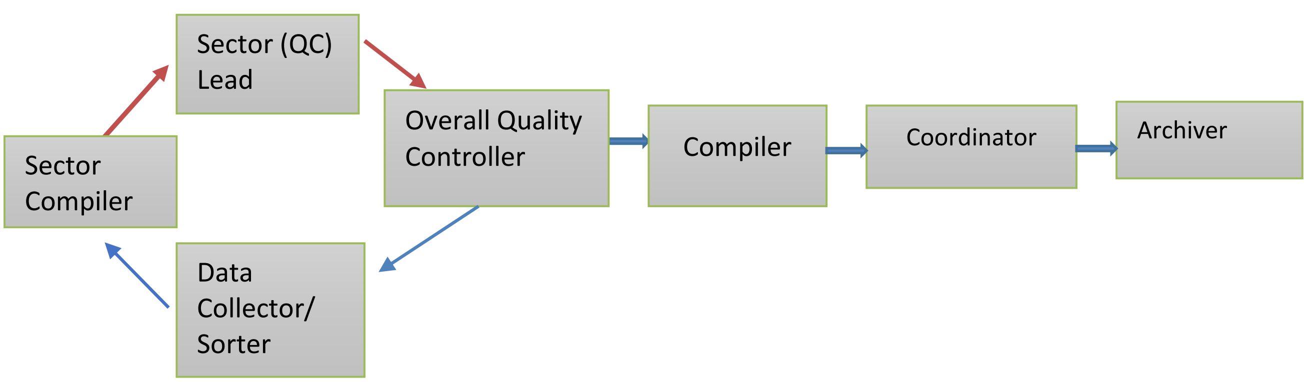


**Figure 3.1: GHG Inventory preparation process**

### 3.3 Methodologies Used and Data Sources

The GHG Inventory for the Third National Communication (TNC) was estimated in accordance with the IPCC 2006 Guidelines. The use of the IPCC software facilitated the ease of preparation of the inventory. Quality control was applied in the inventory preparation across all sectors. Activity data sources for all the sectors are provided in Table 3.1

**Table 3.1: Activity Data Sources for all Sectors**

| No. | SECTOR | | ACTIVITY DATA SOURCE |
|---|---|---|---|
| 1 | Energy | Energy | Energy Regulation Board, Oil marketing companies, Ministry of Energy, Zambia Revenue Authority |
| 2 | IPPU | IPPU | Industry, Zambia Revenue Authority, Central Statistical Office |
| 3 | AFOLU | AGRICULTURE | Ministry of Agriculture, Central Statistical Office, Zambia Revenue Authority |
| | | FORESTRY | ILUA I, ILUA II, Forestry Department |
| | | LIVESTOCK | Ministry of Fisheries and Livestock Central Statistical Office, Diary Association of Zambia, Zambia Farmers Union |
| 4 | Waste | Waste | Central Statistical Office, Ministry of Local Government and Housing, World Bank Database, National Water and Sanitation Company |

Activity data used in estimating GHG emissions from the energy sector came from the energy balance report. Data from sources such as Energy Regulation Board (ERB), Oil Marketing Companies, Central Statistical Office (CSO) which has been renamed the Zambia Statistical Agency (ZAMSTATS) and the Zambia Revenue Authority (ZRA) were collected and compared for confirmation and verification purposes.

For the IPPU sector, activity data used in estimating GHG emissions was obtained from mineral, metal and chemical industries, among others, CSO and ZRA.

Activity data used in estimating GHG emissions from the AFOLU sector was obtained from CSO, ZRA and the Forest Department's Integrated Land Use Assessment (ILUA) I and II data sets respectively.

Estimates of emissions for solid waste disposal, incineration and open burning of waste were based on population, GDP and per capita waste generation. This data was obtained from CSO, International Monetary Fund (IMF) and the World Bank. Default values for Biochemical Oxygen Demand (BOD) generation per capita were used.

The 2006 IPCC Software and Emission Factor Database were used in preparing the inventory. Tier 1 method and default emission factors were used to estimate emissions for the Energy, IPPU, and Waste sectors. Tier 1 was also used for other subcategories under AFOLU, except for the Land sub category for which Tier 2 method was applied.

Changes in methodologies and activity data used for the estimation of emissions necessitated the recalculation of emissions for the years 1994 and 2000 that were presented in the Second National Communication.

### 3.4 Quality Assurance and Quality Control

In order to ensure that the Inventory process was in line with required international standards as stipulated in the Inventory guidelines, quality control was conducted at three levels of the inventory process as follows:

a) Pre-Inventory preparation: This involved activity data compilation and cleaning of the data by sector teams prior to inventory compilation.
b) Inventory preparation: This involved checking and verification of activity data and emission factors and ensuring correct entry of figures in the software.
c) Post Inventory preparation: This involved checking and verification of activity data, emission factors and results of emissions.

The IPCC good practice guidance requires the country's Inventory to be Transparent, Accurate, Consistent, Complete and Comparable (TACCC) to other inventories. In adherence to this, the GHG Inventory report was submitted to the Global Support Programme (GSP) for quality assurance. Further, the report highlighted information gaps where estimations could not be undertaken and the levels of uncertainties.

### 3.5 Greenhouse Gas Emissions For 2010

In 2010, the sector with the highest GHG emissions was AFOLU at 95.75 percent followed by energy at 2.62 percent. IPPU was 1.35 percent and the least was waste at 0.25 percent (Figure 3.2).

The trend is similar for all the time series where emissions are highest in AFOLU followed by energy, IPPU and waste.

The sub category with highest emissions contribution in 2010 was Forest Land with 55.2 percent (i.e. 26.1 percent is from firewood and charcoal production while 29.1 percent is from wood removal for timber). Emissions from crop land is second with 21.3 percent and third is emissions from biomass burning settlements 8.6 percent. Emissions from settlement is fourth at 8.2 percent (Table 3.2).

**Table 3.2:Percentage contribution to overall emissions by sub category for 2010**

| Subcategory | Percentage Contribution to total GHG emissions (percent) |
|---|---|
| 1.A.1 - Energy Industries | 0.17 |
| 1.A.2 - Manufacturing Industries and Construction | 1.32 |
| 1.A.3 - Transport | 0.56 |
| 1.A.4 - Other Sectors | 0.57 |
| 1.B.1 - Solid Fuels Fugitive emissions | 0.0003 |
| 2.A.1 - Cement production | 0.31 |
| 2.A.2 - Lime production | 0.92 |
| 2.C.1 - Iron and Steel Production | 0.001 |
| 2.D.1 - Lubricant Use | 0.01 |
| 2.F.1 - Refrigeration and Air Conditioning | 0.05 |
| 2.G.1 - Electrical Equipment | 0.05 |
| 3.A.1 - Livestock Enteric Fermentation | 1.85 |
| 3.A.2 - Livestock Manure Management | 0.09 |
| 3.B.1 - Forest land | 55.2percent (i.e. firewood and charcoal 26.1percent and Timber 29.1percent) |
| 3.B.2 - Cropland | 21.29 |
| 3.B.5 - Settlements | 8.28 |
| 3.C.1 - Emissions from biomass burning | 8.63 |
| 3.C.3 - Urea application | 0.07 |

| | |
|---|---|
| 3.C.4 - Direct N2O Emissions from managed soils | 0.33 |
| 3.C.7 - Rice cultivations | 0.02 |
| 4.A - Solid Waste Disposal | 0.06 |
| 4.D - Wastewater Treatment and Discharge | 0.19 |

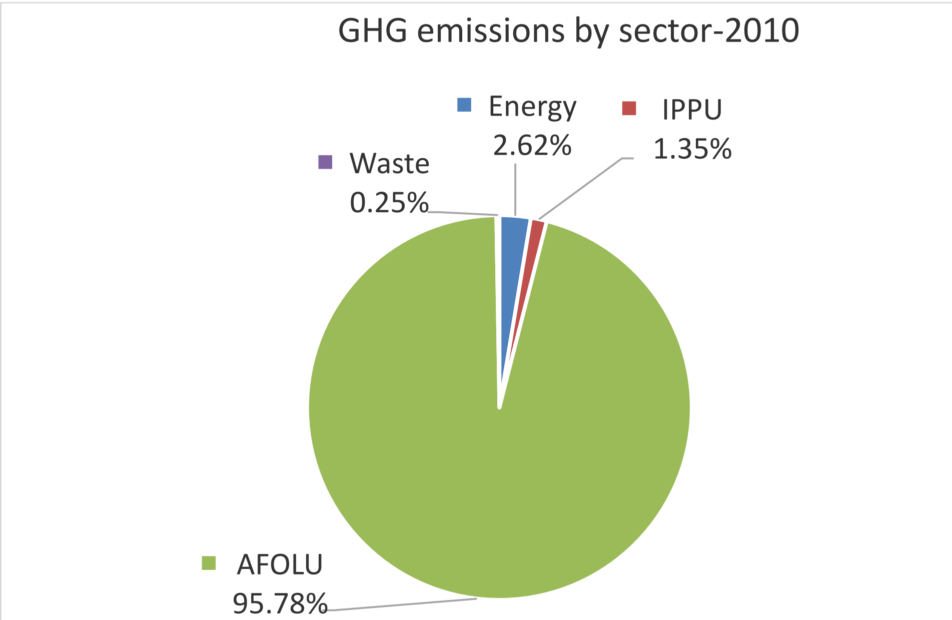


**Figure 3.2:Emissions contribution by sector for 2010**

## 3.6 Greenhouse Gas Emission Trends

Overall emissions results indicate Zambia was a net sink in 1994, 2000, 2005 and 2010. The sink capacity however, has been observed to be reducing over the years. The AFOLU sector has been the major source of emissions, followed by Energy, Industrial Processes and Product Use and Waste. Emissions from Waste, Energy and IPPU are increasingly becoming significant. Carbon dioxide is the most dominant gas among the GHGs emitted in Zambia, followed by methane and nitrous oxide. Other gases are HFC and SF6 from refrigeration and electrical equipment, respectively.

The net sink reduced by 70.6 percent from -57,124.0 Gg $CO_2$ eq. to -16,815.2 Gg $CO_2$ eq. in 1994 and 2010 respectively. Further, the total GHG emissions increased from 85,805.1 Gg $CO_2$ eq. in 1994 to 120,507.7 Gg $CO_2$ eq. in 2010 representing a growth of 40.4 percent. On the other hand, total emission removals reduced from-142,929.2 Gg $CO_2$ eq. to -137,322.9 Gg $CO_2$ eq. in the same period representing a decline of 3.9 percent (Figure 3.3).

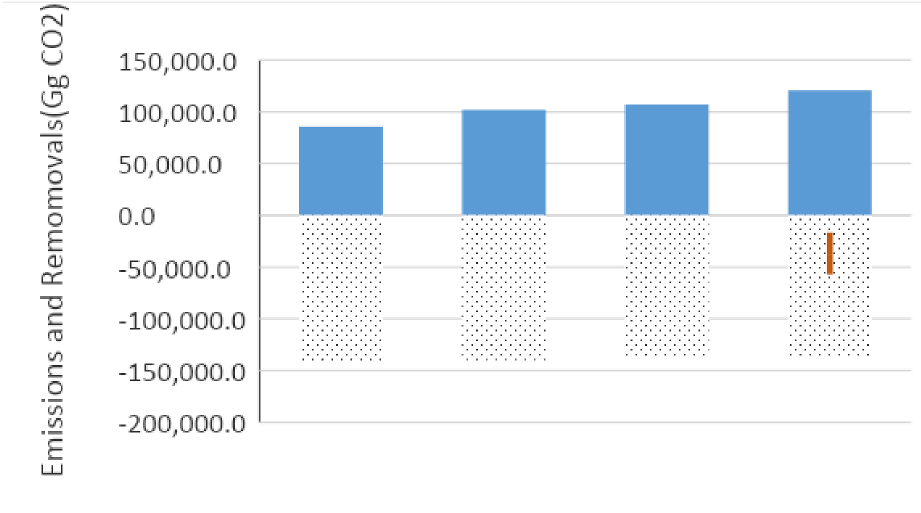


**Figure 3.3: Trends of GHG emissions and removals**

Emissions in the energy sector increased by 44.8 percent from 2,179.4 Gg $CO_2$ eq. in the 1994 base year to 3,155.8 Gg $CO_2$ eq. in 2010 (Table 2.2). Emissions in the IPPU sector increased from 431.2 Gg $CO_2$ eq. in 1994 to 1,621.0 Gg $CO_2$ eq. in 2010. In the Waste sector, emissions increased from 204.5Gg $CO_2$ eq. in 1994 based year to 305.9 Gg $CO_2$ eq. representing a growth of 49.6 percent.

Emission trends for all sectors over the period 1994 to 2010 indicate an increase whilst removals have been reducing over the same period as shown in Table 3.3.

**Table 3.3:GHG emissions (Gg $CO_2$ eq.) by sector for 1994 to 2010**

| | Total With AFOLU | Total Without AFOLU | Energy | IPPU | AFOLU Emissions | Waste |
|---|---|---|---|---|---|---|
| 1994 | 85,805.1 | 2,815.0 | 2,179.4 | 431.2 | 82,990.1 | 204.5 |
| 2000 | 102,003.5 | 3,057.0 | 1,743.5 | 1,091.0 | 98,946.5 | 222.5 |
| 2005 | 106,967.1 | 3,791.7 | 2,158.9 | 1,375.6 | 103,175.3 | 257.3 |
| 2010 | 120,507.7 | 5,082.7 | 3,155.8 | 1,621.0 | 115,425.0 | 305.9 |

Significant amounts of emissions were from the AFOLU sector particularly in the Land category. Total emissions with AFOLU were 85,805.1 Gg $CO_2$ eq. in 1994 base year and 120,507.7 Gg $CO_2$ eq. in 2010. Total emissions without AFOLU were 2,815.0 Gg $CO_2$ eq. in 1994 base year and 5,082.7 Gg $CO_2$ eq. in 2010. The main sources of emissions in the Land category are from wood removals and fuelwood removals. Figure 3.4 shows percentage contribution of emissions by forest classification.

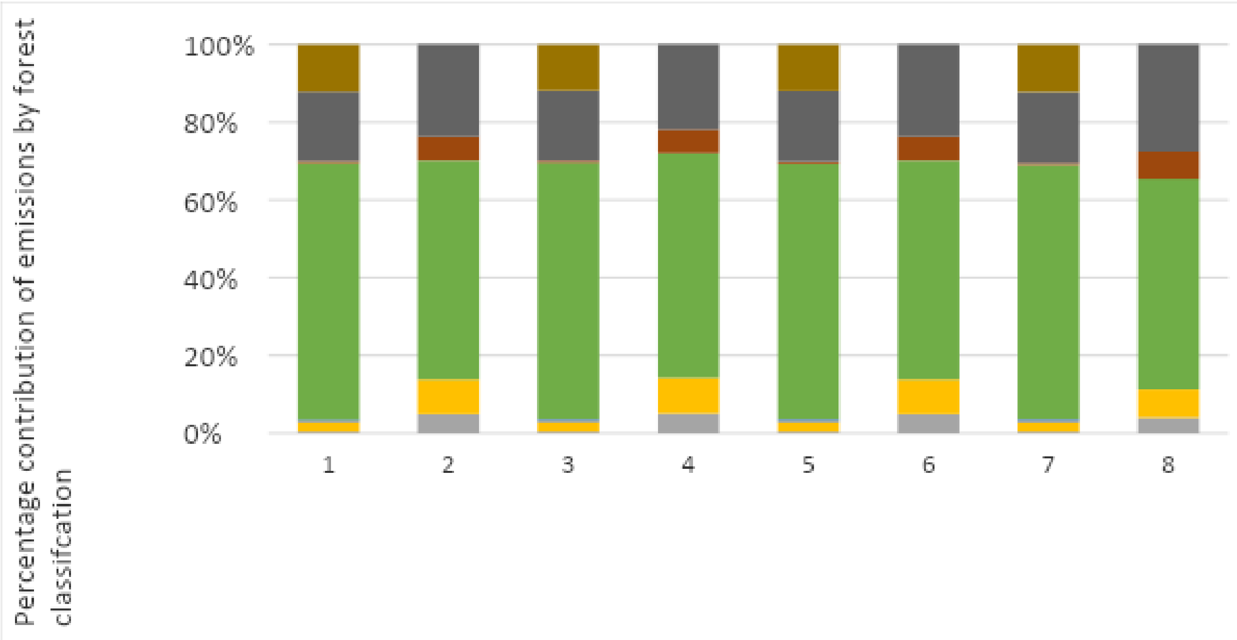


**Figure 3.4:Percentage contribution emissions from Land category**

The emission trends for all categories in the Land Category is provided in Figure 3.5

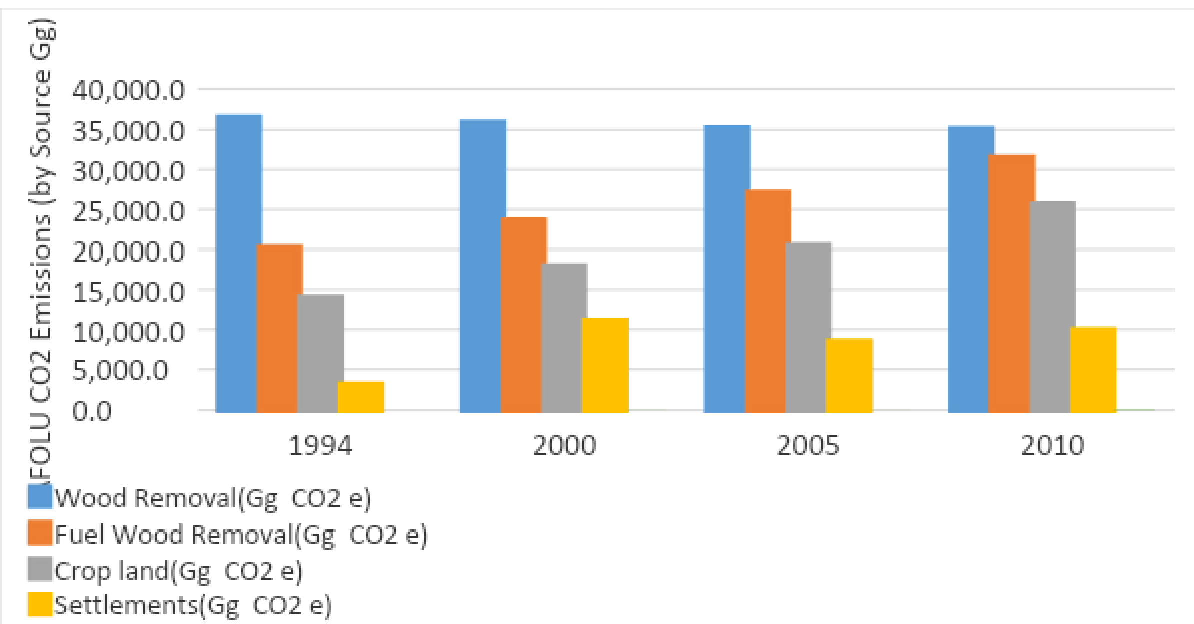


**Figure 3.5:Emissions trends for all categories in the Land Category**

Provided in Figure 3.6 is the percentage contribution and trends of emissions removals by forest classification.

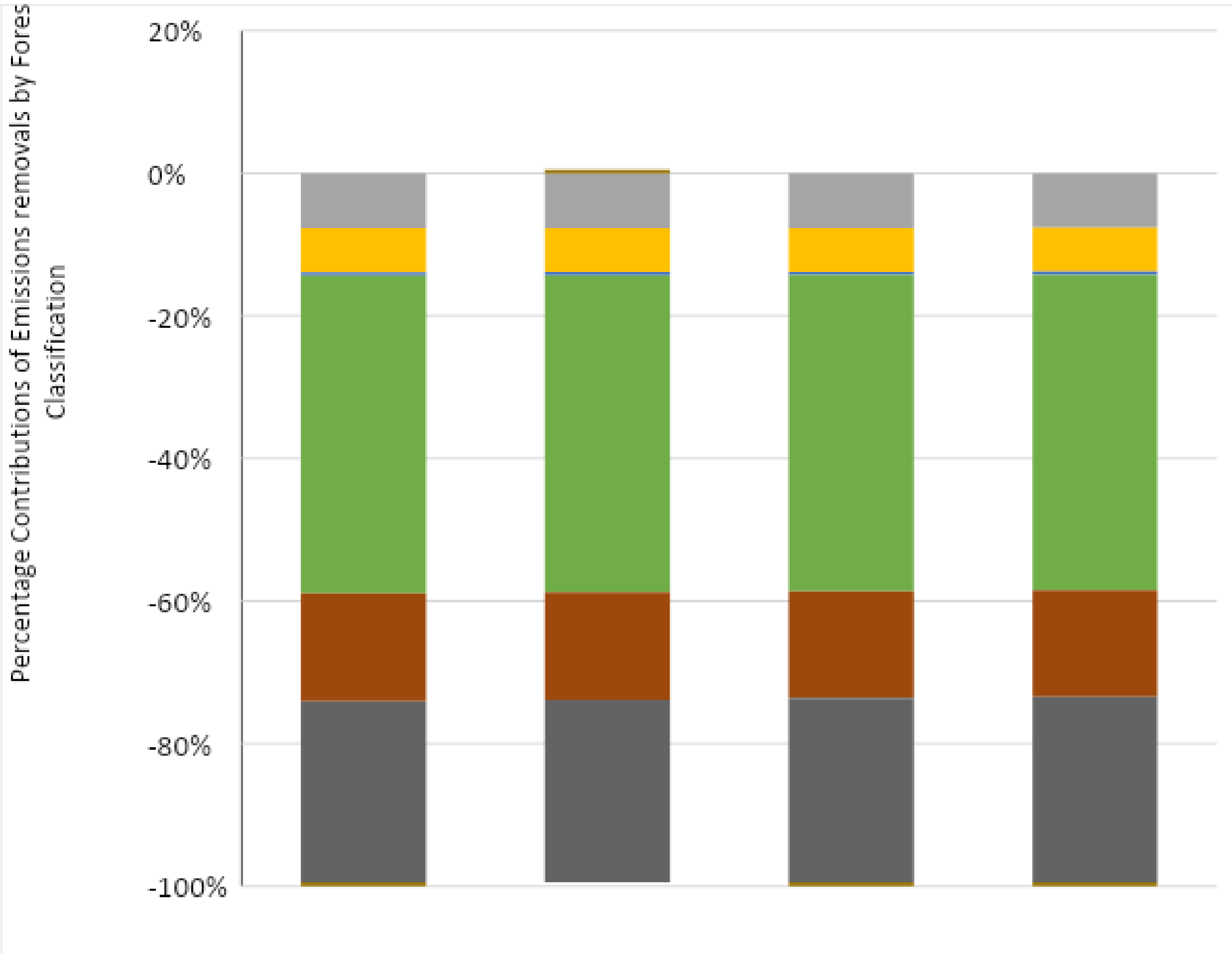


**Figure 3.6: Percentage contribution and trends of emissions removals by forest classification**

In 2010, the highest sink occurred in Forest Woodland with 44.2 percent followed by Other Wood Land at 26.0 percent. Others were Moist Evergreen 14.9 percent, Dry Deciduous 7.7 percent. Dry evergreen 6.1 percent and the least was Pine and Eucalyptus both at 0.5 percent (Figure3.7).

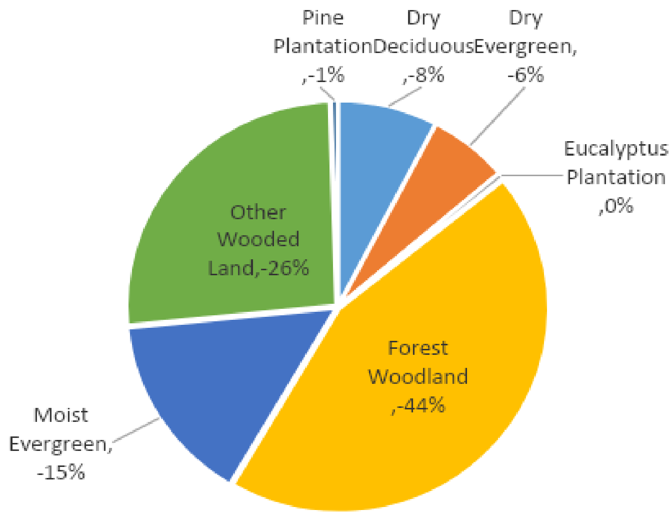


**Figure 3.7:Percentage contribution to sink in 2010**

### 3.7 Greenhouse Gas Emission Trends by Gas

By gas in 2010, $CO_2$ was the highest at 88.4 percent followed by $CH_4$ at 7.9 percent, $N_2O$ was 3.8 percent while the least was HFC and SF6 both at 0.1 percent as shown in Figure 3.8. Precursor gases such as CO, NMVOC, $NO_x$ and $SO_2$ were not estimated with the exception of the AFOLU sector.

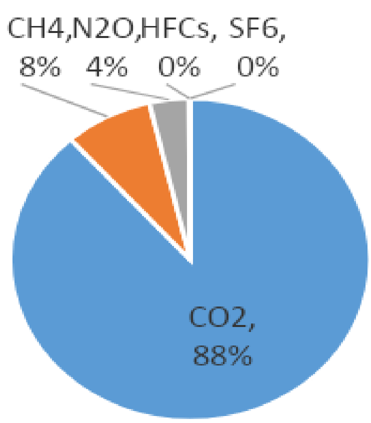


**Figure 3.8:Emissions by Gas For 2010**

The emissions of CO2 increased by 39.7 percent from 76,288.9 Gg $CO_2$ eq. in the 1994 base year to 106,558.0 Gg $CO_2$ eq. in 2010 (Figure 3.9). During the same period, $CH_4$, $N_2O$, HFCs and SF6 increased from 6,880.7 Gg $CO_2$ eq., 2,628.5 Gg $CO_2$ eq, 4.3 Gg $CO_2$ eq, 2.6 Gg $CO_2$ eq in 1994 to 9,540.9 Gg $CO_2$ eq, 4,284.1 Gg $CO_2$ eq 60.6 $CO_2$ eq. and 64.1 $CO_2$ eq in 2010, respectively. Figure 3.9 shows the emissions trends by gas from 1994 to 2010.

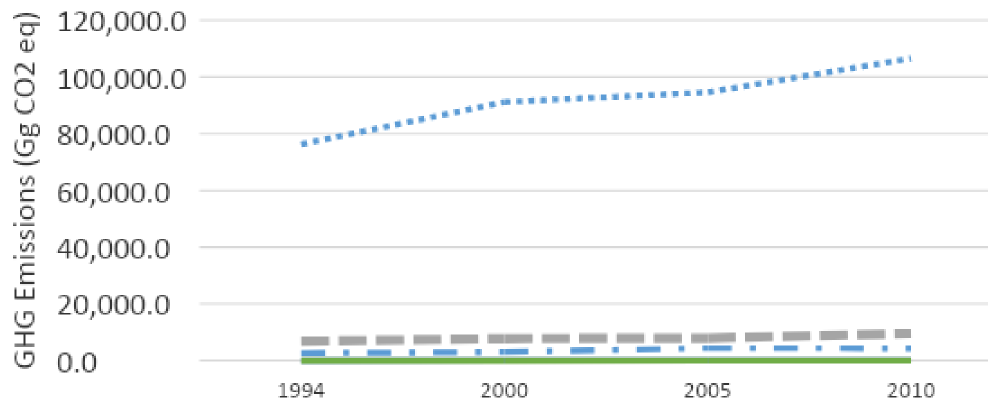


**Figure 3.9:Trend of emissions by Gas from 1994 to 2010**

In 2010, the highest contribution of CO2 emissions in the AFOLU was from Wood Removal at 34 percent followed by Fuelwood removal at 31percent. Emissions from land converted to cropland contributed 25 percent. The least was emissions from land converted to settlements at 10 percent (Figure3.10)

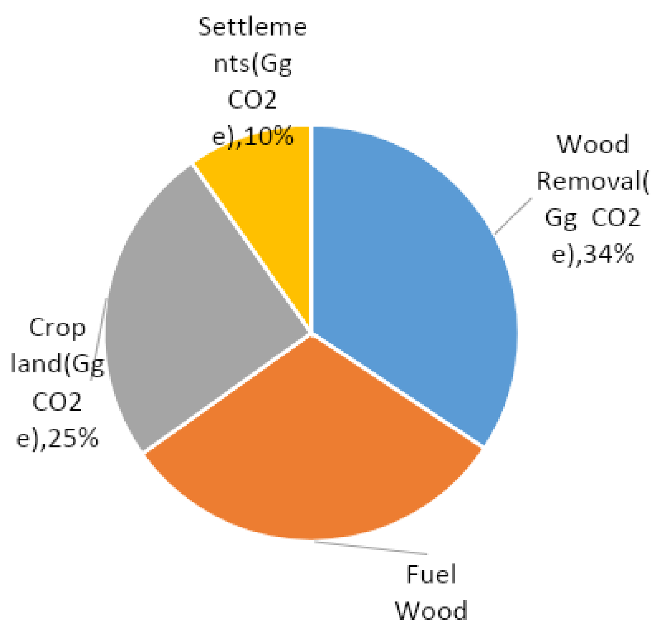


**Figure 3.10: CO2 emissions sources in AFOLU sector**

The emissions in the energy sector increased by 44.8percent from 2,179.4 Gg $CO_2$ eq. in the 1994 base year to 3,155.8 Gg $CO_2$ eq. in 2010 (Table 2). Emissions in the IPPU sector increased from 431.2 Gg $CO_2$ eq. in 1994 to 1,621.0 Gg $CO_2$ eq. in 2010. In the Waste sector, emissions increased from 204.5Gg $CO_2$ eq. in 1994 based year to 305.9 Gg $CO_2$ eq. representing a growth of 49.6 percent. Emissions indicate increasing trends for all sectors over the period 1994 to 2010. Emission removals have been reducing over the same period (Figure 4). Total emissions without AFOLU were 2,815.0 Gg $CO_2$ eq. in 1994 base year and 5,082.7 Gg $CO_2$ eq. in 2010. Total emissions with AFOLU were 85,805.1 Gg $CO_2$ eq. in 1994 base year and 120,507.7 Gg $CO_2$ eq. in 2010 (Table3.4).

**Table 3.4:GHG emissions (Gg CO2 eq.) by sector for 1994 to 2010**

| Year | Total With AFOLU | Total Without AFOLU | Energy | IPPU | AFOLU Emissions | Waste |
|---|---|---|---|---|---|---|
| 1994 | 85,805.1 | 2,815.0 | 2,179.4 | 431.2 | 82,990.1 | 204.5 |
| 2000 | 102,003.5 | 3,057.0 | 1,743.5 | 1,091.0 | 98,946.5 | 222.5 |
| 2005 | 106,967.1 | 3,791.7 | 2,158.9 | 1,375.6 | 103,175.3 | 257.3 |
| 2010 | 120,507.7 | 5,082.7 | 3,155.8 | 1,621.0 | 115,425.0 | 305.9 |

Table 4 provides summary Reporting Table for 2010. $CO_2$ emissions from surface mines was not estimated because oxidation of coal in the atmosphere to produce $CO_2$ is known to occur at surface mines, but emissions from this are not expected to be significant, especially taking into account the effects of rehabilitation of the waste dumps. Rehabilitation practices, which involve covering the dumps with topsoil and re-vegetation, act to reduce oxygen fluxes into the dump and hence reduce the rate of $CO_2$ production (IPCC, 2006 Guidelines). Carbon Dioxide emissions from Lead and Zinc production for 1994 were not estimated due to lack of data. Lead and Zinc production was still occurring in Zambia at the time. However, production of these metals was not occurring for the years 2000, 2005 and 2010. Methane emissions from steel production were not estimated because although $CH_4$ may be emitted from steel–making processes as well, those emissions were assumed to be negligible.

Carbon dioxide emissions from Lubricant Use were not estimated for the years 1994 and 2005 due to lack of data. In Paraffin Wax Use, $CO_2$ emissions were not estimated due to lack of data across all the years. Emissions of HCF from Foam Blowing Agents, Fire Protection, Aerosols and Solvents were not estimated due to lack of data. Evaporative emissions of nitrous oxide ($N_2O$) from Medical applications (anesthetic use, analgesic use and veterinary use) could not be estimated due to lack of data. Nitrous oxide emissions produced, directly and indirectly, during the storage and treatment of manure before it is applied to land or otherwise used for feed, fuel, or construction purposes was not estimated due to lack of data. Emissions from Liming of soils were not estimated due to lack of data. Table 4 provides a summary of reporting table for GHGs in 2010.

**Table 3.5:Summary Reporting Table for 2010**

| Categories | Emissions CO2 Equivalents (Gg) | | | Emissions $CO_2$ Equivalents (Gg) | | | |
|---|---|---|---|---|---|---|---|
| | Net $CO_2$ (1)(2) | $CH_4$ | $N_2O$ | HFCs | PFCs | SF6 | Other halogenated gases |
| Total National Emissions and Removals | -32,295.6 | 10,554.0 | 4,288.6 | 60.586 | 0 | 64.085 | |
| 1 - Energy | 2,789.8 | 1,030.3 | 228.6 | | | | |
| 1.A - Fuel Combustion Activities | 2789.8 | 1029.9 | 228.6 | | | | |
| 1.A.1 - Energy Industries | 188.5 | 5.4 | 10.9 | | | | |
| 1.A.2 - Manufacturing Industries and Construction | 1560.7 | 6.6 | 17.1 | | | | |
| 1.A.3 - Transport | 677.1 | 0.8 | 14.5 | | | | |
| 1.A.4 - Other Sectors | 363.5 | 1017.1 | 186.0 | | | | |
| 1.A.5 - Non-Specified | 0 | 0 | 0 | | | | |
| 1.B - Fugitive emissions from fuels | NE | 0.4 | | | | | |
| 1.B.1 - Solid Fuels | NE | 0.4 | NE | | | | |
| 1.B.2 - Oil and Natural Gas | NO | NO | NO | | | | |
| 1.B.3 - Other emissions from Energy Production | NO | NO | NO | | | | |
| 1.C - Carbon dioxide Transport and Storage | NO | NO | NO | NO | NO | NO | NO |
| 1.C.1 - Transport of CO2 | NO | | | | | | |
| 1.C.2 - Injection and Storage | NO | | | | | | |
| 1.C.3 - Other | NO | | | | | | |
| 2 - Industrial Processes and Product Use | 1496.29 | | | 60.586 | | 64.085 | |
| 2.A - Mineral Industry | 1479.94 | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.A.1 - Cement production | 375.21 | | | | | | |
| 2.A.2 - Lime production | 1103.02 | | | | | | |
| 2.A.3 - Glass Production | NO | | | | | | |
| 2.A.4 - Other Process Uses of Carbonates | 1.72 | | | | | | |
| 2.A.5 - Other (please specify) | NO | NO | NO | | | | |
| 2.B - Chemical Industry | | | | | | | |
| 2.B.1 - Ammonia Production | NO | | | | | | |
| 2.B.2 - Nitric Acid Production | | | NO | | | | |
| 2.B.3 - Adipic Acid Production | | | NO | | | | |
| 2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production | | | NO | | | | |
| 2.B.5 - Carbide Production | NO | NO | | | | | |
| 2.B.6 - Titanium Dioxide Production | NO | | | | | | |
| 2.B.7 - Soda Ash Production | NO | | | | | | |
| 2.B.8 - Petrochemical and Carbon Black Production | NO | NO | | | | | |
| 2.B.9 - Fluorochemical Production | | | | NO | NO | NO | NO |
| 2.B.10 - Other (Please specify) | NO | NO | NO | NO | NO | NO | NO |
| 2.C - Metal Industry | 1.48 | | | | | | |
| 2.C.1 - Iron and Steel Production | 1.48 | 0 | | | | | |
| 2.C.2 - Ferroalloys Production | 0.006 | 0 | | | | | |
| 2.C.3 - Aluminium production | NO | | | | NO | | |
| 2.C.4 - Magnesium production | NO | | | | | NO | |
| 2.C.5 - Lead Production | NO | | | | | | |
| 2.C.6 - Zinc Production | NO | | | | | | |
| 2.C.7 - Other (please specify) | NO | NO | NO | NO | NO | NO | NO |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.D - Non-Energy Products from Fuels and Solvent Use | 14.9 | | | | | | |
| 2.D.1 - Lubricant Use | 14.9 | | | | | | |
| 2.D.2 - Paraffin Wax Use | NE | | | | | | |
| 2.D.3 - Solvent Use | | | | | | | |
| 2.D.4 - Other (please specify) | NO | NO | NO | | | | |
| 2.E - Electronics Industry | | | | | | | |
| 2.E.1 - Integrated Circuit or Semiconductor | | | | NO | NO | NO | NO |
| 2.E.2 - TFT Flat Panel Display | | | | | NO | NO | NO |
| 2.E.3 - Photovoltaics | | | | | NO | | |
| 2.E.4 - Heat Transfer Fluid | | | | | NO | | |
| 2.E.5 - Other (please specify) | NO | NO | NO | NO | NO | NO | NO |
| 2.F - Product Uses as Substitutes for Ozone Depleting Substances | | | | 60.586 | | | |
| 2.F.1 - Refrigeration and Air Conditioning | | | | 60.586 | | | |
| 2.F.2 - Foam Blowing Agents | | | | NO | | | |
| 2.F.3 - Fire Protection | | | | NO | NO | | |
| 2.F.4 - Aerosols | | | | NO | | | |
| 2.F.5 - Solvents | | | | NO | NO | | |
| 2.F.6 - Other Applications (please specify) | | | | NO | NO | | |
| 2.G - Other Product Manufacture and Use | | | | | | 64.085 | 0 |
| 2.G.1 - Electrical Equipment | | | | | NO | 64.08 | |
| 2.G.2 - SF6 and PFCs from Other Product Uses | | | | | NO | NO | |
| 2.G.3 - N2O from Product Uses | | | NE | | | | |
| 2.G.4 - Other (Please specify) | NO | NO | NO | NO | NO | NO | NO |
| 2.H - Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.H.1 - Pulp and Paper Industry | 0 | 0 | | | | | |
| 2.H.2 - Food and Beverages Industry | 0 | 0 | | | | | |
| 2.H.3 - Other (please specify) | 0 | 0 | 0 | | | | |
| 3 - Agriculture, Forestry, and Other Land Use | -35054.1 | 9294.1 | 3862.0 | | | | |
| 3.A - Livestock | | 2336.4 | | | | | |
| 3.A.1 - Enteric Fermentation | | 2228.5 | | | | | |
| 3.A.2 - Manure Management | | 107.9 | NE | | | | |
| 3.B - Land | -35138.20 | | | | | | |
| 3.B.1 - Forest land | -70766.98 | | | | | | |
| 3.B.2 - Cropland | 25653.05 | | | | | | |
| 3.B.3 - Grassland | 0 | | | | | | |
| 3.B.4 - Wetlands | 0 | | NE | | | | |
| 3.B.5 - Settlements | 9975.74 | | | | | | |
| 3.B.6 - Other Land | NO | | | | | | |
| 3.C - Aggregate sources and non-CO2 emissions sources on land | 84.09 | 331.32 | 12.46 | | | | |
| 3.C.1 - Emissions from biomass burning | | 330.253 | 11.183 | | | | |
| 3.C.2 - Liming | NE | | | | | | |
| 3.C.3 - Urea application | 84.09 | | | | | | |
| 3.C.4 - Direct N2O Emissions from managed soils | | | 1.28 | | | | |
| 3.C.5 - Indirect N2O Emissions from managed soils | | | NE | | | | |
| 3.C.6 - Indirect N2O Emissions from manure management | | | NE | | | | |
| 3.C.7 - Rice cultivations | | 1.06457 | | | | | |
| 3.C.8 - Other (please specify) | | NO | NO | | | | |
| 3.D - Other | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3.D.1 - Harvested Wood Products | NE | | | | | | |
| 3.D.2 - Other (please specify) | NE | NE | NE | | | | |
| 4 - Waste | 1.64 | 125.8 | 178.5 | | | | |
| 4.A - Solid Waste Disposal | | 75.6 | | | | | |
| 4.B - Biological Treatment of Solid Waste | NO | NO | NO | | | | |
| 4.C - Incineration and Open Burning of Waste | 1.64 | 0.3 | 0.1 | | | | |
| 4.D - Wastewater Treatment and Discharge | | 49.8 | 178.4 | | | | |
| 4.E - Other (please specify) | | | | | | | |
| 5 - Other | | | | | | | |
| 5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3 | | | | | | | |
| 5.B - Other (please specify) | | | | | | | |
| | | | | | | | |
| Memo Items (5) | | | | | | | |
| International Bunkers | 85.87 | 0.013 | 0.2 | 0 | 0 | 0 | 0 |
| 1.A.3.a.i - International Aviation (International Bunkers) | 85.87 | 0.013 | 0.2 | | | | |
| 1.A.3.d.i - International water-borne navigation (International bunkers) | NO | NO | NO | | | | |
| 1.A.5.c - Multilateral Operations | NO | NO | NO | NO | NO | NO | NO |

## 3.8 Key Category Analysis

According to Approach 1 Level Assessment, the key categories were Forest land Remaining Forest land, Land Converted to Cropland, Land Converted to Settlements, Emissions from biomass burning and Enteric Fermentation. For 2010, seven key categories were identified (five with both the level and trend assessment, one only with the level assessment and one with the trend assessment). All the categories identified as key (except one) are from the AFOLU sector, which reflects the importance of this sector in the country's inventory (Table 3.6). Emissions from biomass burning (3.C.1) and Emissions from Transport (1.A.3.b) with 96.3 percent and 97.0 percent sit at the threshold and qualitatively could be considered as key categories under trend assessment.

**Table 3.6:Summary of key category analysis for inventory year 2010**

| IPCC Category code | IPCC Category | Greenhouse gas | Criteria |
|---|---|---|---|
| 3.B.1.a | Forest land Remaining Forest land | $CO_2$ | T1, L1 |
| 3.B.2.b | Land Converted to Cropland | $CO_2$ | T1, L1 |
| 3.B.5.b | Land Converted to Settlements | $CO_2$ | T1, L1 |
| 3.C.1 | Emissions from biomass burning | $CH_4$ | T1, L1 |
| 3.C.1 | Emissions from biomass burning | $N_2O$ | L1 |
| 3.A.1 | Enteric Fermentation | $CH_4$ | T1, L1 |
| 2.A.2 | Lime production | $CO_2$ | T1 |
| 3.C.1 | Emissions from biomass burning | $N_2O$ | Q |
| 1.A.3.b | Road Transportation | $CO_2$ | Q |

1) The notation keys: L = key category according to level assessment; T = key category according to trend assessment; and Q = key category according to qualitative criteria; should be used to describe the assessment method used.

For 2005, seven key categories were identified (five with both the level and trend assessment, one only with the level assessment and one with the trend assessment). All the categories identified as key (except one) are from the AFOLU sector, which reflects the importance of this sector in the country's inventory (Table 3.7). Detailed results of KCA are provided in Annex II.

**Table 3.7:Summary of key category analysis for inventory year 2005**

| IPCC Category code | IPCC Category | Greenhouse gas | Criteria |
|---|---|---|---|
| 3.B.1.a | Forest land Remaining Forest land | $CO_2$ | L1, T1 |
| 3.B.5.b | Land Converted to Settlements | $CO_2$ | L1, T1 |
| 3.B.2.b | Land Converted to Cropland | $CO_2$ | L1, T1 |

| | | | |
|---|---|---|---|
| 3.C.1 | Emissions from biomass burning | $CH_4$ | L1, T1 |
| 2.A.2 | Lime production | $CO_2$ | T1 |
| 3.A.1 | Enteric Fermentation | $CH_4$ | L1, T1 |
| 3.C.1 | Emissions from biomass burning | $N_2O$ | L1 |

## 3.9 RECALCULATIONS OF GHG EMISSIONS

Re-calculations were made for the years 1994 and 2000 for all the IPCC sectors, as a result of the change of methodology after migration from the 1996 to 2006 IPCC Guidelines. The re-collection of activity data for 1994 and 2000 also necessitated the recalculations. Further, for the AFOLU sector, additional data from the ILUA I and II also necessitated the recalculations and migrated the emission factors to Tier 2.

The overall comparison of 1994 and 2000 sectoral emissions with recalculated figures for Second and TNCs (Gg $CO_2$ eq.) are presented in Tables 3.8 and 3.9

**Table 3.8:Comparison of 1994 emissions with recalculated figures for 2nd and 3rd National Communications (Gg $CO_2$ eq)**

| | Energy | IPPU | AFOLU/ (LULUCF & Agriculture) | Waste | Total |
|---|---|---|---|---|---|
| 3rd National Communication (Recalculation) | 2,179.4 | 431.2 | 82990.1 | 204.5 | 85,805.20 |
| 2nd National Communication (Recalculation) | 2,778 | 2,008 | 46,363 | 371 | 51,520.00 |
| Initial National Communication | 17409.5 | 326.5 | 88586.1 | 1415.2 | 107,737.30 |

**Table 3.9:Comparison of 2000 emissions with recalculated figures for 3rdNational Communication (Gg $CO_2$ eq)**

| | Energy | IPPU | AFOLU/ (LULUCF & Agriculture) | Waste | Total |
|---|---|---|---|---|---|
| Third National Communication (Recalculation) | 1743.5 | 1090.9 | 98946.5 | 222.5 | 102,003.4 |

| | | | | | |
|---|---|---|---|---|---|
| Second National Communication | 2629.0 | 1006.0 | 50669.0 | 412.0 | 54716.0 |

### 3.9.1 Recalculation-Energy Sector

The recalculated figures for Energy in 1994 and 2000 were 21.55 percent and 33.68 percent lower than that submitted in the Second National Communication (SNC), respectively as provided in Table 3.10

**Table 3.10 Energy Sector recalculation of total emissions $CO_2$ eq**

| Year | Second National Communication submission | Third National Communication Submission | Difference | |
|---|---|---|---|---|
| | | | Gg $CO_2$ eq | percent |
| 1994 | 2,778 | 2,179.37 | -598.63 | -21.55 |
| 2000 | 2,629 | 1743.507235 | -885.49 | -33.68 |

### 3.9.2 Recalculation-IPPU Sector

The recalculated figures for IPPU for 1994 were lower than those submitted in the SNC by 78.5percent. However, the recalculated estimates for 2000 indicate an increase by 8.5 percent (Table 3.11).

**Table 3.11: IPPU Sector recalculations of total emissions $CO_2$ eq.**

| Year | Second National Communication submission | Third National Communication Submission | Difference | |
|---|---|---|---|---|
| | | | Gg $CO_2$ eq | percent |
| 1994 | 2,008 | 431.2 | -1576.8 | -78.5 |
| 2000 | 1,006 | 1090.9 | 84.9 | 8.5 |

### 3.9.3 Recalculation-AFOLU Sector

The recalculated figures for AFOLU for 1994 were higher than those submitted in the SNC by 78.9 percent. Similarly, the recalculated estimates for 2000 indicate an increase by 95.3 percent (Table 3.12).

**Table 3.12. Sector recalculations of total emissions $CO_2$ eq**

| Year | Second National Communication submission | Third National Communication Submission | Difference | |
|---|---|---|---|---|
| | Sum of LULUCF and Agriculture | AFOLU | Gg $CO_2$ eq. | percent |
| 1994 | 46,363 | 82973.83 | 36610.83 | 78.97 |
| 2000 | 50,669 | 98990.67 | 48321.67 | 95.37 |

Recalculated emissions removals are much higher due to change of methodology and improved data quality obtained from ILUA I&II (Table 3.13).

**Table 3.13 Total Removals recalculations $CO_2$ eq**

| Year | Second National Communication submission | Third National Communication Submission | Difference | |
|---|---|---|---|---|
| | Sum of LULUCF and Agriculture | AFOLU | Gg $CO_2$ eq | percent |
| 1994 | 46,363.0 | 82990.1 | 36627.1 | 79.0 |
| 2000 | 50,669.0 | 98946.5 | 48277.5 | 95.3 |

### 3.9.4 Recalculation-Waste Sector

The recalculated figures for the waste sector for 1994 were lower than those submitted in the SNC by 44.89 percent. Similarly, recalculated estimates for 2000 indicate a decrease by 46.00 percent (Table 3.14).

**Table 3.14 Waste Sector recalculations of total emissions $CO_2$ eq**

| Year | Second National Communication submission | Third National Communication Submission | Difference | |
|---|---|---|---|---|
| | | | Gg CO2 eq | percent |
| 1994 | 371 | 204.48 | -166.52 | -44.89 |
| 2000 | 412 | 222.48 | -189.52 | -46.00 |

## 3.10 Energy

While the use of energy provides enormous benefits to the nation, the energy sector also contributes significantly to environmental pollution and GHG emissions, thus causing damage to a wide range of receptors, including human health, natural ecosystems and the built environment. In this inventory, the source categories considered for the energy sector were fuel combustion, fugitive emissions and carbon capture and storage. The sub categories under fuel combustion were energy industries, manufacturing industries and transport mobile such as road, rail, navigation, and aviation, commercial/residential. Fugitive emissions include all intentional and unintentional emissions from the extraction, processing, storage and transport of solid, liquid and gaseous fuel to the point of final use. Both sectoral and reference approaches were used to estimate $CO_2$.

### 3.10.1 Emissions based on Reference approach

Reference approach was used to estimate the $CO_2$ emissions of the energy sector based for the years 1994, 2000, 2005 and 2010. Table 3.15 provides the comparison of $CO_2$ emissions between Sectoral and Reference approaches for 2010.

**Table 3.15: Comparison of $CO_2$ emissions between Sectoral and Reference approach for 2010**

| | Reference Approach | | | | Sectoral Approach | | Difference | |
|---|---|---|---|---|---|---|---|---|
| **Fuel** | **Apparent Consumption (TJ)** | **Excluded consumption (TJ)** | **Apparent Consumption (excluding non-energy use and feedstocks) (TJ)** | **CO2 Emissions (Gg)** | **Energy Consumption (TJ)** | **CO2 Emissions (Gg)** | **Energy Consumption (percent)** | **CO2 Emissions (percent)** |
| Crude Oil | 2398.2 | | 2398.2 | 175.9 | 2398.2 | 175.8 | 0 | 0.045 |
| Motor Gasoline | 7876.1 | | 7876.1 | 545.8 | 7079.7 | 490.6 | 11.24764 | 11.25 |
| Aviation Gasoline | 41.2 | | 41.2 | 2.9 | 41.2 | 2.9 | 0 | 0.048 |
| Jet Kerosene | 1225.5 | | 1225.5 | 87.6 | 24.5 | 1.8 | 4900.163 | 4900.16 |
| Other Kerosene | 86.6 | 0.0 | 86.6 | 6.2 | 86.6 | 6.2 | 0 | -0.046 |
| Gas/Diesel Oil | 12943.0 | 0.0 | 12943.0 | 958.6 | 12943.0 | 959.1 | 1.41E-14 | -0.045 |
| Residual Fuel Oil | 1810.4 | | 1810.4 | 140.1 | 1810.4 | 140.1 | 0 | -0.043 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Liquefied Petroleum Gases | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | -100 | -100.000 |
| Other Bituminous Coal | -1.0 | | -1.0 | -0.1 | | | 100 | 100.000 |
| Sub-Bituminous Coal | 10559.5 | | 10559.5 | 1014.4 | 10559.5 | 1014.8 | 0 | -0.035 |

### 3.10.2 Emissions Trends

Generally, emissions from the energy sector are increasing in Zambia. Energy emissions increased by 59.7percent from 2,534.5 Gg $CO_2$ eq. in 1994 to 4,048.6 Gg $CO_2$ eq. in 2010 (Figure 3.11 ). The trend is attributed mainly to an increase in consumption of petroleum products driven by increase in economic activities and vehicle population.

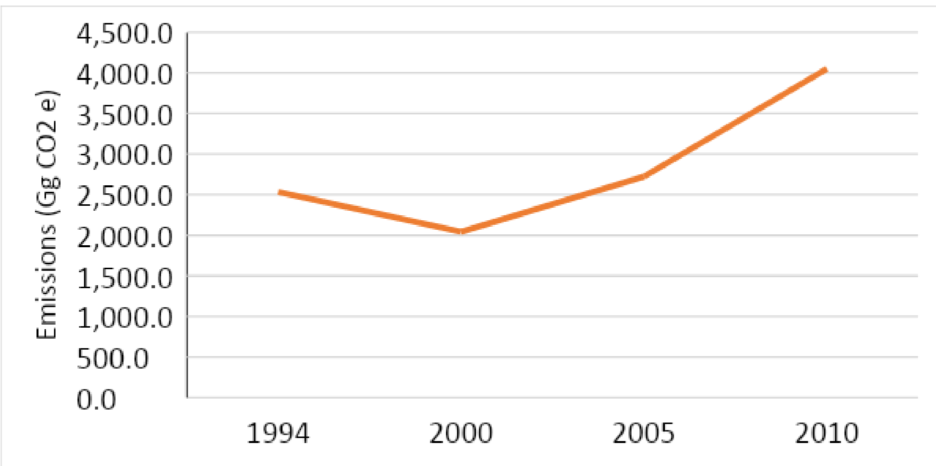


**Figure 3.11 Emission Trends in the Energy Sector**

Compared to the 1994 base year, the emissions from manufacturing and construction industries increased by 41.0percent. On the other hand, emissions from energy industries increased from 165.4 Gg $CO_2$ eq. in 1994 to 204.8 Gg $CO_2$ eq. in 2010, representing a 23.8 percent increase. Transport and other sectors increased by 4.1 percent and 75.1 percent from 1994 base year, respectively (Table 3.16).

**Table 3.16 Trend of emissions for categories in the Energy Sector (Gg $CO_2$ eq.)**

| | 1994 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| 1.A - Fuel Combustion Activities | 2178.66 | 1742.77 | 2158.23 | 3155.45 |
| 1.A.1 - Energy Industries | 165.41 | 34.72 | 177.32 | 204.80 |
| 1.A.2 - Manufacturing Industries and Construction | 905.49 | 675.58 | 759.31 | 1585.40 |
| 1.A.3 - Transport | 653.06 | 581.29 | 671.61 | 679.96 |
| 1.A.4 - Other Sectors | 454.70 | 451.18 | 550.00 | 685.29 |
| 1.A.5 - Non-Specified | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.B - Fugitive emissions from fuels | 0.7 | 0.7 | 0.7 | 0.4 |
| 1.B.1 - Solid Fuels | 0.7 | 0.7 | 0.7 | 0.4 |
| 1.B.2 - Oil and Natural Gas | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.B.3 - Other emissions from Energy Production | 0.0 | 0.0 | 0.0 | 0.0 |

### 3.10.3 Fugitive Emissions from Fuels

Fugitive emissions include all intentional and unintentional emissions from the extraction, processing, storage and transport of solid, liquid and gaseous fuel to the point of final use. Fugitive emissions in the energy sector were from solid fuels and surface coal mining. The geological processes of coal formation also produce methane ($CH_4$), and carbon dioxide ($CO_2$) may also be present in some coal seams. These are known collectively as seam gas, and remain trapped in the coal seam until the coal is exposed and broken during mining. $CH_4$ is the major greenhouse gas emitted from coal mining and handling. The emissions increased slightly from 1994 to 2000 followed by significant reductions in 2005 and 2010 (Figure 3.12).

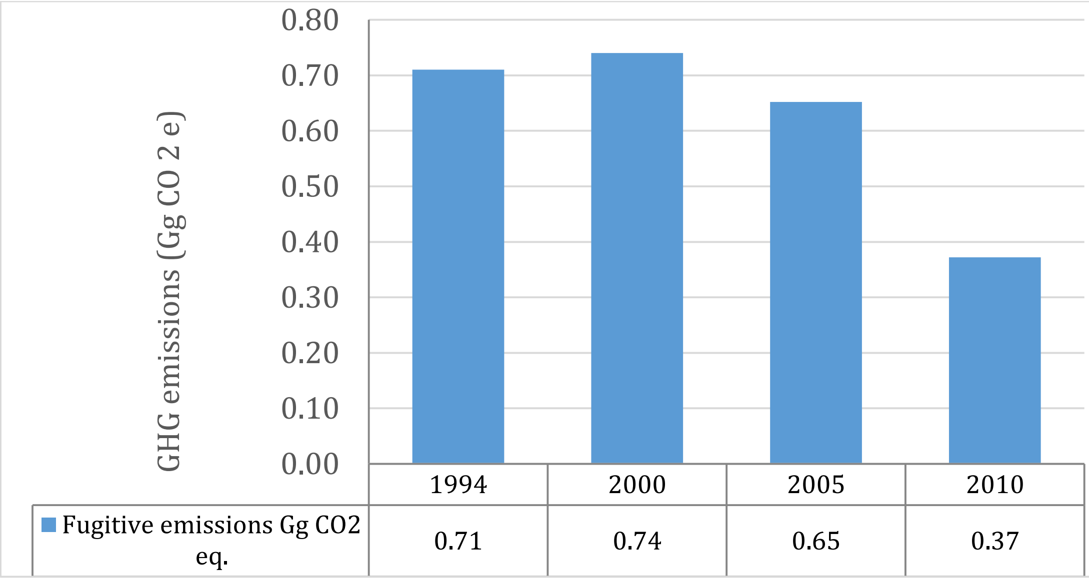


**Figure 3.12: Trend of fugitive emissions from solid fuels**

Emissions from surface coal mining reduced by 8.3 percent from 0.7 Gg $CO_2$ eq. in 1994 to 0.37 Gg $CO_2$ eq. in 2010. The emissions reduction was on account of reduced coal production arising from low demand for coal.

## 3.11 Industrial Processes and Product Use

Industrial Processes and Product Use (IPPU), covers GHG emissions occurring from industrial processes, product use and from non-energy uses of fossil fuel carbon. The main sources of emissions from industrial processes include mineral, chemical, electronic and metal industries. Emissions from product use are mainly substitutes of ozone depleting substances from refrigeration and stationery air conditioning units, use of electrical equipment and other product manufacture and use. Other emissions from non-energy products include fuels and solvent use. The IPPU sector in Zambia is an emission source of $CO_2$, $CH_4$, $N_2O$, HFC, and $SF_6$ gases.

### 3.11.1 Overall Emission Trends Under IPPU

#### 3.11.1.1 Emissions Trends under IPPU

The emissions in this sector increased from 431.2 Gg $CO_2$ eq. in 1994 base year to 1621.0 Gg $CO_2$ eq. Increase in sectoral emissions observed over the longer term are principally due to growth in emissions associated with the manufacture of mineral products, product uses as substitutes for Ozone Depleting Substances and other product manufacture and use.

In 2010, the highest source of emissions in the IPPU sector was from the mineral industry at 91.3 percent with emissions generated from lime and cement production followed by Other Products Manufacture and Use at 4 percent with emissions coming from use of $SF_6$ in electrical equipment. The third source of emissions came from Product Uses as Substitutes for Ozone Depleting Substances which contributed 3.7 percent generated from the use of refrigeration and air conditioning. Non-Energy Products from Use of Fuels and Solvents was the second lowest emission subcategory contributing 0.9 percent and the lowest was from the Metal industry with 0.1 percent. Trends of emissions for categories under IPPU are provided in Figure 3.13.

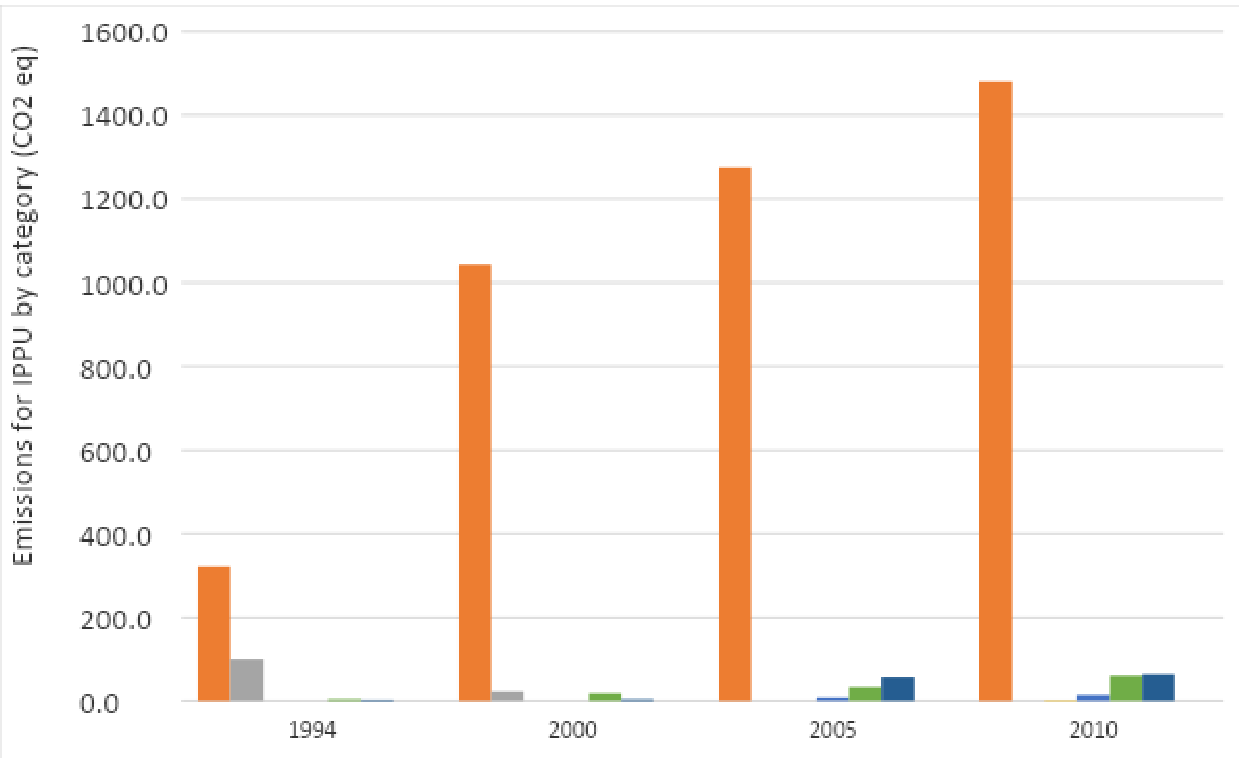


**Figure 3.13: Trends of emissions by category**

## 3.12 Agriculture Forestry and Other Land Use

### 3.12.1 Overall Emissions

#### 3.12.1.1 Emissions Trend by Category

Agriculture Forestry and Other Land Use consist of three categories namely Agriculture, Forestry and Other Land Use. Livestock is a subcategory of the AFOLU sector and estimates GHG emissions from enteric fermentation and manure management. $CO_2$ emissions from livestock are not estimated because annual net $CO_2$ emissions are assumed to be zero–the $CO_2$ photosynthesized by plants is returned to the atmosphere as respired $CO_2$. Land is a subcategory of the AFOLU sector and estimates GHG emission from land conversion. The six land-use categories in the 2006 IPCC Guidelines namely: Forest land, cropland, grassland, wetlands, settlements, and other land. Each land-use category is further subdivided into land remaining in that category and converted from one category to another (e.g. Forest Land converted to Cropland). The Aggregate Sources and Non-$CO_2$ Emissions on Land subcategory estimates emissions of $N_2O$ emissions from managed soils, including indirect $N_2O$ emissions from additions of N to land due to deposition and leaching, and emissions of CO2 following additions of liming materials and urea-containing fertiliser. Managed soils are all soils on land, including Forest Land, which is managed.

There has been a progressive increase in emissions from AFOLU across the trend. Overall emissions from AFOLU increased by 39.1percent from 82,990.1 Gg CO2 eq. in 1994 base year to 115,425.0 Gg $CO_2$ eq. in 2010 (Figure 3.14). On the other hand, total emissions removals reduced from -142,929.15 Gg $CO_2$ eq. in 1994 base year to 137,460.8 Gg $CO_2$ eq. in 2010, representing a reduction of 3.9 percent.

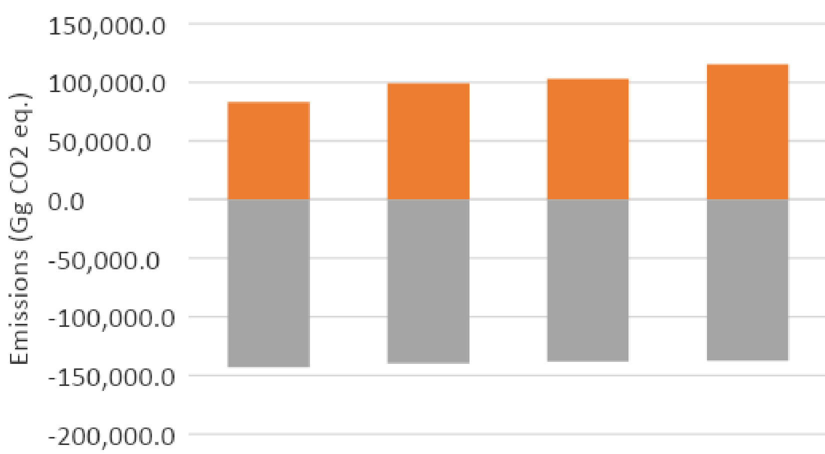


**Figure 3.14: Trends of emissions and removals for AFOLU**

Trends show increasing growth of emissions from Livestock, Land, and Aggregate sources and non-$CO_2$ emissions sources on land (Figure 3.15). In 2010, the highest emissions contribution was from Land with 88.5 percent (102,184.7Gg $CO_{2\ eq.)}$ followed by "Aggregate sources and non-$CO_2$ emissions sources on land" at 9.4percent (10,946.3$CO_2$ eq.). The least was livestock which contributed 2.1 percent (2,422.5 Gg $CO_2$ eq.).

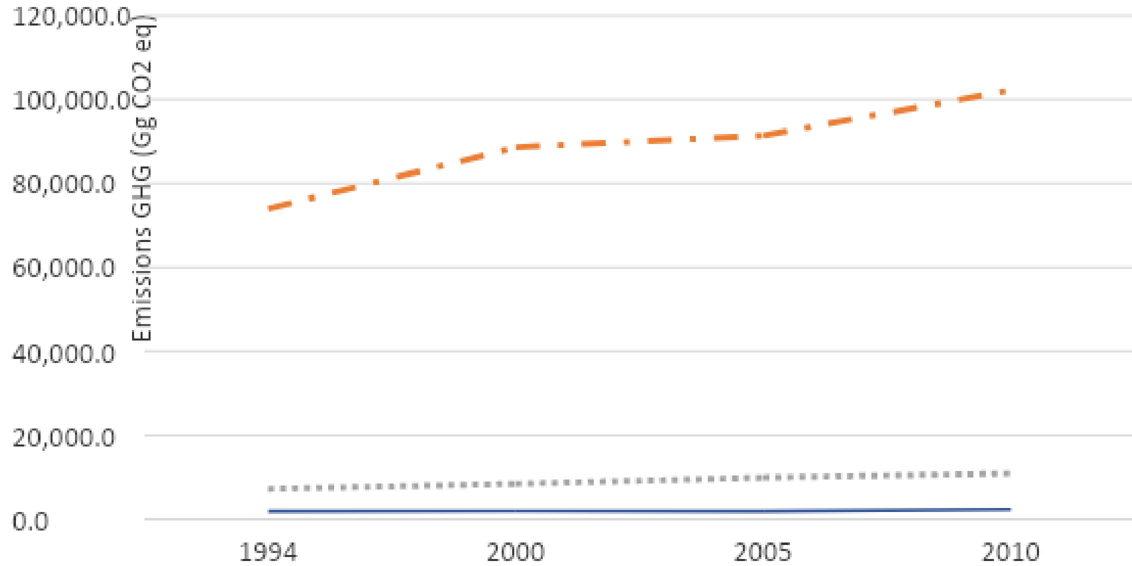


**Figure 3.15: Emissions trends and contribution by category from AFOLU sector**

## 3.13 Waste

GHG emissions from the Waste sector were calculated from solid waste disposal, incineration and open burning of waste and wastewater treatment and discharge. Methane emissions from Solid Waste Disposal Site (SWDS) are the largest source of GHG emissions in the Waste Sector. Methane was also emitted from wastewater treatment and discharge. Carbon Dioxide and Nitrous Oxide produced during incineration and open burning of waste containing fossil carbon (e.g., plastics) are the primary sources of emissions in the Waste Sector. Emissions from Biological treatment of solid waste were not calculated because the activity does not occur in Zambia. The emissions in the Waste sector increased by 49.6 percent from the 1994 base year of 204.5 Gg $CO_2$ eq. to 305.9 Gg $CO_2$ eq. in 2010 as presented in Figure 3.17

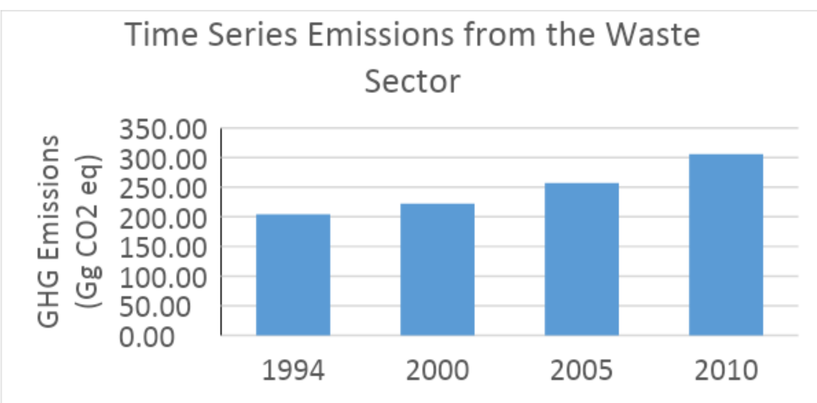


**Figure 3.17: GHG Emissions Trends in the Waste Sector**

### 3.14 Planned Improvements to The GHGi

Zambia estimated the emissions and removals in the GHG Inventory using the simple Tier 1 methods across most sectors. Tier 2 was applied to estimate emissions in Forestry sector for some sub categories. However, default emission factors and country-specific activity data were used due to lack of appropriate data to apply higher-level methods. In addition, the uncertainty estimates were based on default values as guided by IPCC. Due to the process used in the GHG inventory, a number of gaps were identified which will require improvements in the quality and accuracy for future GHG inventories.

To address these gaps, there is need to:

i) develop systems that initiate continuous collection of data aligned to the IPCC guidelines;
ii) enhance the existing data collection tools with data requirements based on the IPCC guidelines;
iii) develop an Information Technology and data sharing platform that links the databases of various key data providers to the central sever located at ZEMA;
iv) continuously build capacity of data providers and sector teams; and
v) investment in surveys and research to generate country specific emission factors and enhance transparency and accuracy.

The following are sector specific gaps and areas for improvements:

#### 3.14.1 Energy

There were inconsistencies between the categories reflected in the national Energy Balance and 2006 IPCC Guidelines. In addition, there has been limited research for the development of country specific emission factors under the sector. Studies have been undertaken by Center for Energy, Environment and Engineering of Zambia (CEEEZ) to generate some emission factors in the electricity sub-sector for the Southern African Power Pool (SAPP). Further, there are notable differences in the data collected for emission estimations in the energy sector from key institutions namely, ZRA, CSO and ERB. Therefore, there is a need to harmonise the database among these key institutions in future to enhance the availability of activity data and accuracy of reporting.

To address these gaps, there is need to:

i. Build capacity in institutions responsible for data collection to enable them disaggregate activity data on fuels and align to IPCC sub categories i.e. cars, light duty trucks, heavy duty trucks and buses, motor cycles, domestic and international aviation;

ii. Undertake studies in the various energy sources such as coal mining to generate emission factors that are currently not available; and
iii. Build capacity in the development of emission factors and estimation of fugitive emissions

### 3.14.2 Industrial Processes and Product Use

Estimation of emissions from IPPU sector was a major challenge due to inadequate activity data and emission factors for all sub categories. Institutions responsible for data provision such as ZRA do not capture adequate GHG inventory parameters in certain types of activity data for purposes of estimating emissions from activities such as refrigeration, fertilisers, petroleum products (lubricants), fire protection, solvents, aerosols and $N_2O$ for medical applications.

In order to address these gaps, there is need to:

i. Enhance activity data collection in all the sub categories. For example, enhancing collection of activity data under mineral industries such as the use of clinker as opposed to cement production and quantities of the various types of lime and proportion of Lime Kiln dust generated during lime production would enhance migration to higher tiers.
ii. Development of data capturing mechanism from various data providers to incorporate GHG inventory parameters aligned to the IPPC guidelines.

### 3.14.3 Agriculture Forestry and Other Land Use

AFOLU sector had detailed data on land-use subcategory whilst data on agriculture was limited and as such, estimates were carried out under Tier 1.
In order to move to Tier 2, country specific emission factors were lacking especially under the Livestock sub category. The main sources of data for agriculture were the CSO crop forecast surveys and administrative data from the Ministry responsible for agriculture. This data did not include information from a number of commercial farms and as such, expert judgment was used in certain areas. In addition, forest classification was limited to 5 classes as opposed to 17.

In order to improve emission estimates in the AFOLU sector, the following should be done:

i. Update the existing soil map using the latest ILUA II data as well as enhance the forest classification from 5 to 17, including data collection on forest disturbance. In addition, there will be a need to undertake further land use assessment with enhanced densities to facilitate additional forest classification
ii. Review and update the crop forecast survey to include data on fertiliser and lime applications for commercial farms including crop residue management.

### 3.14.4 Waste

Data segregation and characterization remained a major challenge in the estimation of emissions from the sector. There was inadequate data on solid and liquid waste as well as their management. Disposal facilities lacked equipment and technical capacity to monitor, quantify and characterize the waste taken to the disposal site. As a result, population and GDP data were used to estimate emissions from the waste sector, resulting in high uncertainties.

In order to address these gaps, there is a need to undertake solid waste characterization and support investment in modern infrastructure with the latest technology that can allow for waste characterization and segregation.

# 4.0 CLIMATE CHANGE IMPACTS AND ADAPTATION

This chapter highlights the country's vulnerability to impacts of climate change, adaptation measures undertaken to address current impacts and proposes future adaptation interventions to respond to projected impacts of climate change in key economic sectors. The preparation of the TNC on climate change impacts and adaptation took into account the differentiated impacts of climate change on men, women, youths and other vulnerable groups. The preparation process was done with reference to the climate change gender action plan (ccGAP, 2018).

## 4.1 Climate Change Impacts

The country has experienced a number of climate hazards over the past decades which include droughts, seasonal and flash floods, extreme temperatures and dry spells. The frequency of occurrence including the intensity and magnitude of droughts and floods have increased since the last national communication, adversely impacting on food and water security, infrastructure, energy, health and sustainable livelihoods of rural communities. The 2009/10 rainy season for example was characterized by heavy rainfall in most parts of the country that resulted in significant damage to roads, health and school and housing infrastructure, among others. In addition, the 2011/2012 rainy season was characterised by floods in the northern half and dry spells in the southern half of the country. The floods resulted in damaged infrastructure; destruction of crops, increased risk of both human and animal diseases and localized food insecurity and dry spells led to massive food insecurity.

The report on the Economics of Climate Change in Zambia estimated that floods and droughts would cost Zambia approximately US$13.8 billion representing a loss of economic growth equivalent to 0.4 percent annually. In the absence of adaptation, rainfall variability alone could keep an additional 300,000 more Zambians below the poverty line and cost between 4.3 to 5.4 US$ billion in GDP loss over the next decade, reducing the annual GDP growth by 0.9 percentage. The cost of intervention across the key economic sectors vulnerable to climate change impacts that include agriculture, energy, water, infrastructure, and natural resources is estimated at USD 212.5 million (GRZ, 2011)[2].

The country has undertaken measures to address current and future climate hazards as a result of the losses and damage experienced in the past. A number of adaptation related actions are being implemented in Zambia since the submission of the SNC. In the Energy sector, adaptation projects that were implemented with mitigation co-benefits included hydro, solar home systems, solar utility scale, and solar mini-grids. Agriculture adaptation projects included conservation farming and agroforestry while in the Natural Resources sector, assisted natural regeneration of forests

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[2] GRZ, 2011: Economics of climate change in Zambia

among some interventions were implemented. In the Water sector, watershed management and borehole drilling for irrigation, domestic and livestock use were implemented. In the Infrastructure sector, adaptation projects that were implemented included the construction of climate resilient roads and clearing of canals.

## 4.2 Methodology

To assess vulnerability to impacts of climate change and identify adaptation measures, various methods were used. These included; detailed desk review, modelling and expert judgement. The assessment was done in a consultative manner involving key stakeholders and experts.

A set of Coupled Multi-Intercomparison Phase 5 (CMIP5) Global Climate Models (GCM) and Regional Climate Models (RCMs) datasets from the IPCC included in the Fifth Assessment Report (AR5) were used in this analysis. The other sources of data were the Coordinated Regional Climate Downscaling Experiment (CORDEX), Climate Research Unit Time-series version 4.02 and Meteorological Station Data (agromet stations). The 30 years historical climatological rainfall and temperature data covering the years 1950 to 2013 was obtained from Zambia Meteorological Department (ZMD) stations. Table 4.1 and Figure 4.1 show the distribution network of the meteorological stations used in this study.

**Table 4.1: Meteorological Stations Used in the Study**

| Station | Latitude (°S) | Longitude (°E) | Variable |
|---|---|---|---|
| Kabwe | 14.448 | 28.469 | Tmin |
| Kafironda | 12.614 | 28.148 | Tmin, |
| Kasama | 10.224 | 31.140 | Tmin, Tmax |
| L/stone | 17.823 | 25.820 | Tmin, Tmax |
| LCA | 15.417 | 28.321 | Tmin, Tmax |
| KKIA | 15.324 | 28.448 | Tmin, Tmax |
| Magoye | 15.998 | 27.617 | Tmin, Tmax |
| Mbala | 8.862 | 31.553 | Tmin |
| Mongu | 15.254 | 23.151 | Tmin, Tmax |
| Mpika | 11.901 | 31.433 | Tmin, Tmax |
| Mt. Makulu | 15.548 | 28.248 | Tmin, Tmax |
| Ndola | 12.994 | 28.659 | Tmin, Tmax |
| Petauke | 14.251 | 31.339 | Tmin, Tmax |

| | | | |
|---|---|---|---|
| Mumbwa | 15.067 | 27.183 | Rainfall |
| Mfuwe | 13.267 | 31.933 | Rainfall |
| Mansa | 11.100 | 28.850 | Rainfall |
| Mwinilunga | 11.750 | 24.433 | Rainfall |
| Solwezi | 12.167 | 26.367 | Rainfall |
| Serenje | 13.233 | 30.217 | Rainfall |

Note: KKIA = Kenneth Kaunda International Airport; LCA= Lusaka City Airport; Tmin= minimum temperature; and Tmax= maximum temperature

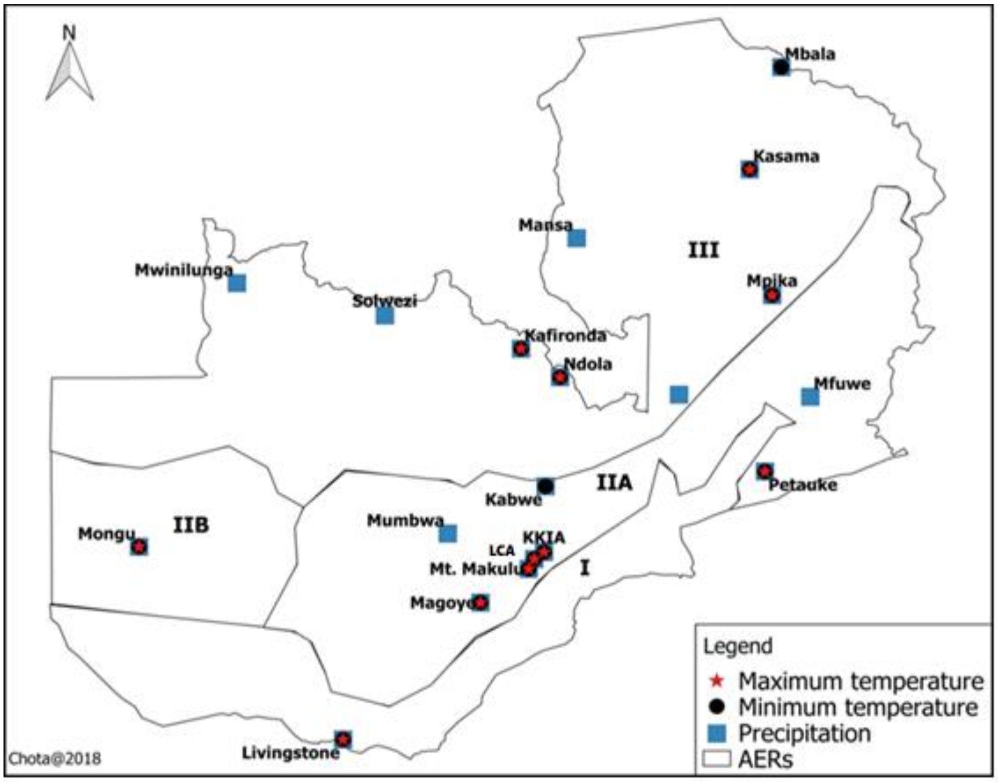


**Figure 4.1: Distribution of meteorological stations used in the study** *Source: Chota, 2018*

Note: LCA = Lusaka City Airport; KKIA = Lusaka City Airport and Kenneth Kaunda International Airport.

### 4.2.1 Re-Analysis of Data

The low-resolution predictors necessary for downscaling precipitation and temperature at surface level were derived from ERA-interim reanalysis dataset of the European Centre for Medium Range Weather Forecasts (ECMWF) (Dee et al., 2011). This dataset runs from 1979 to date and has spatial horizontal resolution of 0.75° x 0.75°. It consists of daily estimates of both surface and atmospheric variables. Predictors considered in this study are shown in Table 4.2. The predictor dataset is accessible at https://www.ecmwf.int/en/forecasts/datasets.

**Table 4.2: Predictor Variables**

| Name | Code | levels (hPa*) | Units |
|---|---|---|---|
| Geopotential height | Z | 1000, 850, 700, 500 | $m^2s^{-2}$ |
| Temperature | T | 1000, 850, 700, 500 | K |
| Specific humidity | Q | 1000, 850, 700, 500 | kg$kg^{-1}$ |
| U-wind component | U | 1000, 850, 700, 500 | $ms^{-1}$ |
| V-wind component | V | 1000, 850, 700, 500 | $ms^{-1}$ |
| Mean sea level pressure | SLP | 0 | Pa |
| 2m Temperature | T2m | 0 | K |

*Source: Statistical Downscaling Portal (www.meteo.unican.es/downscaling/login.html*

*hPa = hectopascals, the SI units for pressure [1 hPa = 1milibar]. Q1000 = specific humidity at 1000hPa height

### 4.2.2 Validation of Climate Data

#### 4.2.2.1 Regional Climate Modeled Data against the CRU-TS

The performance of the models (RCMs) and ensemble were validated by comparing the observed (CRU TS v4.02) and modeled (simulated) annual and monthly cycles of temperature and precipitation. The observational and modeled temperature and total precipitation were computed for 1971 to 2000 and 2021 to 2050, respectively. The metrics used in validating the modeled data were Standard Deviation (SD), correlation and centered RMS difference. The Taylor Diagram (Elvidge et al., 2014; IPCC, 2001; Taylor, 2001; Xu et al., 2016) of spatial pattern of correlations, RSME and standard deviations with respect to the observations was used in displaying the metrics.

### 4.2.3 Downscaling of GCM Scenarios

Apart from using the analogue method in predictor selection, it was also applied in the simulation of future and baseline values for precipitation, minimum and maximum temperature. For the purpose of downscaling GCM simulations, a selected predictor combination was applied to GCMs. In this case, the large-scale atmospheric variable from the GCM for a targeted day $'d'$ (within downscaling period) was compared to large scale variables in the reanalysis record (1981-2010) using Euclidean distance as a measure of similarity. The surface estimate in the reanalysis record corresponding to the analogue was downscaled for a day 'd' This procedure was implemented using a web-based statistical downscaling portal (https://www.meteo.unican.es/downscaling) to downscale daily time series of minimum temperature and maximum temperature for the baseline period (B) (1971-2000) and future period (F) (2020-2049) at weather station level Three GCMs (CanESM2, CNRM-CM5 and MPI-ESM-MR) from the Coupled Model Intercomparison Project Phase Five (CMIP5) under two concentration pathways (RCP4.5 and RCP8.5).

These models were selected based on their demonstrated ability to simulate present annual cycles of temperature and precipitation over Southern Africa (McSweeney et al., 2015; Munday and Washington, 2017) and Zambia (Libanda et al., 2016; Chisanga et al., 2017a). The GCMs used in this analysis were selected on the basis of having complete historical and two Representative Concentration Pathways (RCP4.5 and RCP8.5). RCP4.5 and RCP8.5 represent intermediate and very high GHG emissions scenarios of 500 to 650 ppm and 851 to 1,370 ppm CO2eq, respectively (IPCC, 2014b). The Representative Concentration Pathways (RCPs) depicts greenhouse gas concentration trajectory adopted by the IPCC during the AR5 in 2014 (IPCC, 2014b). The RCP4.5 represents intermediate GHG emissions (650 ppm $CO_2$ eq) while RCP8.5 represents very high GHG emissions (1370 ppm $CO_2$ eq). The Global Climate Models and Scenarios used in the Study are shown in Table 4.3.

**Table 4.3: Global Climate Models and Scenarios used in the Study**

| CMIP5 Model ID | Modelling center | Resolution |
|---|---|---|
| CanESM2 | Canadian Centre for Climate Modelling and Analysis, Canada. | 2.81° x 2.81° |
| CNRM-CM5 | National Centre for Meteorological Research, France. | 1.4° x 1.4° |
| MPI-ESM-MR | Max-Planck Institute for Meteorology, Germany. | 1.875° x 1.875° |

These models were used to project precipitation and temperature for the period 2020 to 2049.
The Expert Team on Sector-specific Climate Indices (ET-SCI) was used to derive indices for daily precipitation and temperature and ClimPACT2 version 1.2.3 software was used to compute climate

indices (Alexander et al., 2013; Alexander and Herold, 2016). Expert judgment was used to correlate historical observed temperature and precipitation to the baseline period, indicator observation and sector performance for agriculture, natural resources and human health. The temperature and precipitation data were checked for quality control using ClimPACT2 v1.2.3 before computing the climate indices. The selected climate indices (Table 4.4) were computed using ClimPACT2 software.

**Table 4.4: Climate Indices Analysed using Station Data**

| **Index** | **Description** | **Unit** |
|---|---|---|
| GSL | Annual count between first span of at least six days after 1st July with TM > 5°C and first span of at least six days after 1st January with TM < 5°C | days |
| TXx | Annual maximum value of daily TX | °C |
| WSDI | Annual count of days with at least 6 consecutive days when TX > 90th percentile | days |
| TX50p | Percentage of days annually when TX > 50th percentile | percent |
| TX90p | Value of 90th percentile of TX | °C |
| SU30 | Annual count when TX ≥ 30°C | days |
| SU35 | Annual count when TX ≥ 35°C | days |
| R20mm | Annual count of days when P ≥ 20mm | days |
| CDD | Annual maximum number of consecutive days with P < 1mm | days |
| PRCPTOT | Annual total precipitation from wet days (P ≥1mm) | mm |
| R95pTOT | Annual percent precipitation from days with P > 95th percentile | percent |
| R99pTOT | Annual percent precipitation from days with P > 99th percentile | percent |
| RX1day | Annual maximum precipitation in 1 day | mm |
| RX5day | Annual maximum precipitation in 5 consecutive days | mm |
| CWD | Annual maximum number of consecutive days with P ≥ 1mm | days |

## 4.3 Evidence of Climate Change

### 4.3.1 Precipitation

Zambia's historical climate data analysis demonstrates that the country has been experiencing climate change and variability. From 1971 to 2005, a 58 mm decline in rainfall (6 percent) relative to 1940 to 1970 was recorded. The South-Western region was the most severely affected with rainfall seasons becoming critically shorter. Rainfall records have shown that southern Zambia had experienced below average rainfall in the period 1886-1925 and above average rainfall between 1926 to 1970. The studied 26 agromet stations for precipitation showed that most of the studied precipitation indices exhibited non-statistically significant trends across Zambia. The rate of change in extreme precipitation at Sesheke, Mumbwa and Mpika were significant with negative trends of 5.36 mm, 5.46 mm and 2.82 mm, respectively. The rate of change in R99pTOT was statistically significant with positive trends at Kafue (0.23 mm), Kasama (0.13 mm), Lusaka (0.19 mm) and Mansa (0.20 mm).

During the reporting period, Zambia also experienced more frequent and intense droughts, dry spells and floods, with serious consequences on livelihoods, infrastructure, water resources, energy, agriculture and health. Since 2000, Zambia has experienced nearly annual episodes of droughts, dry spells and floods.

The 2005/06 was characterized by excessive rains resulting in flooding of low-lying areas across the country. The greatest adverse effect of the rains was on infrastructure especially roads, culverts and bridges. The impact on other sectors was mostly moderate. Most feeder roads became temporarily inaccessible; this coupled with the severely damaged bridges had multiple effects such as disruption of relief distribution in some areas and cutting off access to markets which supply commodities to the affected areas. This resulted in commodity shortage and therefore increased prices[3]. The 2007/08 rainy season caused floods in a number of districts in the country. The floods affected a total number of 274,800 people (45,799.96 households) and caused extensive damage to human settlement and shelter, infrastructure, water and sanitation, health and nutrition, education and agriculture and food security.[4]

The beginning of the 2008/9 rainy season was characterized by normal rains in most parts of the country. However, the southern half of the country (AER I) experienced prolonged dry spells and low-lying areas experienced flash floods. The 2009/10 rainy season was characterised by heavy rainfall in most parts of the country that culminated into flash flood in low-lying areas and water logging in plateau areas affecting a total of 238,258 people (39,710 households). There was

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[3] GRZ,2006: Rapid assessment of the effects of rainfall on livelihoods. ZVAC

[4] GRZ, 2008: multi-sectoral rapid flood impact assessment. ZVAC
GRZ, 2009: In-Depth Vulnerability and Needs Technical Assessment Report

significant damage to roads, health and school infrastructure. About 344 road and drainage structures were damaged.

### 4.3.2 Temperature

Zambia's mean annual temperature increased by 1.3°C since 1960, an average of 0.29°C per decade. Temperature extremes in Zambia indicated patterns of warming with positive trends for temperature indices using data from 1961-2000. The annual daily maximum temperature had increased at 14 agro-meteorological stations from 1950-2010. The Diurnal Temperature Range (DTR) had increased except for Kabwe, Lundazi and Mongu stations. The highest rate of change (0.06°C) was observed at Lundazi and Mount Makulu stations and the lowest rate of increase in warmest temperature in a year was at stations in the North-western Province. The number of summer days (SU) with maximum temperature being greater than 25°C, 30°C and 35°C had increased at all the agro-meteorological stations. The Warmest Daily Maximum Temperature (TXx) had increased representing 71 percent of the stations with positive trends.

This shows that the difference between the maximum and minimum temperature had been increasing. According to New et al. (2006), DTR had shown a consistent increase across Zambia. There had also been an increase in maximum temperature compared to minimum temperature. The annual number of days contributing to events where ≥6 consecutive days experience maximum temperature greater than 90th percentile (WSDI) has been increasing at all stations except Kasempa, Mpika and Mount Makulu. Climate indices, SU and TXx affect the health and agriculture sector.

The percentile-based indices (tx50p, tx90p) indicated that the amount of hot days had increased at all stations as shown in Table 4.5. An increase in maximum and mean temperature had been reported in AER II from 1950 to 2008 (Phiri et al., 2013; Suman, 2007). Other studies showed that between 1961 and 2000, there had been a decrease in extreme cold days and nights at the 5th percentile by -3.7 and -6.0 days per decade, respectively. The occurrence of heat stress at 95$^{th}$ percentile during the day and night had increased by 8.2 and 8.6 days per decade, respectively (Fumpa-Makano 2011).

**Table 4.5: Annual trends for selected Temperature Indices**

| Station | Su | gsl | txx | dtr | wsdi | tx50p | tx90p | su30 | su35 |
|---|---|---|---|---|---|---|---|---|---|
| Kabwe | 0.79* | -0.01 | 0.02* | 0.01 | 0.17* | 0.41* | 0.24* | 0.76* | 0.11* |
| Kafue | 0.56* | 0.00 | 0.02 | 0.01 | 0.22* | 0.35* | 0.26* | 1.31* | 0.23 |
| Kasama | 0.93* | 0.00 | 0.02 | 0.02* | 0.13* | 0.55* | 0.22* | 0.50* | 0.00 |
| Kasempa | 0.89* | 0.00 | 0.01 | 0.02* | 0.20 | 0.75* | 0.31* | 1.41* | 0.15* |
| Kawambwa | 1.16* | 0.00 | 0.04* | 0.04* | 0.11* | 1.13* | 0.40* | 1.57* | 0.00 |
| Livingstone | 0.46* | 0.00 | 0.03* | 0.02* | 0.14* | 0.39* | 0.20* | 1.22* | 0.53* |
| Lundazi | 1.23* | 0.01 | 0.06* | 0.01 | 0.13* | 0.80* | 0.35* | 1.55* | 0.15* |
| Mansa | 0.86* | 0.00 | 0.04* | 0.04* | 0.58* | 0.77* | 0.52* | 1.30* | 0.16* |
| Mongu | 0.35* | 0.00 | 0.03* | 0.00 | 0.18* | 0.57* | 0.27* | 1.55* | 0.45* |
| Mpika | 1.20* | 0.00 | 0.05* | 0.03* | 0.05 | 0.52* | 0.18* | 0.51* | 0.01* |
| Mt. Makulu | 1.24* | 0.00 | 0.06* | 0.03* | 0.11 | 0.72* | 0.24* | 1.18* | 0.25* |
| Mwinilunga | 0.74* | -0.01 | 0.01 | 0.01* | 0.13* | 0.42* | 0.18* | 0.47* | 0.02* |
| Ndola | 1.13* | -0.01 | 0.03* | 0.01* | 0.18* | 0.78* | 0.34* | 1.08* | 0.09* |
| Petauke | 0.70* | 0.00 | 0.03* | 0.01* | 0.24* | 0.45* | 0.27* | 1.16* | 0.29* |

Note: * represent statistical significance at $p<0.05$

The warmest daily maximum temperature (TXx) had increased representing 71 percent of the stations having positive significant trend. The percentile-based indices (tx50p, tx90p) indicated that the amount of hot days had increased at all stations as shown in Table 4.5. Increases in maximum and mean temperature have been reported in AERII from 1950 to 2008 (Phiri et al., 2013; Suman, 2007). Extreme heat is becoming more common and this increases plant water stress, which, if not addressed, results in cessation of photosynthesis and death (NCA, 2014; Steffen et al., 2014). Extreme heat events have a direct impact on health. Long exposure to higher temperatures can cause heat stress, heat stroke, heat exhaustion and ultimately death (Serdeczny et al., 2016). Fumpa-Makano (2011) agrees with the findings of this study. She revealed that between 1961 and 2000, there had been a decrease in extreme cold days and nights at the 5th percentile by -3.7 and -6.0 days per decade, respectively. The occurrence of heat stress at $95^{th}$ percentile during the day and night had increased by 8.2 and 8.6 days per decade, respectively.

The DTR has been increasing for all the stations except for Kabwe, Kafue, Lundazi and Mongu. This shows that the difference between the maximum and minimum temperature has been increasing. According to New et al. (2006), DTR has shown a consistent increase across Zambia. There has also been an increase in maximum temperature compared to minimum temperature. The annual number of days contributing to events where ≥6 consecutive days experience maximum temperature greater than 90th percentile (WSDI) has been increasing at all stations except Kasempa, Mpika and Mount Makulu. Climate indices, SU and TXx affect health and agriculture sectors. The WSDI affects all the three sectors (water resources, health and agriculture). New et al. (2006) observed an increase in SU25 and WSDI across Namibia, Botswana, Zimbabwe and Zambia. Warm spells (WSDI) also increased consistently in Southern Africa at an average rate of 2.4 days/decade.

#### 4.3.3 Precipitation Indices Using Station Data

The climate indices computed using RCMs showed that the number of days when TN>20$^{o}$C (TR) had increased between 1971 and 2000. The number of cold nights and cool days at 10th percentile had reduced between 1971 and 2000. The number of warm nights and hot days at the 90th percentile has increased between 1971 and 2000. The maximum TX, mean TX and mean TM increased significantly during the baseline (1971-2000) from 0.015-0.035$^{o}$C, 0.014-0.024$^{o}$C and 0.016-0.022$^{o}$C, respectively. The TN10p and TX10p showed that the percentage of cold nights and cool days had been reducing at the rate of -0.30 to -0.15 and -0.16 to -0.06 during the baseline over Zambia. The percentile of warm nights (TN90p) and hot days (TX90p) had increased during the baseline. The warm spell duration indicator (WSDI) showed statistically positive trends during the baseline (0.10 to 0.50). This signified that the annual number of days with at least 6 consecutive days when TX > 90$^{th}$ percentile had increased between 1971 and 2000.

### 4.4 Future Climate Projections

#### 4.4.1 Precipitation

AER I is expected to experience precipitation increase in January-February-March (JFM) and October-November-December (OND) under both RCP4.5 and RCP8.5 by 2050. AER II is projected to experience minimal precipitation decrease in JFM and OND under both RCP4.5 and RCP8.5, respectively. AER III is likely to experience a decrease in seasonal precipitation under both RCPs. Seasonal median precipitation would increase in JFM (2.53 mm) and reduce in OND (-5.69 mm) under RCP4.5. However, median precipitation would increase in JFM (2.80 mm) and reduce in OND (-5.74 mm) under RCP8.5. Countrywide, precipitation trends would move towards the south in JFM relative to the baseline. There is a reduction of precipitation in North-western, Western, Copperbelt, Luapula and part of Muchinga Provinces in OND.

##### 4.4.1.1 Annual cycles of monthly mean total precipitation

The downscaled annual cycles of monthly mean total precipitation for AER I are shown in Figure 4.2.

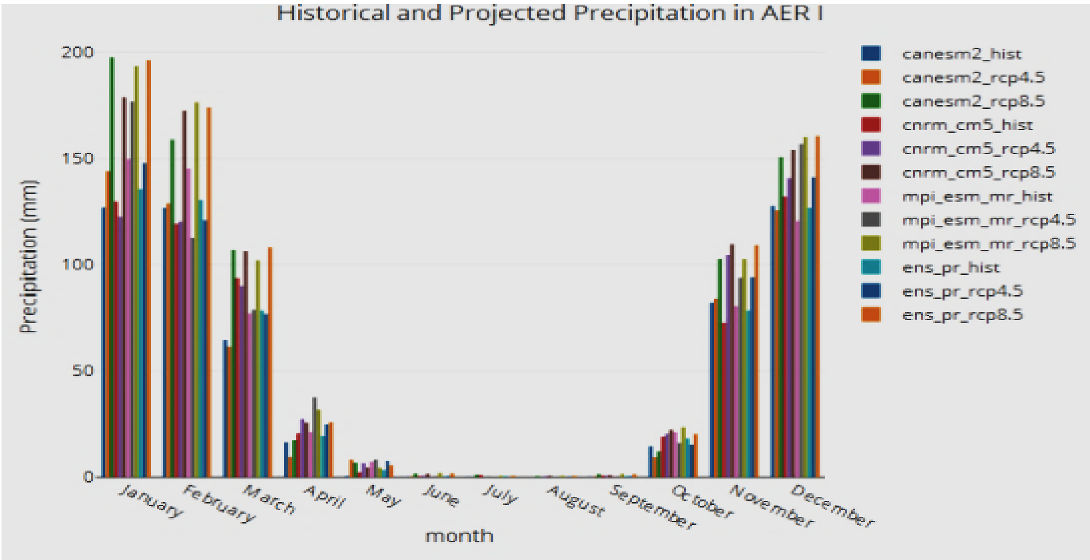


**Figure 4.2:Annual cycles of monthly total mean precipitation in AER I for baseline 1971 - 2000 and future period 2020 - 2049**

The ensemble of models show that precipitation is expected to increase in AER I under RCP4.5 and RCP8.5 scenarios for the months of January, November and December during 2020 to 2049 relative to the baseline. However, reduction is projected under both RCPs for the months of February, March and October. It is likely that the largest amount of rainfall for AER I would occur during the month of January as projected by most models.

Changes in mean total precipitation in AER II are less certain during the months of February, October and December as mixed climate change signals are projected (Figure 4.3).

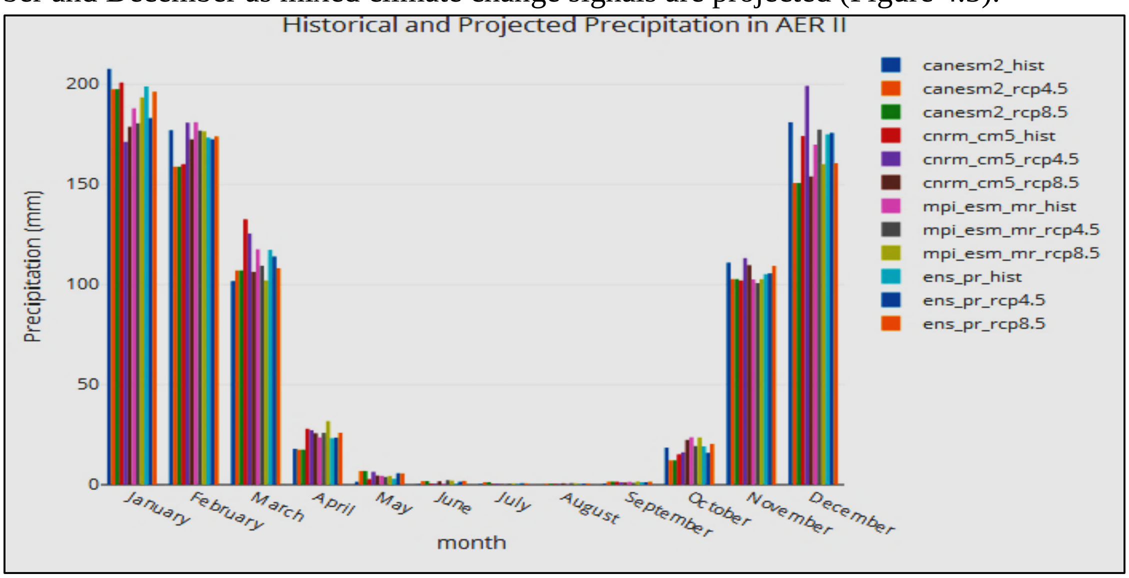

**Figure 4.3: Annual cycles of monthly total mean precipitation in AER II for baseline 1971-2000 and future period 2020-2049**

It is projected that the months of January and March would experience a decrease in precipitation under both scenarios. However, an increase is projected under both RCPs for April and November. Like AER I and AER II would likely experience the largest mean total monthly precipitation during the month of January under both scenarios. Downscaled mean total monthly precipitation shows that AER II would continue receiving more rainfall than AER I despite the projected decrease in some months.

The downscaled annual cycles of monthly mean total precipitation for AERIII for the period 2020 to 2049 and baseline are shown in Figure 4.4.

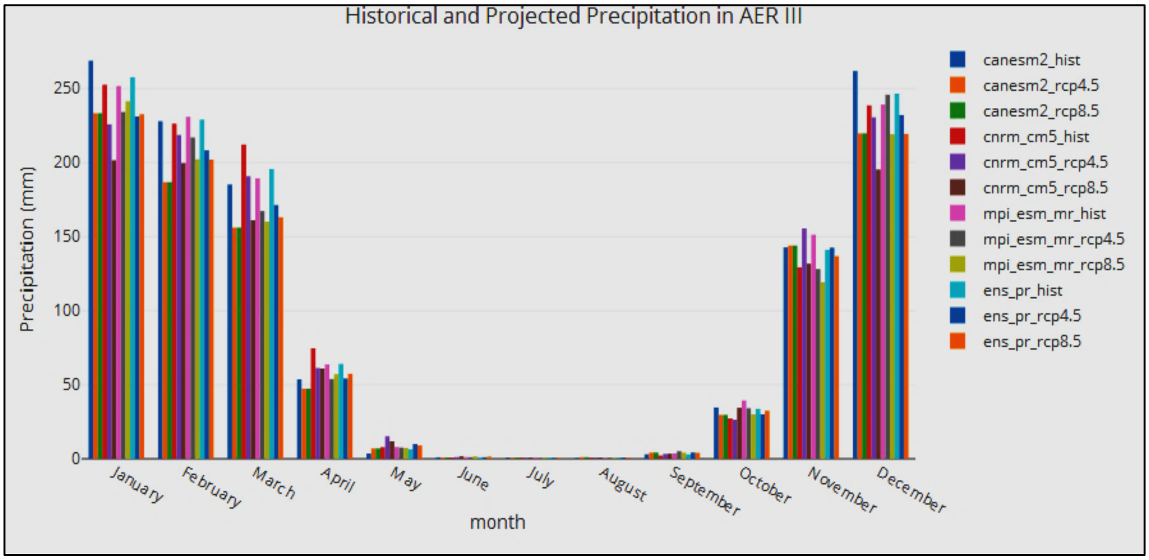


**Figure 4.4: Annual cycles of monthly total mean precipitation in AER III for the baseline (1971-2000) and future scenario (2020-2049)**

The ensemble of models indicates that the region would experience precipitation decrease in the months of January, February, March, April, October, and December. Changes are less certain for the month of November as a mixed climate signal is projected. The largest mean total precipitation is expected to occur during the month of December under RCP4.5 and January under RCP8.5 Scenario.

#### 4.4.1.2 Seasonal Mean Total Precipitation

The downscaled seasonal mean total precipitation varies in character for each AER across the country. According to the ensemble mean, AERI (4.5a) is expected to experience an increase in JFM, AMJ and OND precipitation but decrease during JAS season under both RCP4.5 and RCP8.5 Scenarios. Increases of 1.0 mm (JFM), 10.0 mm (AMJ) and 27 mm (OND) but decrease of 0.2

mm are projected to occur under RCP4.5. Under RCP8.5, changes are poised to be 8.2 mm (JFM), 1.3 mm (AMJ), -0.3 mm (JAS) and 37.3 mm (OND) (Figure 4.5d). Under RCP4.5 Scenario, AERII (4.5d) is projected to experience minimal precipitation decrease of 19.9 mm and 2.1 mm in JFM and OND, respectively. Under RCP8.5 Scenario, decreases of 11.1 mm, and 9.0 mm are more likely to occur during JFM and OND seasons, respectively. Figure 4.5(c) shows downscaled seasonal precipitation for AER III. This region is likely to experience a decrease in seasonal precipitation under both RCPs.

Individual models are consistent with their ensemble in projecting decrease in JFM, AMJ and OND precipitation for AER III (4.5d), JAS precipitation poised to consistently increase marginally. Under RCP4.5 the decrease of 71.5 mm, 6.3 mm and 16.7 mm is projected for JFM, AMJ and OND precipitation, respectively. However, an increase of 1.3 mm is projected for JAS precipitation. Larger seasonal precipitation changes are projected under RCP8.5 than RCP4.5 for JFM, JAS and OND seasons. Changes in seasonal precipitation under RCP8.5 are projected to decrease by 84.4 mm, 3.6 mm and 32.7 mm for JFM, AMJ and OND seasons, respectively.

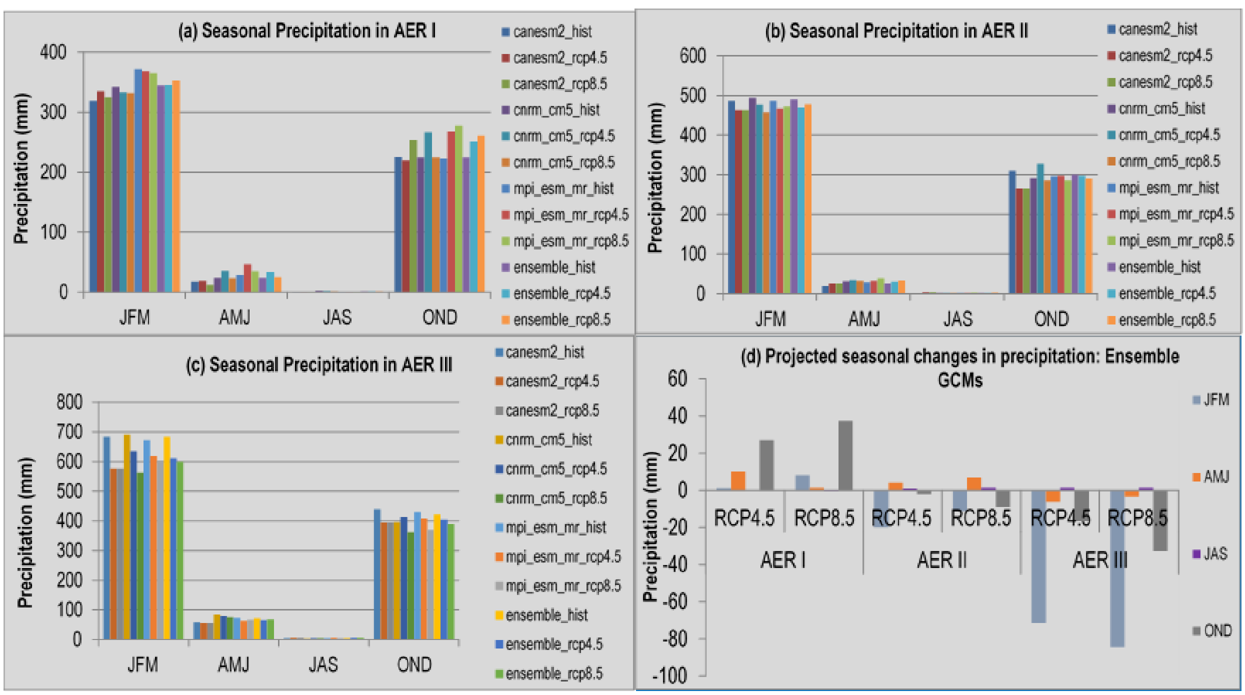


**Figure 4.5: Projected Seasonal Changes in Precipitation**

### 4.4.1.3 Annual precipitation

AER I is projected to experience an increase in annual mean total precipitation to 37.8 mm and 46.5 mm under RCP4.5 and RCP8.5 respectively. Table 4.6 and Figure 4.6 show that AERs II and III are projected to experience a decrease in annual mean total precipitation under both scenarios.

**Table 4.6: Summary statistics for annual mean total precipitation (mm) for each AER**

| | AER I | | | AER II | | | AER III | | |
|---|---|---|---|---|---|---|---|---|---|
| | Hist | RCP4.5 | RCP8.5 | Hist | RCP4.5 | RCP8.5 | Hist | RCP4.5 | RCP8.5 |
| Min | 420 | 492 | 364 | 675 | 699 | 607 | 1040 | 948 | 922 |
| Mean | 592 | 630 | 639 | 817 | 800 | 805 | 1180 | 1080 | 1060 |
| Std. | 92.7 | 85.4 | 123.6 | 56.6 | 75.3 | 73.8 | 73.8 | 61.5 | 72.0 |
| CV | 0.157 | 0.136 | 0.193 | 0.081 | 0.071 | 0.093 | 0.063 | 0.057 | 0.068 |
| Max | 766 | 793 | 904 | 904 | 971 | 918 | 1300 | 1230 | 1200 |

Under RCP4.5, the decrease is expected to be 16.8 mm and 93.1 mm for AER II and AER III, respectively. Further, decreases of 11.7 mm and 119 mm are projected to occur for AER II and AER III, respectively under RCP85. These changes are not statistically significant since their projected means under RCP4.5 and RCP8.5 lie within the first standard deviation of the baseline mean total precipitation. Larger changes are projected for AER I and AER III under RCP8.5.

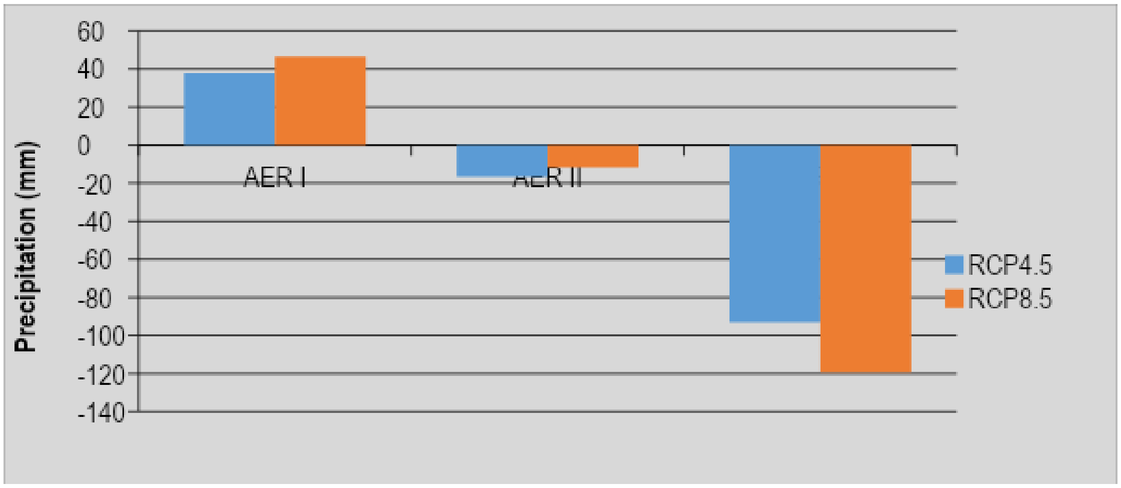


**Figure 4.6: Projected changes in annual precipitation for the period 2020-2049**

#### 4.4.1.4 Precipitation Indices Using Station Data

Extreme precipitation indices namely; PRCPTOT, R30mm, RX5day, R95pTOT and R99pTOT had statistically significant trends at 3, 1, 2, 1 and 4 stations, respectively. The PRCPTOT, R20mm, R30mm, RX5day, R95pTOT and R99pTOT climate indices affect agriculture and water resources sectors. The rate of change in extreme precipitation at Sesheke, Mumbwa and Mpika were significant with negative trends of 5.36 mm, 5.46 mm and 2.82 mm, respectively. The rate of change in R99pTOT was significant with positive trends at Kafue (0.23 mm), Kasama (0.13 mm), Lusaka 1 (0.19 mm) and Mansa (0.20 mm), respectively. Most of the studied precipitation indices station wise did not exhibit statistically significant trends across Zambia and this has also been highlighted by New et al. (2006).

Regionally, R20mm, R30mm, Rx1day and PRCPTOT precipitation indices have decreased with non-statistically significant trends for most of the stations as shown in Table 4.7 CDD was non-significant with positive trends at all stations. However, six stations had significant CWD. Sillmann et al. (2013) noted that there is need to have reliable predictions of extreme climate indices in the short and long-term to reduce potential risks to agriculture, water resources and health. Climate change and extreme weather events lead to crop failure, chronic hunger, food insecurity, undernourishment and ultimately damage human assets (IPCC, 2014b).

**Table 4.7: Annual trends for Rainfall Indices**

| Station | CDD | CWD | R20mm | R30mm | Rx1d | Rx5d | PRCPTOT | R95PTOT | R99PTOT |
|---|---|---|---|---|---|---|---|---|---|
| Kabwe | 0.20 | 0.04 | -0.06 | -0.03 | 0.18 | -0.27 | -2.66 | 0.02 | 0.03 |
| Kafironda | 0.25 | 0.01 | -0.03 | 0.02 | 0.09 | 0.26 | -1.66 | 0.03 | 0.06 |
| Kafue | 0.30 | -0.04 | 0.00 | 0.00 | 0.31 | 0.10 | -1.45 | 0.16 | 0.23* |
| Kasama | 0.21 | 0.06 | -0.04 | 0.02 | 0.40* | 0.45* | 0.05 | 0.06 | 0.13* |
| Kasempa | 0.27 | 0.07 | -0.03 | 0.01 | 0.09 | -0.01 | -0.47 | 0.15 | 0.05 |
| Kawambwa | 0.23 | 0.06 | -0.05 | -0.02 | 0.24 | 0.04 | -2.71 | 0.18* | 0.09 |
| Livingstone | 0.14 | -0.04* | -0.08* | -0.05* | -0.08 | -0.35 | -3.77 | -0.05 | -0.01 |
| Lundazi | 0.31 | -0.04 | -0.05 | -0.03 | 0.02 | 0.14 | -1.80 | 0.07 | 0.05 |
| Lusaka1 | 0.11 | -0.05* | 0.03 | 0.02 | 0.13 | 0.15 | 0.24 | 0.13 | 0.07 |
| Lusaka2 | 0.21 | 0.06* | -0.04 | -0.01 | 0.57 | 0.43 | -1.67 | 0.11 | 0.19* |
| Magoye | 0.26 | -0.02 | -0.02 | -0.03 | 0.72 | 0.44 | -0.68 | -0.07 | 0.26 |
| Mansa1 | 0.00 | 0.00 | -0.01 | -0.02 | 0.60* | 0.54* | -1.69 | 0.15 | 0.20* |
| Mbala | 0.10 | 0.03 | -0.02 | 0.02 | -0.10 | -0.01 | -3.35 | 0.04 | 0.00 |
| Mfuwe | 0.23 | -0.02 | -0.04 | 0.00 | 0.42 | 0.55 | 0.85 | -0.03 | 0.22 |
| Misamfu | 0.72 | 0.01 | 0.00 | -0.10 | 0.27 | -0.22 | -3.89 | -0.15 | -0.04 |
| Mongu | 0.16 | 0.06* | -0.01 | 0.01 | -0.28 | -0.50 | -0.07 | -0.10 | -0.07 |
| Mpika | 0.14 | -0.04 | -0.04 | -0.04 | -0.03 | -0.11 | -2.82* | -0.01 | 0.03 |
| Mt. Makulu | 0.21 | -0.03 | 0.02 | 0.03 | -0.06 | -0.34 | 0.57 | 0.14 | 0.02 |
| Mumbwa | 0.62 | -0.11 | -0.10 | -0.02 | 0.01 | -0.86 | -5.46* | 0.06 | 0.04 |
| Mwinilunga | 0.11 | -0.04 | -0.02 | 0.01 | 0.12 | -0.02 | -1.98 | 0.08 | 0.03 |
| Ndola | 0.14 | 0.05* | -0.03 | -0.01 | 0.10 | -0.06 | -1.03 | 0.05 | 0.06 |
| Petauke | 0.15 | -0.03 | -0.04 | -0.02 | -0.02 | -0.21 | -2.09 | 0.03 | 0.07 |
| Serenje | 0.23 | -0.01 | -0.07 | -0.04 | -0.10 | -0.48 | -3.57 | 0.07 | 0.02 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sesheke | 0.24 | -0.06* | -0.10* | -0.04 | -0.58 | -1.04 | -5.36* | 0.06 | -0.11 |
| Solwezi | 0.25 | -0.01 | -0.03 | -0.03 | 0.10 | -0.02 | -1.36 | -0.01 | 0.03 |

Note: * represent statistical significance at $p<0.05$

## 4.5 Temperature and Precipitation Indices Using RCMS

### 4.5.1 Temperature

Analysis using GCMs projections for 2021 to 2050 have shown an increase and reduction in heatwave duration and cold spell length relative to the baseline. The projected annual changes in minimum and maximum temperature in 2020 to 2049 relative to the baseline using three GCMs (CanESM2, CNRM-CM5, MPI-ESM-MR) under RCP4.5 and RCP8.5 at all meteorological stations would be 0.59-1.32°C and 1.45-2.08°C, respectively. Seasonal temperatures are also projected to increase under both scenarios.

The study of RCMs shows that minimum and maximum temperature would increase in all the seasons in future (2021-2050) relative to the baseline. Zambia would experience higher changes in minimum temperature during January-February-March (JFM), April-May-June (AMJ) and October-November-December (OND) compared to the maximum temperature under both scenarios (RCP4.5, RCP8.5). Higher increase in minimum and maximum temperature will be observed in OND under both scenarios. The ensemble mean temperature changes in JFM, AMJ, July-August-September (JAS) and OND would be 1.34°C, 1.50°C, 1.86°C and 1.85°C under RCP4.5, respectively. On the other hand, the mean temperature changes under RCP8.5 in JFM, AMJ, JAS and OND would be 1.56°C, 1.82°C, 2.03°C and 2.11°C, respectively. There are larger changes under RCP8.5 compared to RCP4.5. Annual number of days with at least six consecutive days would increase in future (2021-2050).

#### 4.5.1.1 Projected changes in annual minimum temperature

Downscaled 30-year annual mean minimum temperature is shown in Table 4.8 and projected changes are presented in Figure 30. Individual models and their ensemble consistently project smaller minimum temperatures for AER III and larger values for AER I. The model range of projected minimum temperatures is 15.6-16.3°C (AER I), 15.6-16.1°C (AER II) and 13.9-14.3°C (AER III) under RCP4.5 Scenario. Minimum temperatures under RCP8.5 Scenario are relatively higher as evidenced by model ranges of 15.8-16.3°C, 15.8-16.2°C and 14.1-14.4°C for AER I, AER II and AER III, respectively.

**Table 4.8:Downscaled Long-Term Averages of Minimum Temperature (˚C)**

| | AER I | | | AER II | | | AER III | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Hist** | **RCP4.5** | **RCP8.5** | **Hist** | **RCP4.5** | **RCP8.5** | **Hist** | **RCP4.5** | **RCP8.5** |
| canesm2 | 14.9 | 16.3 | 16.3 | 15.2 | 16.1 | 16.2 | 13.5 | 14.3 | 14.3 |
| cnrm_cm5 | 14.8 | 15.6 | 15.8 | 15.0 | 15.7 | 15.8 | 13.5 | 13.9 | 14.1 |
| mpi_esm_mr | 14.8 | 16.2 | 16.3 | 15.1 | 16.0 | 16.2 | 13.6 | 14.3 | 14.4 |
| ensemble | 14.9 | 16.0 | 16.1 | 15.1 | 15.9 | 16.1 | 13.6 | 14.2 | 14.3 |

Projected changes are consistently highest in AER I and least in AER III under both scenarios. This is evident from individual models as well as from their ensemble. Moreover, larger changes are projected under RCP8.5 than under RCP4.5 scenario in all AERs (Figure 4.7).

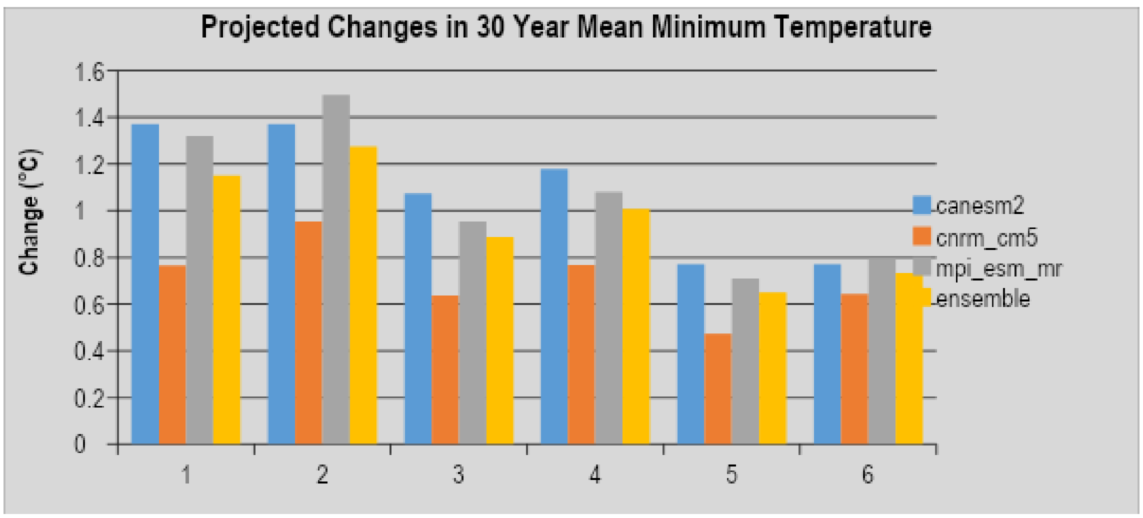


**Figure 4.7: Projected Changes in 30 Year annual mean minimum temperatures for 2020-2049 relative to the baseline 1971-2000 under RCP4.5 and RCP8.5 Scenarios**

Under RCP4.5 Scenario, changes in minimum temperature are projected to be in the range of 0.8-1.4°C, 0.6-1.1 °C and 0.5-0.8°C for AER I, AER II and AER III, respectively. The range of projected changes in minimum temperature for the period 2020 to 2049 relative to 1971 to 2000 means under RCP8.5 are 1.0-1.5°C, 0.8-1.2°C and 0.6-0.8°C for AER I, AER II and AER III, respectively. The projected changes in annual mean minimum temperature are significant for all agro-ecological regions and under both scenarios. This is evident as projected mean minimum temperature under RCP4.5 and RCP8.5 lie outside the first standard deviation of the historical mean (Table 4.9).

**Table 4.9:Summary statistics for annual mean minimum temperature (˚C) for the GCM ensemble**

| | AER I | | | AER II | | | AER III | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Hist** | **RCP4.5** | **RCP8.5** | **Hist** | **RCP4.5** | **RCP8.5** | **Hist** | **RCP4.5** | **RCP8.5** |
| Min | 14.3 | 15.4 | 15.5 | 14.6 | 15.6 | 15.6 | 13.2 | 13.9 | 13.9 |
| Mean | 14.9 | 16.0 | 16.1 | 15.1 | 15.9 | 16.1 | 13.6 | 14.2 | 14.3 |
| Max | 15.5 | 16.7 | 16.8 | 15.6 | 16.5 | 16.5 | 14.0 | 14.6 | 14.6 |
| Std. | 0.26 | 0.34 | 0.35 | 0.20 | 0.25 | 0.23 | 0.15 | 0.18 | 0.21 |
| **CV** | **0.017** | **0.021** | **0.021** | **0.013** | **0.015** | **0.014** | **0.011** | **0.013** | **0.015** |

### 4.5.1.2 Projected Changes in Long Term Annual Mean Maximum Temperature

Downscaled 30-year annual mean maximum temperature is shown in Tables 4.10 and 4.11 and projected changes are presented in Figure 4.8. Individual models and their ensemble consistently project smaller maximum temperatures for AER III and larger values for AER I. The model range of projected maximum temperatures is 31.5-32.8°C (AERI), 29.6-30.8°C (AER II) and 28.9-29.8°C (AER III) under RCP4.5 Scenario. Maximum temperatures under RCP8.5 Scenario are relatively higher as evidenced by model ranges of 31.6-33.1°C, 29.7-31.0°C and 29.1-30.1°C for AER I, AER II and AER III, respectively.

**Table 4.10:Downscaled mean maximum temperature for each AER**

| | AER I | | | AER II | | | AER III | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Hist** | **RCP4.5** | **RCP8.5** | **Hist** | **RCP4.5** | **RCP8.5** | **Hist** | **RCP4.5** | **RCP8.5** |
| canesm2 | 30.6 | 32.8 | 33.1 | 28.6 | 30.8 | 31.0 | 28.0 | 29.8 | 30.1 |
| cnrm_cm5 | 30.4 | 31.5 | 31.6 | 28.4 | 29.6 | 29.7 | 27.8 | 28.9 | 29.1 |
| mpi_esm_mr | 30.7 | 32.4 | 32.5 | 28.7 | 30.4 | 30.6 | 28.0 | 29.6 | 29.8 |
| ensemble | 30.6 | 32.3 | 32.4 | 28.6 | 30.3 | 30.5 | 27.9 | 29.4 | 29.7 |

**Table 4.11:Summary statistics for annual mean maximum temperature (˚C)**

| | AER I | | | AER II | | | AER III | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Hist** | **RCP4.5** | **RCP8.5** | **Hist** | **RCP4.5** | **RCP8.5** | **Hist** | **RCP4.5** | **RCP8.5** |
| Min | 29.9 | 31.4 | 31.8 | 28.0 | 29.5 | 29.9 | 27.4 | 28.8 | 29.1 |
| Mean | 30.5 | 32.2 | 32.4 | 28.6 | 30.3 | 30.5 | 27.9 | 29.4 | 29.6 |
| Max | 31.9 | 33.3 | 33.5 | 29.7 | 31.2 | 31.6 | 29.0 | 30.2 | 30.6 |
| Std. | 0.431 | 0.431 | 0.404 | 0.374 | 0.412 | 0.422 | 0.353 | 0.336 | 0.369 |
| CV | 0.014 | 0.013 | 0.012 | 0.013 | 0.014 | 0.014 | 0.013 | 0.011 | 0.012 |

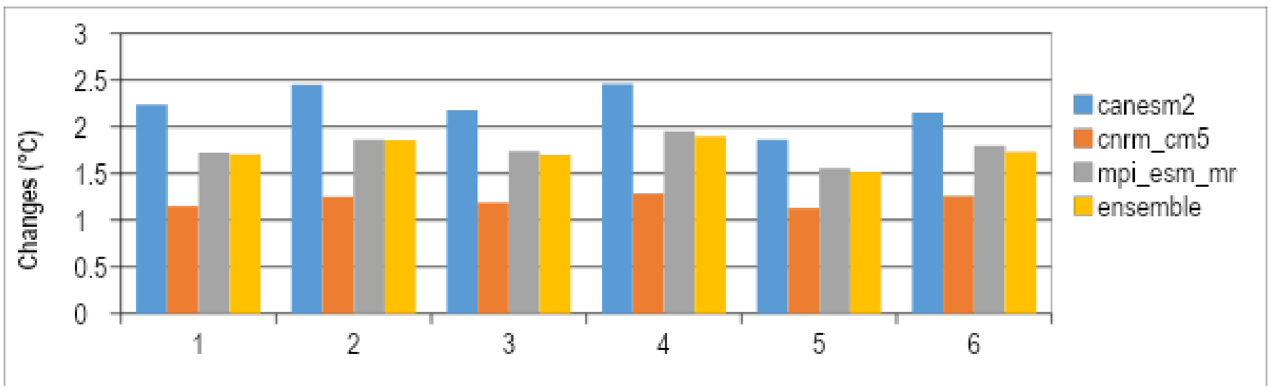


**Figure 4.8:Projected Changes in 30 Year annual mean maximum temperatures for 2020-2049/1971-2000 under RCP4.5 and RCP8.5 scenarios**

Projected changes in 30-year annual mean maximum temperature are consistently lower in AER III than in the other two regions under both scenarios. This is evident from individual models as well as from their ensemble. Moreover, larger changes are projected under RCP8.5 than under RCP4.5 scenario in all agro-ecological regions (Figure 4.8). Under RCP4.5 scenario, changes in annual mean maximum temperature are projected to be in the range of 1.15-2.23°C, 1.19-2.17 °C and 1.13-1.86°C for AER I, AER II and AER III, respectively. The range of projected changes in maximum temperature for the period 2020-22049 relative to 1971-2000 means under RCP8.5 are 1.25-2.45°C, 1.29-2.46°C and 1.26-2.158°C for AER I, AER II and AER III, respectively. These projected changes in annual mean maximum temperature are significant for all agro-ecological regions and under both scenarios. This is evident as projected mean minimum temperature under RCP4.5 and RCP8.5 lie outside the first standard deviation of the historical mean (Figure 4.9).

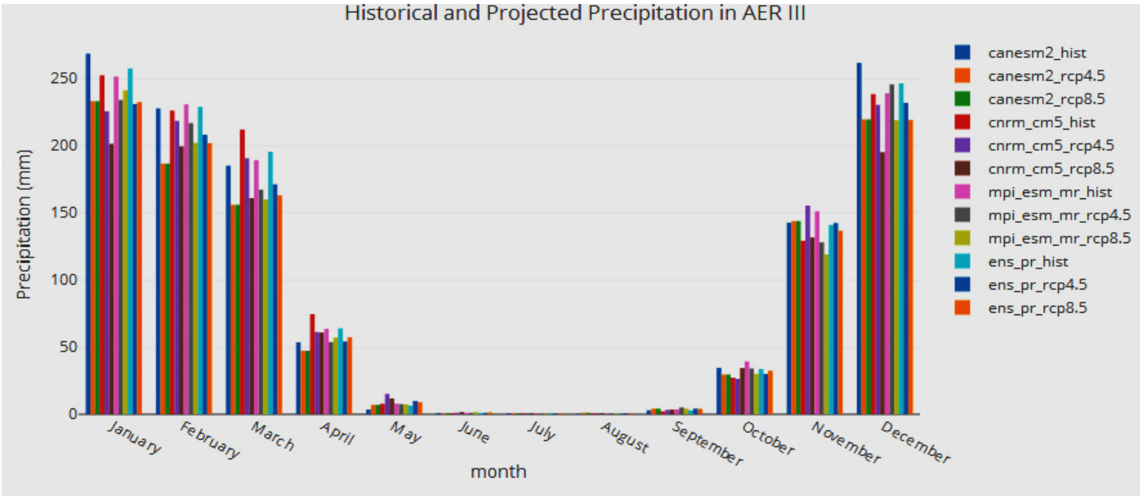


**Figure 4.9 Annual cycles of monthly total mean precipitation in AER III for the baseline (1971-2000) and future scenario (2020-2049)**

## 4.6 Vulnerability Risks, Hazards, Assessments and Development Of Adaptation Measures

This section identifies the current vulnerabilities of the agriculture, health, water and natural resource sectors. It also proposes adaptation measures to combat the identified vulnerabilities.

### 4.6.1 Vulnerabilities in the Agriculture Sector

#### 4.6.1.1 Vulnerabilities and Impacts

An assessment of the likely impacts of climate change on yields of selected crops namely; maize, beans, cotton, millet and groundnuts in each of the 10 provinces of Zambia covering the periods 2011-2040/1971-2040, 2040-2069/1971-2040 and 2070-2099/1971-2040 was undertaken. Scenarios for climate change indicators involving increased and reduced temperatures were created for purposes of assessing possible future impacts on yields of the above-mentioned crops adaptation. Three GCMs namely CAN-ESM22, MPI-ESM-MR and CNRM-ESM under two Representative Concentration Pathways (RCP4.5 and RCP8.5) were used.

Trends showing increased temperatures of an average of 0.34$^{o}$ C per decade and a decrease in rainfall at an average of 1.9 mm per month threaten livelihoods. At agricultural field level, the consequences of this scenario will lead to waterlogged fields, water shortages, destruction of crops and higher incidences of crop and livestock diseases.

### a) Impacts on Maize Production

For maize, climate change may significantly reduce maize yields in Southern and Eastern Provinces especially in the far future horizons (Syampaku et al., 2019). However, in the Copperbelt, Eastern, Luapula, North-Western and Southern Provinces maize yield may reduce marginally under both near and far future as shown in Table. 4.12. Maize yields for Central, Luapula, Northern and Muchinga Provinces may increase only marginally in both near and far future. Thus, adaptation measures may need to focus mostly in the Copperbelt, Eastern and Southern parts of Zambia.

**Table 4.12: Ensemble mean and standard deviation of maize yield by province using a GCM ensemble**

| | **Historical** | | **RCP4.5** | | **RCP8.5** | |
|---|---|---|---|---|---|---|
| Province | Mean | sd | 2011-2040 | 2040-2069 | 2011-2040 | 2040-2069 |
| Central | 0.02 | 1.24 | 0.34ns | 0.12ns | 0.71ns | -0.45ns |
| Copperbelt | 0.03 | 0.86 | -0.12ns | -0.11ns | -0.11ns | -0.41ns |
| Eastern | -0.01 | 0.27 | -0.13ns | -0.32* | -0.10ns | -0.67* |
| Luapula | -0.02 | 0.42 | -0.01ns | -0.11ns | 0.04ns | -0.07ns |
| Lusaka | 0.01 | 0.73 | 0.06ns | -0.04ns | 0.09ns | -0.19ns |
| Muchinga | -0.01 | 0.13 | 0.07ns | 0.07ns | 0.11ns | 0.15* |
| Northern | 0.00 | 0.54 | 0.18ns | 0.15ns | -0.05ns | 0.06ns |
| North-Western | -0.03 | 0.42 | 0.17ns | -0.16ns | 0.02ns | -0.84ns |
| Southern | -0.01 | 0.31 | 0.06ns | -0.19ns | 0.02ns | -0.70* |
| Western | -0.04 | 0.22 | 0.08ns | 0.01ns | -0.06ns | -0.24ns |

*Source: Syampaku et al. (2019)*

* = Means significant P≤0.05; ns = non-significant at P≤0.05

### b) Impacts on Beans Production

Beans production would increase in both near and far future in Central and Eastern Provinces while production in Copperbelt and Northern Provinces, under near and far futures would decrease (Syampaku et al., 2019). Furthermore, in Luapula, Lusaka, North-Western and Western Provinces, the changes in mixed bean production would not exceed historical natural variability in the near future period, but would likely decrease in the far future. Notwithstanding, the change in production of mixed beans would not exceed historical natural variability in Southern and Muchinga Provinces both for the near and far future periods as shown in Table 4.13. Thus, adaptation measures may need to be directed to all the provinces of Zambia.

**Table 4.13: Ensemble mean and standard deviation of beans yield by province using a GCM Ensemble**

| Province | | | RCM4.5 | | RCM8.5 | |
|---|---|---|---|---|---|---|
| | **Mean,** | **sd,** | **2011-2040** | **2040-2069** | **2011-2040** | **2040-2069** |
| Central | 0.07 | 0.18 | 0.19ns | 0.13ns | 0.18ns | -0.04ns |
| Copperbelt | 0.23 | 0.14 | -0.27** | -0.37** | -0.30*** | -0.51*** |
| Eastern | -0.05 | 0.19 | 0.13ns | 0.21ns | 0.15ns | 0.14ns |
| Luapula | -0.06 | 0.20 | 0.03ns | -0.03ns | 0.00ns | -0.29* |
| Lusaka | -0.10 | 0.31 | -0.27ns | -0.46* | -0.22ns | -0.64* |
| Muchinga | -0.08 | 0.38 | 0.03ns | -0.14ns | -0.05ns | -0.26ns |
| Northern | 0.18 | 0.24 | -0.14* | -0.18* | -0.15* | -0.37** |
| North-western | 0.08 | 0.13 | -0.02ns | -0.06ns | -0.02ns | -0.10ns |
| Southern | -0.15 | 0.08 | 0.01ns | -0.01ns | 0.00* | -0.05ns |
| Western | 0.32 | 0.45 | -0.10ns | -0.27* | 0.03ns | -0.43ns |

* = Means significant P≤0.05; ns = non-significant at P≤0.05

### c) Groundnut Production

In the case of groundnuts Syampaku et al. (2019), production is projected to rise with varying degrees in Central, Copperbelt, Eastern, Luapula, Muchinga, Northern, Lusaka and North-Western provinces. However, Southern and Western provinces are expected to have marginally reduced productivity. Thus, adaptation efforts will need to be directed towards these provinces.

### d) Millet

Syampaku et al. (2019) and Chisanga (2019), projected significant increases in millet production in Eastern Province in both near and far future horizons whereas significant decreases are projected in Western and Southern Provinces for the same time horizons. The rest of the country is likely to remain more or less normal in both time horizons. The mean ensemble millet yields using three GCMs (CANESM2, CNRM-CM5 and MPI-ESM-MR) for Eastern, Southern and Western Provinces would be highly very significant under RCP4.5 and RCP8.5 during the 2020s and 2050s. Central, Copperbelt, Luapula, Lusaka, Muchinga, Northern and North-Western Provinces ensemble millet yields for the mid-and-far future would be non-significant. Millet yield would be affected by changes in temperature and precipitation in Eastern, Southern and Western Provinces. The diverse water balance parameters affected the millet yield per province differently. However, drought and floods are likely to reduce millet yield in major agriculture producing provinces (Mwila et al., 2008). The prolonged dry spells and variability in rainfall during the near and mid-century would reduce millet yield in some provinces (Table 4.14). Thus, adaptation efforts need to be directed at Western and Southern provinces for this crop.

**Table 4.14 Ensemble mean and standard deviation of millet yield by province using a GCM Ensemble**

| **Province** | | | **RCM4.5** | | **RCM8.5** | |
|---|---|---|---|---|---|---|
| | **Mean,** | **sd,** | **2011-2040** | **2040-2069** | **2011-2040** | **2040-2069** |
| **Central** | 0.31 | 0.03 | -0.14ns | -0.16ns | -0.18ns | -0.18ns |
| **Copperbelt** | -5.52 | 0.25 | -5.63ns | -5.67ns | -5.58ns | -5.59ns |
| **Eastern** | -0.30 | 0.03 | 0.14*** | 0.14*** | 0.16*** | 0.16*** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Luapula** | 0.58 | 0.15 | -0.10ns | -0.14ns | -0.09ns | -0.07ns |
| **Lusaka** | -0.17 | 0.64 | -0.02ns | -0.24ns | -0.22ns | -0.11ns |
| **Muchinga** | 1.17 | 0.44 | -0.18ns | -0.16ns | -0.20ns | -0.25ns |
| **Northern** | 0.64 | 0.05 | -0.14ns | -0.16ns | -0.16ns | -0.20ns |
| **Northwestern** | 0.77 | 0.18 | -0.09ns | -0.12ns | -0.12ns | -0.13ns |
| **Southern** | -0.30 | 0.04 | 0.01*** | 0.00*** | -0.07*** | -0.23*** |
| **Western** | -0.67 | 0.05 | -0.03*** | -0.05*** | -0.14*** | -0.44*** |

*Sources: Chisanga (2019)*

**Note:** ***=very significant, **=significant, ns=not significant

#### e) Impacts on Cotton Production

Climate change may reduce yields of cotton in the northern half of the country covering Central, Copperbelt, Luapula, Muchinga and Eastern provinces with varying degrees (Syampaku et al. 2019). Therefore, there is need for adaptive and mitigation measures to minimize the impacts of climate change on cotton yields in these provinces. However, in North-western, Western, Southern and Lusaka provinces, productivity is likely to increase by varying degrees. Thus, adaptation efforts towards raising cotton productivity in provinces where there is an increase in production may be very minimal.

### 4.6.1.2 Adaptation measures in the Agriculture Sector

Adoption of CSA practices offer potentially substantial climate change mitigation co-benefits likely to increase productivity and resilience while decreasing the sector’s GHGs. However, currently CSA has low adoption rates due to high labour demand, poor access to critical labour-saving equipment, and limited knowledge and capacity. Table 4.15 provides climate impacts and associated indicators, and adaptation options in the agriculture sector.

**Table 4.15 Climate and climate impact indicators, Climate impacts and adaptation options in the Agriculture Sector**

| Climate indicators | Expected change by 2050 | Climate impact indicators | Climate impact (vulnerability) | Adaptation options |
|---|---|---|---|---|
| Increased Temperature | High | • -Reduced crop yields and livestock production due to increased temperatures<br>• Increased number of cases of crop and animal pests and diseases | • Prolonged dry spells<br>• Drought (Leading to water stress disruption of livelihoods)<br>• Reduction of water levels (Lakes, rivers, streams etc.)<br>• | • Develop and introduce Crops (cereals, roots and tubers and horticultural crops) tolerant to high temperatures<br>• Propose to add other crops that are easily adaptable<br>• Strengthening of the early warning systems and preparedness<br>•<br>• Introduce crops resilient to climate change/variability<br>• |
| | | • Increased animal and crop pests and diseases | • Number of livestock and crop Hectares affected<br>• Number of pests and disease outbreaks | • Promotion of well adapted livestock and crops resilient to pests and disease.<br>• Adopt integrated Pest Management for crops and livestock,<br>• Sustainable Land management<br>• Agroforestry<br>• Develop sustainable and appropriate programmes<br>• Conservation agriculture<br>• Promotion of alternative livelihoods |
| Low rainfall | High | • percent reduction in crop yield and livestock production. | • -Increased number of food insecure households<br>• -Drying up of dams and lowering water tables.<br>• -It Prompts innovation in | • Develop and introduce Crops (cereals, roots and tubers and horticultural crops) resilient to drought<br>• promote investment in Agricultural Infrastructure (Dams, Water harvesting, water recycling). |

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| | | | improved varieties of crops and animals | ● Promote sustainable crop and livestock management. |
| High rainfall | | ● Reduction in crop yield<br>● Flooding, damage to infrastructure<br>● Increased water stress leading to disruption in crop production leading to food insecurity.<br>● Increased pest outbreaks. | ● Raised ground water table.<br>● Increased water harvesting in dams<br>● -Disruption of livelihoods,<br>● reduced crop yield. | ● Develop and Promote cultivation of crops tolerant to water logging.<br>● Promote contour ploughing<br>● Promotion of well adapted livestock and crops resilient to pests and disease.<br>● Adopt integrated Pest Management for crops and livestock<br>● Promote investment in Agricultural Infrastructure (Dams, Water harvesting, water recycling).<br>● Promote sustainable crop and livestock management.<br>● Promote prevention measures through vaccinations<br>● Promote investment in Agricultural Infrastructure (Dams, Water harvesting, water recycling).<br>● Promote sustainable crop and livestock management.<br>● Promote prevention measures through vaccinations<br>● Increased opportunities for water harvesting for productive use.<br>● Increasing the production crops e.g. Rice<br>● Promotion of aquaculture.<br>● Enhancing water conservation technologies (Water demand management, drip irrigation)<br>● Wastewater recycling<br>● Climate smart agriculture |

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| | | | | • Conservation<br>• Agriculture<br>• Enhancing water conservation technologies (Water demand management, drip irrigation)<br>• Wastewater recycling<br>• Climate smart agriculture<br>• Conservation<br>• Agriculture |
| | | • Reduction in livestock production (disease outbreak) | • Reduced income at household level | • Promote prevention measures through vaccinations |
| | | • Reduction of arable land | • Number of food insecure households | • Promote sustainable water management practices (Drainage) |

Provided in Table 4.16 are adaptation measures to climatic hazards in different agro-ecological regions of Zambia.

**Table 4.16 Adaptation measures to Climatic Hazards in different Agro-ecological Regions of Zambia**

| Relevant Vulnerable Regions | Climate Hazards | Adaptation Measure |
|---|---|---|
| Agro-Ecological Regions (AER) I, II & III, especially Eastern, Central, Western and Southern provinces | Prolonged dry spells, Heat wave & high temperature, Drought, Seasonal and periodic floods, -water logging, Changes (shortened growing season), and delayed on-set of the rains. | • Introduce Crops (cereals, roots and tubers and horticultural crops) resilient to climate change/ variability including promotion of early maturing/drought resistance crops and tolerant to pests & diseases<br>• Develop sustainable and appropriate programmes for both crops, fisheries and livestock in the face of climate change (including climate smart agriculture and conservation agriculture)<br>• Promotion of well adapted livestock breeds/strains |

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| | | • Promotion of fast-growing culture fish species for aquaculture<br>• Diversification of fish species cultured<br>• Improvement on fish pond technology including use of dam liners<br>• Promote water harvest technologies<br>• Sustainable Land management<br>• Crop diversification<br>• Agroforestry<br>• Control of fires in cultivated fields and rangelands<br>• Conservation agriculture<br>• Combating soil acidification (Due to Inorganic fertilization)<br>• Rehabilitation of degraded lands<br>• Farmer/Technocrats exposures to climate change issues<br>• Promotion of use of improved pasture varieties<br>• Training and public awareness on climate change<br>• Technology transfer (being able to respond to climate change)<br>• Promotion of irrigation and efficient use of water resources<br>• Use of technologies for fertility improvement and moisture storage (including soil conservation measures)<br>• Improvement of manure management<br>• Improved crop & soil management practices for efficient nutrient and water use<br>• Improved crop varieties for efficient nutrient and water use<br>• Enhance the capacity to measure, report and verify GHG emissions<br>• Strengthening of the early warning systems and preparedness<br>• Water harvesting<br>• Development of weirs, dams, boreholes and water storage structures. |

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| | | ● Providing incentives for adoption of more efficient irrigation techniques.<br>● Promotion of Improved crop and livestock management practices<br>● Application of drones, GIS/remote sensing in mapping of drought and flood prone areas<br>● Improved Rangeland Management,<br>● Introduction of crop land inventory (10m * 10m) technology for monitoring small and large-scale agriculture, rangeland & water resources on near real-time basis<br>● Increased budgetary support to R & D<br>● Improve post-harvest storage and marketing of produce<br>● Promotion of alternative livelihoods<br>● Sustainable capture fisheries<br>● Promotion of aquaculture<br>● Introduction of appropriate fish species suitable to restock the lakes, rivers and dams |

#### 4.6.1.3 Cost of Adaptation for Agriculture

Table 4.17 provides the identified vulnerabilities, adaptation measures and costings in the agriculture sector.

**Table 4.17 Identified Vulnerabilities, Adaptation measures and Costings in the Agriculture Sector**

| | Vulnerability | Adaptation Measure | Cost of adaptation Action (US$) |
|---|---|---|---|
| 1 | Threatened food security due to droughts, floods, and increased temperature changes | Introduce crops ***(cereals, roots and tubers and horticultural crops)*** resilient to climate change/ variability including promotion of early maturing/drought resistance cultivars and tolerant to pests & diseases | 4,200,000 |
| 2 | Disruption of livelihoods as farmers as farmers lose their agricultural economic sources of income | Develop sustainable and climate smart programmes for crops, fisheries and livestock in the face of climate change<br><br>Promotion of well adapted livestock breeds/strains | 34,389,000<br><br>900,000 |

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|---|---|---|---|
| 3 | Destruction of natural resources base as farmers seek for alternative sources of income (charcoal burning/ deforestation, *forest produce*) | Promotion of alternative livelihoods e.g. Beekeeping, Small livestock, Fish farming | 20,000,000 |
| 4 | Destruction of agriculture resource base due to; poor management practices- overgrazing (reduced grazing area), cultivation methods (farmers tending to continue with the same conventional farming systems/tillage amidst changed climate conditions), aridness | Control of fires in cultivated fields and rangelands<br><br>Rehabilitation of degraded lands<br><br>Use of technologies for fertility improvement and moisture storage (including soil conservation measures) | 1,000,000<br><br>350,000<br><br>1,500,000 |
| 5 | Disruption of family activities' due to erratic rainfall, increased temperatures, power outages | Promotion of irrigation and efficient use of water resources | - |
| 6 | Poor responsiveness to adaptation measures among farmers | Training and public awareness on climate change | 110,000 |
| 8 | Inadequate research support to respond to climate change challenges | Increased budgetary support to R&D | - |
| 9 | Reduced productivity, crop failure | Promotion of conservation agriculture | 20,000,000 |
| 10 | Inability to measure, report and verify GHG emissions from AFOLU | Enhance the capacity to measure, report & verify GHG | 3,000,000 |
| 11 | Crop Pest/Disease outbreak | Crop diversification<br><br>Technology transfer (being able to respond to climate change)<br><br>Strengthening of the early warning systems and preparedness | 1,000,000<br><br>400,000<br><br>672,000 |

### 4.6.2 Vulnerabilities and Adaptation of the Water Sector

#### 4.6.2.1 Vulnerability and Impacts for Water Sector

Climate change is projected to reduce water availability by about 13 percent by 2100. Scenarios for climate change indicators involving increased and reduced temperatures were created for purposes of assessing possible future impacts and adaptation options to future impacts in the water sector. The different impacts on the water sector are expected to range from reduced water recharge in the case of increased temperature and reduced rainfall, compromised water quality, destruction to infrastructure and general reduction in water availability.

Water resources in the northern part of the country are likely to remain unchanged or slightly increase during the assessment period 2020 to 2050. There may be reduced quantities of water resources in river basins in the Eastern, Southern and Western parts (that is, Zambezi, Kafue and Luangwa). Climate change may worsen water stress in Zambia, as there may be significant differences at river basin level (Muhlenbruch, 1992).

Scientific evidence points to an increased inter-annual variability, with extremely wet periods and more intense droughts in the future. Observable and potential effects of climate change on water resources in Zambia include: flooding, drought, change in the frequency and distribution of rainfall, drying-up of rivers and receding of water bodies among others. Shortage of water due to reducing water levels in Lusaka is evident especially during summer.

Climate change affects the amount and seasonality of rainfall and inflows into most rivers which has in turn affected the amount of electricity generated using hydroelectric. Zambia has invested significantly in hydroelectric power facilities. Reservoir storage in these facilities shows marked sensitivity to variations in runoff during periods of drought. Major dams have reached critical levels, threatening industrial activities. The tourism sector has not been spared from the consequences of climate change in Zambia. Drought has negatively affected the tourism sector especially in Livingstone owing to the reduced water levels at the Victoria Falls which is Zambia's prime tourist attraction. Even though the impact has not been quantified, the number of tourists visiting Livingstone reduced during the drought period.

#### 4.6.2.2 Proposed Adaptation Measures for Water Resources

The following measures are proposed:

1. Promoting of irrigation and ensuring all year-round agricultural production, especially among small-scale farmers so as to improve household food security and incomes.

2. Promotion of energy efficiency and alternative and renewable energy sources such as solar, thermal, and nuclear energy to reduce over dependence on hydro power generation which requires use of water resources.
3. Research and feasibility of development of inter-basin water transfer
4. Integrated watershed management to prevent land degradation, siltation, deforestation and depletion of ground water designated watershed areas;
5. Investment in early warning systems and timely dissemination of information
6. An integrated water and land use management
7. Public awareness and sensitization campaign in climate change impacts: the general public needs to be sensitized on climate change issues and their implications on water resources scarcity and availability
8. Developing local rainwater harvesting measures.
9. Protecting groundwater through management and technical measures like regulatory frameworks, water licensing, artificial recharge especially for threatened aquifers and enhancing the country's water storage capacities
10. Legislating and enforcing laws and regulations required for efficient water resources management, conservation and groundwater use.

Table 4.18 presents the possible climate impact indicators as a result of temperature increase, reduced rainfall or increased rainfall in future.

**Table 4.18: Climate and Climate impact indicators, Climate impacts and Adaptation options in the Water Sector**

| Climate Indicators | Expected Change by 2050 | Climate Impact Indicators | Climate Impact (vulnerability) | Adaptation Options |
|---|---|---|---|---|
| Increased Temperatures | High Temperatures | -Increased innovations for alternative interventions.<br>-Increased evapo-transpiration on surface water sources leading to water scarcity<br>-Reduced water recharge<br>-Reduced water table | -Reduced availability of water<br><br>-Transformational of perennial streams into seasonal ones Lowered water table | -Investing in climate resilient water infrastructure, Strengthening early warning<br>-Promote afforestation and reforestation of catchment area<br>- Creation awareness among local people of the catchment areas<br>-promote eco-friendly infrastructure |

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|---|---|---|---|---|
| Increased Rainfall | High Rainfall | -Recharge of surface and underground water<br>-Water quality is compromised, Destruction of water infrastructure<br>-Over flooding | -Flooding, disrupted livelihoods<br><br>-Damage to water infrastructure (Dams) | -Enhancement of technologies to harvest and manage water<br><br>-Promote and invest in water transfer infrastructure |
| Low Rainfall | Low Rainfall | -Enhanced innovation<br><br>-Decreased water quantity and quality<br><br>-Reduced water availability | Dry spells and droughts<br><br>-Drying up of dams/boreholes/wells<br>-Increases in number of people affected by water borne diseases<br>-Reduced Hydro-electric power generation | -Incentivize water saving innovations<br>-Promote afforestation and reforestation of catchment area<br>-Conduct water resources assessment and quantification for an integrated water resources data and information system<br>-Conduct basin and catchment water potential assessment<br>- Invest in water transfer infrastructure<br>- Invest in climate resilient infrastructure (Dams) |

### 4.6.2.3 Cost of Adaptation Actions

Table 4.19 provides the identified vulnerabilities, adaptation measures and costings in the Water sector.

**Table 4.19: Identified vulnerabilities Adaptation Measures and Costings**

| Vulnerability | Adaptation options | Cost of adaptation Action (US$) |
|---|---|---|
| Reduced availability of water | Investing in climate resilient water infrastructure | 25,800,000<br><br>2,524,831 |

| | | |
|---|---|---|
| | Enhancement of technologies to harvest and manage water (in three out of six catchment areas) | 3,000,000 |
| | Conduct water deficit/availability assessment in AER I and AER II | |
| Transformation of perennial streams into seasonal ones | Promote afforestation and reforestation of catchment area | Budgeted under mitigation |
| | Creation awareness among local people of the catchment areas. | |
| | Integrated watershed management to prevent land degradation, siltation, deforestation and depletion of ground water in designated watershed areas | 1,029,166.69 |
| Lowered water table | Legislating and enforcing laws and regulations required for efficient water resources management, conservation and groundwater use | 2,580,000 |
| | Promote eco-friendly infrastructure | 2,979,300.58 |
| -Flooding, disrupted livelihoods | Strengthening early warning | 3,675,000 |
| | Create awareness among local people | 923,261 |
| -Damage to water infrastructure (Dams) | Promotion of Water transfer infrastructure development | 64,500,000 |
| | Research and development of inter-basin water transfer | 1,260,018.46 |
| Dry spells and droughts | Incentivize water saving innovations | 782,080.46 |
| Reduced Hydro-electric power generation | Undertake water resources assessment and quantification for an integrated water resources data and information system for ground water aquifers | 2,077,501.6 |
| | Promotion of energy efficiency and alternative renewable energy sources | Budgeted under mitigation |

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|---|---|---|
| | Conduct basin and catchment water potential assessment | 1,086,222.84 |

### 4.6.3 Vulnerabilities and Adaptation of Health Sector

Health is also a sector that has been critically hit by climate change. Health and quality of life are influenced by key determinants such as access to safe and adequate water, good sanitation, housing, nutrition and food security, and education, among others. The health sector has been highly vulnerable to climate change resulting in increased disease prevalence for diseases such as; Malaria, Diarrhea, Malnutrition, respiratory infections. Other health related climate change implications include, injuries and death due to accidents arising from damage on tyres caused by increased temperatures as well Water and Sanitation. Malaria continues to be a major public health problem in Zambia and climate change has contributed to its persistence.

#### 4.6.3.1 Adaptation Measures

Table 4.20 presents proposed adaptation measures and suggests implementing institutions to handle the proposed adaptation measures.

**Table 4.20 Health Adaptation Policies and Measures**

| Adaptation option | Action required | Implementing Institution | Timeframe |
|---|---|---|---|
| Tracking of diseases and trends related to climate change | ● Set up disease and climate indicators sharing platform among stakeholders at all levels<br>● Strengthening of HMIS by integrating health data with meteorological variables | MoH, MLG, ZMD | Short term |
| Investigation of infectious water, food- and vector borne diseases | ● Combat conditions that expose children to pathogens such as access to safe water and sanitation, flushable toilets with good sewer systems, decent accommodation, good health services<br>● Setup robust public health laboratory systems<br>● Conservation of genetic resources<br>● Review the Public health Act to incorporate community health structures | MoH, MLG, MWDSEP, Ministry of Housing and Infrastructure, Academia, | Long-term |

| | | | |
|---|---|---|---|
| Informing the public and policymakers about health impacts of climate change | ● Develop a communication strategy for enhancing literacy in the population regarding impact of climate change on health<br>● Sensitization of the public about climate change<br>● Promote preparedness of citizens through accurate weather reports | MoH, MLG,Media, CSO and traditional leaders | Long-term |
| Food safety and security | ● Enhance food security among poor rural through promoting efficient food production methods e.g. irrigation schemes, fish farming, improved storage of harvests.<br>● Maintaining biodiversity for food and agriculture<br>● Promote alternative sources of livelihood apart from agriculture<br>● Promote conservation and planting of trees like Moringa which has nutrition benefits.<br>● Social protection through cash transfers, empowerment of women and youths, infant and child feeding at under-five clinics and School Health Nutrition (SHN) in schools<br>● Supporting contribution of underutilized and neglected species | Ministry of Agriculture, MoH, Ministry of Fisheries and Livestock, MOGE, Ministry of Community Development | Long term |
| Capacity building and research | ● Promote training on tools for developing climate scenarios and analysis<br>● Research and develop more early-maturing seed varieties<br>● Encourage adult women education<br>● Train and recruit more public health specialists<br>● Conservation of genetic resources<br>● Contribution of indigenous genetic resources, protect them and put them into practice through traditional knowledge<br>● Equipment and tools for irrigation should be available to farmers<br>● Traditional, Community and scientific knowledge should be combined in finding solutions to food security such as producing, preservation and preparation of food | Academia and Research Institutions | Long term |
| Community resilience | ● Review the Public health Act to incorporate community health structures<br>● Training for community resilience | MoH, MLG | |

Furthermore, particular strategies have been developed to help address some of the impacts recorded in Table 4.20. These are as follows:

1. Strengthening surveillance systems for potential disease outbreaks and quick response strategies.
2. Updating and improving compliance (enforcement) of the existing laws on public health.
3. Promoting sustainable medical facilities and practices.
4. Improving access to clean water and sanitary facilities to limit outbreaks of waterborne diseases, alongside strong public awareness programmes to promote better hygiene.
5. Renovating and rehabilitating the existing health infrastructure to bring them to the minimum acceptable standards.

Scenarios for climate change indicators involving increased and reduced temperatures were created for purposes of assessing possible future impacts and adaptation options to future impacts in the health sector. Table 4.21 presents the possible climate impact indicators as a result of temperature increase, reduced rainfall or increased rainfall in future. The different impacts on the health sector are expected to range from increased proliferation of pathogens, contamination of water sources, and increased proportion of malnourished population.

**Table 4.21 Climate and climate indicators, climate impacts and adaptation options in the Health sector**

| Climate indicators | Expected change by 2050 | Climate impact (vulnerability) | Impact indicators | Adaptation options |
|---|---|---|---|---|
| Increased Temperature | Higher Temperatures | Increased proliferation of pathogens | Increased disease burden | - Health promotion and education |
| | | Spatial and temporal widening of the vector populations | Emerging of new strains of diseases | Research on vector behavior Strengthen and promote the use of integrated vector management |
| | | Increased food insecurity and poor nutrition | Increased proportion of Malnourished population | - Strengthen Food fortification<br>- Promotion of Crop diversification |
| | | Increased pollutants in the air | Increased respiratory infections and allergies | -Establish control and preventive measures for RTIs |

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| Increased Rainfall | Flooding | Contamination of water sources | Increased water diseases | -Case management for fishing camps<br>-Enhance preparedness and early warning systems<br>-Integrated district planning |
| | | Increased stagnation of water | Increased vector Borne diseases | -Promotion of Environmental management<br>- Strengthen the use of IVM |
| | | Destruction of infrastructure | Loss of habitat<br>Increased mental health cases<br>Reduced access to health services | -Construction of climate smart infrastructure<br>-Enhanced operation and maintenance of infrastructure |
| Reduced Rainfall | Crop failure | Reduced crop yield leading to food insecurity | Increased proportion of Malnourished population. | -Promote Crop diversification<br>-Promotion of dietary shifts |
| | Drought | Reduction in livestock production | Increased proportion of Malnourished population.<br>- Increased mental health cases | -Promote alternative foods rich in proteins |
| | Drought | - Reduced non wood Forest Products | - Loss of household income leading to mental health issues<br>-Reduced access to health services due to loss of incomes<br>-Increased number of malnutrition cases | -Promotion of alternative sources of income<br>-Cultivate tree crops as alternative non wood Forest Products<br>-Promotion of alternative diets |
| | | -Reduced water available for hydro power generation leading to usage of charcoal and other fossil fuels | -Increased Respiratory Tract Infections | -Promotion and access to clean energy<br>-Strengthen research in climate change and RTIs |

### 4.6.3.2 Cost of Adaptation Actions

**Table 4.22 outlines Identified vulnerabilities and costings of adaptation measures in the health sector.**

| S/N | Vulnerability | Adaptation Measure | Cost of adaptation Action (US$) |
|---|---|---|---|
| 1 | Malaria vectors have widened their range | Early warning systems | 97,483.72 |
| | | Research on vector susceptibility/behavior | 68,569 |
| 2 | Drug resistance in malaria vector | Research on vector susceptibility/behavior | 68,569 |
| | | Strengthen case management | 1,000,000 |
| 3 | Presence of two competing vectors | Strengthen the use of Integrated Vector Management (locally driven) (Luapula, Northern and Muchinga provinces) | 4,103,463.60 |
| 4 | Contamination of the environment with insecticides | Environmental Safeguards | 1,000,000 |
| | | Develop new programs where necessary to prevent and reduce the severity of future risks | |
| | | Active surveillance | 100,000 |
| | | Capacity building for specialists | 100, 000 |
| 5 | Fishing camps and fishermen | Strengthen case management (Mass Drug Administration) | 2,000,000 |
| | | Awareness raising | 50,000 |
| 6 | Access to safe water and sanitation | Provide adequate infrastructure for water and sanitation | 238,252.70 |
| | | Strengthen Communication with communities and Policy Makers | 50,000 |
| 7 | Inadequate infrastructure Planning | Integrated town and country planning/ Engagement of stakeholders | 33,426.55 |
| 8 | Flood prone areas leading to contamination of water sources | Preparedness and early warning | 57,108.44 |
| | | Integrated district planning | 33,426.55 |
| | | Immunizations | 214,575.02 |
| 9 | | Preparedness and early warning | 57,108.44 |

| | | | |
|---|---|---|---|
| | Drought prone areas leading to water borne diseases due to limited availability of water | Water purification | 30,000 |
| 10 | Food insecurity causing stunting wasting, stunting and underweight in children | Strengthen food preservation | 300 000 |
| | | Promotion of dietary shifts from the usual to alternative diets | 20,000 |
| | | Strengthen research in various climate change and health areas (nutrition and NCDs) | 200,000 |
| | | Forging collaborations with sectors such as water and infrastructure to promote activities to improve population health in a changing climate | 20,000 |
| 11 | Flooding and droughts damaging crops leading to malnutrition energy based | Preparedness and early warning and Food relief food | 2,000,000 |
| 12 | Flooding and droughts damaging livestock leading to malnutrition protein based | Preparedness and early warning and Food relief | 2,000,000 |
| 13 | Drought causing dry forests in turn no forests to provide forest food: animals, wild vegetables, fruits and roots | Preparedness and early warning, sensitizations on conservation of forests | 500,000 |
| 14 | Lowered immunity prominent in HIV/AIDS | Nutritional food supplements/ sensitizations on suitable diets | 1,000,000 |
| 15 | Chemicals susceptibility in lowered immunity due to deficiency in calcium and zinc | Calcium and Zinc supplements | 1,000,000 |
| 16 | Indoor Household Air Pollution | Promotion and access to clean energy | Cost as developed under energy |
| | | Development of National guidelines for Household Air pollution | 33,426.55 |
| | | Establish control and preventive measures to effectively manage health risks due to elevated | 6,097,264 |

| | | | |
|---|---|---|---|
| | | levels of air pollution, heat waves, cold weather and floods. | |
| | | Research on climate change and RTIs, heat waves, cold weather and floods | 500,000 |
| 17 | Cross cutting issues | Capacity building | 1,000,000 |
| | | Inter-ministerial TWG focused on health and climate change | 10,000 |
| | | Mainstreaming gender in health and climate change | 50,000 |

### 4.6.4 Vulnerabilities and adaptation of the Natural Resources Sector

#### 4.6.4.1 Vulnerability and Impacts

The natural resources sector is vulnerable to the impacts of climate change as it can be seen from the climate related degradations in wildlife, forestry and wetlands. The negative impacts in the sector have been as a result of changing rainfall and temperature patterns that have transformed the ecosystems.

##### 4.6.4.1.1 Wildlife

Over the past decades massive changes have been observed in Zambia's wetland ecosystems as a result of droughts and the conversion of wildlife ecosystems to grazing land. In entirely natural systems, such changes would probably mean gradual changes in vegetation type, loss of foliage and a lower stocking rate for many wildlife species. For example, the Department of National Parks and Wildlife has recorded a gradual decline in the lechwe's population and abundance in all of its habitats (Kafue and Bangweulu wetlands) largely due to the habitat being invaded by the invasive plant species *Mimosa pigra*, harvesting of wetland vegetation and cattle grazing.

The Mweru-Wantipa ecosystem has dried out largely due to the reduced rainfall and the human presence in the ecosystem has greatly exacerbated these impacts. DNPW has continued to record increased number of mortalities in Kafue Lechwe and Hippo populations arising from the drying out of permanent water lagoons in Kafue National Park and South Luangwa National Parks. High fire occurrence due to the rising temperatures has been observed to affect the abundance of grazing herbivores like the Puku, Zebra and Waterbuck (DNPW, 2007, 2018, 2019). In addition, the main threat to Black Cheeked Love-Bird is the gradual drying up of water bodies in southwest Zambia where the distribution of this bird is concentrated probably due to warming and drying (Warbutorn and Perrin, 2005).

The following are the adaptation measures for wildlife:

1. Developing a National Wildlife Adaptation Strategy;
2. Establish more community wildlife ranches and reserves as an additional conservation effort for the conservation of endangered species as well as biodiversity enhancement;
3. Improving the carrying capacity of rangelands (e.g. through the construction of watering-points/dams in parks and animal translocation); and
4. Culling of animals to reduce competition for water and food.

#### 4.6.4.1.2 Forests

The main climatic hazards that threaten the forestry sector are extended droughts, which lead to land degradation and loss of soil fertility, as well as forest fires. The distribution of vegetation types is related to the amount of rainfall, moisture content and temperature prevailing at a given area. Based on this study, climatic changes seem to be jeopardizing regeneration of miombo forests, which normally regenerates easily and fast. The existing forested areas are expected to undergo changes in vegetation types and species composition including emergence of invasive species. Following changes in rainfall patterns and temperature, some vegetation may shift to higher elevations, while some may become extinct. Simulations show that miombo and *Baikiea spp.* would reduce as the climate changes (GRZ, 2004). In addition, rise in temperatures and varying rainfall patterns could extend the ecosystems' range of pests and pathogens. This is likely to affect many aspects of forests such as tree-growth, survival, yield and quality of wood and non-wood products.

A recent Pan-African study of the distribution range of the baobab (*Adansonia digitata*) using Maxent spatial range modeling forecasts a considerable contraction in the future distribution of this iconic tree species (Sanchez et al., 2011). Figure 4.10 based on the HadCM3-A2a future climate scenario shows that the baobab future potential range will contract to four isolated areas within what is now a continuous distribution range in Zambia.

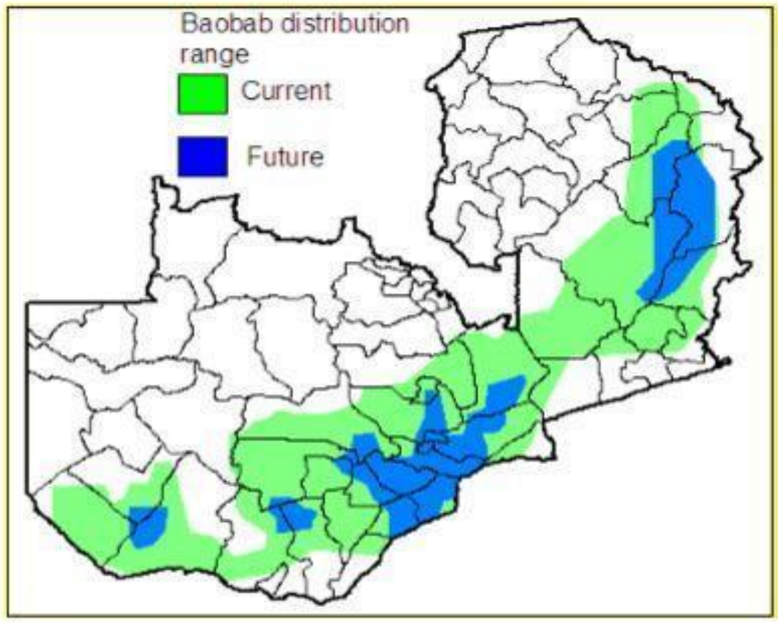


**Figure 4.10 Current and potential future distribution range of baobab in Zambia**, *Source: Sanchez et al., 2011*

The proposed adaptation measures focusing on Forest fires, Forest species diversity and deforestation include:

1. Forest enhancement including natural regeneration and afforestation/reforestation
2. Promote landscape approaches in the management of forests and other natural resources.
3. Conduct public campaigns and awareness on SFM and climate change adaptation.
4. Sustainable charcoal production to include improved kilns
5. Enhance participatory forestry management as part of good governance in the forestry sector.
6. Provide incentives for private sector and community participation in sustainable forestry management.
7. Strengthen the management and regulatory frameworks for charcoal production and use.
8. Enhance forest fire management programmes at the national and local levels.
9. Addressing the essential knowledge gap about climate change impacts on forests through research on forest adaptation.
10. Taking appropriate measures to adapt forests ecosystems to the projected adverse impacts of climate change in order to increase ecological resilience of forest ecosystems
11. Improve governance and management of forests in order for the sector to adapt to climate change impacts

12. Raising awareness among the general public, forest dependent communities and forest professionals in order to enhance their capacities in responding to climate change.
13. Creation of more community forests

#### 4.6.4.1.3 Wetlands

Climate variability and change has become one the threats to sustainable management of wetlands in the country. Reduced rainfall is likely to impact on available water in the wetlands and recharge of the groundwater aquifers. In addition, high temperatures will likely disturb the ecological functioning of the wetlands thereby affecting biodiversity endowment.

#### 4.6.4.2 Adaptation Measures

In order to improve the resilience of wetlands ecosystem to natural and anthropogenic shocks, the following measures will be undertaken:

i. Develop and implement conservation plans, programmes and guidelines for sustainable management of wetlands;
ii. Implement and maintain wetlands ecosystems restoration mechanisms;
iii. Put in place mechanisms and infrastructure to enhance wetlands ecosystems protection and resilience.

Table 4.23 presents the possible climate impact indicators as a result of temperature increase, reduced rainfall or increased rainfall in future. The different impacts on the natural resource sector are expected to range from reduced availability of habitat leading to extinction of biodiversity in the case of increased temperature and reduced rainfall, to increase in invasive alien species.

**Table 4.23 Climate and climate impact indicators, climate impacts and adaptation options in the Natural Resources sector**

| Climate indicators | Expected change by 2050 | Climate Impact indicators | Climate impact (vulnerability) | Adaptation options |
|---|---|---|---|---|
| Increased Temperature | High temperatures with reduced rainfall | Increased Innovation Alternative interventions<br><br>Loss of Biodiversity (e.g. drying up sites like Victoria Falls) | Reduced availability of habitat leading to extinction of Biodiversity<br><br>Increase in invasive alien species | -Promote Assisted Natural Regeneration (ANR) in indigenous forests and the establishment of forestry plantations in degraded forest areas by state institutions, the private sector and communities.<br>- Develop a National Wildlife Adaptation Strategy<br>-Encourage participatory approach to management involving communities living in or around wildlife-protected areas. |

### 4.6.4.3 Cost of Adaptation Actions

Table 4.24 present identified vulnerabilities and costings of adaptation measures in the natural resource sector

**Table 4.24 Identified vulnerabilities and costings of adaptation measures in the Natural Resource Sector**

| Number | Vulnerability | Adaptation Measure | Cost of adaptation Action |
|---|---|---|---|
| 1 | Wildlife Diversity | 1. Develop a National Wildlife Adaptation Strategy<br>2. Develop, implement and review Sector Adaptation Plans<br>3. Promote community/public/private partnerships in the sustainable management of wildlife resources. | 450,000<br><br>800,000<br><br>3,775,000 |

| | | | |
|---|---|---|---|
| | | 4. Develop management plans for the three focal landscapes in the Zambezi, Kafue and Luangwa watersheds.<br>5. Enforce equitable benefit sharing arrangements among government, communities and the private sector in the management of natural resources.<br>6. Promote fire management programmes to protect and enhance wildlife species in specific ecosystems.<br>7. Translocate endangered wildlife species to safer sites (refuges). | 1,060,429<br>550,000<br>341,610<br>1,388,658 |
| 2 | Wildlife Habitat | 1. Develop a National Wildlife Adaptation Strategy<br>2. Construct watering points in strategic sites for watering wildlife in critical drought periods.<br>3. Develop management plans for the three focal landscapes in the Zambezi, Kafue and Luangwa watersheds.<br>4. Map and protect wildlife corridors and refuges.<br>5. Promote community/public/private partnerships in the sustainable management of wildlife resources.<br>6. Monitoring, management and remediation of degraded rangelands<br>7. Creating community wildlife ranches and reserves as an additional conservation effort for the conservation of endangered species as well as biodiversity enhancement | 450,000<br>1,666,389<br>1,060,429<br>6,615,000<br>3,775,000<br>500,000<br>1,250,000 |
| 3 | Rangeland quality | 1. Develop a National Wildlife Adaptation Strategy<br>2. Monitoring, management and remediation of degraded rangelands<br>3. Develop, implement and review Sector Adaptation Plans<br>4. Encouraging participatory approach to rangeland management involving communities living in or around wildlife-protected areas, and who depend on rangeland resources for their livelihoods<br>5. Creating community wildlife ranches and reserves as an additional conservation effort for the conservation of endangered species as well as biodiversity enhancement | 450,000<br>500,000<br>800,000<br>300,000<br>1,250,000 |

| | | | |
|---|---|---|---|
| | | 6. Improving the carrying capacity of rangelands (e.g. through the construction of watering-points/dams in parks and animal translocation) | 1,666,389 |
| 4 | **Forest fires** | 1. Prepare forest management plans to guide forest management and utilization activities. | 138,841 |
| 5 | **Forest species diversity** | 1. Promote Assisted Natural Regeneration (ANR) in indigenous forests and the establishment of forestry plantations in degraded forest areas by state institutions, the private sector and communities.<br>2. Undertake forest inventories to assess species composition stocking and determine annual allowable cut.<br>3. Set up pilot projects, with participation of forest dependent communities to demonstrate and compile best practices of SFM in all forest types | 56,070,822<br>515,694<br>4,837,157 |
| 6 | **Deforestation** | 1. Promote sustainable forestry management practices anchored on ecosystem and landscape approaches.<br>2. Develop and implement criteria and indicators to clearly define SFM; prepare manuals and guidelines to monitor progress towards it.<br>3. Develop and implement mechanisms to reduce deforestation, carbon emissions and enhance forests' capability to sequester more emissions from the atmosphere. | 2,689,532<br>99,701<br>21,472,422 |

## 5.0 MEASURES TO MITIGATE CLIMATE CHANGE

This section discusses Zambia's measures to mitigate climate change. It also highlights sources of emissions, factors that influence emissions in various sectors as categorised by the IPCC and proposes mitigation options to reduce emissions of GHGs. Accordingly, the mitigation measures were considered to be any human (anthropogenic) interventions that could either reduce greenhouse gas (GHG) emissions (abatement) or enhance the sinks (sequestration). These measures are part of the country's efforts to contribute to global efforts to hold the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels. The Mitigation assessment considered the following issues:

1. Key developments since the last National Communication;
2. Zambia's NDC ambitions (2016-2020) and implementation status;
3. Key policies and measures;
4. Emissions trends, drivers and projections;
5. Mitigation and financial needs assessments;
6. Identification of possible mitigation measures and
7. Pipeline GHG mitigation projects.

The mitigation assessment analysed the country's mitigation potential based on the baseline and projected GHG emissions. The analysis was informed by future developmental scenarios through identification of appropriate policies, measures, practices, projects and interventions in various sectors.

### 4.6 Emission Drivers

During the reporting period, the following drivers of emissions were identified in the key sectors namely, energy, IPPU, AFOLU and waste.

#### 4.6.1 Energy

The projected baseline emissions in the energy sector will be influenced by increasing fossil fuel (liquid) consumption for transport, domestic aviation and railway. Coal consumption is likely to increase due to the anticipated increase in thermal power production. During the reporting period, the country's thermal power production from coal was 300 MW and was anticipated to increase to 940 MW by 2030. This increase in coal consumption is likely to further increase GHG emissions in the energy Sector.

Baseline setting for use of biomass in the country will be characterized by biomass consumption in rural areas for cooking in form of firewood and charcoal, and lighting through use of kerosene and candles; and use of petrol and diesel engines for providing lighting, maize milling, shelling and irrigation. The baseline scenario setting also includes the urban and peri-urban areas where populations rely on biomass for cooking in form of firewood and charcoal, and lighting through use of kerosene and candles.

### 5.1.1 Industrial Processes and Product Use

Under the IPPU category, the baseline setting was based on the assumption that the emissions in the Mineral Industry will continue to increase mainly from anticipated increase in cement and lime production. Emission in the metal industry will also increase from iron and steel production. There are plans to begin steel production from iron ore which will likely drive emissions high in this category. Emissions are also expected to increase for Chemical Industry and Non-Energy Products from Fuels and Solvent Use.

### 5.1.2 Agriculture, Forestry and Other Land Use

The projected baseline in the AFOLU sector is assumed to have increased emissions from livestock, land and aggregate sources and non-$CO_2$ emissions on land. The emissions drivers for Livestock (enteric fermentation and manure management) are increasing animal population of cattle, buffalo, sheep, goats, swine, and poultry stimulated by future increase in demand for meat and milk as a result of projected increase in human population. It is anticipated that rearing of dairy animals will be based on grazing with low production per cow and that most cattle will be multi-purpose, providing draft power and some milk within farming regions. It is also anticipated that the feeding situation may not be very different from the current situation where some cattle graze over very large areas.

In the land category the historical drivers of emissions were forest land conversion to cropland and settlements. Wood removals for commercial timber and for fuelwood were other drivers of emissions in the land category. In the baseline scenario it is anticipated that cropland and settlements will keep on expanding thereby increasing GHG emissions. The wood harvesting for commercial timber and firewood and charcoal production is anticipated to take place in the open forests in customary land. The harvesting methods for trees characterized by unregulated and usually patch wood harvesting and techniques for tree harvesting to completely clear tree felling are likely to continue. Forest areas will continue to be exploited by logging operations, agriculture expansion, settlements and fuelwood collection and charcoal production. The respective areas may either regenerate at a slower pace, most probably with lower productivity and biodiversity, or remain bare due to inadequate protection. Continuation of unsustainable charcoal production and utilization characterized by unregulated patch wood harvesting coupled with clear felling of trees, traditional earth kiln for charcoal production and usage of ordinary charcoal cookstoves will further contribute to emission of greenhouse gases.

The baseline scenario also assumes that there will be a continued inefficient use of inorganic fertilizers and a limited use of organic fertilizers in the absence of the intervention on sustainable agriculture through sustainable crop management and livestock farming.

### 5.1.3 Waste

In the baseline scenario it is assumed that infrastructure for solid waste management will be inadequate due to the high rate of urban population growth characterized by mismanagement of waste including uncollected waste, poor and indiscriminate disposal. Majority of people in urban areas are likely to continue to reside in the low cost and peri-urban areas. As regards waste water, it is assumed that connecting to and using/ maintaining sewer will still be out of reach for the low-income households residing in peri-urban areas. In addition, many of the existing sanitation systems will be unlikely to harness the gas from the sewer facility for either heat or power. The population growth will continue to drive emissions in the solid waste and wastewater during the projected period.

## 5.2 Mitigation Policies and Measures

This section outlines various policies and measures taken by the country to transition to a low carbon development pathway. Through its Vision 2030, Zambia has prioritised Sustainable Development as one of the seven key basic principles which by inference encompasses low carbon climate resilient economic development for the country. Deriving from the Vision 2030, the country in the short-term developed the 7NDP, which mainstreamed Climate change mitigation measures. The country's National Policy on Climate Change provides for strategic measures for addressing GHG emissions. Specific policies and measures for each sector are elaborated in the following sections:

### 5.2.1 Energy

In the energy sector, Zambia intends to ensure universal access to clean, safe, reliable and affordable energy at the lowest cost, consistent with national development aspirations. The country is committed to grow and diversify the energy sector to enhance its contribution to economic diversification by expanding power generation and transmission capacities using energy efficient and renewable energy sources.

#### 5.2.1.1 Mitigation Policies to Reduce Emissions

Mitigation policies and measures for the energy sector are spelt out in the Vision 2030, National Energy Policy, strategies and programmes which are elaborated below:

**(i) The Vision 2030**

Zambia intends to increase access to electricity in rural areas to 51percent and in urban areas to 90 percent by 2030. It further aspires to expand the deployment and development of renewable and alternative energy sources in the country's energy mix from less than 2 percent to 15 percent by 2030.

**(ii) The National Energy Policy of 2019**

The Revised Energy Policy of 2019 provides for the enhancement, development and deployment of renewable energy technologies by encouraging and supporting local systems design, assembly and manufacture of components of these technologies. The policy also promotes the participation of private sector in the investment in generation, transmission and distribution of power. The Policy supports the development and implementation of standards and codes for appropriate use of renewable energy technologies, and provision of appropriate financial and fiscal instruments. It also encourages improvement of the technology of charcoal production and utilization through encouraging the adoption of techniques which are more efficient and cost effective. In addition, it promotes appropriate alternatives to wood fuel and reduces its consumption. The Policy also promotes efficient energy use practices in all sectors of the economy.

The Energy Regulation Act No.12 of 2019, provides for a liberalized power sector in Zambia and creates an open access regime that encourages production, generation and transmission of energy. It also encourages development of electricity generation from renewable energy sources. This enables private players in generation, transmission and distribution through the Grid Code which sets the framework for equitable access to transmission network by all Independent Power Producers.

#### 5.2.1.2 Mitigation Strategies and Programmes

The Renewable Energy Feed in Tariff Strategy *(*REFiT Strategy) was formulated in 2017 to promote investments in renewable energy development. The objective of the REFiT Strategy is to harness the renewable energy sector's potential to drive economic growth and improve the quality of life for all Zambians. This is being achieved through the promotion of small and medium-sized renewable energy projects of up to 20 megawatts (MW), quick deployment of private investment for small- and medium-sized renewable energy projects and ensuring cost-effective tariffs through transparency and competition in the sector[5] (MoE, 2018).

Global Energy Transfer Feed in Tariff (GETFiT) Zambia which was also formulated in 2017 is designed to assist the Zambian Government in the implementation of its REFiT Strategy. In line with this Strategy, GETFiT Zambia aims to procure 200 MW of renewable energy.and supports small- to medium-scale Independent Power Producer (IPP) projects up to 20 MW. In addition, the GETFiT Programme leverages tariffs for projects to be developed under the REFiT strategy.

Further, the Government is collaborating with other stakeholders in implementing the UN Sustainable Energy for All (SE4ALL) Initiative which supports the; (i)provision of universal access to modern energy services, (ii) doubling the global rate of improvement in energy efficiency, and (iii) doubling the share of renewable energy in the global energy mix.

In addition, the country is also implementing the Scaling up Renewable Energy Program for Low Income Countries (SREP) which aims to help increase energy access through renewable energy use.

**(i) Capital Support**

The Industrial Development Corporation (IDC) Limited is charged with a mandate of spearheading the Zambian Government's commercial investments agenda aimed at strengthening Zambia's industrial base and job creation. Government through IDC is spearheading the diversification of the country's energy mix by establishing alternative sources of power such as solar. Currently, IDC is spearheading the Scaling-up Solar Initiative with a target of installing a total of 600MW grid-connected Solar PV.

Further, the Government through the Rural Electrification Authority (REA) is providing capital support of up to 100 percent to mini-hydro power and mini-grid power projects using renewable energy sources. The aim of the capital support is to reduce the tariff to promote community access to electricity.

[5] Ministry of Energy Scaling-Up Renewable Energy Programmes (SREP) Investment Plan For Zambia December 2018

### (ii) Incentives

In 2011, the Zambian government issued Statutory Instrument No. 15 of 2011, which declared energy as a priority sector, thereby establishing the right of the energy sector to qualify for incentives provided under ZDA Act of 2006 as amended in 2010. Before this Amendment, only mini hydro power plants qualified for tax concessions, as opposed to major power plant projects (ZDA, 2011). Some of the incentives include, zero percent tax rate on dividends for 5 years from the year of first declaration of dividends, zero percent import duty rate on capital goods, machinery including specialized motor vehicles for five years and investment guarantees and protection against state nationalization, among others.

### (iii) Other Measures

The Government issued a Statutory Instrument No. 74 of 2016 banning the manufacturing and importation of incandescent lamps in line with SADC Agreement of phasing out incandescent bulbs. This is expected to reduce demand by 200 MW, effectively freeing up generating capacity over a shorter time frame and at lower cost than could be achieved by building new capacity. Further, in order to promote energy efficient lighting such as CFLs and LEDs, Government wavered duty and VAT on energy efficient lamps and other equipment.

### (iv) Projects

In addition to policies, strategies, programmes and other measures, there are a number of renewable energy projects and energy efficiency projects being implemented in Zambia. These projects include; grid extension/electrification, solar PV (utility scale and solar home systems), Geothermal, hydro and wind.

## 5.2.2 Industrial Processing and Product Use

The mitigation policies and measures for the Industrial Processes and Product Use sector are spelt out in the Vision 2030 and other relevant policies, strategies and plans. The Vision 2030 provides a framework for sustainable development.

### 5.2.2.1 Mitigation Policies to Reduce Emissions

### i. National Industrial Policy of 2018

The National Industrial Policy (NIP) seeks to promote interventions towards climate change and encourage investment using green and clean technology. One of the strategic objectives of the NIP is to promote environmentally sustainable industrial production.

### ii. The Standards Act of 2017

The Standards Act No.4 of 2017 provides for standardization and quality assurance of all industrial products manufactured within the country as well as those imported. The Act also provides for the setting up of national standards and provision of conformity assessment services to products and services.

#### 5.2.2.2 Mitigation Strategies and Programmes

##### i. The National Investment Strategy, 2018 to 2022

The National Investment Strategy for the period 2018 to 2022 was put in place to create a conducive environment for investment growth through the implementation of a coordinated approach to sustainable investment promotion, facilitation and maintenance. The Strategy identifies priority sectors for investment in manufacturing, construction, agriculture, tourism, education, energy, information and communication technology and health. These sectors and their subsequent sub-sectors are chosen in line government policy of industrialisation, job creation and export products diversification. The manufacturing, tourism, construction and agriculture sectors have been identified as priority sectors due to their potential for employment creation and industrial development. The Strategy provides for consideration of climate change and environmental protection in industrial processes.

##### ii. Other Measures

The sector has continued to apply environmental impact assessments and strategic environmental assessments that aim at promoting sustainable production and consumption.

### 5.2.3 Agriculture Forestry and Other Land Use

The Government has developed a number of policies, strategies and plans and put in place measures to facilitate reduction of GHG emissions within the AFOLU sector. These include:

#### 5.2.3.1 Mitigation Policies to Reduce Emissions

##### i. The Second National Agriculture Policy of 2016

One of the Policy objectives is to promote the sustainable management and use of natural resources through the following measures: (a) Promotion of sustainable land management technologies (including conservation agriculture, appropriate stock densities); (b) Promotion of afforestation, community woodlots and agro-forestry; (c) Promote characterization, conservation and sustainable utilization of indigenous animal genetic resources including climate change resilient indigenous breeds (establish biodiversity conservation centres).

### ii. National Forestry Policy, 2015

One of the Policy objectives is to improve the role of forests in addressing climate change in order to contribute to reducing its impact through mitigation measures. This will be achieved through creating public awareness on the environmental and socio-economic effects of climate change, deforestation and forest degradation arising from unsustainable forest management.
An appropriate legal framework is in place to facilitate the establishment of appropriate monitoring systems for reducing deforestation and forest degradation would also need to be put in place. Other measures include; provision of incentives for development of alternative energy sources and technology to reduce reliance on biomass energy sources.

### 5.2.3.2 Mitigation Strategies, Programmes and Plans

### i. The REDD+ Strategy, 2015

The REDD+ Strategy, 2015 for Zambia aims at assisting the country to reduce emissions in an effective, efficient, transparent and accountable way, and anchored on fairness and inclusiveness. The goal of the Strategy is to contribute to national reductions in GHG emissions by improving forest and land management and ensure equitable sharing of both carbon and non-carbon benefits among stakeholders. The objective of the Strategy include among others; (a) to effectively manage and protect threatened and unsustainably managed national and local forests so as to reduce emissions from deforestation and forest degradation and contribute to ecosystem services across selected landscapes; (b) promote adoption of good agricultural practices that mitigate carbon emissions; (c), regulate production of wood fuel (charcoal & firewood) and improved its utilization; (d) promote wide adoption of appropriate and affordable alternative energy sources; (d) threatened and sensitive protected areas legislated as "no-go areas” for mining and infrastructure development.

### ii. National Investment Plan for REDD- 2018-2022

Zambia has developed a “National Investment Plan to Reduce Deforestation and Forest Degradation”, for the period 2018 to 2022. The aim of the investment plan is to support conservation, management and restoration of forests through investment in the needs of local communities which include functional local level management structures, ecotourism, general enterprises, food agricultural practices, markets and market linkages. The Plan also aims at addressing energy from biomass through appropriate supply and usage. Generally, the Plan seeks to address underlying drivers of deforestation by providing alternatives in terms of good practices as well as sources of income. The key components of the plan relevant to emissions reduction include conservation and management of high value forests areas and resilient landscape, sustainable agriculture and energy.

### Other Measures

In addition, the Climate Smart Agriculture Framework of 2018 was under implementation which aimed at mainstreaming climate smart agriculture approaches and interventions in line with the Second National Agriculture Policy, the Zambia National Agriculture Investment Plan (ZNAIP), NPCC, National Climate Change Response Strategy (NCCRS), NDC and other sectoral policies relevant to agriculture and climate change.

### 5.2.4 Waste

During the reporting period, the country had no dedicated policy on waste management. However, there are a number of measures that have a bearing on addressing waste management in the country, which includes both solid and liquid waste.

#### 5.2.4.1 Mitigation Policies to Reduce Emissions

**(i) Vision 2030**

The Vision 2030 sets the goal on environment and natural resources as "a productive environment and well conserved natural resources for sustainable socioeconomic development by 2030". The vision aims at rehabilitating and re-constructing sewerage treatment facilities in all major towns and cities, collecting and transporting of solid waste, and upgrading of unplanned settlements to enhance access to clean drinking water and sanitation facilities.

**(ii) National Policy on Environment of 2007**

National Policy on Environment of 2007 provides general policy directions on waste management. Some of the policy measures include development of sanitation master plans, improvement of waterborne sanitation systems, and enhancement of solid waste segregation and disposal.

**(iii) Energy Policy of 2008**

The Energy Policy of 2008 promotes renewable energy technologies including energy generation from wastes. It specifically mentions industrial/municipal organic wastes as one of the sources of biomass energy generated from organic matter. The following are the policy measures for biomass energy from industrial/municipal waste resources: (i) Promote the use of biogas as a source of energy for cooking, lighting and other uses; (ii) Build capacity of project implementers in biomass gasifiers and other technologies. Biomass (combustion and gasification) has potential for electricity generation from wastes in general. Biomass (biomethanation) has potential for electricity generation for heating and cooking from municipal and industrial waste and waste water.

### (iv) Solid Waste Management Strategy of 2004

Solid Waste Management Strategy, 2004 was formulated to enhance protection of the environment and control of pollution in the waste sector, promote sustainable waste management practices and to protect and preserve human health. The Strategy addressed waste generation, collection and treatment.

### (v) Environmental Management Act of 2011

The Act provides a legal framework for waste management including setting of standards, licensing of waste disposal sites and control of various types of wastes. The Act also provides for Extended Producer Responsibility (EPR), which prescribes that any person or persons whose activities generate waste with potential to pollute the environment employs essential measures to minimise, treat, reclaim, re-use, re-cover or recycle waste.

### (vi) The Solid Waste Regulation and Management No. 20 of 2018

The Act provides for the sustainable regulation and management of solid waste, including operation, maintenance and construction of landfills and other disposal facilities.

### (vii) The Water Supply and Sanitation Act of 2007

The Act provides for sustainable management and regulation of water supply and sanitation services (waste water and other liquid effluent). It also mandates a Utility or service provider to enforce by-laws relating to provision of water supply and sanitation services as may be issued by the Local Authority.

### (viii) Public Health Act of 1997

The Act provides a framework for management of solid and liquid waste in order to minimise the potential for GHG emissions.

### (ix) Water Resources Management Act of 2011

The Act provides for management, development, conservation, protection and preservation of water resources and its ecosystems as potential sinks.

### (x) Public Private Partnership Act of 2009

The Act provides for the promotion and facilitation of private sector involvement in the financing and implementation of programmes/projects in the waste sector including those aimed at reducing GHG emissions.

### 5.2.4.2 Mitigation Strategies, Programmes and Plans

The country embarked on a number of programmes and projects in the waste sector aimed at encouraging stakeholder participation in waste management. These programmes/projects were supported by both Central Government and other Cooperating Partners.

**i. Lusaka Sanitation Programme**

The Lusaka Sanitation Programme (LSP) focused on:

a) Construction and rehabilitation of sewer networks, pump stations and treatment plants;
b) Provision of sanitation facilities in public institutions as well sanitation marketing hygiene education;
c) Construction of faecal sludge management systems;

**ii. Kafubu Sustainable Water and Sanitation Improvement Project**

The Kafubu Sustainable Water and Sanitation Improvement Project (KSWSIP) activities included;

a) Rehabilitation of Kanini and Lubuto Sewage Treatment Plants. The plants were rehabilitated to its original capacity; however, the sludge digesters were not rehabilitated;
b) Rehabilitation of re-pumping stations; and
c) New sewerage network in Main and Mine Masala.

**iii. The Devolution Trust Fund**

The Devolution Trust Fund (DTF) was established in 2001 to provide for funding windows to Commercial Utilities (CUs) to extend water and sanitation services to the urban poor and enhance their financial viability. Additionally, the fund also supported development of sewerage infrastructure and construction of biogas plants.

### iv. Sewer Network Extension and Biogas Digesters

This project was implemented to establish a sewerage network construction and other key infrastructure such as biogas digesters to capture methane which was used for cooking, heating and lighting. In addition, other facilities included Fecal Sludge Management (FSM).

## 5.3 Mitigation Pathways and Key Assumptions

The mitigation analysis has identified plausible pathways that Zambia could traverse in contributing to the global emissions reduction. The mitigation pathways were formulated based on the prevailing policy context, review and consideration of the mitigation scenarios contained in Zambia's NDC and aspirations of the Nationally Appropriate Mitigation Actions (NAMAs). The climate mitigation assessment for Zambia was carried out for the period up to 2050 from 2010 as the base year. The mitigation options were categorized into three scenarios (refer to section 5.3.1) based on the investment requirements.

Mitigation actions under energy are projected to be the major contributors to emissions reductions in scenario 1 and to certain extent scenario 2. Mitigation actions in other sectors such as agriculture and forestry are projected to contribute more emissions reductions under scenario3. Implementation of mitigation actions for Energy, Agriculture Forestry and Other Land Use, and Waste will require considerable investment. Currently Zambia has invested significantly in the development of renewable energy projects. More international support is needed for Zambia to increase its ambition to reduce greenhouse gases.

### 5.3.1 Mitigation Pathways

The mitigation analysis and projections were made for the period 2010 to 2050 for the following sectors: Energy; Transport; Industry; Agriculture, Forestry and Other Land Use; and Waste. The future GHG emissions projections were undertaken through use of models and spreadsheets for energy, industrial processes and product use, AFOLU and Waste. Key input parameters for emissions projections included; historical GHG emissions, projected future economic growth, population growth, and deforestation rates. The mitigation pathway as part of mitigation analysis are provided as follows:

Baseline pathway assumes that Zambia's total emissions will continue to grow from 2010 if measures are not put in place to reduce emissions. The timeline for baseline emissions projections is from 2010 to 2050;

**Scenario 1** assumes implementation of current technologies and measures that are being implemented by 2030. This scenario projects that Zambia's emissions will shift from net sink to net source by 2031;

**Scenario 2** assumes implementation of current technologies and measures that are being implemented by 2030 with part of the measures from the NDC mitigation actions combined with

NAMAs. This scenario projects that Zambia's net sink status will be delayed until 2042 after which it will shift into net source; and

**Scenario 3** assumes emissions reduction from current technologies and measures that are being implemented by 2030 and NDC mitigation actions through both domestic and substantial international funding, including emissions reductions under NAMAs. Scenario 3 trajectory is projected to result in Zambia's maintaining net sink status throughout the projected period.

### 5.3.2 Key Assumptions for Baseline Emissions Projection

#### 5.3.2.1 Energy

Greenhouse gas emission projections for the energy sector were determined using Emission Factors provided for in the 2006 IPCC Guidelines. The projections for energy use were determined using average population growth rate of 3.0 per cent (for residential sector) and average GDP Growth rate of 3.0 percent for the economic sectors. The associated calorific values for the conversion of energy use from metric tons to Tera Joules were also derived from the 2006 IPCC Guidelines.

In undertaking the analysis, the Long-range Energy Alternatives Planning System (LEAP) was used for assessment of the projected energy demand as well as the GHG emissions. LEAP is an integrated, scenario-based modelling tool that is used to track energy consumption, production and resource extraction in all sectors of an economy.

#### 5.3.2.2 IPPU

Greenhouse gas emissions projections for the IPPU sector were determined using carbon intensity, derived from historical emissions. Carbon intensity was adopted from the World Resource Institute (WRI) approach and IPCC WG3 chapter 7 Energy System. Carbon intensity measured in $CO_{2\ eq.}$ per 2011 PPP million $ GDP is the level of GHG emissions per unit of economic activity, usually measured at the national level as GDP. Carbon intensity is a factor of GDP and historical emissions. GDP is expressed in a national currency or U.S. dollars. For future emissions projection, the carbon intensity was multiplied by the future GDP purchasing power parity (Equations 5.1 and 5.2) expressed in constant 2011 international dollars to facilitate international comparisons:

*Equation 0-1: carbon Intensity Calculations*

$$CI \quad = \frac{E_s}{GDP}$$ ---------------------------------------------------------------------------------Equation 1

Where: $CI$ is Carbon Intensity; $E_s$ is sector category emissions; $GDP$ is historical GDP at constant prices

*Equation 0-2:Emissions Calculations*

$$\text{Emissions}_p = \text{CI} * GDP_p$$ ----------------------------------------------------------------Equation 2

Where: $Emission_p$ is sector category emissions; $CI$ is Carbon Intensity; $GDP_p$ is projected GDP at constant prices

The GDP at constant prices for Zambia in 2014 stood at US$ Million 19733.1 while in 2018 it was US$ 13,290.1(Table 5.1).

**Table 0.1:GDP for Zambia from 2011 to 2018**

| | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** |
|---|---|---|---|---|---|---|---|---|
| GDP Constant 2010 Prices (US$) | 21,114.1 | 21,476.7 | 21,517.1 | 19,733.1 | 14,484.8 | 12,579.6 | 14,133.7 | 13,290.1 |
| Real GDP Growth (percent) | | 7.6 | 5.1 | 4.7 | 2.9 | 3.8 | 3.5 | 3.7 |
| Nominal GDP (Million ZMW) | 114,029.7 | 131,271.9 | 151,330.8 | 167,052.5 | 183,381.1 | 216,098.1 | 246,251.8 | 279,441.2 |
| Nominal GDP (Million $US) | 23,460.4 | 25,531.8 | 28,068.9 | 27,140.9 | 21,249.3 | 20,960.0 | 25,921.2 | 26,679.8 |
| GDP Per Capita (US$) | 1,710.1 | 1,805.0 | 1,925.1 | 1,806.6 | 1,373.2 | 1,315.4 | 1,580.1 | 1,579.8 |
| Exchange rate (US$ to ZMW) | 4.9 | 5.1 | 5.4 | 6.2 | 8.6 | 10.3 | 9.5 | 10.5 |

*Source: CSO, 2018*

Provided in Table 5.2 are carbon intensity factors for Energy and IPPU.

**Table 0.2:Carbon Intensity Gg CO2 eq per 2011 PPP million $ GDP**:

| Sector | **1994** | **2000** | **2005** | **2010** | **Average** |
|---|---|---|---|---|---|
| Energy | 0.14 | 0.09 | 0.09 | 0.089 | 0.10 |
| Industrial Processes and Product Use | 0.024 | 0.049 | 0.046 | 0.035 | 0.038 |

### 5.3.2.3 AFOLU

i. **Livestock and Aggregate Sources and Non-CO2 Emissions Sources on Land**

Emissions projections for Livestock and aggregate sources and non-CO2 emissions sources on land categories were carried out using emissions per capita. The projected emissions were calculated (Equation 5.3 and 5.4) as a product of per capita emissions and projected human population (Table 5.3).

*Equation 0-3: Emissions per Capita*

$$E_{per\ capita} = \frac{E_h}{P_h}$$ ------------------------------------------------------------------------------------------Equation 3

Where: $E_{Per\ Capita}$ is average historical emissions per capita; $E_h$ is historical emissions; $P_h$ Historical human population

*Equation 0-4: Projected Emissions*

$$E_{projected\ (i)} = E_{per\ capita} * P_p$$ ------------------------------------------------------------Equation 4

Where: $E_{projected\ (i)}$ emissions; $E_{per\ capita}$ is emissions per capita; $P_p$ is Projected population

**Table 0.3:Zambia's projected population (millions)**

| Year | 2000 | 2010 | 2011 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Projected Population | 9.88 | 13.09 | 14.27 | 16.10 | 18.67 | 21.59 | 24.86 | 28.44 | 32.33 | 36.51 | 41.00 |

*Source: CSO, 1990*

ii. **Land Emissions Projections**

Baseline emissions projections for Land (forest land, crop land, grassland, and settlements) were determined by applying annual deforestation rate (0.7percent)[6] to the historical baseline emissions. Based on a land cover change analysis between 2000 and 2014, the official annual deforestation

[6] Shakacite, O(1), Chungu, D(1)., Ng'andwe, P(1)., Chendauka, B(2), Siampale, A(2), Tavani, R(3), Roberts, W(3), Vesa, L(3) (2016). *Integrated Land Use Assessment Phase II – Report for Zambia*. The Food and Agriculture Organization of the United Nations and the Forestry Department, Ministry of Lands and Natural Resources, Lusaka, Zambia.

rate was estimated to be 0.6percent; losing approximately 276,021 ha per annum for the period 2000 to 2014. This rate is presented and endorsed as the official deforestation rate for Zambia. For the period 2000 to 2010, the deforestation rate was recorded as being 0.5percent; losing approximately 250,003 ha on an annual basis. For the period 2010 to 2014, the deforestation rate increased to 0.7percent; losing approximately 341,067 ha of forest per annum (Shakacite, et.al, 2016).

#### 5.3.2.4 Waste Sector

Emissions projections for Waste categories were undertaken based on emissions per capita. The projected emissions were calculated (Equation 5.5 and 5.6) as a product of per capita emissions and projected human population.

*Equation 0-5:Per Capita emissions from waste*

| | |
|---|---|
| $E_{per\ capita} = \frac{E_h}{P_h}$ | -----------------------------------------------------------------------------------------Equation 5 |
| Where: $E_{Per\ Capita}$ is average historical emissions per capita ; $E_h$ is historical emissions; $P_h$ Historical human population | |

*Equation 0-6: Project Emission from Waste*

| | |
|---|---|
| $E_{projected\ (i)} = E_{per\ capita} * P_p$ | -----------------------------------------------------------Equation 6 |
| Where: $E_{projected\ (i)}$ emissions; $E_{per\ capita}$ is emissions per capita; $P_p$ is Projected population | |

## 5.4 Aggregate Projections for GHG Emissions

### 5.4.1 Aggregate Projected Baseline Emissions

Total baseline emissions are projected to increase from 120,785.2 Gg $CO_{2\ eq}$. in 2010 to 171,532.1Gg $CO_{2\ eq}$. in 2050, representing a growth of 42.0percent (Table 5.4). The highest growth rate is projected to occur in the waste sector, where emissions are projected to increase from 305.9 Gg $CO_{2\ eq}$. in 2010 to 1,706.8 Gg $CO_{2\ eq}$. representing a growth of 457 percent. This is followed by the IPPU sector where emissions are projected to increase by 344 percent from 1,621 Gg $CO_{2\ eq}$. to 7,196.3 Gg $CO_{2\ eq}$. The third fastest growing emission source will be the energy sector which is projected to increase from 3,433.3 Gg in 2010 to 10,055.7 Gg $CO_{2\ eq}$. representing 193 percent increase.

**Table 0.4:Projected baseline emissions by sector**

| Year | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Energy | 3,433.3 | 3,927.5 | 4,491.9 | 5,137.4 | 5,875.8 | 6,720.3 | 7,686.4 | 8,791.6 | 10,055.7 |
| IPPU | 1621.0 | 2260.8 | 2693.5 | 3172.8 | 3737.5 | 4402.6 | 5186.1 | 6109.1 | 7,196.3 |
| AFOLU | 115,425.0 | 119,521.8 | 123,764.0 | 128,156.8 | 132,705.6 | 137,415.8 | 142,293.1 | 147,343.6 | 152,573.3 |
| Waste | 305.9 | 536.2 | 638.8 | 752.5 | 886.5 | 1,044.2 | 1,230.0 | 1,448.9 | 1,706.8 |
| Total Baseline | 120,785.2 | 126,246.3 | 131,588.3 | 137,219.6 | 143,205.3 | 149,582.9 | 156,395.7 | 163,693.2 | 171,532.1 |

The slowest growth in emissions is projected to be experienced in the AFOLU sector at 32percent increase from 119,629.9 Gg $CO_{2\ eq}$. in 2010 to 152,573.3 Gg $CO_{2\ eq}$.in 2050 (Figure 5.1).

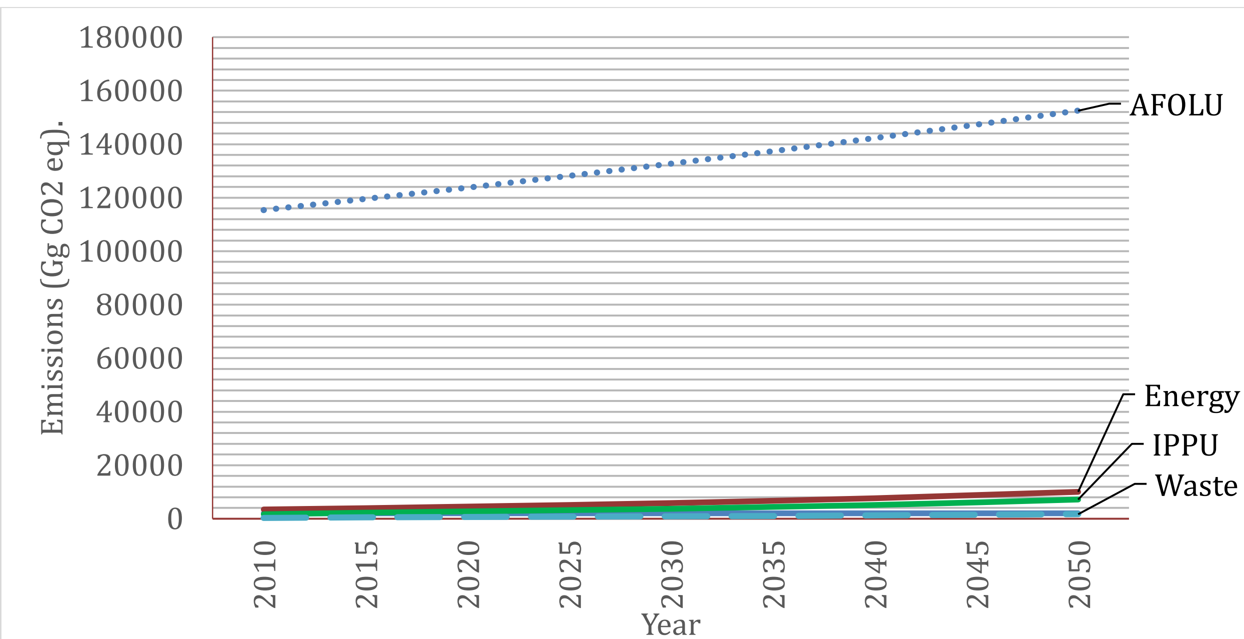


**Figure 0.1:Projected emissions trends**

### 5.4.2 Aggregate Projected Sequestration

The gross emissions removal projections were determined as a function of annual deforestation rate of 0.7percent (approximately 276,021 ha per annum) arising from increasing settlements, crop land, wood removals for commercial timber and wood removal for wood fuel (firewood and charcoal). Total removals/sink is projected to reduce from -137,322.9Gg $CO_2$eq. in 2010 to -103,684.3 Gg $CO_2$ eq. in 2050 representing a 25percent reduction (Table 5.5).

**Table 0.5: Aggregate projected national sequestration Gg $CO_2$ eq.**

| Year | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Net Baseline Emissions | -16538.2 | -6338.6 | 3579.0 | 13628.0 | 23878.7 | 34374.2 | 45162.6 | 56298 | 67843 |
| Total Removals | -137322.9 | -132583.5 | -128007.5 | -123589.6 | -119324.1 | -115205.8 | -111229.6 | -107390 | -103684 |

Under the baseline or business as usual, net emissions will increase from -16,538.2Gg $CO_2$ eq. to 67,843.0 Gg $CO_2$ eq. in 2050. Analyses of projected emissions show that Zambia transitioned from net sink to net source in 2018.

### 5.4.3 Aggregate Mitigation

Aggregate mitigation analysis indicates a shift in GHG emissions from net sink to net source by 2031 under scenario 1 projections. Projections for Scenario 2 show that Zambia's net sink status will be delayed until the year 2042 after which it will shift into net source. Scenario 3 trajectory indicates net sink status throughout the projected period of 2010 to 2050. Scenario1 trajectory shows that overall mitigation emissions are projected to increase from 1,450.6Gg $CO_2$ eq. in 2015 to 48,808.9 Gg $CO_2$ eq. in 2050. Scenario 2 mitigation pathway indicates mitigation emissions will increase substantially from 1,450.6Gg $CO_2$ eq. in 2015 to 93,367.8 Gg $CO_2$ eq. in 2050 compared to Scenario 1. Scenario 3 pathway shows greater ambition with projected emissions from 1,450.6 Gg $CO_2$ eq. in 2015 to 129,647.5 Gg $CO_2$ eq. in 2050 (Table 5.6).

**Table 0.6: Projected annual emissions for each scenario**

| Year | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Scenario 1 | 0 | 1450.6 | 3157.8 | 14722.8 | 32845.3 | 42834.3 | 46492.9 | 47650.9 | 48808.9 |
| Scenario 2 | 0 | 1450.6 | 13539.7 | 33497.7 | 56790.2 | 71931.2 | 80742.7 | 87054.7 | 93367.8 |
| Scenario 3 | 0 | 1450.6 | 20978.9 | 45743.7 | 73842.9 | 93790.7 | 107408.9 | 118527.7 | 129647.5 |

Total GHG emissions mitigation potential under Scenario 1, without sequestration are projected to increase from 120,784.8Gg $CO_2$ eq., in 2010 to 123,307.3 Gg $CO_2$ eq. in 2050. For Scenario 2 emissions mitigation potential are projected to decrease from 120,784.8Gg $CO_2$ eq., in 2010 to 78,748.3 Gg $CO_2$ eq. in 2050 (Table 5.7). In case of Scenario 3, national emissions mitigation potential is projected to decrease from 120,784.8. Gg $CO_2$ eq. in 2010 to 42,468.6 Gg $CO_2$ eq. in 2050 (Figure 5.2). The decrease in Scenarios 2 and 3 are due to projected higher rates of increase in baseline emission than that of mitigation.

**Table 0.7: Mitigation emissions reduction with and without sequestration**

| | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Scenario 1- | 120784.8 | 124794.2 | 128428.7 | 123083.5 | 110946.3 | 107334.5 | 110488.3 | 116627.1 | 123307.3 |
| Scenario 2 | 120784.8 | 124794.2 | 118046.8 | 104308.6 | 87001.5 | 78237.6 | 76238.4 | 77223.2 | 78748.3 |
| Scenario 3 | 120784.8 | 124794.2 | 110607.6 | 92062.6 | 69948.7 | 56378.1 | 49572.2 | 45750.2 | 42468.6 |
| Scenario 1 with Sequestration | -16538.2 | -7789.2 | 421.2 | -506.0 | -8377.8 | -7871.3 | -741.4 | 9236.3 | 19623.0 |
| Scenario 2 With Sequestration | -16538.2 | -7789.2 | -9960.7 | -19280.9 | -32322.6 | -36968.2 | -34991.2 | -30167.5 | -24936.0 |
| Scenario 3 With Sequestration | -16538.2 | -7789.2 | -17400.0 | -31526.9 | -49375.4 | -58827.6 | -61657.4 | -61640.5 | -61215.7 |

With sequestration, the emissions profiles across scenarios change (Figure 5.2). Scenarios 2 and 3 show net sink throughputs during the projected period while Scenario 1 indicate net sink emissions until after 2040.

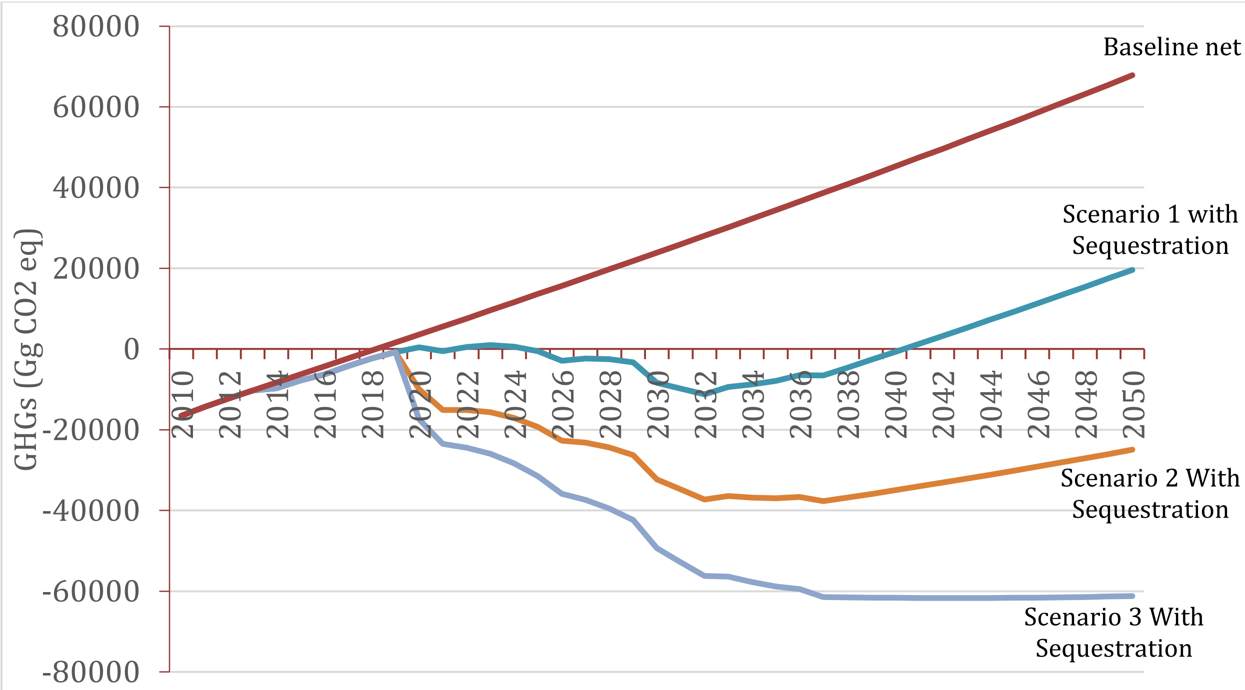


**Figure 0.2:Trends of emissions for mitigation across the scenarios with and without sequestration**

In all scenarios (Figure 5.2), emissions begin to reduce around 2018 mainly due to a number of renewable energy and energy efficiency projects that are being implemented with a definite timeline either under construction, or with strong indications of being completed by 2030. Mitigation actions under energy are projected to be the major contributors to emissions reductions in Scenario 1 and to a certain extent Scenario 2. Mitigation actions in other sectors such as agriculture and forestry are projected to contribute more emissions reductions under Scenario 3. Analysis revealed that under the baseline, Zambia shifted from net sink to net source in 2018. However, with mitigation consideration under Scenario 1 the net sink is being deferred until 2038. In case of Scenarios 2 and 3 the net sink will be maintained throughout the projection period.

## 5.5 CONTRIBUTION TO NDC

This section of the report provides a comparison of mitigation emissions against NDC mitigation ambitions. Pursuing Scenario 1 will achieve a cumulative amount of 57,409.9 Gg $CO_2$ eq. since 2010 base year, almost double the NDC emissions target of 38,000 Gg $CO_2$ eq. by 2030. This implies Scenario 1 emissions will have a surplus of 19,409.9 Gg $CO_2$ eq. beyond the emissions target for 2030 (Table 5.8). If Zambia follows Scenario 2 emissions trajectory, it will reduce emissions to approximately 104,265.6 Gg $CO_2$ eq. by 2030 thereby meeting the 2030 NDC emissions target with surplus emissions reduction of 66,265.6 Gg $CO_2$ eq. (Figure 5.3).

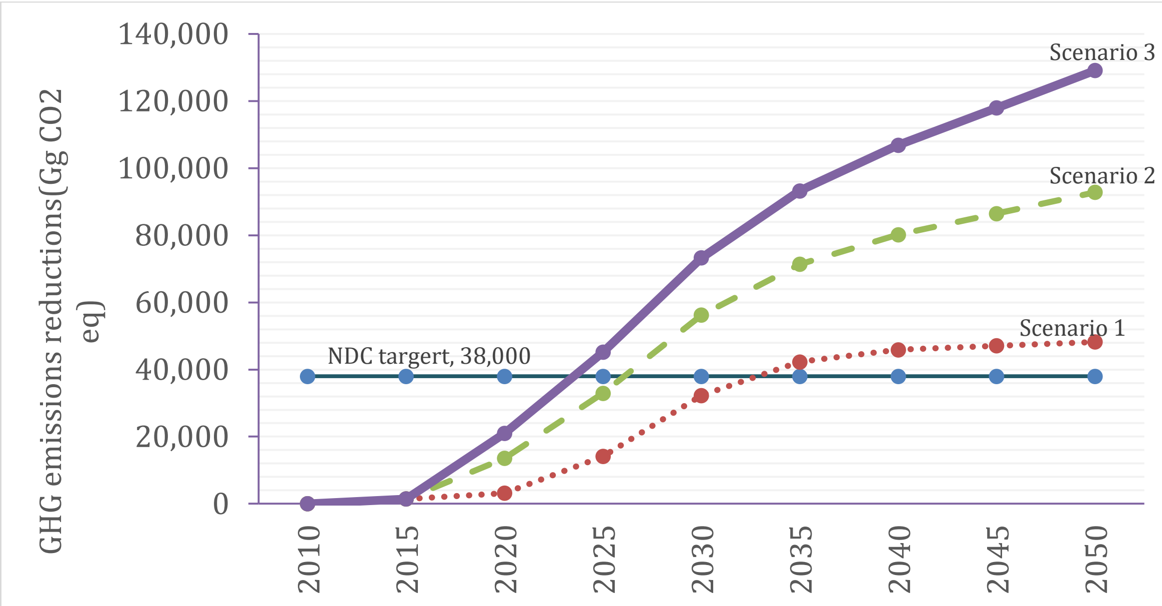


**Figure 0.3:Trends of mitigation pathways against the NDC target**

Tracking Scenario 3 emissions reduction profile will enable Zambia attain emissions reduction of 137,409.7 Gg $CO_{2\ eq.}$ and achieve the NDC target by 2030 (Table 5.8).

**Table 0.8:Cumulative mitigation emissions (Gg CO2 eq.) according to three trajectories**

| | **201 0** | **2015** | **2020** | **2025** | **2030** | **2035** | **2040** | **2045** | **2050** |
|---|---|---|---|---|---|---|---|---|---|
| Scenario 1 | 0.0 | 2,901.2 | 5,524.0 | 25,147.2 | 57,409.9 | 83,289.9 | 91,576.5 | 93,892.5 | 96,208.5 |
| Scenario 2 | 0.0 | 2,901.2 | 15,906.0 | 61,593.4 | 104,265.6 | 140,453.1 | 159,045.5 | 171,669.3 | 184,295.3 |
| Scenario 3 | 0.0 | 2,901.2 | 23,345.2 | 85,124.0 | 137,409.7 | 183,210.7 | 211,416.6 | 233,653.9 | 255,893.4 |

Analysis indicates that cumulative emission projections across the scenarios will increase to 96,208.5 Gg $CO_{2\ eq.}$, 184,295.3 Gg $CO_{2\ eq}$, 255,893.4 Gg $CO_{2\ eq}$ by 2050 for Scenarios, 1, 2 and 3, respectively. A total of 4,328.1Gg $CO_{2\ eq}$ is projected to be reduced in 2019, representing 11.0percent progress against the 2030 NDC target. The achievement is attributed largely to greater ambition and projects being implemented in the renewable energy and energy efficiency sub-sector.

### 5.6 Sectoral Baseline and Mitigation Emissions

### 5.6.1 Emissions Projections Under Energy Sector

#### 5.6.1.1 Baseline Emissions

Historical emissions for the period 1994 to2010 were characterized by an increase in emissions trends arising from use of both liquid and solid fuels in all key socio-economic sectors of the country. The increase in emissions were influenced by increase in population growth and enhanced economic activities. The LEAP was used to ascertain the emissions projections under each category. This section highlights the emission projections for each category as well as the overall energy sector position using the LEAP model based on assumptions highlighted in subsection 5.1.1.

#### 5.6.1.2 Overall Projected Baseline in Energy Sector

Overall projected baseline emissions for the energy sector is projected to increase from 3,433.3 Gg $CO_{2\ eq}$. in 2010 to 10,055.7 Gg $CO_{2\ eq}$. in 2050. Table 5.9 and Figure 5.4 provide projected GHG emissions for the overall energy sector and for categories.

**Table 0.9: Projected emissions for the overall energy sector and for categories. (Gg CO2 eq)**

| **Year** | **2010** | **2015** | **2020** | **2025** | **2030** | **2035** | **2040** | **2045** | **2050** |
|---|---|---|---|---|---|---|---|---|---|
| 1 - Energy | 3433.3 | 3927.5 | 4491.9 | 5137.4 | 5875.8 | 6720.3 | 7686.4 | 8791.6 | 10055.7 |
| 1.A - Fuel Combustion Activities | 3432.9 | 3926.0 | 4490.1 | 5137.3 | 5873.3 | 6717.4 | 7683.0 | 8787.5 | 10050.9 |
| 1.A.1 - Energy Industries | 189.2 | 216.1 | 246.9 | 282.1 | 322.3 | 368.2 | 420.7 | 480.6 | 549.1 |
| 1.A.2 - Manufacturing Industries and Construction | 1585.4 | 1811.3 | 2069.4 | 2364.3 | 2701.1 | 3086.0 | 3525.8 | 4028.1 | 4602.1 |
| 1.A.3 - Transport | 680.0 | 1776.9 | 887.6 | 21014.0 | 1158.6 | 1323.6 | 1727.7 | 1512.2 | 1973.9 |
| 1.A.4 - Other Sectors | 978.4 | 1121.8 | 1286.3 | 1474.9 | 1691.3 | 1939.6 | 2224.4 | 2551.0 | 2925.8 |
| 1.B - Fugitive emissions from fuels | 0.0 | 1.5 | 1.8 | 2.1 | 2.5 | 2.9 | 3.4 | 4.1 | 4.8 |
| 1.B.1 - Solid Fuels | 0.4 | 1.5 | 1.8 | 2.1 | 2.5 | 2.9 | 3.4 | 4.1 | 4.8 |

Provided in Figure 5.4 are trends of emissions for baseline energy emissions from 2010 to 2050

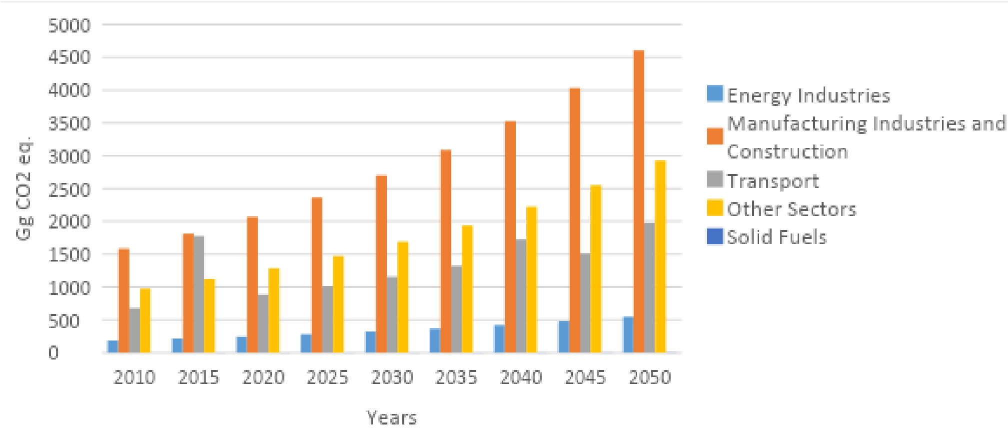


**Figure 0.4:Projected emissions for the overall energy sector and for categories. Gg CO2 eq**

### 5.6.1.3 Mitigation Emissions

Actions to mitigate GHG emissions in the energy sector include; rural and urban electrification, solar home systems, electricity generation (i.e. from on-grid Solar PV utility scale, hydro, biomass, wind, geothermal) energy efficiency and efficient cook-stoves. Mitigation emissions for each action is provided in Table 5.10. Annual emissions reduction in the energy sector will increase from 1,417.2Gg $CO_{2\ eq}$. in 2015 to 48,012.6 Gg $CO_{2\ eq}$. in 2050.

**Table 0.10:Mitigation emissions for each action under energy (Gg CO2 eq.)**

| | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Electrification | 0.0 | 0.0 | 29.4 | 4,637.0 | 12,288.4 | 14,730.1 | 15,869.3 | 17,008.6 | 18,147.8 |
| Solar PV utility scale-on-grid | 0.0 | 0.1 | 173.5 | 1,734.9 | 1,734.9 | 1,734.9 | 1,734.9 | 1,734.9 | 1,734.9 |
| Solar Home Systems | 0.0 | 0.0 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 |
| Small hydro Off grid | 0.0 | 0.0 | 179.5 | 179.5 | 179.5 | 179.5 | 179.5 | 179.5 | 179.5 |
| Hydro –on-grid | 0.0 | 1,417.1 | 2,496.6 | 6,225.8 | 15,819.5 | 23,348.1 | 25,848.6 | 25,848.6 | 25,848.6 |
| Energy Efficiency | 0.0 | 0.0 | 127.6 | 127.6 | 127.6 | 127.6 | 127.6 | 127.6 | 127.6 |
| Wind | 0.0 | 0.0 | 0.0 | 257.6 | 1,116.1 | 1,116.1 | 1,116.1 | 1,116.1 | 1,116.1 |
| Biomass | 0.0 | 0.0 | 49.3 | 842.7 | 842.7 | 842.7 | 842.7 | 842.7 | 842.7 |
| Geothermal | 0.0 | 0.0 | 0.0 | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 |
| Total | 0.0 | 1,417.2 | 3,062.9 | 14,020.4 | 32,124.1 | 42,094.4 | 45,734.1 | 46,873.3 | 48,012.6 |

Across the projected period (2010-2050), hydro electricity generation is projected to contribute to more emissions reduction in the energy sector. The contribution from hydro was marginal in 2015, but is projected to increase substantially after 2030 when it is envisaged most planned hydro power stations will be completed. Electrification of rural and peri-urban areas will increasingly become more prominent in emissions reduction through switching from use of firewood and charcoal to electricity in electrified houses, especially after 2025 (Figure 5.5). The mitigation analysis for electrification took into consideration the fact that the switch from charcoal or firewood to electric stoves is not 100percent after a household is electrified. Households still continue to use charcoal even after being electrified but the quantities reduce considerably. Solar home systems will also continue to play a significant role in emissions reduction through switching from kerosene, diesel and candle use to solar lighting, across the projected period.

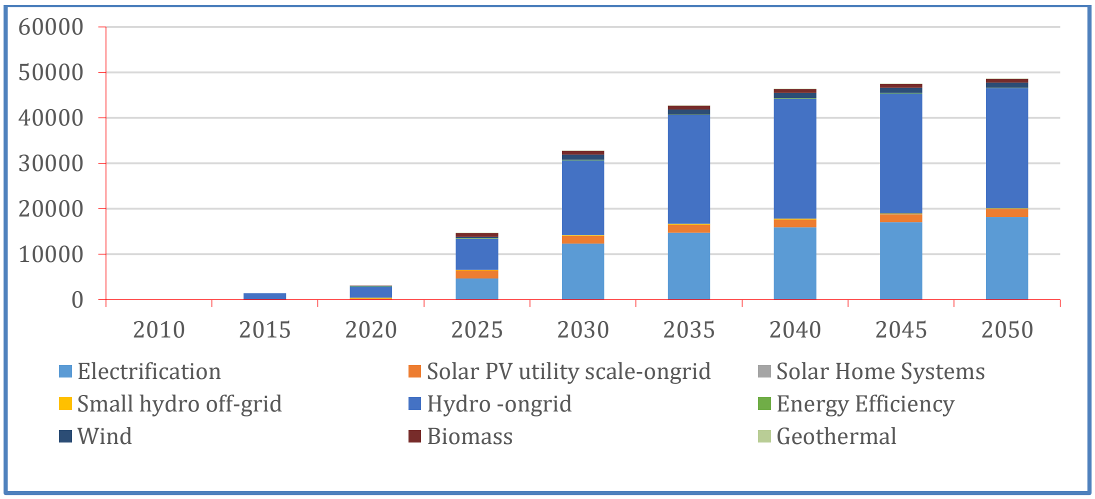


**Figure 0.5:Contribution to emissions reduction by each mitigation action**

### 5.6.1.4 Emissions Reductions under Electrification

Through the National Rural Electrification programme, it is expected that about 22,000 low-income households and about 1,000 medium and Small-Scale Enterprises (MSEs) in rural areas are expected to be connected to the main grid at a subsidized rate, covering over 115,000 beneficiaries by 2022. These interventions are part of Rural Electrification Master Plan (REMP) whose overall target is to increase the rural electrification access rate from 3percent to 51percent by 2030. Further, the country is decommissioning diesel power stations and providing a backbone for increased access to electricity services.

Further the GRZ has also embarked on a project entitled "Increased Access to Electricity and Renewable Energy Production". The overall objective of the project is to increase access to clean, reliable and affordable energy and promote renewable energy production and energy efficiency. The project which will be implemented from 2017 to 2022 focuses on enhancement of policy, legal and regulatory environment and capacity building for renewable energy and energy efficiency, feasibility studies and demonstration projects.

GHG emissions reduction from electrification of households in rural and peri-urban areas are projected to increase from 12.6 Gg $CO_{2\ eq.}$ in 2018 to 18,147.8 Gg $CO_{2\ eq.}$ in 2050 (Table 5.11).

**Table 0.11:Projected Emissions Reduction from Electrification**

| Year | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| National Electrification Project (NEP) | 0.0 | 0.0 | 29.4 | 4,637.0 | 12,288.4 | 14,730.1 | 15,869.3 | 17,008.6 | 18,147.8 |

### 5.6.1.5 Emissions Reductions under Solar PV Utility Scale

Emissions reductions from recently installed or planned solar Photovoltaic (PV) utility scale are projected to grow from 0.1 Gg $CO_2$ eq. in 2015 to 1734.9 Gg $CO_2$ eq. in 2050 (Table 5.12). It was assumed that all the planned PV utility scale will be connected to the National Grid and thus the baseline is the Southern African Power Pool (SAPP). The emission factor used to calculate projected emissions reduction under this mitigation action is the regional emission factor for combined margin $CO_2$ emission factor for the project electricity system applicable to the wind and solar power generation (0.9801 $tCO_2$/MWh)[7](UNFCCC, 2019). The capacity factor for the solar PV utility scale was assumed to be 0.2[8](IRENA, 2019).

A number of initiatives are being implemented to upscale deployment of solar PV utility scale in Zambia through private sector involvement and support from cooperating partners. The programmes are part of the GET FIT initiative. Detailed emission reduction potential for each scheme is provided in Table 5.12

[7] Pages 13-14 ACM0002 CDM methodology. Grid emission factor for SAPP

[8] https://www.irena.org/costs/Charts/Hydropower

**Table 0.12: GHG emissions reductions under Solar PV Utility Scale-Gg $CO_2$ eq**

| Project | Capacity (MW) | Capacity factor | Energy Units Generated (MWh) | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wind solar hydro resource study in Luapula | 0.3 | 0.2 | 525.6 | 0.0 | 0.0 | 0.0 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Industrial development cooperation (MW)-Bangweulu Project | 54 | 0.2 | 94608 | 0.0 | 0.0 | 92.7 | 92.7 | 92.7 | 92.7 | 92.7 | 92.7 | 92.7 |
| IDC - | 46 | 0.2 | 80592 | 0.0 | 0.0 | 79.0 | 79.0 | 79.0 | 79.0 | 79.0 | 79.0 | 79.0 |
| Industrial development cooperation (MW) | 500 | 0.2 | 876000 | 0.0 | 0.0 | 0.0 | 858.6 | 858.6 | 858.6 | 858.6 | 858.6 | 858.6 |
| CEC(MW) | 1 | 0.2 | 1752 | 0.0 | 0.0 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 |
| GIZ working with 8 companies with each to install 1MW with batteries | 8 | 0.2 | 14016 | 0.0 | 0.0 | 0.0 | 13.7 | 13.7 | 13.7 | 13.7 | 13.7 | 13.7 |
| ZESCO Shang'ombo 1MW by 2021 battery system to replace diesel | 1 | 0.2 | 1752 | 0.0 | 0.0 | 0.0 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ZESCO-300MW in Serenje, Choma, Itezhi-Tezhi | 300 | 0.2 | 525600 | 0.0 | 0.0 | 0.0 | 515.1 | 515.1 | 515.1 | 515.1 | 515.1 | 515.1 |
| ZESCO HQ solar plant | 0.025 | 0.2 | 43.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Parliament | 0.025 | 0.2 | 43.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| GETFiT Solar Project Phase I | 100 | 0.2 | 175200 | 0.0 | 0.0 | 0.0 | 171.7 | 171.7 | 171.7 | 171.7 | 171.7 | 171.7 |
| **Total** | | | | **0.0** | **0.1** | **173.5** | **1734.9** | **1734.9** | **1734.9** | **1734.9** | **1734.9** | **1734.9** |

### 5.6.1.6 Emissions Reductions Under Solar Photo Voltaic Systems

Emissions reduction potential were estimated based on projects implementing solar home systems such as Power Woman, REA Sustainable Solar Marketing Project (SSMP), and Beyond the Grid projects as provided in Table 5.13.

**Table 0.13:Emission reduction potential Gg CO2 eq. for Solar PV Systems**

| Year | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Power woman project in 3 | 0.000 | 0.000 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 |
| Sustainable Solar Market Packages (SSMP) in Isoka, Kalomo, Lukulu, Mwinilunga, Chama, Lundazi | 0.000 | 0.000 | 0.047 | 0.047 | 0.047 | 0.047 | 0.047 | 0.047 | 0.047 |
| Beyond the Grid Project. The Power Africa: | 0.000 | 0.000 | 6.916 | 6.916 | 6.916 | 6.916 | 6.916 | 6.916 | 6.916 |
| Solar Mini-Grids Lunga | 0.000 | 0.000 | 0.090 | 0.090 | 0.090 | 0.090 | 0.090 | 0.090 | 0.090 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mpanta Solar Mini grid (600KW) | 0.000 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 |
| Muhanya Solar 30kW, in Eastern Province | 0.000 | 0.000 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 |
| Chunga in Kafue national park | 0.000 | 0.000 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 |
| Mpanta on the shores of lake Bangweulu | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 |
| Total | 0.000 | 0.020 | 7.125 | 7.125 | 7.125 | 7.125 | 7.125 | 7.125 | 7.125 |

Solar home systems at existing and planned projects will result in projected annual emission reduction to increase from 0.02 Gg $CO_{2\ eq.}$ in 2015 to 7.1 Gg $CO_{2\ eq.}$ in 2050 (Table 5.14). The baseline for the solar home systems is continued use of kerosene, diesel lamps and candles for lighting. Kerosene consumption for lighting was assumed to be 1.4 litres per household per month.[9](ESMAP, 2019).

In addition, Power Africa-Beyond the Grid Fund for Zambia is implementing an ambitious undertaking to bring clean energy access to one million Zambians and accelerate private-sector growth in energy generation and distribution in the country. Through this initiative solar home systems are being deployed in households not connected to electricity. Non-Governmental Gender Organisations Coordinating Council (NGOCC) has also been promoting the use of solar PV and has been involved in the distribution of solar lamps, healthy cooking solutions targeting 200 households. Details of solar home systems initiatives are provided in Table 5.14.

**Table 0.14: Solar Homes systems**

| **Project Description** | **Number of Households** |
|---|---|
| NGOCC/Rural Electrification Authority (REA) Power Woman project | 200 |
| REA Solar PV (SSMP) in Isoka, Kalomo, Lukulu | 1130 |
| Solar water heaters installation in public institutions | 90 |
| Beyond the Grid Project. The Power Africa: | 167,000 |
| Chunga Solar Mini Grid (200 kW) in Kafue | 230 |

[9] https://www.esmap.org/sites/default/files/esmap-files/Rpt_householdenergyuseindevelopingcountriescomplete.pdf

| | |
|---|---|
| Mpanta Solar Mini Grid (60kW) | 478 |
| Lunga Solar Mini Grid(300kW) in Luapula | 1,059 |
| Muhanya Solar 30kW in Eastern Province, | 120 |

#### 5.6.1.7 Emissions Reductions Electricity Generation-Small Hydro Off Grid

Small hydro off-grid electricity generation considered for mitigation include; Chipata small hydro targeting 11,206 households and Kasanjiku mini hydro (0.64MW) in Mwinilunga under Chief Ntambu targeting 4,144 direct beneficiaries and 12,913 indirect beneficiaries. Another small hydro is Zengamina (0.75 MW) targeting 1,000 households. The baseline for off-grid small hydro is use of charcoal and firewood for cooking in rural and urban areas. However, Zengamina was not included in the emissions reductions as it is considered to be under voluntary carbon trading. Annual emissions reductions from off grid small hydro was estimated at 179.5 Gg $CO_2$ eq. (Table 5.15).

**Table 0.15: Emission reduction potential for off-grid small hydro (Gg $CO_2$ eq.)**

| Year | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Kasanjiku | 0.0 | 0.0 | 48.4 | 48.4 | 48.4 | 48.4 | 48.4 | 48.4 | 48.4 |
| Chipota | 0.0 | 0.0 | 131.0 | 131.0 | 131.0 | 131.0 | 131.0 | 131.0 | 131.0 |
| Total | 0.0 | 0.0 | 179.5 | 179.5 | 179.5 | 179.5 | 179.5 | 179.5 | 179.5 |

#### 5.6.1.8 Emissions Reductions Electricity Generation-On-Grid

The total installed capacity of the recently completed and planned schemes for on-grid electricity generation is 6,734 MW with other hydro schemes planned to be completed between 2030 and 2050. It was further assumed that all the planned schemes will be connected to the National Grid and thus the baseline is the Southern African Power Pool (SAPP)[10]. The capacity factor for hydro was assumed to be 0.45 while that of biomass electricity generation was 0.55. Based on the above-mentioned assumptions and other parameters, emissions reductions from electricity generation were projected to increase from 1417.09 Gg $CO_2$ eq. in 2015 to 26,437.43Gg $CO_2$ eq. in 2050 (Table 5.16).

[10] The emission factor used to calculate projected emissions reduction under this mitigation action was the regional emission factor for operating margin $CO_2$ for the project electricity system (0.9958 $tCO_2$/MWh).

**Table 0.16: Emission reduction potential for on-grid electricity generation Gg $CO_2$ eq**

| Project | Capacit | Annual | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Kafue | 750 | 2956500 | 0 | 0.0 | 0.0 | 2944.1 | 2944.1 | 2944.1 | 2944.1 | 2944.1 | 2944.1 |
| Batoka | 1200 | 4730400 | 0 | 0.0 | 0.0 | 0.0 | 4710.5 | 4710.5 | 4710.5 | 4710.5 | 4710.5 |
| Luapula | 350 | 1379700 | 0 | 0.0 | 0.0 | 0.0 | 1373.9 | 1373.9 | 1373.9 | 1373.9 | 1373.9 |
| Kalungwi | 200 | 788400 | 0 | 0.0 | 0.0 | 785.1 | 785.1 | 785.1 | 785.1 | 785.1 | 785.1 |
| Kariba | 360 | 1419120 | 0 | 1413. | 1413. | 1413.2 | 1413.2 | 1413.2 | 1413.2 | 1413.2 | 1413.2 |
| Itezhi- | 120 | 473040 | 0 | 0.0 | 471.1 | 471.1 | 471.1 | 471.1 | 471.1 | 471.1 | 471.1 |
| CEC | 40 | 157680 | 0 | 0.0 | 157.0 | 157.0 | 157.0 | 157.0 | 157.0 | 157.0 | 157.0 |
| Lufubu | 163 | 642546 | 0 | 0.0 | 0.0 | 0.0 | 639.8 | 639.8 | 639.8 | 639.8 | 639.8 |
| Shiwanga | 1 | 3942 | 0 | 3.9 | 3.9 | 3.9 | 3.9 | 3.9 | 3.9 | 3.9 | 3.9 |
| Zambia | 4 | 19272 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 19.2 | 19.2 | 19.2 | 19.2 |
| Devil’s | 500 | 1971000 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 1962.7 | 1962.7 | 1962.7 | 1962.7 |
| Mpata | 540 | 2128680 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 2119.7 | 2119.7 | 2119.7 | 2119.7 |
| Mumbotut | 300 | 1182600 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 1177.6 | 1177.6 | 1177.6 | 1177.6 |
| Mambilim | 202 | 796284 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 792.9 | 792.9 | 792.9 | 792.9 |
| Mambilim | 124 | 488808 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 486.8 | 486.8 | 486.8 | 486.8 |
| Kabwelu | 96 | 378432 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 376.8 | 376.8 | 376.8 | 376.8 |
| Kundabwi | 151 | 595242 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 592.7 | 592.7 | 592.7 | 592.7 |
| Mutinond | 40 | 157680 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 157.0 | 157.0 | 157.0 |
| Luchenen | 30 | 118260 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 117.8 | 117.8 | 117.8 |
| Mkushi – | 65 | 256230 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 255.2 | 255.2 | 255.2 |
| Mumbotut | 300 | 1182600 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1177.6 | 1177.6 | 1177.6 |
| Mambilim | 202 | 796284 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 792.9 | 792.9 | 792.9 |
| GETFiT | 100 | 394200 | 0 | 0.0 | 392.5 | 392.5 | 392.5 | 392.5 | 392.5 | 392.5 | 392.5 |
| Lusiwasi | 15 | 59130 | 0 | 0.0 | 58.9 | 58.9 | 58.9 | 58.9 | 58.9 | 58.9 | 58.9 |
| Lusiwasi | 86 | 339012 | 0 | 0.0 | 0.0 | 0.0 | 337.6 | 337.6 | 337.6 | 337.6 | 337.6 |
| Muchinga | 230 | 906660 | 0 | 0.0 | 0.0 | 0.0 | 902.9 | 902.9 | 902.9 | 902.9 | 902.9 |
| Mulembo/ | 330 | 1300860 | 0 | 0.0 | 0.0 | 0.0 | 1295.4 | 1295.4 | 1295.4 | 1295.4 | 1295.4 |
| Mwamba | 85 | 335070 | 0 | 0.0 | 0.0 | 0.0 | 333.7 | 333.7 | 333.7 | 333.7 | 333.7 |
| **Total** | **6584** | | **0** | **1417.** | **2496.** | **6225.7** | **15819.5** | **23348.** | **25848.6** | **25848.** | **25848.** |

*Source: Adapted from ZESCO, Renewable Energy Division, Copperbelt Energy Corporation (CEC) and Ministry of Energy*

### i) Emissions Reductions from Energy Efficiency

There are a number of initiatives to promote energy efficiency in Zambia. Energy efficiency projects planned or being implemented include: (i) solar street lighting retrofits (ii) installation of solar geysers, (iii) promotion of use of LED/CFL lighting in households (iv) reduction of technical losses through Reactive Power Compensation.

In addition, mining firms are planning to reduce consumption of electricity through capture of waste heat from smelters and switching from fossil fuels through installation of biodiesel plants, and use of alternative fuel in kilns such as natural gas and waste materials.

Use of LED/CFL in households in 2016 resulted in the savings amounting to 31.5 GWh which translated to emissions reduction of 31.4 Gg $CO_2$ eq. (Table 5.17). Successful implementation of energy efficiency projects such as solar street lighting retrofit, solar geysers, and reactive power compensation will result in total annual savings of 159.6 GWh which is projected to result in annual emission reduction of 127.6 Gg $CO_2$ eq. It was assumed that energy efficiency interventions will reduce energy consumption on the national grid.

**Table 0.17: Emission reduction potential for energy efficiency (Gg $CO_2$ eq)**

| **Projects** | **Annual Savings (GWh)** | **2010** | **2015** | **2016** | **2020** | **2025** | **2030** | **2035** | **2040** | **2045** | **2050** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mopani Mine-Waste Heat Power Generation Annual Savings (41.8GWh) | 41.8 | 0.0 | 0.0 | 0.0 | 41.6 | 41.6 | 41.6 | 41.6 | 41.6 | 41.6 | 41.6 |
| Solar street lighting retrofit. Annual Savings (14GWh) | 14 | 0.0 | 0.0 | 0.0 | 13.9 | 13.9 | 13.9 | 13.9 | 13.9 | 13.9 | 13.9 |
| Solar geysers. Annual Savings (29.3GWh) | 29.3 | 0.0 | 0.0 | 0.0 | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 | 29.2 |
| LED/CFL Lighting in households. Annual Savings (31.5 GWh) | 31.5 | 0.0 | 0.0 | 31.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Reactive Power Compensation. Annual Savings (43GWh) | 43 | 0.0 | 0.0 | 0.0 | 42.8 | 42.8 | 42.8 | 42.8 | 42.8 | 42.8 | 42.8 |
| **Total** | **159.6** | **0.0** | **0.0** | **31.4** | **127.6** | **127.6** | **127.6** | **127.6** | **127.6** | **127.6** | **127.6** |

*Source: Adapted from Energy Efficiency Investment Opportunities in Africa; Country Note – Zambia, 2018: World Bank Group-Energy and Extractives*

### ii) Emissions Reductions from Wind Power

Emission reductions are expected from wind power plants installations across the country. It was assumed that wind power interventions will be connected to the national grid and thus the baseline is the Southern African Power Pool (SAPP). It is projected that annual emissions reductions of 1528.3 Gg $CO_{2\ eq.}$ will be achieved from a total installation of 550 MW by 2050 (Table 5.18)

**Table 0.18:Emission reduction potential for Wind power generation (Gg $CO_2$ eq)**

| **Project** | **Capacity (MW)** | **2010** | **2015** | **2020** | **2025** | **2030** | **2035** | **2040** | **2045** | **2050** |
|---|---|---|---|---|---|---|---|---|---|---|
| ZESCO-Wind | 150 | 0.0 | 0.0 | 0.0 | 669.7 | 669.7 | 669.7 | 669.7 | 669.7 | 669.7 |
| Mpepo power 400 MW | 400 | 0.0 | 0.0 | 0.0 | 0.0 | 858.6 | 858.6 | 858.6 | 858.6 | 858.6 |
| **Total** | **550** | **0.0** | **0.0** | **0.0** | **669.7** | **1528.3** | **1528.3** | **1528.3** | **1528.3** | **1528.3** |

*Source: Adapted from ZESCO and Ministry of Energy*

### *iii)* Emissions Reductions from Geothermal Power

The potential for the country to generate geothermal power exists and a number of research and exploration activities are on-going. For example, Kalahari Geo-energy Limited has identified 80 hot springs with the potential for electricity generation of 1 MW. Arising from the implementation of the identified geothermal power initiatives, an estimated emissions reduction of 8.3 Gg $CO_{2\ eq.}$ will be achieved as shown in Table 5.19.

**Table 0.19: Emission reduction potential for geothermal power generation (Gg $CO_2$ eq.)**

| Project Description | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| 1 MW under Kalahari geothermal | 0.0 | 0.0 | 0.0 | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 |

*Source: Adapted from Ministry of Energy*

### iv) Emissions Reductions from Biomass Energy

Zambia has been undertaking a number of biomass related mitigation actions with potential to contribute to emissions reductions in the energy and AFOLU sectors. These actions include; promotion of efficient charcoal and firewood cook stoves, briquetting distribution of tier 4 cook stove, and use of improved kilns for charcoal production. For example, COMACO through the Efficient Cook Stoves in Zambia is promoting the distribution and installation of 50,000 to 80,000 efficient cooking stoves for households in rural Zambia. In addition, Netherlands Development Organisation (SNV) has been promoting and up scaling construction of 3500 biogas digesters in rural areas for provision of energy. The implementation of efficient cook-stoves, biogas for cooking and heating will result in annual emissions reductions of 842.7 Gg $CO_2$ eq. from 2025 to 2050 (Table 5.20).

**Table 0.20:Emission reduction potential for Biomass energy (Gg $CO_2$ eq.)**

| Project Description | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Efficient cook stoves and pellets-COMACO | 0.0 | 0.0 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 |
| Assisted Natural Regeneration Project in Serenje – Cook stoves | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Zambia Integrated Forest Landscape Project (ZIFLP)-Cook stoves | 0.0 | 0.0 | 45.9 | 45.9 | 45.9 | 45.9 | 45.9 | 45.9 | 45.9 |
| SNV Biogas Energy for Agriculture. | 0.0 | 0.0 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 |
| Biodiesel CEC 300,000 litres | 0.0 | 0.0 | 0.0 | 793.4 | 793.4 | 793.4 | 793.4 | 793.4 | 793.4 |
| **Total** | **0.0** | **0.0** | **49.3** | **842.7** | **842.7** | **842.7** | **842.7** | **842.7** | **842.7** |

### v) Emissions Reductions under NAMAs

Zambia prepared its Nationally Appropriate Mitigation Actions (NAMA) as part of the global effort to reduce emissions. The NAMAs prepared included the Transport, Hydro, Agriculture, Waste and Charcoal. The Transport NAMA involves development of tramway systems for Lusaka and Kitwe Districts. The total number of tramway lines to be constructed is four (4) for Lusaka (Figure 5.7) and three (3) for Kitwe having an estimated length of 140 kilometres and 26 kilometres, respectively

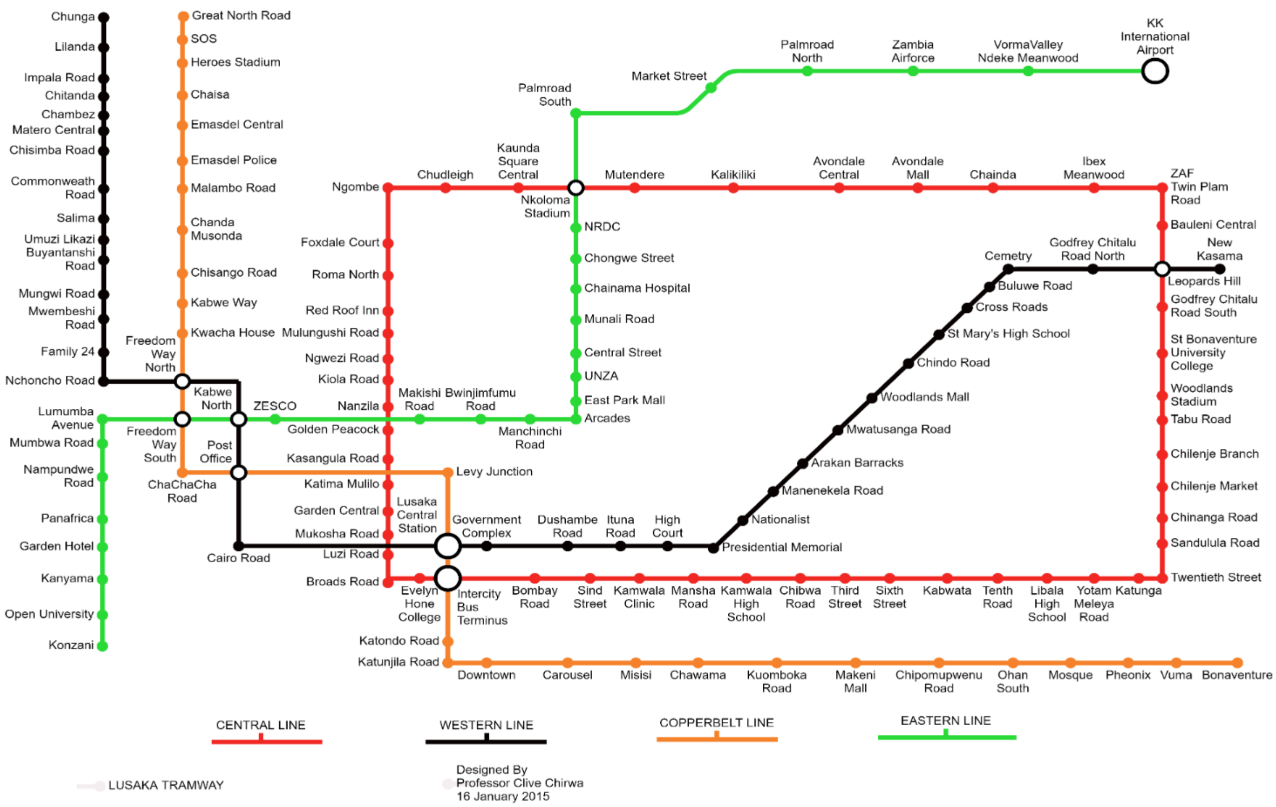


**Figure 5.6 Route design for the tram for Lusaka,** *Source: Chirwa, 2015*

Mitigation emissions from transport NAMA will increase from 73.4 Gg $CO_2$ eq. in 2025 to 92.2 Gg $CO_{2.}$ eq. (Table 5.21).

**Table 0.21:Emission Reduction Potential for Transport NAMA (Gg $CO_2$ eq.)**

| Year | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Transport NAMA | 0 | 0 | 0 | 73.4 | 92.5 | 92.2 | 92.2 | 92.2 | 92.2 |

The hydro NAMA was not added to the emissions reductions because the baseline emissions from diesel gen-sets have been replaced through grid extension. The emissions reduction from decommissioned diesel gen sets was not added to the total mitigation since the gen sets have been re-deployed in other parts of the country after decommissioning them from original installations.[11](ZESCO, 2017).

### 5.6.2 Emissions Projections Under IPPU

#### 5.6.2.1 Baseline Emissions Projections

Industrial Processes and Product Use (IPPU) covers GHG emissions occurring from industrial processes, product use and from non-energy uses of fossil fuel carbon. The main sources of emissions from industrial processes include; mineral, chemical, and electronic and metal industries. Emissions from product use are mainly substitutes of ozone depleting substances from refrigeration and stationery air conditioning units, use of electrical equipment and other product manufacture and use. Other emissions from non-energy products include fuels and solvent use.

#### 5.6.2.2 Assumptions and key Parameters

The baseline for IPPU was assumed to be increased production of cement and lime, chemicals and iron and steel. With regard to process emissions, the projections were based on Carbon Intensity $CO_{2\ eq}$ per 2011 PPP million $ GDP and GDP constant prices. These parameters together with historical emissions were used to project future emissions extended to 2050 based on projected GDP constant prices and carbon intensity. Carbon emissions intensity is the level of GHG emissions per unit of economic activity, usually measured at the national level as GDP. The baseline emissions are projected to increase from 1,856.1 Gg $CO_2$ eq. in 2011 to 7,196.3 Gg $CO_2$ eq. in 2050 with main contribution coming from cement and lime production (Table 5.22).

[11] Zesco Integrated Report 2017 page 20, Managing Director's report item 4-social and relationship

**Table 0.22: Baseline Emissions Projections for Industrial Processes and Product Use (Gg $CO_2$ eq.)**

| Year | 2011 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| 2 - Industrial Processes and Product Use | 1856.1 | 2260.8 | 2693.5 | 3172.8 | 3737.5 | 4402.6 | 5186.1 | 6109.1 | 7196.3 |
| 2.A - Mineral Industry | 1681.4 | 2048.0 | 2439.9 | 2874.1 | 3385.6 | 3988.2 | 4697.9 | 5534.0 | 6518.8 |
| 2.A.1 - Cement production | 410.1 | 499.5 | 595.1 | 701.0 | 825.7 | 972.7 | 1145.8 | 1349.7 | 1589.9 |
| 2.A.2 - Lime production | 1270.8 | 1547.9 | 1844.2 | 2172.4 | 2559.0 | 3014.4 | 3550.8 | 4182.8 | 4927.1 |
| 2.A.3 - Glass Production | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2.A.4 - Other Process Uses of Carbonates | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.1 | 1.3 | 1.5 | 1.8 |
| 2.A.5 - Other (please specify) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2.B - Chemical Industry | 80.4 | 97.9 | 116.6 | 137.4 | 161.8 | 190.6 | 224.6 | 264.5 | 311.6 |
| 2.B.1 - Ammonia Production | 24.8 | 30.2 | 35.9 | 42.3 | 49.9 | 58.7 | 69.2 | 81.5 | 96.0 |
| 2.B.2 - Nitric Acid Production | 55.6 | 67.7 | 80.7 | 95.1 | 112.0 | 131.9 | 155.4 | 183.0 | 215.6 |
| 2.C - Metal Industry | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 1.0 | 1.1 | 1.3 | 1.6 |
| 2.C.1 - Iron and Steel Production | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.1 | 1.3 | 1.5 |
| 2.D - Non-Energy Products from Fuels and Solvent Use | 7.3 | 8.9 | 10.5 | 12.4 | 14.6 | 17.2 | 20.3 | 23.9 | 28.2 |
| 2.D.1 - Lubricant Use | 7.3 | 8.9 | 10.5 | 12.4 | 14.6 | 17.2 | 20.3 | 23.9 | 28.2 |
| 2.F-Product Uses as Substitutes for Ozone Depleting Substances | 43.1 | 52.4 | 62.5 | 73.6 | 86.7 | 102.1 | 120.3 | 141.7 | 166.9 |
| 2.F.1- Refrigeration and Air Conditioning | 43.1 | 52.4 | 62.5 | 73.6 | 86.7 | 102.1 | 120.3 | 141.7 | 166.9 |
| 2.G-Other Product Manufacture and Use | 43.6 | 53.1 | 63.3 | 74.6 | 87.9 | 103.5 | 121.9 | 143.6 | 169.2 |
| 2.G.1 - Electrical Equipment | 43.6 | 53.1 | 63.3 | 74.6 | 87.9 | 103.5 | 121.9 | 143.6 | 169.2 |

#### 5.6.2.3 Emissions Reduction from IPPU Mitigations Actions

This section of the report provides some initiatives that could potentially contribute to emissions reduction in the IPPU sector. The initiatives being undertaken by various industries are elaborated in (Table 5.23). These include energy efficient measures, use of electric furnaces and use of eco-friendly refrigerators.

**Table 0.23: Initiatives to Reduce GHG Emissions in the IPPU sector**

| Industry | Planned/ongoing Potential Mitigation Initiatives | Sub-sector |
|---|---|---|
| Lafarge Cement | Energy efficiency which also includes monitoring how energy is being used on a monthly basis. | Cement production |
| Zambezi Portland | Planning to substitute the use of clinker with limestone so as to reduce the amount of carbon dioxide emissions. | Lime production |
| Scaw Limited | Introduce use of electric Induction furnaces in the steel production process thereby reducing on emission. | Iron and steel production |
| Copperbelt Energy Corporation (CEC) | Green procurement policy on eco-friendly refrigerators | Refrigeration and air conditioning |

### 5.6.3 Emissions Projections Under AFOLU

This section of the report provides an elaboration of baseline and mitigation emissions under AFOLU.

#### 5.6.3.1 Baseline Emissions For AFOLU

AFOLU emissions are mainly from Livestock, Land and Aggregate and Non-$CO_2$ Sources. Livestock is a subcategory of the AFOLU sector and GHG emissions from this source arise from enteric fermentation and manure management. Carbon dioxide emissions from livestock are not estimated because annual net $CO_2$ emissions are assumed to be zero as the $CO_2$ photosynthesized by plants is returned to the atmosphere as respired $CO_2$.

Land is a subcategory of the AFOLU sector and GHG emission from land conversion occur in six land-use categories namely: Forest land, cropland, grassland, wetlands, settlements, and other land.

Each land-use category is further subdivided into land remaining in that category and converted from one category to another (e.g. Forest Land converted to Cropland).

Aggregate Sources and Non-$CO_2$ Emissions on Land occur in managed soils, including indirect $N_2O$ emissions from additions of N to land due to deposition and leaching, and emissions of $CO_2$ following additions of liming materials and urea-containing fertilisers. Managed soils are all soils on land, including Forest Land, which is managed. The baseline scenario assumes that there will be a continued inefficient use of inorganic fertilizers and limited use of organic fertilizers in the absence of the intervention on sustainable agriculture that is attained through sustainable crop management and livestock farming.

The baseline further assumes Land use and/or emissions profile for an area prior to mitigation intervention, which serves as a benchmark to measure the impact of future actions and this include; forest areas which have been exploited by logging operations, agriculture expansion, settlements and fuelwood collection, charcoal production and the use of inefficient cook stoves. This high utilization of forest coupled with low regeneration rate is expected to result in lower productivity and reduced carbon. Net emission from AFOLU is projected to increase from -21,898.0 Gg $CO_2$ eq. in 2010 to 48,889.0 Gg $CO_2$ eq. in 2050 (Table 5.24). The main emissions sources will be wood removal for commercial wood, wood removal for fuel wood, cropland, settlements, and aggregate sources and non-$CO_2$ emissions sources on land.

Total gross removals/sink is projected to reduce from -137,322.9 Gg $CO_2$ eq. in 2010 to -103,684.3 Gg $CO_2$ eq. in 2050 representing a 25 percent reduction. Total baseline emissions from AFOLU will increase from 115,425.0 Gg $CO_2$ eq. in 2010 to 152,573.3 Gg $CO_2$ eq. in 2050. Emissions from Forest Land emanating from wood removal for commercial timber, wood removal for firewood and charcoal are projected to increase from 66,556.0 $CO_2$ eq. in 2010 to 87,976.3 Gg $CO_2$ eq. in 2050.

**Table 0.24: Projected Baseline AFOLU emissions by category (Gg $CO_2$ eq.)**

| Year | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| 3 - Agriculture, Forestry, and Other Land Use | -21898.0 | -13061.7 | -4243.5 | 4567.3 | 13381.5 | 22210.0 | 31063.5 | 39952.9 | 48889.0 |
| 3.A - Livestock | 2336.4 | 2994.8 | 3474.3 | 4016.4 | 4623.7 | 5290.0 | 6012.8 | 6792.1 | 7626.1 |
| 3.A.1 - Enteric Fermentation | 2228.5 | 2873.4 | 3333.5 | 3853.7 | 4436.3 | 5075.6 | 5769.1 | 6516.8 | 7317.0 |
| 3.A.2 - Manure Management | 107.9 | 121.4 | 140.8 | 162.8 | 187.4 | 214.4 | 243.7 | 275.3 | 309.1 |
| 3.B - Land | -35138.2 | -26771.8 | -18440.3 | -10133.4 | -1841.0 | 6447.2 | 14741.2 | 23051.3 | 31387.5 |
| 3.B.1 - Forest land (Net Emissions) | -70767.0 | -63665.2 | -56643.1 | -49692.2 | -42803.8 | -35969.6 | -29181.1 | -22430.0 | -15708.0 |
| 3.B.2 - Cropland | 25653.0 | 26563.6 | 27506.4 | 28482.7 | 29493.6 | 30540.5 | 31624.5 | 32746.9 | 33909.2 |
| 3.B.5 - Settlements | 9975.7 | 10329.8 | 10696.5 | 11076.1 | 11469.2 | 11876.3 | 12297.8 | 12734.3 | 13186.3 |
| 3.C - Aggregate sources and non-CO2 emissions sources on land | 10903.8 | 13231.4 | 15349.9 | 17745.4 | 20428.5 | 23372.1 | 26565.5 | 30008.7 | 33693.5 |
| 3.C.1 - Emissions from biomass burning | 10402.0 | 12632.3 | 14654.9 | 16941.9 | 19503.5 | 22313.8 | 25362.6 | 28649.9 | 32167.9 |
| 3.C.2 - Liming | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3.C.3 - Urea application | 84.1 | 42.6 | 49.4 | 57.1 | 65.7 | 75.2 | 85.5 | 96.6 | 108.4 |
| 3.C.4 - Direct N2O Emissions from managed soils | 395.3 | 488.6 | 566.8 | 655.2 | 754.3 | 863.0 | 980.9 | 1108.1 | 1244.1 |
| 3.C.5 - Indirect N2O Emissions from managed soils | 0.0 | 54.4 | 63.1 | 73.0 | 84.0 | 96.1 | 109.3 | 123.4 | 138.6 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3.C.6 - Indirect N2O Emissions from manure management | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3.C.7 - Rice cultivations | 22.4 | 13.5 | 15.7 | 18.2 | 20.9 | 23.9 | 27.2 | 30.7 | 34.5 |

Total emissions from Land (forest land, cropland, grassland, settlements, aggregate sources and non-CO2 emissions sources on land) are projected to increase from 102184.7 Gg $CO_2$ eq. in 2010 to 135071.9 Gg $CO_2$ eq. in 2050 (Table 5.25).

**Table 0.25: Projected baseline sequestration and emissions for AFOLU (Gg $CO_2$ eq.)**

| **Year** | **2010** | **2015** | **2020** | **2025** | **2030** | **2035** | **2040** | **2045** | **2050** |
|---|---|---|---|---|---|---|---|---|---|
| Forest land (Net Emissions) | -70767.0 | -63665.2 | -56643.1 | -49692.2 | -42803.8 | -35969.6 | -29181.1 | -22430.0 | -15708.0 |
| Forest land Gross emissions | 66556.0 | 68918.3 | 71364.4 | 73897.4 | 76520.2 | 79236.2 | 82048.6 | 84960.8 | 87976.3 |
| Forest land (Gross Removals) | -137322.9 | -132583.5 | -128007.5 | -123589.6 | -119324.1 | -115205.8 | -111229.6 | -107390.7 | -103684.3 |
| Total Land Emissions | 102184.7 | 105811.6 | 109567.2 | 113456.2 | 117483.1 | 121653.0 | 125970.9 | 130442.0 | 135071.9 |
| Total Emissions from AFOLU | 115425.0 | 119521.8 | 123764.0 | 128156.8 | 132705.6 | 137415.8 | 142293.1 | 147343.6 | 152573.3 |

#### 5.6.3.2 Emissions Reductions from Mitigation Actions Under AFOLU

**(i) Agriculture**

Planned or ongoing interventions identified in the agriculture sector with potential to contribute to climate change mitigation are sustainable agriculture NAMA, and conservation agriculture scaling up project.

The NAMA on sustainable agriculture seeks to reduce GHG emissions as well as increased crop and livestock productivity in the country. The interventions include promotion of use of fertilisers with high nutrient efficiencies and use of improved varieties and management practices through conservation agriculture.

Sustainable Agriculture under the NAMA is expected to cover 1,000,000 ha by 2020 and 1,500,000 ha by 2030 whilst Conservation Agriculture Scaling Up (CASU) is estimated to cover 260, 000 ha. Fertiliser application rates for conventional and conservation agriculture practices which were used to derive projected emissions reductions for agriculture are presented on Table 5.26

**Table 0.26: Fertiliser application rates for conventional and conservation agriculture**

| Fertiliser Type | D compound | Urea |
|---|---|---|
| Conventional Agriculture (kg /hectare) | 200 | 200 |
| Conservation Agriculture (kg/hectare) | 100 | 200 |
| N content percent | 13percent | 46percent |

Mitigation emissions reduction potential in the agriculture sector are projected to increase from 15.8 Gg $CO_2$ eq. in 2010 to 136.0 Gg $CO_2$ eq. in 2050 (Table 5.27).

**Table 0.27: Projected emissions reduction for agriculture under for AFOLU (Gg $CO_2$ eq.)**

| Year | 2018 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|
| Ministry of Agriculture-Conservation Agriculture | 15.8 | 23.3 | 42.1 | 60.9 | 79.7 | 98.4 | 117.2 | 136.0 |

**(ii) Forestry**

The mitigation actions in the forest sector are those arising from completed, planned and ongoing initiatives with potential to contribute to emissions reductions in the forestry sector in Zambia. Potential mitigation projects in the forestry sector include; (i) promoting climate resilient community-based regeneration, (ii) plantation establishment, (iii) agro forestry, (iv) REDD+ related projects (Table 5.28)

**Table 0.28: Tree planting mitigation actions**

| Organisation | Description | Hectares planted |
|---|---|---|
| ZAFFICO | Plantations of pine, Eucalyptus, *Gmelaina Borel* (used in timber industries, construction industries, match sticks). | 50,000 |
| | Plantations of pine, Eucalyptus, *Gmelaina Borel*- Ndola -most plantations being 10years and below. | 19,000 |
| | Planned tea and cashew-nuts plantations in Kawambwa | 300 |
| | Planned cashew-nut plantations in Mongu | 103 |
| | Plantations in eastern province, Pemba and Luwingu these two are set to begin this financial year). For Pemba, earmarked hectares will not be less than | 5,000 |
| SNV-Agroforestry | Agroforestry- planting trees on existing farm land with 20,000 farmers in Katete and Lundazi with 8 agricultural camps. | |
| SNV rehabilitation of tree stamps | 1, 800 farmers, 6 villages, 60 lead farmers and 30 follower farmers for each lead farmer. Each has 1 hectare dedicated for this purpose. 20X33 trees per hectare | |
| SNV-Planting bamboo for charcoal making. | Started 300 seedlings with 5X5 metres spacing producing 400 bamboo per hectare | 400 |

In estimating projected emissions, it was assumed that the growth rate for plantations of pine, eucalyptus, *Gmelaina Borel* (used in timber industries, construction industries, and match sticks) was 15$m^3$/year per hectare. The growth rate for the Musangu tree used in agro-forestry was assumed to be 3.5 $m^3$/year per hectare for the period (6-18 Years). Additionally, one cubic meter (1$m^3$) of wood was assumed to be equivalent to 304 kg mass. Other parameters used in estimating emissions reduction under forestry are provided in Table 5.29.

**Table 0.29:Parameters and assumptions used in calculating emissions reduction under forestry**

| | **Musangu** | **Pine** | **Natural Regeneration** |
|---|---|---|---|
| Growth rate $m^3$/year (6-18 Years) | 3.5 | 15 | 1.5 |
| Conversion $1m^3$=304 kg | 304 | 304 | 304 |
| Carbon Fraction of Dry Matter (tonnes C/tonne dm.) | 0.43 | 0.47 | 0.43 |

Mitigation in the forestry sector will result in an annual emissions reduction of 71.5 Gg $CO_2$ eq. (Table 5.30).

**Table 0.30: Projected emissions reduction for forestry under for AFOLU (Gg $CO_2$ eq.)**

| **Year** | **2010** | **2015** | **2020** | **2025** | **2030** | **2035** | **2040** | **2045** | **2050** |
|---|---|---|---|---|---|---|---|---|---|
| ZAFFICO | 0.0 | 33.4 | 33.4 | 33.4 | 33.4 | 33.4 | 33.4 | 33.4 | 33.4 |
| SNV- Agroforestry (to reduce agricultural expansion) | 0.0 | 0.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| SNV rehabilitation of tree stamps (to reduce agricultural expansion) | 0.0 | 0.0 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| **Total (Gg $CO_2$ eq.)** | **0.0** | **33.4** | **71.5** | **71.5** | **71.5** | **71.5** | **71.5** | **71.5** | **71.5** |

**(iii) Emission Reductions Under NAMAs**

The charcoal NAMA proposes implementation of sustainable wood harvesting through introduction and promotion of coupe system and charcoal retort kilns in selected customary areas. The NAMA also promotes the use of improved cook stoves aimed at reducing energy losses thereby contributing to reduction in deforestation and GHG emissions. In addition to sustainable wood harvesting, the NAMA will establish charcoal retorts which will enhance sustainable charcoal production in three charcoal production areas. Table 5.37 shows areas and hectarage where sustainable wood harvesting is carried out.

**Table 0.31: Proposed hectarage under coupes and shelterbelt strip system**

| Charcoal production areas | Area under alternate coupes and shelterbelt strips(ha) | Area under shelterbelt strip(ha) | Hectares for coupe | Hectares harvested for charcoal production* |
|---|---|---|---|---|
| Rufunsa | 10,000 | 5,000 | 5,000 | 1000 |
| Kapiri Mposhi | 10,000 | 5,000 | 5,000 | 1000 |
| Mpongwe/Masaiti | 10,000 | 5,000 | 5,000 | 1000 |

The emissions reductions for the charcoal NAMA are projected to increase from 3,197.8 Gg $CO_2$ eq. in 2025 to 3,492.3 Gg $CO_2$ eq. in 2050 as outlined in Table 5.32. Due to funding challenges, emission reduction is estimated to occur from 2025 onwards.

**Table 0.32:Projected emissions reduction potential for charcoal NAMA (Gg $CO_2$ eq.)**

| Year | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Charcoal NAMA | 0 | 0 | 0 | 3,197.8 | 3,255 | 3,312.7 | 3,371.6 | 3,431.4 | 3,492.3 |

### 5.6.4 Emissions Projections Under Waste

#### 5.6.4.1 Baseline Emissions for Waste

Baseline emissions in the waste sector are projected to increase almost three times from 305.9 Gg $CO_2$ eq. in 2010 to 924.6 Gg $CO_2$ eq. in 2050 driven by population and economic growth (Table 5.33).

**Table 0.33: Baseline Emissions for Waste Gg $CO_2$ eq**

| Year | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| 4 - Waste | 305.9 | 363.1 | 421.2 | 487.0 | 560.6 | 641.4 | 729.0 | 823.5 | 924.6 |
| 4.A - Solid Waste Disposal | 75.6 | 88.5 | 102.6 | 118.6 | 136.6 | 156.2 | 177.6 | 200.6 | 225.2 |
| 4.C - Incineration and Open Burning of Waste | 2.0 | 2.6 | 3.0 | 3.4 | 3.9 | 4.5 | 5.1 | 5.8 | 6.5 |
| 4.D - Wastewater Treatment and Discharge | 228.3 | 272.1 | 315.7 | 364.9 | 420.1 | 480.6 | 546.3 | 617.1 | 692.9 |

#### 5.6.4.2 Emissions Reductions from Mitigation Actions Under Waste

The proposed interventions in the waste sector include construction and installation of Mechanical Biological Treatment (MBT) plants, corresponding anaerobic digesters and gas engines. The other intervention includes segregation, collection and disposal of municipal solid waste to facilitate waste recycling. Emissions reduction potential for waste under the NDC constrained scenario are projected to increase from 400.7 Gg $CO_2$ eq. in 2020 to 1,121.4 Gg $CO_2$ eq. in 2050 (Table 5.34). On the other hand, emissions under the enhanced scenario are projected to increase from 799.6 Gg $CO_2$ eq. to 1,401.7 Gg $CO_2$ eq. in 2050.

**Table 0.34: Mitigation potential for constrained and enhanced support scenario under NDC Gg $CO_2$ eq.**

| Year | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| NDC-Waste Constrained scenario | 0.0 | 0.0 | 400.7 | 520.8 | 640.9 | 761.0 | 881.2 | 1001.3 | 1121.4 |
| NDC-Waste Enhanced scenario | 0.0 | 0.0 | 679.1 | 799.6 | 920.0 | 1,040.4 | 1160.9 | 1,281.3 | 1401.7 |

## 5.7 Measuring Reporting and Verification (MRV)

Zambia is developing an MRV system in the context of the Enhance Transparency Framework building on previous MRV following the adoption of the Paris Agreement. The National MRV System is envisaged to contain three main components namely, MRV of emissions, mitigation and support (i.e. finance, technology transfer and capacity building) and will be characterized by the following:

a) Mechanism for tracking emissions, mitigation actions, finance, capacity building, and technology transfer;
b) Online monitoring plans;
c) Facility for accrediting independent verifiers;
d) Guidelines, instructions and audit procedures;
e) MRV Institutional coordination structures, responsibilities and competencies;
f) Interactive NDC database and IT Platform;
g) Web based, Multi-user;
h) Geospatial Database with interactive map of Zambia showing implementation of climate change projects; and
i) An interactive database showing NDC mitigation and adaptation projects, support received and SDGs progress contributions of NDC projects.

The institutional arrangements for the MRV system will be based on the provision of the national policy on climate change with established linkages to sub-national and sectoral institutions. The benefits of institutionalization include: Improved inventory quality; data documentation; archiving; and transparency. The development of an MRV system will contribute to efficient measuring, reporting and verification of emissions from different sectors of the economy, thereby enhancing transparency of mitigation actions.

## 5.8 Financial Requirements

In order to implement the various mitigation actions, financial and investment are required across all the sectors namely; Energy, Agriculture, Forestry and Other Land Use, and Waste. The summary for the cost is presented in Table 5.35

**Table 0.35 Summary Cost for Mitigation**

| s/n | Mitigation action area | Investment costs (million US$) |
|---|---|---|
| 1 | Financial Investment for solar PV utility scale mitigation actions | 679.6 |
| 2 | Financial Investments for Solar Homes Systems mitigation actions | 23.99 |
| 3 | Financial Investment for electricity generation mitigation actions | 17145 |
| 4 | Financial Investment for energy efficiency mitigation actions | 28.45 |
| 5 | Financial Investment for wind power generation mitigation actions | 1210 |
| 6 | Financial Investment for Geothermal mitigation action | 4 |
| 7 | Financial investment for biomass | 0.3 |
| 8 | Charcoal NAMA | 27.17 |
| 9 | Agriculture NAMA | 205 |
| 10 | Transport NAMA | 3530 |
| 11 | Waste NAMA | 126.05 |
| 12 | UNRED | 404.7 |
| | **TOTAL COST** | **22,707.36** |

Zambia has also developed an ambitious energy investment programme to be implemented under the Rural Electrification Master Plan (REMP), which will require US$ 1,103 million to realize all 180 Project Packages by 2030. This means approximately US$ 50 million per year is needed from 2008 to 2030.
The National Electrification Programme supported by World Bank commenced in 2018 with a budget of USD26.5 million targeting 22, 000households by 2022. Provided in Table 50 are indicative investment costs based on generic international cost estimate per kW of solar PV utility scale.

The National Investment Plan to Reduce Deforestation and Forest Degradation indicates that in order to finance and implement the National Strategy to Reduce Emissions from Deforestation and Forest Degradation (REDD), the country will require investment of US$ 32 million, US$194.6million and US$ 178.1 million for enabling environment, conservation & management of high value forest areas, resilient landscapes sustainable agriculture and energy, respectively

The detailed costs for each action are presented in the Tables 5.36 to 5.42

**Table 0.36: Financial Investment for solar PV utility scale mitigation actions**

| Project | Capacity (MW) | Investment costs (million US$) |
|---|---|---|
| Kasanjiku in Mwinilunga | 0.64 | 0.896** |
| Wind-Solar (Kasoma Lunga District) in Luapula | 0.3 | 0.42** |
| REA - Chunga in Kafue national park | 0.2 | 0.28** |
| REA - Mpanta on shores of lake Bangweulu | 0.06 | 0.084** |
| Muhanya Solar mini grid 30KW | 0.03 | 250,000 |
| Industrial Development Cooperation (MW) | 100 | 140** |
| CEC(MW) | 1 | 1.4** |
| GIZ working with 8 companies | 8 | 11.2** |
| Scaling up solar (MW) | 74 | 103.6** |
| ZESCO Shangombo 1MW | 1 | 1.4** |

| | | |
|---|---|---|
| ZESCO-300MW in Serenje, Choma, Itezhi-Tezhi | 300 | 420** |
| ZESCO HQ solar plant | 0.035 | 0.035** |
| Parliament | 0.035 | 0.035** |

***Estimated costs based on generic international cost estimate per kW of solar PV (1400US$/kW)*

**Table 0.37: Financial Investments for Solar Homes Systems mitigation actions**

| **Project** | **Investment cost** |
|---|---|
| REA Solar PV Sustainable Solar Market Packages (SSMP) in Isoka, Kalomo, Lukulu | US$2.6 Million |
| Beyond the Grid Project. The Power Africa: | 20 million Euros |

**Table 0.38: Financial Investment for electricity generation mitigation actions**

| **Project** | **Capacity (MW)** | **Million US$**[12] |
|---|---|---|
| Batoka (Build operate & transfer) | 1200 | 6000 [13] |
| CEC Kabompo | 40 | 220 |
| Devil's Gorge | 500 | 1500** |
| Itezhi-Tezhi Hydro | 120 | 245 |
| Kabwelume Falls - 62 MW | 62 | 186** |
| Kafue Gorge Lower | 750 | 2400[14] |
| Kalungwishi | 200 | 600** |
| Kariba North Bank Extension | 360 | 420[15] |
| Kundabwika Falls – 101 MW | 101 | 303** |

[12] Estimates of investment costs for electricity generation mitigation actions were derived from International Renewable Energy Agency cost estimates per kW (3000US$/kW) for hydro

[13] 2016 ERB Energy Sector Report 2017

[14] Ministry of Energy: 2018 Annual Progress Report

[15] http://www.zesco.co.zm/projects/generation

| | | |
|---|---|---|
| Luapula | 350 | 1050** |
| Luchenene – 30 MW | 30 | 90** |
| Lufubu | 200 | 600** |
| Mambilima Falls SiteI–202 MW | 202 | 606** |
| Mkushi – | 65 | 195** |
| Mpata | 540 | 1620** |
| Mumbotuta | 300 | 900** |
| Mutinondo - 40 MW | 40 | 120** |

***Estimated cost based on 3000US$/kW for hydro (International Renewable Energy Agency)*
*Source: ZESCO, Renewable Energy Division, Copperbelt Energy Corporation (CEC) and Ministry of Energy*

Investment cost for energy efficiency projects is provided in Table 5.39

**Table 0.39: Financial Investment for energy efficiency mitigation actions**

| Project | Cost |
|---|---|
| Solar street lighting retrofit. | Estimated total investment cost: USD 1.68 million (LED retrofit only) USD 3.84 million (full off-grid solar solution) |
| Solar geysers. | USD 9.4 million |
| LED/CFL lighting in households | USD 4 million |
| Reactive Power Compensation | USD 9.53 million |

Cost for electricity generation from wind were estimated by deriving from generic international cost per kW (US$2200/kW[16]) for on-shore wind project (Table 5.40).

[16] International Renewable Energy Agency (IRENA)
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**Table 0.40: Financial Investment for wind power generation mitigation actions**

| Project | Investment cost (Million US$) |
|---|---|
| ZESCO- Wind 150MW | 330 |
| Mpepo power 400 MW | 880 |

*Source: Adapted from ZESCO and Ministry of Energy*

**Table 0.41: Financial Investment for Geothermal mitigation action**

| Project Description | Investment cost (Million US$) |
|---|---|
| 1 MW under Kalahari geothermal | 4 |

*Source: Adapted from Ministry of Energy*

**Table 0.42: Financial investment for biomass**

| Project Description | Investment Costs |
|---|---|
| Assisted Natural Regeneration Project in Serenje – Cook stoves | 300,000[17] |

### 5.8.1 Agriculture NAMA financial requirements

The investment cost for agriculture NAMA is USD 205 Million covering cost of purchase of Coated Urea fertilizer, Coated D-Compound fertilizer, Herbicides, Insecticides, Lime, Organic Manure, Seeds, Legumes and equipment in three districts.

### 5.8.2 Charcoal NAMA financial requirements

**Table 0.43:Financial Investment for implementation charcoal NAMA**

| Years | 2017 (US$) | 2018 (US$) | 2019 (US$) | 2020 (US$) | 2021 (US$) | Total (US$) |
|---|---|---|---|---|---|---|
| Project management | 346,500 | 154,500 | 154,500 | 154,500 | 154,500 | 1,039,500 |
| Coupe system | 843,436 | 524,252 | 524,252 | 524,252 | 524,252 | 2,940,444 |
| Retort | 1,171,036 | 288,330 | 288,330 | 288,330 | 288,330 | 2,324,356 |

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| | | | | | | |
|---|---|---|---|---|---|---|
| Adoption of ICS | 161,000 | 61,000 | 61,000 | 61,000 | 61,000 | 405,000 |
| Social enterprise company | 0 | 2,719,922.2 | 2,934,682 | 3,756,310 | 4,822,835 | 14,233,749 |
| Capacity building | 681,000 | 342,000 | 357,000 | 597,000 | 265,000 | 2,242,000 |
| Charcoal Revolving Fund | 324,500 | 1,164,500 | 1,164,500 | 1,1645,00 | 164,500 | 3,982,500 |
| **Grand total** | | | | | | **27,167,549** |

### 5.8.3 Transport NAMA financial requirements

## Table 0.44:Financial Investment for implementation of Transport NAMA

| Activity | Estimated Costs(US$) | Estimated Time Frame in months |
|---|---|---|
| Detailed feasibility study | $200,000 | 6 months |
| Detailed engineering design | US 1 million | 6 months |
| Construction of lines 2 and 3 covering 50km and procurement of 20 Trams for Lusaka (Phase I) | US$ 1.13 Billion | 2018 – 2020 |
| Construction of Kitwe line covering 26 km and procurement of 10 Trams for Kitwe (Phase I) | US$ 0.54 Billion | 2018 – 2020 |
| Construction of Lines 4 covering 54 km and procurement of 10 Trams for Lusaka (Phase II) | US$ 1.09 Billion | 2021 - 2023 |
| Construction of line 1 covering 36km and procurement of 10 trams for Lusaka (Phase III) | US$ 0.73 Billion | 2024 – 2026 |
| Capacity building | US$ 35 Million | 2018 – 2030 |
| **Total** | **US$ 3.525 Billion** | |

### 5.8.4 Waste NAMA Financial Requirements

**Table 0.45:Financial investment for implementation of Waste NAMA**

| Activity | Estimated Costs (US$) |
|---|---|
| Undertake studies to enhance understanding of establishing waste recovery | 500,000 |
| Public awareness and sensitization | 1,500,000 |
| Capacity building for Municipal councils, private sector, and financial institutions | 3,000,000 |
| Policy intervention for enhanced environment | 1,000,000 |
| Financing for implementation of selected innovative technologies | 120,045,571 |
| Total | 126,045,571 |

### 5.8.5 UNREDD

**Table 0.46:Financial requirements for implementing the REDD**

| | Amount (million US$) | | | | | |
|---|---|---|---|---|---|---|
| **CIP** | **Year1** | **Year2** | **Year3** | **Year4** | **Year4** | **Total** |
| Enabling Environment | 10.21 | 7.6 | 5.5 | 4.2 | 4.2 | 32 |
| Conservation and management of high value forest areas | 54.7 | 39.4 | 33.5 | 25.1 | 20.7 | 194.6 |
| Resilient landscapes, sustainable agriculture and energy | 48.2 | 40.1 | 34.7 | 31 | 24.1 | 178.1 |

## 5.9 Recommendations

Analysis of baseline emission projections indicate that Zambia shifted from being a net sink to a net source in 2018. This could be attributed to increasing emissions from opening up new land for settlements and agriculture, wood removals for firewood and charcoal and commercial timber. Other causes of emission increase are from fertiliser use and use of fossil fuels. It was observed that greater efforts and ambitions are being made in the energy sector to increase energy security using renewable energy and energy efficiency. These efforts are also consequentially contributing to reducing greenhouse gas emissions in the sector. To enable Zambia assume its original net sink status, there is need to undertake the following:

Increase and enhance actions to reduce deforestation by minimising opening up of new land for agriculture and settlements. Thus, there is need to promote high-rise residential areas to minimise opening up of new land for settlement in urban areas;

The unstainable charcoal production has reached critical levels and there is need to urgently address the issue so as to reduce deforestation and hence GHG emissions. There is need to restrict use of charcoal and provide support in connecting all un-electrified households in urban areas and increase the rate of electrification in rural areas. The increasing electricity generating capacity Zambia is experiencing will help to sustain the likely increase in demand due to electrification. There is also need for promotion of alternative energy sources for cooking and heating such as LPG, gel, pellets. These could also act as back up in times of power outages. Alongside the promotion efforts, awareness campaigns should be carried out on the availability, safe use and economic viability of these alternatives;

There is need to incorporate climate change programmes into the school curriculum and increase awareness and sensitisation of communities on sustainable agriculture  and forest management;

There is need to increase and enhance activities aimed at increasing productivity in the agriculture sector which would result in reducing opening up of new land for agriculture; and

There is need to increase funding to afforestation and reforestation programmes including provisions of incentives to attract private sector investment in the mitigation initiatives.

# 6 OTHER INFORMATION RELEVANT TO THE CONVENTION

This section provides other information on actions taken by the country relevant to the achievement of the objectives of the Convention. The focus is on the integration of climate change issues in the development planning process, technology development and transfer, research and systematic observation, education, training and public awareness, and capacity building.

## 6.1 Integration of Climate Change Issues into Policies and Strategies

Zambia has put in place a National Policy on Climate Change (NPCC) whose overall objective is to provide a framework for coordinating climate change programmes in order to ensure climate resilient and low carbon development pathways for sustainable development towards the attainment of Zambia's Vision 2030. The policy promotes mainstreaming of climate change into policies, plans and strategies at all levels to inform decision-making and implementation. Arising from this policy direction, the country has taken measures to mainstream climate change in the national development planning process. The Seventh National Development Plan (7NDP) mainstreamed climate change as an overarching guidance to promote social wellbeing, including better health, growth of the economy and at the same time reduce environmental risks, such as shortage of water, air pollution and other effects.

In an effort to adapt to and mitigate the effects of climate change in the agriculture sector, Zambia is promoting the adoption of environment-friendly agricultural practices such as conservation agriculture. In the water sector the country recognized the effect of climate change on water resources and has prioritized water resource infrastructure development and increasing water resources availability as long term measures to mitigate the impact of climate change and build resilience through water harvesting technology and water catchment management.

In the health sector, the country has identified that climate change-related water supply and sanitation challenges have potential to compromise human health and living conditions of citizens. In this regard, the country has prioritized strengthening of climate related diseases surveillance.
In the energy sector, the country has identified energy supply deficits as being exacerbated by the effects of climate change on the availability of water considering that Zambia was highly dependent on hydro-power. To address this, the country through its energy policy, has prioritized increasing energy supply from other sources of energy including geothermal, wind and solar.

Climate change has had an adverse impact on infrastructure development, particularly roads. The country is addressing this by integrating climate resilient codes and standards in road construction. In order to adequately address climate change-related disasters, Zambia revised its 2005 National Disaster Management Policy that was devoid of climate change considerations and put in place a disaster risk reduction-oriented Disaster Management Policy of 2015.

Zambia's tourism is largely wildlife-based and the country recognizes that wildlife is not immune to the effects of climate change and that there is need for innovative mitigation and adaptation solutions for wildlife in order to secure it for future generations. Zambia therefore mainstreamed climate change in the National Parks and Wildlife Policy to ensure long-term responses to impacts on the sector. Zambia has also mainstreamed climate change in the National Tourism Policy in order to promote a "green" environmentally responsible tourism that enhances the country's natural and cultural resources and addresses environmental threats such as climate change, poaching, over-fishing and deforestation. Table 6.1 shows the current status of integration of climate change into policies, plans and strategies.

**Table 6.1: Status on integration of Climate Change in Sector Policies, Plans and Strategies**

| **Sector** | **Mainstreamed instrument** | **Other related processes** |
|---|---|---|
| Agriculture | National Agriculture Investment Plan | Integrating agriculture sector in the National Adaptation Plan (NAP-Ag) |
| Energy | Renewable Energy Feed-in Tariff (REFiT) Strategy<br>Investment Plan for Zambia | Scaling up renewable energy in low income countries |
| Health | National Health Policy | Health-NAP |
| Water | National Water Policy | Integrated Water Resources Management Information System (IWRMIS) |
| Forestry | Forestry Policy<br>Forests Act | Reducing Emissions from Deforestation and Forest Degradation (REDD+) Strategy<br>Investment Plan to reduce Deforestation and Forest Degradation. |
| Tourism | National Tourism Policy | |
| Wildlife | National Parks and Wildlife Policy | |
| Infrastructure | | Climate resilient codes and standards for road infrastructure |

### 6.1.1 Legal Frameworks that Cover Climate Change

A number of legislations have been put in place to address Climate Change in Zambia. For instance, the Zambian Constitution, Article 257 provides for establishment of mechanisms to address climate change. Further, the Environmental Management Act No.12 of 2011 ensures the protection of the environment and control of pollution. Other pieces of legislation with relevance to climate change are shown in the Table 6.2

**Table 6.2: Legislations with Relevance to Climate Change**

| ENABLING ACT | PURPOSE |
|---|---|
| Forest Act No. 4 of 2015 | The Act provides for the conservation and protection of forests and trees |
| Zambia Wildlife Act No. 15 of 2015 | The Act is responsible for wildlife management and conservation |
| Lands Act Cap 184 | The Act is responsible for the management and administration of land in Zambia |
| Agriculture Lands Act Cap 187 | The Act provides for sustainable agricultural practices, development, investment and management |
| Agriculture (Fertilizer and Feed) Act No. 13 of 1994, Cap 226 | The Act provides for the regulation and control of manufacture, processing, importation and sale of agriculture fertilizers. |
| Energy Regulations Act No. 23 of 2003 | The Act among other issues regulates energy use and efficiency |
| Mines and Minerals Act 11 of 2015 | The Act provides for mineral and mines development |
| Urban and Regional Planning Act No. 3 of 2015 | The Act provides for planning for all land in Zambia |
| Road Traffic Act No. 11 of 2002 | The Act provides for road safety and transport management |
| Water Resources Management Act No. 21 of 2011 | The Act provides for the regulation and management of water resources |
| Zambia Development Agency Act No. 11 of 2006 | The Act provides for the trade, investment and industrial development in Zambia |
| National Heritage Conservation Commission Act, Cap 173 | The Act provides for heritage conservation and management |
| Fisheries Act No. 22 of 2011 | The Act provides for sustainable fisheries and aqua-cultural development and management. |
| Disaster Management Act No. 13 of 2010 | The Act provides for Disaster preparedness and response. |
| Public Finance Act No. 15 of 2004 | The Act provides for the control and management of Public Finances |

## 6.2 Development and Transfer of Environmentally Sound Technologies

In implementing the provision of Article 4 of the UNFCCC, Zambia received support towards the development and transfer of Environmentally Sound Technologies (ESTs). These technologies have since been applied to adaptation and mitigation actions in line with the provision of the NPCC. The Policy provides for the development and promotion of appropriate technologies and building national capacity to benefit from climate change technological transfer.

In an effort to have a coordinated approach to the implementation of ESTs, the National Designated Entity (NDE) was established in 2015 under the Ministry responsible for science and technology. The main objective of the NDE is to accelerate and enhance climate technology development and transfer at country level. Since its establishment, the NDE has been used as a platform to spearhead the implementation of adaptation and mitigation actions. During the period under review, the country was able to access technologies in the following areas:

### 6.2.1 Renewable Energy and Energy Efficiency

The country has made significant progress in scaling up renewable energy and diversifying the energy mix that has increased energy generation from renewable sources. Among the projects implemented is the China-Zambia South to South Cooperation on Renewable Technology Transfer that aims at improving energy access and living conditions in rural Zambia through South to South Cooperation. Under this project, two centers of excellence have been established for purposes of training, testing and demonstration of appropriate technologies. The project has also enabled the country to access financial and technical support in the construction of a 200KW Mini-Hydro Power Plant to provide electricity to an estimated rural population of 15, 000 including public facilities such as schools and health centers in the Central province of Zambia.

Further, Zambia has accessed support from the Global Energy Transfer Feed-in Tariff (GET FiT) towards the Renewable Energy Feed-in Tariff (RE FiT) Strategy. GET FiT aims to strengthen the Zambian power market by encouraging private sector participation by a wider range of developers, construction firms and financial institutions. Through this Strategy, the country's power utility company is expected to procure 200MW of renewable energy from various small to medium scale independent power producers. In addition, a 54MW solar power plant was commissioned and is expected to power over 30,000 households.

In the area of energy efficiency, some industries have implemented technologies aimed at reducing their carbon footprint. For example, Lafarge Zambia PLC which uses coal and diesel as their major energy source in cement production, has replaced its wet technology with a dry process which has significantly reduced the amount of coal used in the production chain. Further, Zambia Sugar is producing fuel from cane waste.

On energy switch, mining firms such as Mopani and Konkola Copper Mines have adopted cleaner technologies such as Electric Driers which have replaced the use of Cord Wood resulting in significant reduction in GHG emissions. In addition, the country's power utility, ZESCO Limited decommissioned five out of the seven diesel powered generators after expanding its main grid to remote areas. The decommissioning of these generators was an important milestone in climate change mitigation as it resulted into reduction in country's emission of greenhouse gases.

### 6.2.2 Agriculture

The country has accessed technologies in the areas of climate information and early warning systems and seed breeding, among others. Under the early warning systems, Zambia has implemented several projects on strengthening climate information and early warning systems in order to enhance the adaptive capacities of vulnerable farmers and rural communities. Some of these initiatives such as installation of modern hydro-meteorological technologies have enabled the country to improve provision of information on weather parameters and facilitate informed decision making by the farmers and local communities. In terms of seed breeding, the country has received support in breeding of seed varieties that are drought, disease and pest tolerant and are high yielding. This has not only supported farmers' adaptation but also mitigation efforts through reduced fertilizer and chemical usage.

There are also a number of initiatives in the agriculture sector promoting climate smart technologies. The promotion of Climate Smart Agriculture (CSA) reflects a commitment by the Zambian government to improve the integration of agriculture development and climate responsiveness on livelihoods and the environment. For instance, Conservation Agriculture Scaling-up (CASU) project which was implemented from 2013 to 2017 employed technologies such as use of basins, ripping, crop rotation that contributed to improved productivity and food security while promoting sustainable use of natural resources in vulnerable communities.

### 6.2.3 Forestry

Zambia has implemented a number of technologies to assess forest cover, growing stock, biomass, carbon, species abundance, regeneration and deforestation. Some of the technologies implemented include Geographical Information System (GIS) and Remote Sensing which are satellite-based monitoring tools for forest management. Ultimately, the country has been able to improve its capacity in monitoring and managing of forest resources.

### 6.2.4 Water

In order to improve the adaptive capacity of the water sector to climate change impacts, several ESTs have been adopted. In this regard, hydrometric monitoring networks have been deployed, which have assisted the country to establish a national ground and surface water data base and enhanced planning and efficient utilization of water resources.

Government has also prioritized the construction of water harvesting infrastructure such as multi-purpose dams to support other economically viable activities including agriculture. The construction of multi-purpose dams has improved community and wildlife access to water all year round, and has led to the expansion of economic activities in areas around the dams for livelihood sustenance.

### 6.2.5 Challenges to ESTs Development and Transfer

The country has faced challenges in developing and accessing ESTs. The current efforts and established systems are inadequate to facilitate a fully-fledged deployment of ESTs. For instance, although the country established its NDE in 2015, its full operationalization has remained a challenge. In addition, access to ESTs has been hampered by inadequate financial resources especially for technologies that require acquisition of Intellectual Property Rights (IPR). Further, the problem has been compounded by inadequate mechanisms for stakeholder engagement on linking project development with the provisions of the Technology Needs Assessment.

## 6.3 Research and Systematic Observation

### 6.3.1 Research Related to Climate Change

The policy objective on research and development is to enhance understanding and decision making in responding to climate change. Research has been undertaken on climate change on the aspects of impacts, vulnerability, adaptation, mitigation, modelling and policy. Research and development work conducted has contributed to enhancing resilience to climate change in areas such as improving crop varieties, soil and water management practices and improving energy efficient stoves and biogas generation.

Some of the institutions that have conducted research include; the Zambia Agriculture Research Institute, University of Zambia, Copperbelt and Mulungushi Universities, National Remote Sensing Center, Disaster Management and Mitigation Unit (DMMU) and Ministry of Health. NGOs such as Indaba Agricultural Policy Research Institute, Networking for Environmental Concern, Energy and Environmental Concerns for Zambia and Center for Energy, Engineering and Environment in Zambia have also carried out research activities in climate change. Support for this research was secured from the Central government and other Cooperating Partners. Some of the notable research works include:

1. Emissions from Refrigeration and Air Conditioning
2. Socio Economic Implication of Climate Change in Zambia
3. Adaptation of Farming Communities to Climate Change in Rural Kitwe
4. Provision of Satellite based field planning and crop yield estimations for Small Scale Farmers
5. Generation of Agriculture Drought Risk Prediction Models for Zambia
6. Earth Observation for Drought Soil and Vegetation Monitoring
7. Vulnerability and Needs Assessment Reports on Impacts of Climatic Extremes in Zambia
8. Climate analysis in support of the projects on Climate Smart Agriculture and National Adaptation Plans for the Agriculture Sector
9. Impacts of Climate Change on Water Resources Availability in Zambia: Implications for Irrigation Development
10. Drivers of Deforestation and Potential for Carbon Trading in Miombo Woodlands.
11. Soil and Water Management Practices for Climate Adaptation and Mitigation
12. Development of Livestock, Pastures and Feeds for Climate Adaptation and Mitigation

### 6.3.2 National Systematic Observation

The country has been undertaking systematic observation of weather and climate variables for sectors such as agriculture, water, energy, health and social protection. These observations have facilitated better planning, decision-making and policy formulation for mitigation and adaptation actions. In addition, the systematic observations have further improved understanding and reduced uncertainties regarding the causes, effects, magnitude and prediction of climate change.
The common weather and climate variables that are observed are rainfall, air and soil temperature, wind speed and direction, relative humidity, cloud amounts, tropical cyclones, visibility and present weather. Observations are undertaken at standard pre-set times and places, and monitor atmosphere and terrestrial systems.

In undertaking the observation and analysis, the country has been collaborating with regional and international organizations as shown in Table 6.3:

**Table 6.3: Regional and International Collaboration on Systematic Observation**

| Organizations | Area of collaboration |
|---|---|
| Southern African Development Community – Climate Services Centre (SADC-CSC), Gaborone, Botswana | • Preparing the regional statistical models, analysis and dissemination of the Southern African Regional Climate Outlook Forum (SARCOF);<br>• Issuance of extreme weather alerts and warnings including monitoring; |

| | |
|---|---|
| | • Promotion of capacity building and sustainable development<br>• Resource mobilization<br>• Coordination and Networking<br>• Data and information sharing |
| Africa Centre of Meteorological Applications for Development (ACMAD), Niamey, Niger | • Human resource capacity building<br>• Data and information sharing<br>• Promotion of sustainable development |
| European Meteorological Satellites organizations (EUMETSAT), Darmstadt, Germany | • Data sharing<br>• Capacity building |
| United Kingdom Meteorological Office, Blacknell, UK | • Data sharing<br>• Capacity building |
| International Civil Aviation Organization (ICAO), Montreal, Canada | • Regulations in the provision of meteorological services to Civil Aviation, for the safety and economic operations of aircrafts. |
| World Meteorological Organization (WMO), Geneva, Switzerland | • Standardization of weather codes, observation, recording and transmission times by national Hydro-Met service providers<br>• Capacity building<br>• Raw and processed data sharing and exchange between WMO member states.<br>• Resource mobilization and promotion of sustainable development |

### 6.3.3 Climate Monitoring

Zambia has established several manual and automated stations to observe and monitor weather parameters. In total, 140 manual operational stations had been installed across the country of which 100 are privately owned. In addition, government had installed 85 operational Automatic Weather stations (AWS) and the number of stations is expected to increase. The improvement in the weather station infrastructure has enabled the country to provide timely climate information and early warning. Figure 6.1 highlights the location of weather stations across the country.

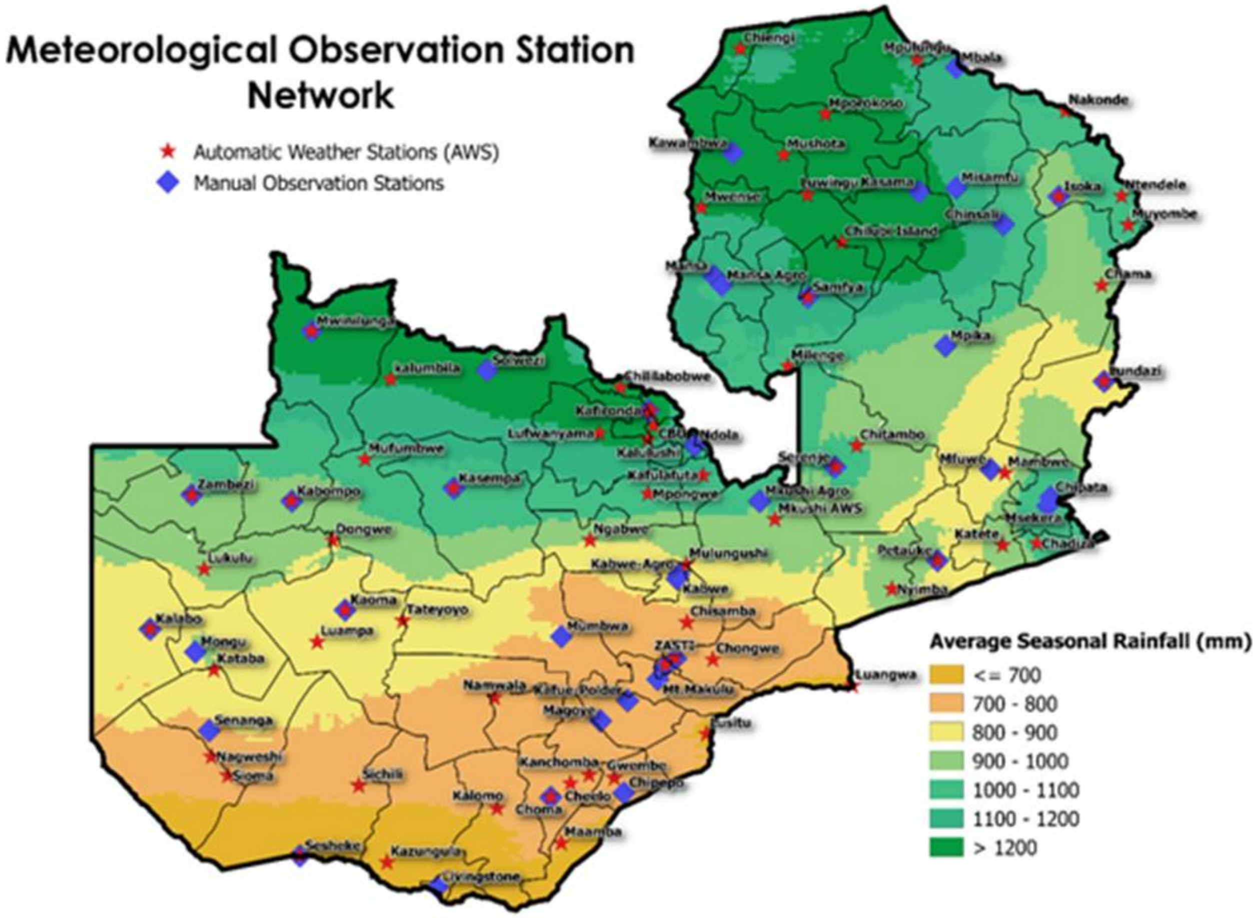


**Figure 6.1. Location of the Weather Stations** *Source: ZMD, 2015*

### 6.3.4 Climate Predictions and Early Warning

In ensuring accuracy of forecasts and quality of data, the country utilized global, regional and country climate models and tools that have assisted in providing information on annual seasonal forecast, ten days weather forecast, daily weather forecast, public and aviation forecasts and ten (Dekadal) crop weather bulletin. The other information generated was on flash Flood Forecast, soil Moisture Indices, drought warning and temperature projections and trends. These are disseminated using various channels of communication among them; electronic and print media, internet, bulletins and meetings.

### 6.3.5 Challenges in Research and Systematic Observation

#### 6.3.5.1 Challenges in Undertaking Research

Among the challenges identified in undertaking research during the reporting period were:

1. Lack of coordination and harmonization among institutions conducting climate change and other researches in Zambia.
2. Dependency on external funding for research which in most cases does not address national priorities.
3. Inadequate laboratory and field infrastructure for climate change research.

#### 6.3.5.2 Challenges in Systematic Observation

Despite the country having made some improvement in the area of systematic observation, gaps still exist in the following areas:

- climate modelling and downscaling
- modern climate information infrastructure
- institutional structures and staffing levels

### 6.3.6 Efforts in addressing Gaps in Research and Systematic Observation

#### 6.3.6.1 Efforts in Undertaking Research

In an effort to address the identified research challenges, Government has established the Strategic Research Fund under the National Science and Technology Council (NSTC) aimed at supporting basic and applied research in Zambia. Policies have been put in place to strengthen the national technical and scientific capacity to develop and apply methodologies and models to assess vulnerabilities and the impact of floods, drought and epidemic hazards.

#### 6.3.6.2 Efforts in Systematic Observation

In an effort to address the challenges and strengthen systematic observation and promote access to information, the country undertook various initiatives supported by the central Government and the Cooperating Partners. Zambia is in the process of formulating legislation on Meteorological products and services to strengthen the systematic observation, promote access to and exchange of meteorological data. The country also enhanced her capacity and capabilities on systematic observation through financing of national level activities aimed at promoting research, data collection and systematic observation. Further, the country has established a network of stakeholders for data sharing through the Voluntary Rainfall stations (VRS). In addition, support was received from GEF-LCDF to implement climate information and early warning systems that facilitated strengthening of national capacity to provide information to farmers and communities for informed decision making.

## 6.4 Education, Training and Public Awareness

Zambia has taken measures to implement its obligation on education, training and public awareness related to climate change, and encouraged wider participation of its citizens in the implementation of the above activities in accordance with Article 4, Paragraph 1 (i) of the Convention.

As part of its obligation to enhance education, training and public awareness, the country has developed and implemented several education and public awareness programmes including promoting access to information on climate change and its effects. The objective is to enhance the understanding of climate change and its impacts and build capacity of the citizens to address climate change challenges.

### 6.4.1 Education and Training

Education and training are important elements in enhancing the country's capacity to effectively undertake climate change actions. In order to ensure sustained implementation of education and training activities in the country, the National Policy on Education (*Educating Our Future, 1996*) was formulated to provide a framework for education at primary and secondary school levels. Through the implementation of this policy, a number of programmes that address environmental management in general have been undertaken. However, it should be noted that during implementation of the policies on education and training, gaps related to integration of climate change were identified. Accordingly, measures were undertaken to revise the policies to integrate climate change.

In view of the above, a number of institutions of learning such as the University of Zambia, Mulungushi and Copperbelt Universities offer programmes and courses that directly address climate change issues at both undergraduate and postgraduate levels.

The following were challenges limiting the full implementation of initiatives on education and training:

1. Inadequate mainstreaming of climate change into education and training curricula.
2. Limited resource centers and equipment to promote learning and field demonstration on climate change.

### 6.4.2 Public Awareness and Information Sharing

In order to implement activities on public awareness covered under Article 6 of the Convention, Zambia has since developed the National Climate Change Communication and Advocacy Strategy, which provides a clear and effective mechanism for fostering the flow of information, participation and dialogue of different stakeholders all of which are crucial for a nationwide participatory response to climate change.

In line with this Strategy, Zambia has implemented the following activities on public awareness and information sharing;

1. Establishment of climate information and early warning systems such as SMS and email alert system that has enhanced the levels of information dissemination and awareness on climate related parameters;
2. Enhanced capacity of the media, schools, scientists, researchers, Government Departments and other organisations involved in climate change to effectively engage and disseminate climate change information through training and provision of information;
3. Production of educational materials on Climate Change targeting different stakeholders;
4. Promotion of collaboration and networking among the various stakeholders for sharing information and lessons;
5. Commemoration of significant environmental days which have provided a platform for Government and other stakeholders to share information related to climate change;
6. Up scaling implementation of media programmes which included trainings, presentation of awards to deserving climate change champions, radio and television programmes, fields trips and spot adverts;
7. Hosting of national consultative meetings as a way of promoting dialogue and stakeholder participation;
8. Strengthening of an Information and Documentation Centre at ZEMA to provide climate related information to stakeholders and the general public; and
9. Development of a Climate Change Learning Strategy as a tool to create sustainable individual and institutional capacities to plan and implement effective climate change actions.

The country acknowledges that indigenous knowledge is critical to climate change adaptation. However, there is limited dissemination of indigenous technologies and knowledge due to inadequate documentation. Therefore, the country has prioritized documentation of indigenous knowledge.

### 6.4.3 Capacity Building

Government, with support from Cooperating Partners, has made progress towards developing its capacity as an important aspect in responding to the challenges of climate change. During the reporting period, the following were some of the important capacity building activities undertaken:

1. Establishment of a GHG Inventory System at ZEMA. This has enhanced the country's capacity to report on national GHG inventories. Further, the country has strengthened institutional capacity for GHG lead sectors namely; agriculture and livestock, forestry, energy, industrial processes and waste in compilation and management of sector GHG inventories;
2. Creation of a dedicated Climate Change Department for coordination of implementation of climate change programmes in the country;
3. Establishment of the National Designated Authority (NDA) for Green Climate Fund (GCF) under the Ministry responsible for Development Planning, which has facilitated effective country programming on resource mobilization from GCF;
4. Establishment of the National Designated Entity (NDE) for Climate Technology Center Network (CTCN) under the Ministry responsible for Science and Technology to facilitate the development and transfer of ESTs. Further, the incubator programme under CTCN brought together key national stakeholders to identify and prioritize specific technology actions for NDC implementation;
5. Training of experts was undertaken at PhD, Masters, Bachelors and Diploma levels which has contributed to enhanced technical expertise, knowledge base and service delivery in the area of climate change;
6. Establishment of two centers of excellence for training, testing and demonstration in solar (University of Zambia) and Mini Hydro (Kafue Gorge Regional Training Centre) under the South to South Cooperation between Zambia and China;
7. Training of experts in Land Degradation Neutrality (LDN) target setting that has facilitated the development of strategies for achieving sustainable land management and productivity through national target setting;
8. Establishment of a civil society network in 2012 namely; the Zambia Climate Change Network (ZCCN) that has provided a platform for Civil Society Organizations to build capacity to undertake climate actions which include training and awareness; and
9. Strengthened support to climate change learning targeting schools in the country through initiatives such as training of climate change ambassadors.

### 6.5 Constraints and Gaps and Related to Financial, Technical and Capacity Needs

Zambia conducted a study on climate information needs and gaps in order to develop an analytical knowledge base required for sound decision making coupled with the need to meet the various requirements under the Convention and its Kyoto Protocol and Paris Agreement. The assessment revealed gaps related to access to climate information required to make informed decisions on climate change actions and the role of stakeholders in the dissemination of climate information. The assessment also outlined gaps related to documentation of adaptation and mitigation activities to support adoption of various climate change actions. In order to address the information gaps, the National Climate Change Communication and Advocacy Strategy was developed in 2011. The strategy has been used as an important tool for engagement of stakeholders in the dissemination of climate change information in the country.

The country also conducted the technology needs assessment to identify and prioritize country driven technologies that can contribute to achievement of mitigation and adaptation goals. This assessment enabled the country to identify barriers hindering the acquisition, deployment and diffusion of prioritized technologies. Further the country developed technology action plan specifying activities and enabling frameworks to overcome the barriers and facilitate transfer, adoption and diffusion of technology.

In addition, an economic assessment of the impacts of climate change cost was conducted in 2010, which estimated the cost of climate change for different sectors in the country. A situation analysis on the state of climate finance readiness in Zambia was conducted in 2014 under the UNDP readiness for climate finance "experiences from Eastern and Southern Africa". The analysis revealed that although Zambia has tapped into climate resources, these remain inadequate to meet the scale and urgency of need for both adaptation and mitigation. Capacity is still needed at both national and local government levels particularly in raising climate funds and translating policies and strategies into bankable projects and implementing them. National capacity to access climate finance was limited by the absence of an accredited National Designated Authorities (NDA) for Green Climate Fund (GCF) and Adaptation Fund. The country's capacity to access climate finance is further limited by the low participation of the private sector. However, in an effort to scale up mobilization of climate finance, Zambia has established an NDA for GCF which continues to play an active role in building awareness about GCF, climate financing and facilitates project preparation with sector ministries in collaboration with international accredited entities to GCF.

The country continues to face constraints and gaps on access to climate finance, Technology development and transfer and capacity building due to inadequate and unpredictable financial resources from domestic and external sources. Despite these constraints and gaps, government has provided an enabling environment to facilitate smooth implementation of climate change actions by enacting the National Policy on Climate Change which provides legal and institutional framework for coordinated response to climate change challenges.

### 6.5.1 Support Received for Implementation of Climate Change Activities

Zambia continues to propose and leverage opportunities on climate financing from bilateral, multilateral and other sources. The country mobilized resources amounting to USD 530,601,180 for various mitigation and adaptation actions. The government also received financial support from GEF amounting to USD 500,000 for the preparation of the TNC. In addition, government also contributed USD 62,000 as in-kind contribution towards the process. Technical support for the preparation of TNC was received from the GSP, UNEP, UNDP, GIZ, UNFCCC and the National Technical Committee on climate change. Table 6.4 summarizes the financial support received towards implementation of climate change activities;

**Table 6.4: Financial Support Received Towards Implementation of Climate Change Activities**

| No. | Programme/Project | Focal Area | Status | Amount (USD) | Source of Support |
|---|---|---|---|---|---|
| 1. | Adaptation to The Adverse Effects of Climate Change and Variability in Agriculture in Agro Ecological Zone I And II (Parts of Western, Southern and Provinces) | Agriculture Productivity | On going | 3,795,000 | GEF/UNDP |
| 2. | China-Zambia South-South Cooperation on Renewable Energy Technology Transfer | Enhanced capacity for South-South development cooperation between China and countries in Africa within renewable energy transfer has been developed and tested. | On going | 2,624,000 | UNDP, Denmark, China |
| 3. | Conservation Agriculture Scaling Up | Conduct adaptive CA research<br>• Promote ADP & mechanization for tillage, spraying & | On going | $12,760,000.00 | EU/FAO |

| | | | | | |
|---|---|---|---|---|---|
| | | other CA farming functions | | | |
| 4. | Development of Renewable Energy Feed-in Tariff (REFiT) Strategy and Implementation of Global Energy Technology Feed-in Transfer (GETFiT) | • Improved planning and utilisation of Energy Resources<br>• Promotion of Private Sector participation in Energy sector | Closed in 2017 | $88,460,000.00 | KfW, USAID, GCF, AfDB |
| 5. | Earth observations for drought, soil and vegetation monitoring | • Tools for processing satellite images to monitor temperature, vegetation cover, stress and soil moisture were developed. These tools will enable the remote quantification of geographical effects of climate change such as temperature rise as well as the climate change induced drought experienced by several local communities. These will be among the tools set up to combat the adverse effects of climate change. | On-going | $13,580.00 | GRZ |
| 6. | Electricity Services Access Program (ESAP) | Increased access to electricity | Ongoing | $26,500,000.00 | WB |
| 7. | GRZ-UN Joint Programme on Climate Change and Disaster Risk Reduction | Revised and harmonized policy, legal and regulatory frameworks for the coordination of climate change | Closed | $20,150,000.00 | UNDP, FAO, WFP, UN-Habitat, UNICEF, UNIDO, UNCCD |

| | | | | | |
|---|---|---|---|---|---|
| | | adaptation, mitigation responses in agriculture, forestry, energy, industry and water sectors in place and functional | | | |
| 8. | Health National Adaptation Plan (HNAP) to Climate Change | Strengthened mainstreaming of the response of the heath sector to climate change;<br>• Reduced climate change, risks | On going | $101,021,000.00 | UNJP, UNDP |
| 9. | Monitoring Land Use Land Cover dynamics using remote sensing Drought research & Flood monitoring | • Land Cover Maps for capturing and monitoring the status of land parcels in terms of the type of geographic features on the land parcel | On going | $15,000.00 | |
| 10. | Nationally Determined Contributions Support Programme | NDC governance/management system, with associated Measuring Reporting and Verification (MRV) system | On going | $806,000.00 | UNDP |
| 11. | Phasing out incandescent bulbs & distribution of energy saving bulbs | Increase efficiency in energy use | Yet to be implemented | $10,000,000.00 | none |
| 12. | Scaling Renewable Energy Project (SREP) | Diversified energy mix.<br>• Increased energy generation from renewable energy sources.<br>• Improved energy security due to increased energy mix | On going | $40,300,000.00 | WB, CIF |

| | | | | | |
|---|---|---|---|---|---|
| 13. | Scaling up Renewable Energy (Solar) (Scaling Solar Project-Round 1 of up to 100 megawatts (MW): 2 plants of 50 MW each. | • Diversified energy mix.<br>• Increased energy generation from renewable energy sources | On going | $252,000.00 | WB, IFC, Power Africa |
| 14. | Strengthening Climate Resilience in the Kafue Sub – basin | Reduction in damage /loss from extreme climate events<br>• Opening up access to markets for the famers for selling their farm produce by construction and rehabilitation of an all-weather road from Kalomo-Dundumwezi road. | On going | $36,000,000.00 | World Bank |
| 15. | Strengthening Climate Resilience of Agricultural Livelihoods in Agro-Ecological Zones I & II in Zambia | Smallholder farmers are able to plan for and manage climate risks to inform resilient-agricultural production<br>•Farmers adopt and maintain resilient agricultural livelihoods in the face of changing rainfall, increasing drought and occasional floods<br>•Increasing farmers' access to markets and commercialization of resilient agricultural products | On going | $47,500,000.00 | GEF, UNDP |

| | | | | | |
|---|---|---|---|---|---|
| 16. | Strengthening Integrated Adaptation Planning and Implementation in Southern Africa Smallholder Agricultural Systems to Support Food Security. | •Strengthened technical capacity for synthesis, analysis and transfer of climate and bio-physical data and information for assessment of vulnerabilities and risks and promoted climate information services | On going | - | FAO/Government of Flaunders |
| 17. | Zambia Strengthening Climate Resilience – Pilot Programme for Climate Resilience Phase II in the Barotse Sub – basin | Enhancing resilience through provision of the Climate smart infrastructure, information provision, | Ongoing | $36,000,000.00 | World Bank |
| 18. | Upscaling charcoal briquette project in Mambwe District of Western Province | Setting up production facilities of charcoal briquette and Skills transfer | On going | $10,600.00 | NTBC |
| 19. | Implementation of the 'Green Village Programme' piloted through the Lundazi Green village Project (Micro-Grid Solar Power system – 48 KW) | Electrification of a village of 300 households; the Chief's Palace; a health Centre; a school and 20 local business houses using renewable energy technology (48 KW Off-grid micro grid Photo-Voltaic (PV) Solar system | On going | $959,000.00 | Dannish, Finnish/GRZ<br><br>(IEF) |
| 20. | Promoting climate resilient, community-based regeneration of indigenous forests in Zambia's Central Province | Strengthened technical and institutional capacity of foresters and communities in Central Province to implement appropriate climate- | On going | $3,885,000.00 | UNDP |

| | | | | | |
|---|---|---|---|---|---|
| | | resilient agro-forestry and natural regeneration practices | | | |
| 21. | Strengthening Climate information and Early warning system in Eastern and Southern Africa for climate resilient development and adaptation to climate change (National with emphasis in AER I &II) Strengthening Climate information and Early warning system in Eastern and Southern Africa for climate resilient development and adaptation to climate change (National with emphasis in AER I &II) | 28 Automatic Weather Stations (AWS) installed in 28 districts<br>• 41 existing Manual Weather stations rehabilitated. | Closed in 2018 August | $4,000,000.00 | GEF, UNDP |
| 22. | Zambia Integrated Forest Landscape Programme | Increased carbon mitigation from agriculture and forestry;<br>• Improved agricultural productivity; | On going | $95,550,000.00 | WB, IDA, GEF |

### 6.5.2 Capacity Needs

In order to improve the National Communication process, Zambia will require various capacity building support. The support will be required in GHG inventory, Vulnerability and Adaptation Assessment, mitigation process and in research and systematic observation. The major support areas required are elaborated as follows:

#### 6.5.2.1 GHG Inventory

The GHG inventory carried out under the TNC has a number of gaps as a result of inadequate activity data, country specific emission factors and the overall technical capacity among the various institutions. In order to improve the accuracy of the inventory, the following capacity needs have been identified:

i. Financial and technical support to research institutions to enable them undertake specialised studies that can enhance generation of activity data and country specific emission factors across the energy, IPPU, AFOLU and waste sectors.
ii. Development of training courses for sectors and institutions responsible for specific inventory processes such as energy, industry and waste, among others.
iii. Infrastructure development for data sharing and archiving to ensure harmonized reporting formats for activity data.
iv. Financial support towards tools for data collection and analysis.

#### 6.5.2.2 Vulnerability and Adaptation Assessment

i. Strengthen capacity among research institutions and coordinating bodies in the use of various climate models to enhance vulnerability assessments;
ii. Financial support to enhance climatic data collection and analysis in order to ascertain their impact on key economic sectors such as agriculture and food security, health, water resources and hydrology, tourism, forestry, infrastructure etc.;
iii. Technological support towards enhancing early warning systems;
iv. Technical support in the area of strategic environmental assessment as an enabling environment to ensure proper planning and development of key infrastructure that could be resilient to climate change.
v. Technical and financial support for research to enhance adaptive capacity key sectors such water, health and agriculture.

#### 6.5.2.3 Mitigation Process

i. Technical capacity among research institutions and coordinating bodies in the use of various climate mitigation models; and
ii. Technical support on the feasibility studies on alternative energy sources.

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## ANNEX

### Table 7.1 List of Stakeholders Consulted for the preparation of the TNC

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| 7. | Ministry of Commerce, Trade and Industry (Dept of Industry) | Mr. John A. Mulongoti (Director Industry)/<br>Charity Banda (Senior Economist) | John.Mulongoti@mcti.gov.zm<br>+260 211230096/226454<br>charity.banda@mcti.gov.zm |
| 8. | COMACO | Mr. Richard Mumba (Chief Agric Officer) Edward Zulu (Senior M&E officer) Japhet Seulu | crmumba@itswild.org<br>0976918300,<br>ezulu@itswild.org<br>0977716534,<br>jseulu@itswild.org<br>0955265499 |
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| 11. | Ministry of Lands & Natural Resources | Mr. Biston Mbewe (Project Manager) | biston.mbewe@undp.org<br>0978887399 |

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|---|---|---|---|
| | (FD) –Regeneration Project | | |
| 12. | ZEMA | Mr. Micheal Annel Phiri (Manager-Natural Resources & Climate Change)<br>Mr. Chrispin Simwanza (Principal Inspector-Air & Noise)<br>Josphat Sichula (Senior Inspector) | aphiri@zema.org.zm<br>0977510864 or 0211254130<br>csimwanza@zema.org.zm<br>0966668843<br>jsichula@zema.org.zm |
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| 16. | MUHANYA SOLAR | Mr. Geoffrey Kaila (Managing Director) | geoffreykaila@gmail.com<br>muhanyasolar@zamnet.zm<br>0975998340 or 0955882152 |
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| 22. | ZCCN | Mr. Patrick Kapanda Kabanda | kabandapk@gmail.com<br>kabandapk@zccn.org<br>0978574924 |
| 23. | Ministry of Transport | Mr. John C Chiluwe (Assistant Director Transport – Road and Railway) | johnchiluwe@yahoo.co.uk<br>0955113006/ 0977400594 |

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| 34. | Dangote | Mr. Victor Mpundu (Acting Environmental Coordinator) | victor.mpundu@dangote.com<br>victormpundu23@gmail.com<br>+260 971260607/ +260 964710912 |
| 35. | Zambezi Portland | Mr. Muyunda Aongola (Safety and Environment Manager)<br>Mr. Raul (Acting General Manager) | safety@zpcltd.net<br><br>+260 968739840 |
| 36. | Ndola Lime | Mr. Sydney Matamwandi (Engineering Manager)<br>Mr. Gilbert Sikazwe (Acting Production Manager) | smmatamwandi@ndolalime.co.zm<br>Sydney.matamwandi@outlook.com<br>+260 966617190<br>gsikazwe@ndolalime.co.zm |

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|---|---|---|---|
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