The United Republic of Tanzania

NATIONAL CLIMATE CHANGE STATISTICS REPORT, 2019

TANZANIA MAINLAND

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Production of National Climate Change Statistics Report, 2019 (NCCSR, 2019) is a collaborative effort between the National Bureau of Statistics, (NBS); a designated National Technical Committee (NTC), with members drawn from various Ministries, Departments and Agencies (MDAs); the Germany International Cooperation, (GIZ); United Nations Statistics Division (UNSD); the Global Partnership for Sustainable Development Data, (GPSDD) and the United Nations Environment Program, (UNEP). Financial resources for this work were provided by the Government of the United Republic of Tanzania, (URT); the Germany International Cooperation, (GIZ); and the United Nations Environment Program, (UNEP).

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Foreword

The National Climate Change Statistics Report, 2019 is the first report concerning climate change to be produced by the National Bureau of Statistics (NBS). Data used in this Report have been synthesized from various publications and reports which are relevant to climate change. Such publications and reports have been produced by various Ministries, Departments and Agencies, (MDAs) and they report on various aspects of the climate change such as: - emissions; conditions of weather and atmosphere; hydrological and water resources or occurrence of extreme events and disasters, to mention but a few. These bits of information relevant to various elements of climate change have been coined into this statistical report: the National Climate Change Statistics Report, 2019 (NCCSR). Publication of NCCSR, 2019 is therefore, the first ever effort in Tanzania of pooling together climate change data that are scattered across a range of institutions into analytical report, which provides a statistical perspective of the problem of climate change in Tanzania.

Impacts of climate change are already experienced in Tanzania. There are already obvious manifestations of its impacts in many places of the country. Some of these impacts include: - frequently occurring floods and draughts; rise of sea level; reduced crop productivity and dwindling of water resources. For this reason, climate change effects are likely to have huge impacts on social and economic subsystems and potentially hampering efforts towards achievement of national and global development aspirations. In response to threats posed by climate change, Tanzania has been implementing a number of programs with the overall objective of: - mitigating climate change process drivers; enhancing adaptive capacities; and responding to the call of the international community to protect the planet.

In order to track progress of all development frameworks and programs related to climate change, availability of timely data, accessibility and its use are critical. For this reason, publication of the NCCSR, 2019 is a vital undertaking for enhancing availability of data and for building awareness of climate change and its impacts. The NCCSR, 2019 will provide vital insights into a number of programs for addressing climate change, particularly data for following-up the some important Multilateral Environmental Agreements (MEAs) on climate change such as: - the Kyoto Protocol to the United Nations Framework Convention on Climate Change

1997; the Montreal Protocol on Substances that Deplete Ozone Layer, 1987; and the Paris Agreement for Climate Change, 2016.

Production of NCCSR, 2019 is a result of collaborative efforts between the National Bureau of Statistics, (NBS); a designated National Technical Committee (NTC), with members drawn from Ministries, Departments and Agencies (MDAs); the Germany International Cooperation, (GIZ); the United Nations Environment Program, (UNEP); the Global Partnership for Sustainable Development Data, (GPSDD) and the United Nations Statistics Division, (UNSD).

Financial resources for this work were provided by the Government of the United Republic of Tanzania, (URT); the Germany International Cooperation, (GIZ); and the United Nations Environment Program, (UNEP). For this reason, I would like to extend my sincere gratitude to the Government of URT; the GIZ; and the UNEP for financing this important national undertaking. I am also very appreciative of members of the NTC for their tireless efforts to ensure this report is of the expected quality.

Comments and suggestions for improving quality of future reports are welcome.

Dr. Albina Chuwa,
Statistician General.
National Bureau of Statistics.

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Acronyms and Abbreviations

°C	Degrees Celsius
BAU	Business – As - Usual
BEST	Biomass Energy Strategy in Tanzania
CFCs	Chlorofluorocarbons
CH_4	Methane
CO_2	Carbon Dioxide
DGA	Data Gap Assessment
FDES	Framework for Development of Environment Statistics
GDP	Gross Domestic Product
Gg	Giga gram
GHGs	Green House Gases
GIZ	Germany International Cooperation
HCFCs	Hydro chlorofluorocarbons
IMS	Institute of Marine Science
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter Tropical Convergence Zone
JNIA	Julius Nyerere International Airport
LTM	The Long Term Mean
LULUCF	Land Use, Land-Use Change and Forestry
MDAs	Ministries, Departments and Agencies
MEAs	Multilateral Environmental Agreements
MT	Metric Tons
N_2O	Nitrous oxide
NBS	National Bureau of Statistics
NCCSR	National Climate Change Statistics Report
FYDP II	Five Year Development Plan II
NMVOCs	Non - Methane Volatile Organic Compounds
NOx	Nitrogen Oxide
NTC	National Technical Committee
NTP	National Transport Policy
ODS	Ozone Depleting Substances
SO_2	Sulfur dioxides
TANESCO	Tanzania Electricity Supply Company
TMA	Tanzania Meteorological Agency

UNFCCC	United Nations Framework Convention on Climate Change
UNSD	United Nations Statistics Division
URT	United Republic of Tanzania
DfID	Department of International Development
DLDD	Land Desertification, Land Degradation and Drought
GCM	Global Circulation Model
GgCO2e	Giga gram of carbon dioxide equivalent
Ha	Hectare
$ktCO_2e$	Kilo tons of carbon dioxide equivalent
LUCF	Land Use Change and Forestry
Mm	Millimeters
MNRT	Ministry of Natural Resources and Tourism
MoM	Ministry of Minerals
MoWI	Ministry of Water and Irrigation
$MtCO_2e$	Metric tons of carbon dioxide equivalent
NEMC	National Environment Management Council
NESR	National Environment Statistics Report
NTC	National Technical Committee
^oF	Degree Fahrenheit
SDGs	Sustainable development Goals
SEI	Swedish Environmental Institute
SNC	Second National Communication
tCO_2e	Tons of carbon dioxide equivalent
UN	United Nations
UNEP	United Nations Environment Programme
USD	United States Dollars
VPO	Vice President's Office
NASA	National Aeronautics and Space Administration
SNC, 2014	Second National Communication Report, 2014

Definitions

Monthly mean minimum temperature refers to average minimum temperature for a period of one month.

The Long term mean (LTM) minimum temperature is the mean value of monthly average minimum temperature over the period of 30 years (1981 - 2010).

Monthly mean maximum temperature refers to average maximum temperature for a period of one month.

Long Term Mean (LTM) maximum temperature is the mean value of monthly average maximum temperature over the period of 30 years (1981–2010).

Annual Mean Maximum Temperature refers to average maximum temperatures for a period of one year.

Annual Mean Minimum Temperature refers to average minimum temperature for a period of one year.

Annual rainfall refers to total amount of rainfall over a period of one year for the location (station).

Monthly total rainfall refers to total amount of rainfall accumulated over a period of one month.

Long term mean (LTM) rainfall is the mean value of monthly total rainfall over the period of 30 years (1981 – 2010).

Sea level rise refers to a gradual increase in the level of the surface of the sea in relation to the land.

A forest is defined as a piece of land with trees more than 0.5 ha and a canopy cover of at least 10% and where the trees have a height of more or equal to 5 metres.

Forest resources means a forest and forest products including anything which is produced by or from trees or grows in a forest or is naturally found in the forest.

Endemic flora and fauna species are species which occur in only one geographical region.

Coral bleaching refers to the loss of the zooxanthellae by the host (i.e. the coral), or the loss of photosynthetic pigments within the alga itself, which makes the coral transparent.

An extreme event is one that is rare within its statistical reference distribution at a particular location.

A disaster is an unforeseen and often sudden event that causes great damage, destruction and human suffering.

Climate change mitigation refers to efforts to reduce or prevent greenhouse gas emissions.

Climate change adaptation is an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Greenhouse gases: The atmospheric gases responsible for causing global warming and climatic change.

Acknowledgements

Appreciations are particularly extended to Ruth Minja, (Ag. Director for Population Census and Social Statistics; and the Environment Statistics and Further Analysis Departmental Manager, NBS); Jafari chobo, (Tanzania Meteorological Agency, TMA); Ndalu Youbert Amos (National Environment Management Council, NEMC); Diana Kimbute (Ministry of Water and Irrigation); Jackson Birore, (Ministry of Mineral); Dr. Annes Mahenge, (Ardhi University); and Deogratius Malamsha; Pius Kaskana; John Lyakurwa; Moris Mulilo; and Hashim Njowele (NBS).

Executive Summary

The National Climate Change Statistics Report, 2019 (NCCSR) is structured in five chapters. Chapter One presents overview of climate change in Tanzania and methodology for development of the NCCSR. Main statistical tables, charts and analysis for climate change are presented from Chapter Two to Chapter Four. Chapter Five focuses on mitigation and adaptation efforts undertaken by the Government of Tanzania to curb emissions of Green House Gases (GHGs) and build resilience against the impacts of climate change.

Statistics in Chapter Two analyses emissions of GHGs (Carbon Dioxide, CO2; Methane, CH4; and Nitrous Oxide, N2O). The national estimates indicate that, Tanzania has negligible emissions levels of GHGs in terms of total and per capita whereby per capita emissions are estimated at 0.2 tCO2e. The principal source of GHGs emissions in Tanzania is the Land Use, Land-Use Change and Forestry (LULUCF). Emissions from the LULUCF sector contribute about two-thirds of overall emission levels in Tanzania. Other sectors which contribute to greenhouse gas emissions in the country are Agriculture, Energy, Waste and Industrial Process and Product Use.

With regard to the use of Ozone Layer Depleting Substances (ODS), results reveal that, HC 600a is the most used ODS alternative in Tanzania. Its consumption increased from 232.6 MT in 2012 to 636.4 MT in 2015. Other ODS alternatives in great use are HFC-134a and R-717, with consumption increasing from 18.2 MT to 30.4 MT and 16.7 MT to 30.2 MT respectively between 2012 to 2015.

Statistics in Chapter Three show evidences of climate change in recent periods. The mean monthly maximum temperatures (28.5 °C) for the short period (2012-2018) are slightly higher than the long term monthly means for 1981-2010 recorded at 28.2 °C which indicates an increasing pattern of temperature over the same shorter period. The data also indicate increased trends of precipitation in recent period. The monthly average rainfall (85.4 mm) observed for the short period of 2012 - 2018 is slightly higher than the monthly average rainfall (83.3 mm) recorded for the long term period, 1981-2010. In addition, there is a gradual rise of mean sea level from 1,992 mm in 2000 to 2,115 mm in 2019.

Chapter Four presents the impacts and vulnerability associated with climate change on social economic development initiatives in the country. The chapter

presents the impact and vulnerability of climate change in water resources from water bodies of Mtera Reservoir and Lake Salunga as a case study. The selected case studies indicate increased stress on water resources due to climate change. For instance, geo-spatial images of Mtera Reservoir and Lake Salunga indicate dwindling of water resources over time. It is found that as of 2018, nearly half of the Mtera reservoir held between 20 - 30 percent of water levels it once held. The same is observed for Lake Sulunga, with nearly half of it transforming from water to no water from 2001 to 2019.

Lastly, Chapter Five focuses on mitigation and adaptation. Despite the negligible emissions of GHGs, Tanzania is actively participating in mitigation activities to contribute sustainable national development. Several policies, legislations, regulations, strategies, plans and guidelines have been put in place for climate change mitigation. Some of such policies and frameworks include:- The National Energy Policy (2015); The National Petroleum Policy of Tanzania (2015); Petroleum Act (2015); Paris Agreement on Climate Change (2018); National Framework for Climate Services (2018); and the National Climate Change Strategy (2012).

The country has also developed and implemented programmes and projects for climate change adaptation including: Adaptation Fund project implemented in the Coastal regions of Tanzania (2017); Implementation of Concrete Adaptation Measures to Reduce Vulnerability of livelihood and economy of Coastal Communities of Tanzania (2012-2018); Mainstreaming Environmental and Climate Change into development plans and, national policies 2012-2015; and Africa Adaptation Programme project (2010- 2012).

CHAPTER ONE

An Overview of Climate Change in Tanzania

1.1 Introduction

Climate change is one of the greatest environmental challenges facing the world. Its impacts are felt in all countries but the impacts are differently distributed amongst regions, generations, and socio economic classes. The adverse impacts of climate change such as droughts and floods are already evident in almost all sectors of the economy in the Tanzania leading to major economic costs, loss of life, properties and other human capital.

1.2 Difference between Weather Variability and Climate Change

Weather is measured in a short periods or time spans and refers to changes in the atmosphere at a specific place and time. An example is the weather report on the nightly news which gives a synopsis of recorded changes in the atmosphere for a few hours up to a week, whether it is sunny, windy, cloudy or rainy. Climate, on the other hand, happens over longer periods of time and is the calculated average state of the weather over seasons, decades or centuries. In simple words, weather is examined in days and weeks while climate is measured very slowly over time, spanning many years.

Climate change is a long-term shift in weather conditions identified by changes in temperature, precipitation, winds and other indicators. Climate change can involve both changes in average conditions and changes in variability, including extreme events.

Is the Global Climate Changing?

The earth's climate naturally changes and this is evident throughout history. Scientists have attributed these changes to slight variations in the earth's orbit and the amount of energy from the sun that enters the earth. Other natural changes to climate can be volcanic eruptions and changes in the ocean.

Many people in the scientific community believe, however, that the world's climate has changed at a faster pace since the advent of the industrial revolution that took place from the 18th and 19th centuries. Before the revolution, people used basic hand tools and machines, engaged in farming and worked from home. The revolution saw a departure from this towards the use of heavy specialized machines, construction of factories and mass production. Metals such as iron ore were used in the production of steel; fossil fuels, such as coal, were used as energy. It is believed that human activities that began at that time and persisted and grew throughout the following centuries resulted into a faster increase of the earth's warming leading to climate change. The burning of fuels such as coal, oil and gas has caused gases that trap heat e.g. carbon dioxide (CO_2) to enter the air. These gases are referred to as **greenhouse gases** and contribute to **global warming.**

The data from global estimate shows that, with the exception of 1998 which registered an average temperature of 0.64^{o}C, the ten warmest years have all occurred since 2000. The warmest years by far were recorded in 2015 and 2016 with increased temperatures of 0.87^{o}C and 0.99^{o}C respectively.

1.2 Climate Change in Tanzania

Tanzania is one of the largest countries in East Africa and has a rapid population Rated at 2.7 percent per annum and economic growth of about 7.0 percent per year. Growing population and economy are putting more pressure on natural resources utilization and increasing GHG emissions hence making the country more vulnerable to climate change impacts.

According to Tanzania National Population Projections of 2018, the population of Tanzania in 2019 is 56 million. This population is expected to increase to 133 million by 2050. One-third of the population lives in urban areas characterized by high population densities which eventually lead to inadequate access to social services. A larger proportion of population in urban areas lives in informal

settlements which are mostly at risk from water scarcity, flooding and heat extremes.

About two-thirds of the population lives in rural areas, which largely depend on rain fed agriculture. Population pressure and climate change may negatively impact on production of important food crops including maize, beans, sorghum and rice. This might endanger livelihoods and food security. In addition, population which depends on coastal and inland fisheries is increasingly threatened by increasing ocean and freshwater temperatures, and sedimentation after heavy rains. Sea level rise is putting coastal infrastructure, coastal populations (about 25 percent of the total population), and coastal ecosystems at risk of inundation, salinization and storm surge (World Bank 2015).

Since 2008, Tanzania has witnessed severe floods and drought spells in different parts of the country, including Dar es Salaam, Kilosa, Mpwapwa, and Kilombero that resulted into severe infrastructure and houses destruction and displacement of people. Moreover, water wells pollution has been witnessed along the coast due to the rise of sea level attributed to climate change. Evidences have shown some considerable submerging of the Islands such as Pangani and Fuvu la Nyani in Rufiji due to the rise of sea level. Also there has been gradual decrease of glaciers on the top of Mount Kilimanjaro since 1912 due to increase in temperature.

1.3 Methodological Approach for Developing the NCCSR, 2019

Compilation of national climate change statistics report is a challenging undertaking in many developing countries including Tanzania, because data informing on climate change is scattered across different institutions. This hinders coordination and harmonization, as it results into existence of datasets which are incomparable and incomplete with most of the data required not being produced.

In order to come up with the NCCSR,2019 desk reviews were conducted based on the Framework for Development of Environment Statistics (FDES, 2013) in which data availability, accessibility, data sources, frequency of data production, producing agencies were assessed.

1.4 Data collection

The process of developing this report started by conducting identification of agencies which produce climate change related data. National datasets from published documents, reports and agencies' websites were used. Where national datasets were not available, data were extracted from reputable international agencies' datasets available on their respective publications and websites. Most of agencies producing data on climate change related in Tanzania with exception of Tanzania Meteorological Agency (TMA) did not have adequate data on climate change. Most had data for the past five to ten years depending on the nature and type of the data in question. The review of available data was carried out to make sure data coincide with national requirements, FDES and Inter-Governmental Panel on Climate Change (IPCC) guidelines.

NBS established the National Technical Committee with representatives from Ministries, Departments and Agencies (MDAs); working on disciplines related to climate change such as TMA, National Environment Management Council (NEMC), Ministry of Water and Irrigation (MoWI), Ministry of Agriculture (MoA), Prime Minister's Office (PMO), Vice President's Office (VPO) and Ministry of Energy (MoE). The main tasks of the National Technical Committee were to coordinate data collection for climate change statistics at their respective institutions and engage in compilation of this report.

Customized data collection tools (questionnaires) were also developed to collect data from the identified agencies. Data collection tools were pretested and information collected was used to test the validity of designed tables of each chapter and subchapters of the report.

1.5 Data gap assessment

The main objective of conducting the Data Gap Assessment (DGA) was to assess the national capacity in production of data related to climate change. The first level of DGA involved assessing various attributes of data production at MDAs. It focused on data availability, frequency of data production, accessibility, producing institutions, data sources, availability of proxy indicators for missing data and institutional capacity in data production and management.

The second level of DGA involved review and domestication of the draft list of climate change indicators developed by the UN Statistics Division (UNSD). It involved mapping of domesticated climate change indicators with programs such

as National Five Year Development Plan II; 2016/2017 – 2020/2012 and the Sustainable Development Goals; 2030.

Data gap assessment revealed that, the existing National Environment Statistics Report (NESR) 2017; provides general set of environment statistics at the national level in which climate change statistics is imbedded. However, there is no specific chapter or separate section which provides in more details indicators which can be used to assess climate change in separate fashion.

The FDES, 2013 provides in more details 105 indicators which can be used to assess climate change. Out of 105 identified indicators, 10 indicators (9.5 percent) are also stated within the FYDP II, and 25 indicators (23.8 percent) are aligned with SDGs. A total of 95 indicators (90.5 percent) and 80 indicators (76.2 percent) are not found explicitly within the FYDP II and SDGs respectively. Out of 105 identified indicators 67 of them (63.8 percent) are currently being collected and compiled under the NESR. The summary of DGA results is presented in Table 1.1.

Table 1. 1: Results of the DGA and mapping of climate change indicators

Category of indicator	Total	Number of indicators in each FDES 2013 tiers			Identified climate change indicators according to FDES				Potential indicators which can be collected	Indicators which cannot be collected
					Aligned with		Not aligned with			
		Tier [1]1	Tier [2]2	Tier [3]3	FYDP II	SDGs	FYDP II	SDGs		
Climate change process drivers	14	3	11	0	0	1	14	13	14	0
Climate change evidence	14	7	6	1	1	0	13	14	14	0
Climate change impacts and vulnerability	56	19	17	20	6	20	50	36	33	23
Mitigation and Adaptation	21	4	8	9	3	4	18	17	21	0
Total	105	33	42	30	10	25	95	80	82	23
Percentage Total	**100**	**31.4**	**40**	**28.6**					**78.1**	**21.9**

[1] ***Tier 1*** *is the basic minimum set of environment statistics which all countries, at any stage of development, are recommended to consider collecting;*

[2] ***Tiers 2*** *include environmental statistics that countries are highly encouraged to have if the situations apply.*

[3] ***Tier 3*** *includes environmental statistics which, while still important and widely applicable, require a more significant investment in time, resources or technological development.*

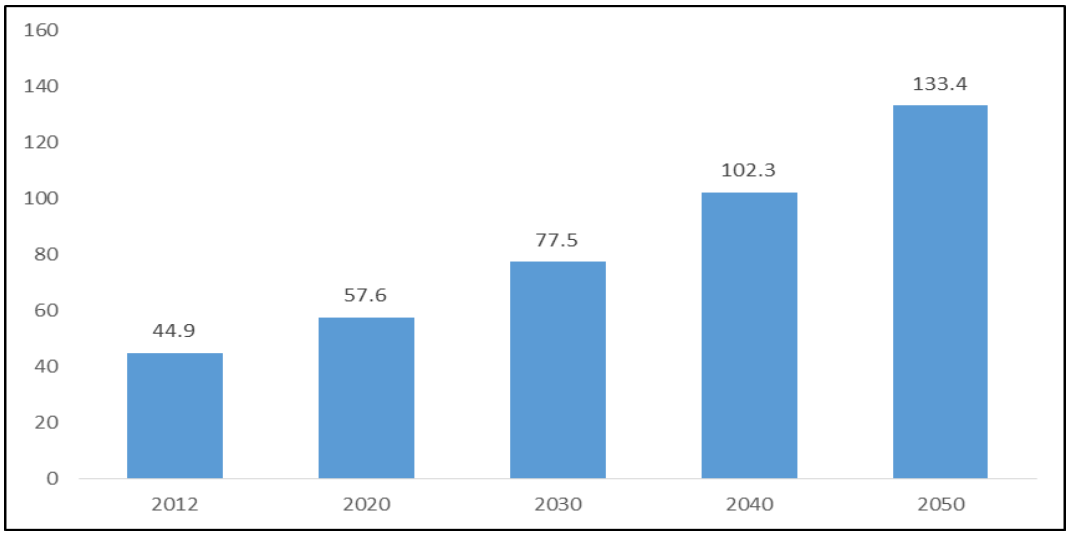
CHAPTER TWO

Climate Change Process Drivers

2.1 Introduction

Climate change process drivers are GHG emissions associated with current production and consumption patterns. The key drivers of emissions include population growth and economic development. By 2050, Tanzania's rural population is expected to grow by more than 60 percent, which will intensify pressure on natural resources. The share of the population living in rural areas is expected to drop from 70.4 percent in 2012 to 47 percent in 2050, as people continue to migrate to urban areas and establishment of new urban areas. However, due to high population growth, the absolute number of people in rural areas is expected to increase from 32 million in 2012 to 63 million in 2050. These rapid demographic changes will be important in changing patterns (both spatial and temporal) of future demand for energy and transport services, and will in turn affect GHG emissions.

Chart 2. 1: Projected population growth in Tanzania, 2010-2050



Source: National Population Projections, 2018

Human activities are also important drivers of GHG emissions due to the linkage between energy demand and social-economic activities. The growing population, rapid urbanization, industrialization, use of high technology production

equipment; construction of roads and bridges, and high demand for vehicles, all are likely to make the country more vulnerable to potential impacts of climate change.

2.2 Greenhouse gas emissions in Tanzania

According to Tanzania's Intended Nationally Determined Contribution (INDC) 2015, the country has negligible emissions of greenhouse gases (total and per capita), whereby per capita emissions are estimated at 0.2 tCO_2e. On the other hand, the country has a total of 88 million hectares of land areas, of which 48.1 million hectares are forested land and under different management regimes, with a current estimated total of 9.032 Trillion Tons of carbon stock (INDC, 2015).

2.3 Emissions to Air

Emissions to air are gaseous and particulate substances released to the atmosphere by establishments and households as a result of production, consumption and accumulation processes. IPCC considers five sectors to be the major contributors of greenhouse gas emissions. These are:- Land Use Land Use Change and Forest (LULUCF); Agriculture; Waste; Energy; and Industrial processes. Table 2.1 highlights the potential emissions of these sectors in Tanzania economy.

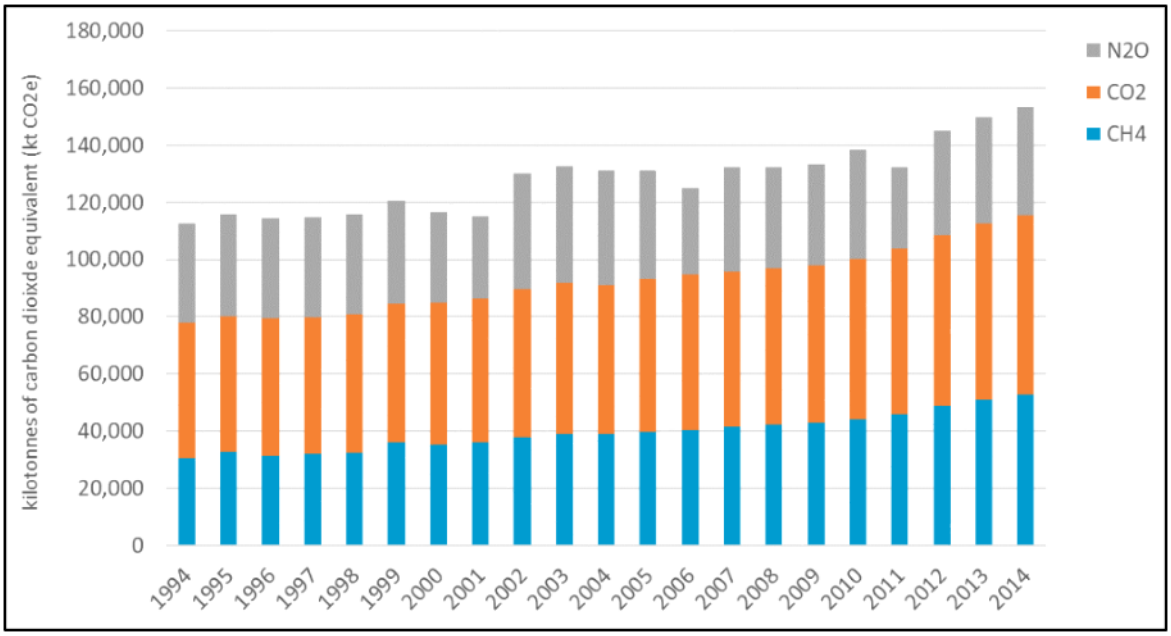
Table 2. 1: Major Sources of Emissions

Sector	CO_2	CH_4	N_2O	NO_X	NMVOC	SO_2
LULUCF	√	√	√	√	×	√
Agriculture		√	√	√		
Waste		√	√			
Energy	√	√	√		√	√
Industrial processes	√	√	√			√

2.4 Direct GHG Emissions

Emissions of GHG can be analyzed from two dimensions; direct GHG and indirect GHG. The direct GHGs are considered to be the main climate change process drivers. These are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The indirect GHGs are sulfur dioxide (SO_2), nitrogen oxides (NOx) and Non-Methane Volatile Organic Compounds (NMVOCs). Due to lack of data, emissions of these gases have not been estimated.

Chart 2. 2: Summary of national GHGs emissions (1994-2014) by gas



Source: Vice President's Office

The national estimates for emissions of direct GHGs presented in Chart 2.2 indicates that, in terms of magnitudes, the chief contributor of emission of direct GHGs in Tanzania is Carbon dioxide (CO2) followed by Methane (CH4) and to a lesser extent Nitrous oxide (N2O). Chart 2.2 also indicates that, there has been a steady increases of emissions of Carbon dioxide and methane over the years, albeit gradually. Emissions from nitrous oxide haven't had a definite trend across the time series.

2.5 GHGs Emissions by Sector

Chart 2. 3: Summary of national GHGs emissions (1994-2014) by Sector

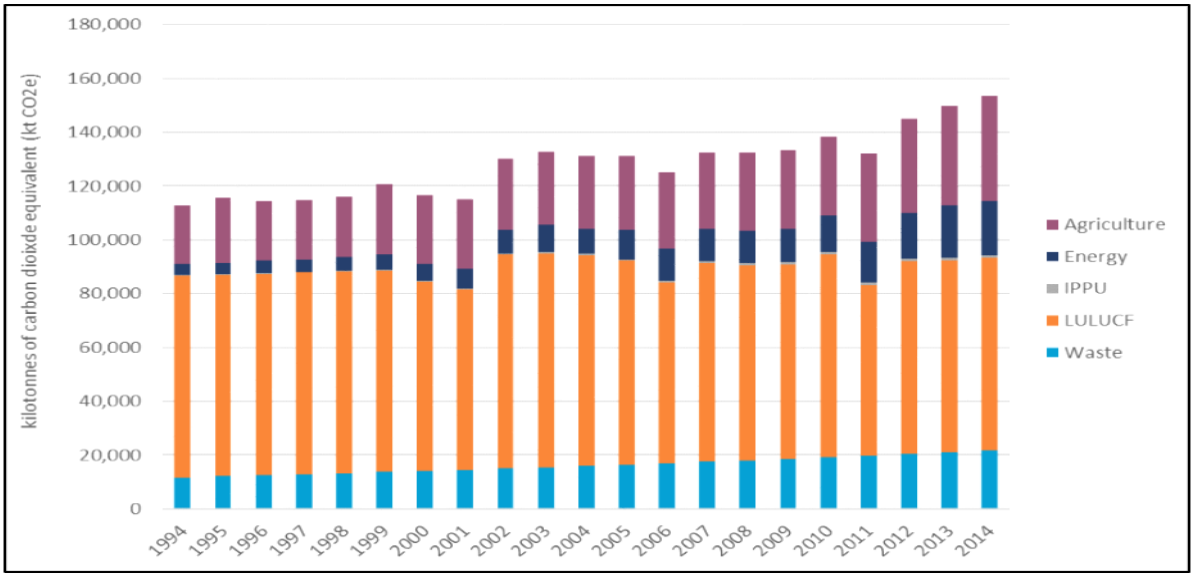
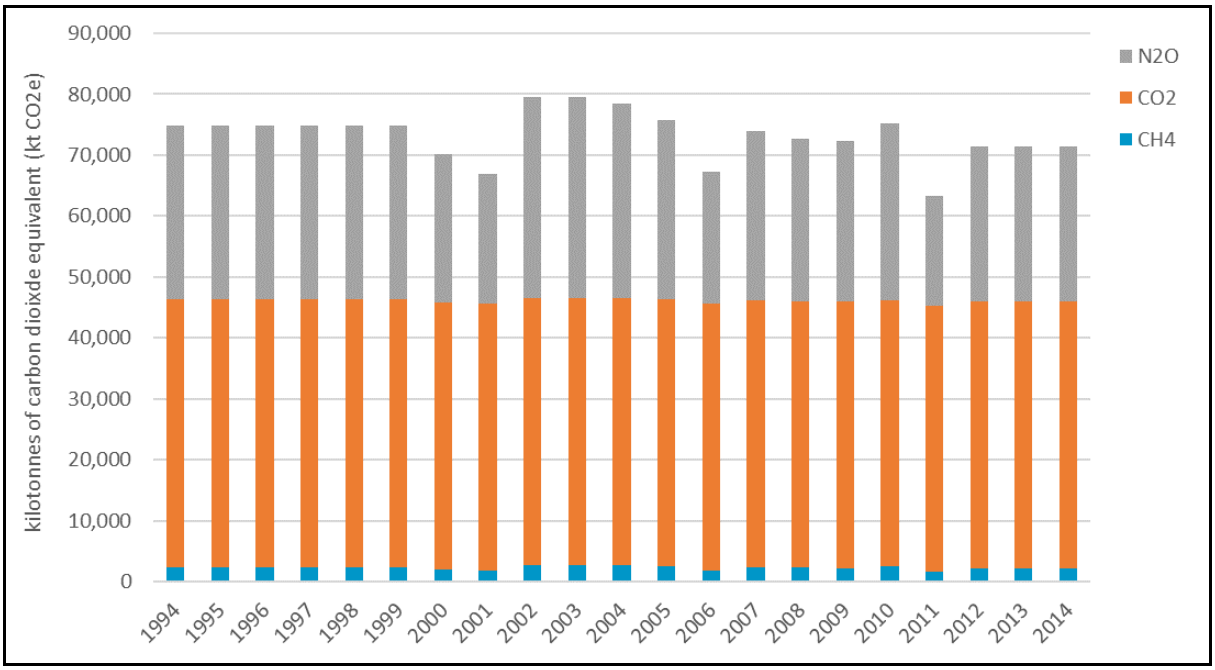


Chart 2.3 indicates that, Tanzania's GHG emissions are primarily from the Land-Use, Land-Use Change and Forestry (LULUCF). Emissions from the LULUCF sector contributes about two-thirds of overall emission levels in Tanzania. However, the contribution of emissions from the LULUCF sector has been slightly declining over years compared with other sectors notably, the agriculture and energy sectors. Chart 2.3 also indicates that agriculture is the second most dominant contributor of GHGs emissions followed by the waste sector and the Energy sector, with Industrial Processes and Product Use (IPPU) being the least contributor of GHGs.

2.5.1 Land use, Land Use Change and Forestry (LULUCF)

LULUCF emissions are a result of conversion of forest land to other land uses. The change of forest to non-forest lands produces emissions of CO_2, due to the loss of carbon in the living biomass and deadwood. On the other hand, biomass burning is the second source of GHGs emissions reported in LULUCF sector. Chart 2.4 presents estimates of emission of direct GHGs from the LULUCF sector.

Chart 2. 4: LULUCF sector emissions by gas 1994 - 2014



Source: VPO 2018

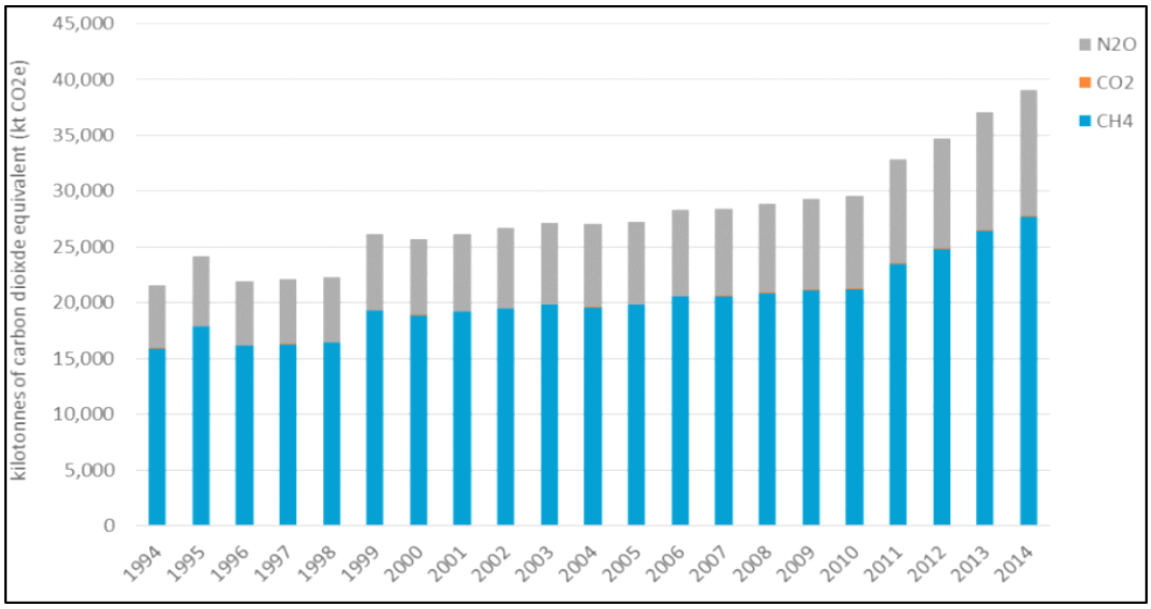
Chart 2.4 indicates that, emissions of carbon dioxide and methane have been more or less the same along the time series. On the other hand, emissions of

nitrogenous oxide haven't portrayed a definite trends, but have slightly declined over the recent period.

2.5.2 Agricultural sector

Emissions of GHGs from this sector relate to all anthropogenic emissions from agricultural activities, including enteric fermentation, manure management, and agricultural soils emissions from the field burning of agricultural residues and emissions from savannah burning.

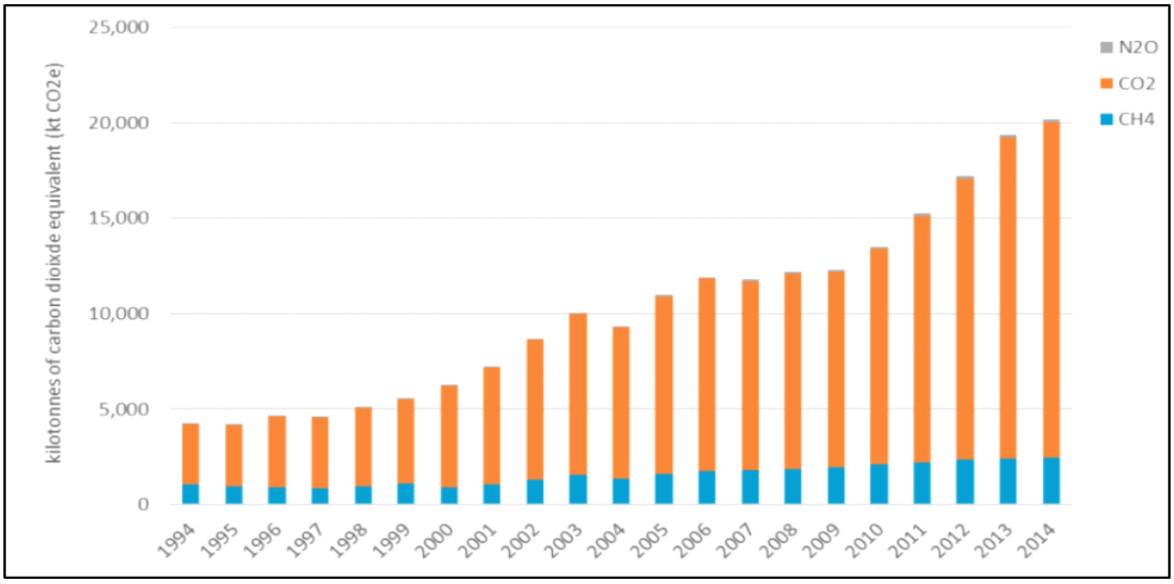
Chart 2. 5: Agricultural GHG emissions by gas 1994 – 2014



Source: VPO 2018

The national GHGs emission by gas for the Agriculture Sector (1994 - 2014) is shown in Chart 2.5 The most significant gas is methane (CH_4) followed by nitrous oxide (N_2O). The overall trend shows a rise in emissions across the time series, but more significantly in the last four years of the time series. This trend is primarily from methane emissions and, to a lesser degree, nitrous oxide emissions.

Chart 2. 6: Energy sector emissions by gas 1994 - 2014



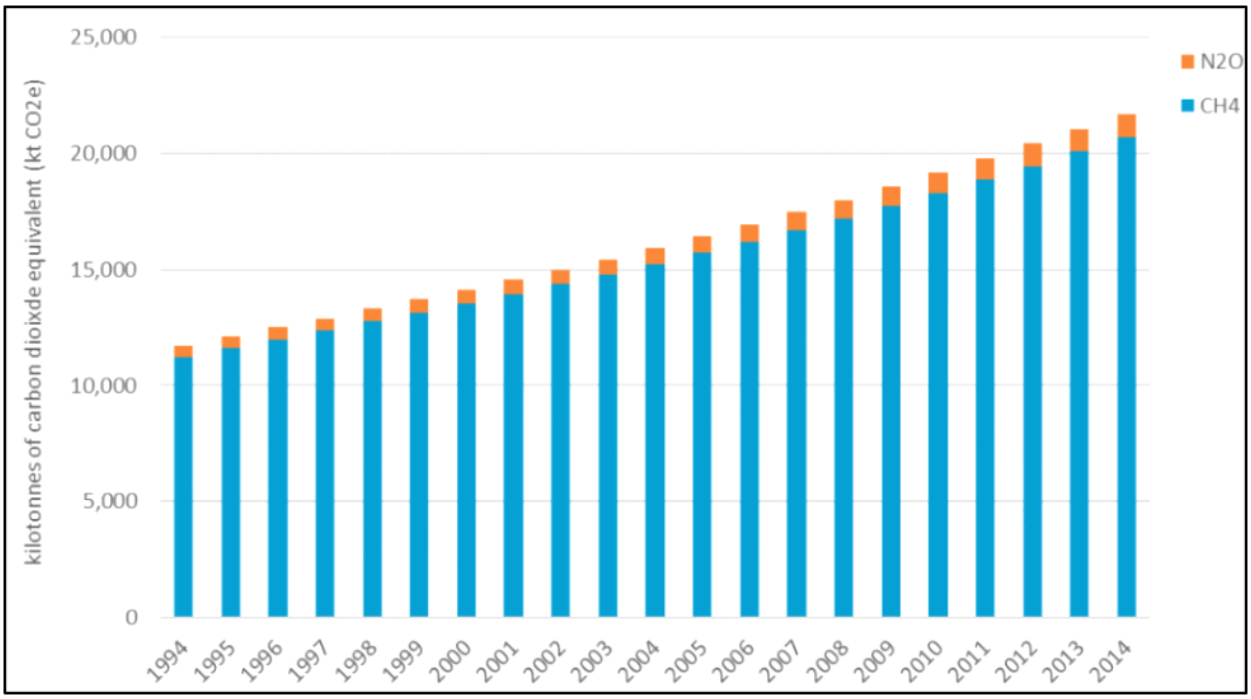
Source: VPO 2018

The emissions of GHGs from the Energy Sector (1994 - 2014) are shown in Chart 2.6. The results indicates that, the most significant emissions are from carbon dioxide (CO_2). The overall trend shows a rise in emissions across the time series, primarily contributed by carbon dioxide emissions and, to a lesser degree, methane emissions.

2.5.3 Waste management

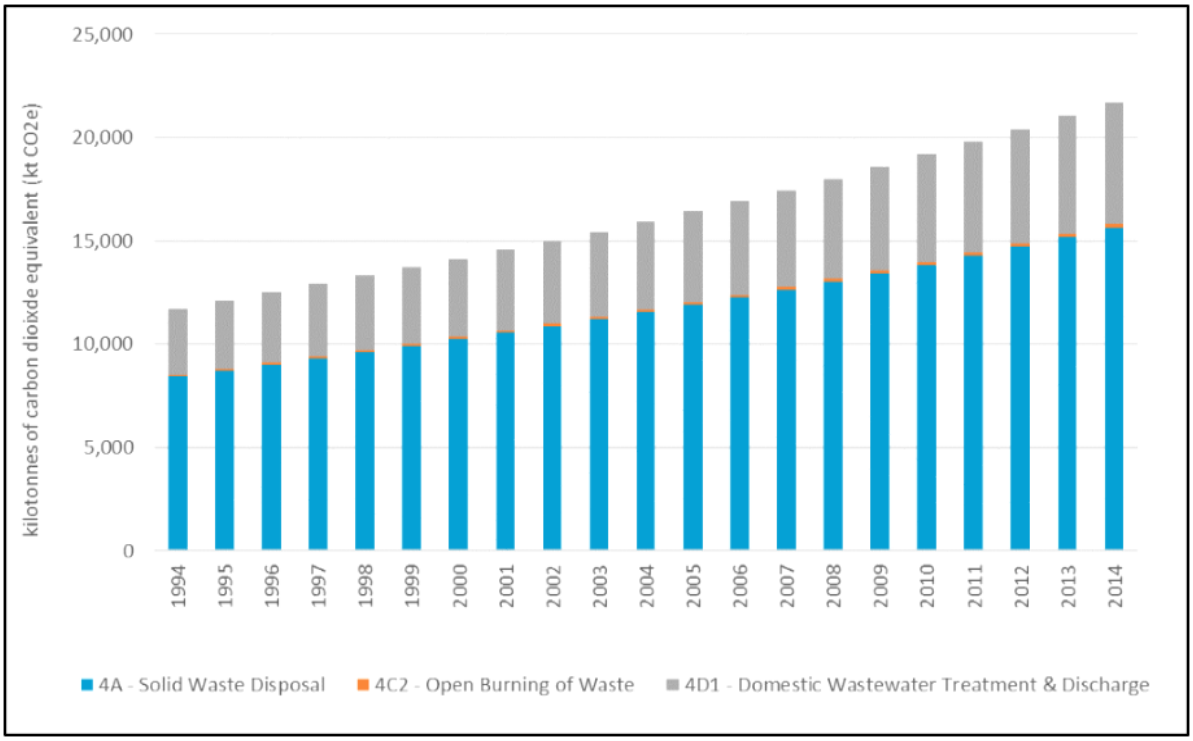
The national GHGs emissions by gas and category for the Waste Sector (1994 - 2014) are shown in Chart 2.7 and Chart 2.8. The most significant gas is methane (CH_4). The overall trend shows a steady rise in emissions across the time series. The most significant category is solid waste disposal followed by domestic wastewater treatment. These two categories have shown a gradual growth across the time series.

Chart 2. 7: Waste sector emissions by gas 1994 - 2014



Source: VPO 2018

Chart 2. 8: Waste Sector Emissions by Category



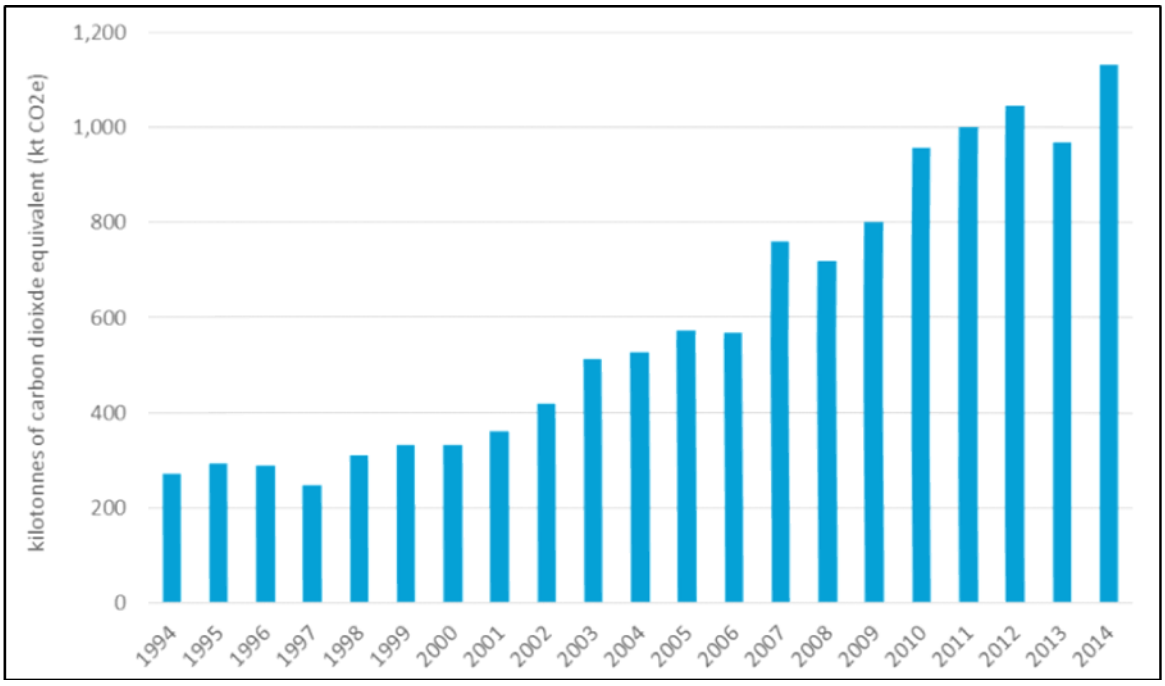
2.5.4 Industrial Processes and Product Use

Traditional industries in Tanzania include steel rolling mills, food processing, cement, textiles, breweries, soap and detergents, cigarettes, and beverages. Currently, there is also a growing number of mining industries.

According to Annual Survey of Industrial Production, 2015 and 2016; Tanzania had a total number of 2,389 industrial establishments. Manufacturing sub-sector had the highest number of establishments (1,864; 78.0%), followed by mining and quarrying (384; 16.1%), water supply, sewerage, waste management and remediation activities (103; 4.6%) and lastly electricity, gas, steam and air conditioning supply (31; 1.3%) (NBS, 2018).

Carbon dioxide (CO_2) emission is important contributor of atmospheric concentration of GHGs in the Industrial Processes and Product Use (IPPU) sector. Chart 2.9 indicates increasing trend in emissions of carbon dioxide over the years.

Chart 2. 9: IPPU emissions by gas 1994 – 2014



Source: VPO 2018

With the recent emphasis on industrialization in Tanzania, CO_2 emissions are likely to scale up. For this reason, it is important to adopt sustainable industrialization approach to limit potential emissions of GHGs. This may involve actions such as: - advocating for the use of new technologies; incorporating and increasing renewable energies; making older equipment more energy efficient; and expanding the use of natural gas for power production, cooking and transport.

2.5.5 Consumption of Ozone-depleting Substances

Ozone-depleting substances (ODS) are any substance containing chlorine or bromine that destroys the stratospheric ozone layer. The stratospheric ozone absorbs most of the biologically damaging ultraviolet radiation. ODS is another important category of emissions that is actively monitored by the Montreal Protocol. Despite the difficulty in measuring the emissions of these substances, reported statistics worldwide have shown this protocol to be very effective in phasing out the use of these substances.

These substances include; Chlorofluorocarbons (CFCs); Hydrochlorofluorocarbons (HCFCs); Halons; Methyl chloroform; Carbon tetrachloride and Methyl bromide. These emissions substances are difficult to measure directly; they are reported on the apparent consumption of ODSs. Tanzania is generally a low volume consuming country in terms of ODS alternatives in all sectors although there has been an increase in the use of ODS alternatives in recent years. For instance, Table 2.7 reveals that, HC 600a is one of the most common ODS alternatives used in Tanzania and its consumption has increased from 232.6 MT in 2012 to 636.4 MT in 2015.

Table 2. 2: Estimated use of ODS alternative Ozone by Types of ODS, 2012-2015, MT

Alternative	Estimated Use			
	2012	2013	2014	2015
				HFC
HFC-134a	18.2	20.9	27.0	30.4
HFC-227ea/HFC-365mfc	-	-	-	-
HFC blends				
R-404A	0.4	0.5	0.6	0.7
R-407C	0.5	0.6	0.7	0.9
R-410A	0.8	1.4	1.8	1.9
R-507A	0.2	0.4	0.5	0.6
HFO				
HFO-1234yf	-	-	-	-
OTHERS	-	-	-	-
HC-290	5.1	7.2	10.1	23.0
HC-600a	232.6	330.2	587.6	636.4
Pentane (C, N, I)	*0.0*	*0.0*	*0.0*	*24.7*
R-744	0.8	0.8	0.8	1.0
R-717	16.7	23.4	27.5	30.2
Others	275.5	385.8	657.0	725.5

Source: ODS Alternative National Survey Report 2016

CHAPTER THREE

Climate Change Evidence

3.1 Introduction

This chapter presents statistics about physical characteristics of the environment and their associated changes over time. Changes of the environmental physical parameters may be attributed to a number of factors including climate change. The evidences of climate change at global level are unequivocal. These include global temperature rise, shrinking ice sheets and glacial retreats. At a local level these evidences are manifested by erratic rainfalls and temperature and increasing frequency and intensities of extreme weather and climate change events such as strong winds, floods and droughts. These are often associated with devastating socio-economic and ecological implications.

3.2 Atmosphere, Climate and Weather

The information on atmosphere, climate and weather is compiled and managed by Tanzania Meteorological Agency (TMA). The Agency is responsible for provision of meteorological services; weather forecasts, climate services and warnings and advisory information for the country. According to TMA, Tanzania has a tropical climate that is characterized by regional variations due to topography. Seasonal rainfall is driven mainly by migration of the Inter Tropical Convergence Zone (ITCZ). ITCZ migrates southwards across Tanzania in October and December, reaching the southern parts of the country in January and February, and returning northwards in March, April and May. This results in north and east parts of Tanzania to experience two rainy seasons, the short rains from October to December and long rains from March to May. The central parts experience one rainy season from October to April or May.

3.3 Temperature

Tanzania experiences a wide range of temperature variation due to geographical location and altitude. Temperatures in highlands range between 10°C and 20°C during cold seasons and hot season respectively. The rest of the country has temperatures that rarely fall below 20^0C. The hottest periods extend between November and February, where temperatures range from 25°C – 31 °C while the coldest periods occur between May and August with temperatures ranging from 15°C – 20 °C (TMA, 2018).

3.3.1 Monthly Mean Minimum Temperature

The minimum temperature averages presented in Table 3.1 are averages of all meteorological stations in Tanzania. It is indicated that, the long term mean minimum temperature was 18.3°C compared to 18.6°C for the period of 2012 to 2018.

Table 3. 1: Monthly Mean Minimum Temperature (°C), 2012-2018

Year	Jan	Feb	Mar	Apr	May	Jun	July	Au	Sep	Oct	Nov	Dec	Mean
2012	19.8	20.4	19.9	19.4	18.2	16.6	15.8	16.9	18.1	19.6	19.9	20.2	**18.7**
2013	20.3	20.1	20.5	19.7	18.2	15.9	15.6	16.7	18.1	19.5	20.5	20.1	**18.8**
2014	19.9	19.9	19.8	19.4	18.3	17.9	16.4	18.1	17.9	19.7	19.7	19.8	**18.9**
2015	19.9	20.**0**	19.6	18.6	18.6	16.9	16.4	16.9	18.**0**	20.1	20.2	20.1	**18.8**
2016	19.9	20.2	20.9	20.**0**	18.3	16.7	15.8	15.6	17.3	18.7	20.**0**	18.1	**18.5**
2017	19.7	19.7	19.2	18.9	17.9	16.5	15.5	16.8	16.9	18.7	19.**0**	19.8	**18.2**
2018	19.2	19.4	19.2	18.7	17.7	15.6	15.5	15.8	17.3	18.6	19.5	19.7	**18.0**
Mean (2012-2018)	**19.8**	**20.0**	**19.9**	**19.2**	**18.2**	**16.6**	**15.9**	**16.7**	**17.6**	**19.3**	**19.8**	**19.7**	**18.6**
LTM (1981-2010)	**19.5**	**19.5**	**19.5**	**19.2**	**18.0**	**16.3**	**15.6**	**16.3**	**17.5**	**18.8**	**19.5**	**19.6**	**18.3**

Source: Tanzania Meteorological Agency (TMA)

Table 3.1 indicates that the lowest mean minimum temperature was observed in July for both long term and shorter period of 2012 to 2018 with 15.6°C and 15.9°C respectively. Likewise, when compared to the long term mean (1981 – 2010) with seven years' period from 2012 to 2018, monthly mean minimum temperature shows no significant changes in temperature trends. Although the monthly mean minimum temperature for shorter period (2012 - 2018) was slightly higher than the long term mean. This indicates an increasing pattern of temperature trends.

3.3.2 Monthly Mean Maximum Temperature

The mean maximum temperature presented in Table 3.2 are averages of monthly maximum temperature of all meteorological stations in the country. Overall, long term mean monthly maximum temperature was 28.2°C while, for the shorter period of 2012 to 2018, mean monthly maximum temperature observed was 28.5°C. The hottest month with the highest mean monthly maximum temperature for both long term and shorter period (2012 - 2018) is October with temperature of 29.4°C and 29.9°C respectively.

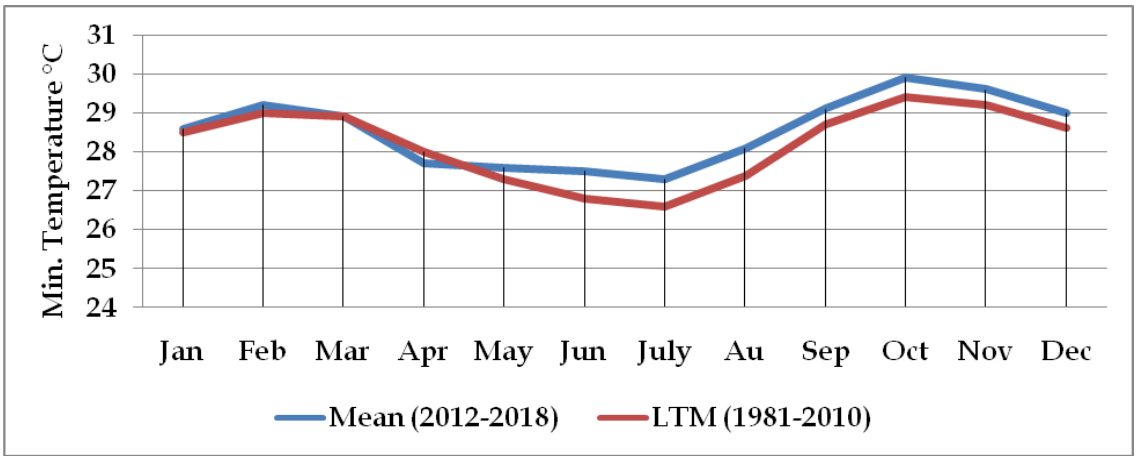
The comparison of temperature between the shorter period (2012 - 2018) and long term mean maximum temperature indicates that, the shorter period are higher than long term from May to December as indicated in Chart 3.1.

Table 3. 2: Monthly Mean Maximum Temperature (°C), 2012-2018

Year	Jan	Feb	Mar	Apr	May	Jun	July	Au	Sep	Oct	Nov	Dec	Mean
2012	29.3	29.9	29.5	28.1	27.5	27.4	27.5	28.2	29.2	30.3	29.5	28.9	**28.8**
2013	29.3	29.9	29.3	28.2	27.7	27.3	27.5	27.9	29.3	30.0	30.0	28.8	**28.8**
2014	29.0	28.4	28.9	28.2	27.4	27.8	27.4	28.4	28.4	29.8	29.7	29	**28.5**
2015	28.6	30.0	29.8	28.0	27.8	27.7	27.9	28.6	29.6	29.9	29.0	28.7	**28.8**
2016	28.4	28.9	29.8	27.9	27.9	27.3	26.8	28.1	28.5	29.9	29.6	28.5	**28.5**
2017	27.8	27.2	26.7	26.1	27.4	27.4	27.1	27.1	29.2	30.3	29.3	30.0	**28**.0
2018	27.7	30.2	28.1	27.4	27.6	27.4	26.9	28.3	29.5	29.5	30.2	29.1	**28.5**
Mean (2012-2018)	**28.6**	**29.2**	**28.9**	**27.7**	**27.6**	**27.5**	**27.3**	**28.1**	**29.1**	**29.9**	**29.6**	**29**.0	**28.5**
LTM (1981-2010)	**28.5**	**29**.0	**28.9**	**28**.0	**27.3**	**26.8**	**26.6**	**27.4**	**28.7**	**29.4**	**29.2**	**28.6**	**28.2**

Source: Tanzania Meteorological Agency (TMA)

Chart 3. 1: Monthly Mean Maximum Temperature from 2012 to 2018 Compared With Long Term Mean 1981-2010



Source: Tanzania Meteorological Agency (TMA)

3.3.3 Annual Mean Minimum Temperature

Table 3.3 shows Annual Mean Minimum Temperature records for meteorological stations from 2012 to 2018. It is indicated that, the annual mean minimum temperature was 17.7°C from 2012 to 2018. In addition, the highest mean minimum temperature was 23.3°C observed at JNIA Meteorological Station in Dar es Salaam in 2017 while, the lowest minimum temperature was about 11.0°C observed at Mbeya Meteorological Station in 2017.

Table 3. 3: Annual Mean Minimum Temperature (°C) by Stations, 2012 - 2018

Station	2012	2013	2014	2015	2016	2017	2018	Mean
Bukoba	17.9	18.1	18.4	18.6	18.9	18.5	18.6	**18.4**
Mwanza	17.9	17.5	18.6	18.9	18.6	19.1	18.6	**18.5**
Musoma	18.2	18.7	17.9	18.3	17.7	19.9	19.0	**18.5**
Kigoma	19.2	19.4	19.9	19.7	19.8	19.6	19.1	**19.5**
Tabora	17.7	17.6	16.9	16.9	15.9	17.5	17.4	**17.1**
Dodoma	17.7	17.8	17.9	17.7	17.7	18.2	17.8	**17.8**
Iringa	15.3	14.7	15.5	15.3	15.2	15.8	15.6	**15.3**
Arusha	15.1	14.6	15.3	15.5	15.3	15.3	14.5	**15.1**
Kilimanjaro	18.0	17.6	17.1	17.6	18.6	18.0	17.9	**17.8**
Dar es Salaam	**22.4**	**22.3**	**22.5**	**23.1**	**23.2**	**23.3**	**22.4**	**22.7**
Mtwara	21.5	20.9	21.2	21.5	21.4	21.6	21.5	**21.4**
Songea	14.9	14.2	15.7	12.2	15.6	15.2	14.9	**14.7**
Mbeya	11.7	20.9	14.1	12.0	14.4	11.0	11.5	**13.7**
Mean	**17.5**	**18**.0	**17.8**	**17.5**	**17.9**	**17.9**	**17.6**	**17.7**

Source: Tanzania Meteorological Agency (TMA)

3.3.4 Annual Mean Maximum Temperature

Table 3.4 shows Annual Mean Maximum Temperature records for meteorological stations in Tanzania from 2012 to 2018. It is observed that, the overall annual mean maximum temperature is 28.6°C. The results further indicate that, the highest annual mean maximum temperature observed was 33.2°C recorded at Kilimanjaro Meteorological Station in 2017. The lowest annual mean maximum temperature was 24.1°C recorded at Mbeya Meteorological Station in 2017.

Table 3. 4: Annual Mean Maximum Temperature (°C), by Stations 2012 - 2018

Station	2012	2013	2014	2015	2016	2017	2018	Mean
Bukoba	26.5	26.5	26.4	27.3	26.2	26.8	26.4	**26.6**
Mwanza	28.6	27.3	28.3	28.6	28.9	28.6	28.4	**28.4**
Musoma	28.7	28.9	28.2	29.7	28.6	28.9	28.7	**28.8**
Kigoma	29.5	29.2	28.1	29.9	30.0	28.2	29.4	**29.2**
Tabora	30.3	30.2	29.5	30.3	30.5	28.8	28.4	**29.7**
Dodoma	29.2	29.6	29.1	29.6	29.4	32.4	28.8	**29.7**
Iringa	27.8	27.4	26.4	27.4	27.2	28.8	26.4	**27.3**
Arusha	26.2	25.7	25.8	26.5	26.6	26.8	25.9	**26.2**
Kilimanjaro	30.8	30.3	29.7	30.4	30.1	33.2	29.4	**30.6**
Dar es Salaam	32.2	32.1	32.0	32.0	31.3	32.1	31.5	**31.9**
Mtwara	30.6	30.9	30.7	31.1	30.9	31.1	31.1	**30.9**
Songea	27.4	27.3	27.2	27.9	28.0	27.1	27.5	**27.5**
Mbeya	25.1	24.7	24.7	25.0	24.8	24.1	24.8	**24.7**
Mean	**28.7**	**28.5**	**28.2**	**28.9**	**28.7**	**29**.0	**28.2**	**28.6**

Source: Tanzania Meteorological Agency (TMA)

3.4 Precipitation

Table 3.5 indicates that on average, for the period of 2012 to 2018, Tanzania received annual rainfall of 939.7 mm recorded from different meteorological stations. It is also observed that, the amount of rainfall recorded in bimodal areas ranged from 411.8 mm recorded at Kilimanjaro International Airport (KIA) Meteorological Station to 2,676.2 mm at Bukoba Meteorological Station.

On the other hand, rainfall recorded in unimodal areas ranged from 428.0 mm at Dodoma Meteorological Station to 1,369.4 mm at observed at Mtwara Meteorological Station. The available rainfall statistics show that the annual rainfall variability is not significantly pronounced because of the nature of rainfall patterns. However, inter-seasonal and inter-annual variability and shift in rainfall patterns are very common.

Table 3. 5: Annual Rainfall (mm) by Stations, 2012 – 2018

Rainfall Regime	Station	2012	2013	2014	2015	2016	2017	2018	Mean
Bimodal Areas	Bukoba	2280.0	1863.3	2227.2	1755.1	1452.9	2676.2	1706.9	**1994.5**
	Mwanza	1307.5	1125.6	971.4	1530.7	1039.3	872.2	1153.0	**1142.8**
	Dar es Salaam	702.6	1004.4	1278.9	1038.9	782.9	1248.6	1208.4	**1037.8**
	Musoma	646.3	766.2	720.9	1038	627.2	622.5	1031	**778.9**
	Kilimanjaro	429.2	411.8	501.7	482.8	492.5	442.3	861.8	**517.4**
	Morogoro	646.7	551.8	993.8	587.6	587.6	762.2	1138.1	**752.5**
Unimodal Areas	Mtwara	646.3	1157.1	1023.9	1072	1332.9	1369.4	1180.7	**1111.8**
	Songea	896.0	1072.7	1010.8	852.3	846.7	1226.1	1039	**991.9**
	Tabora	810.8	939.8	826.5	957.4	911.6	885.3	1112.9	**920.6**
	Kigoma	735.3	999.9	832.7	951.6	913.5	869.2	985.1	**898.2**
	Mbeya	508.1	1028.3	1220.3	876.0	952.6	1043.6	1731.9	**1051.5**
	Iringa	545.3	859.1	885.5	555.4	757.6	622.1	509.3	**676.3**
	Dodoma	620.9	487.4	489.7	452.2	545.2	428.0	679.3	**529**.0
	Mean	**828.8**	**872.7**	**968.8**	**934.6**	**864.8**	**1005.2**	**1102.9**	**939.7**

Source: Tanzania Meteorological Agency (TMA)

3.4.1 Monthly Average and Monthly Long-Term Average Rainfall

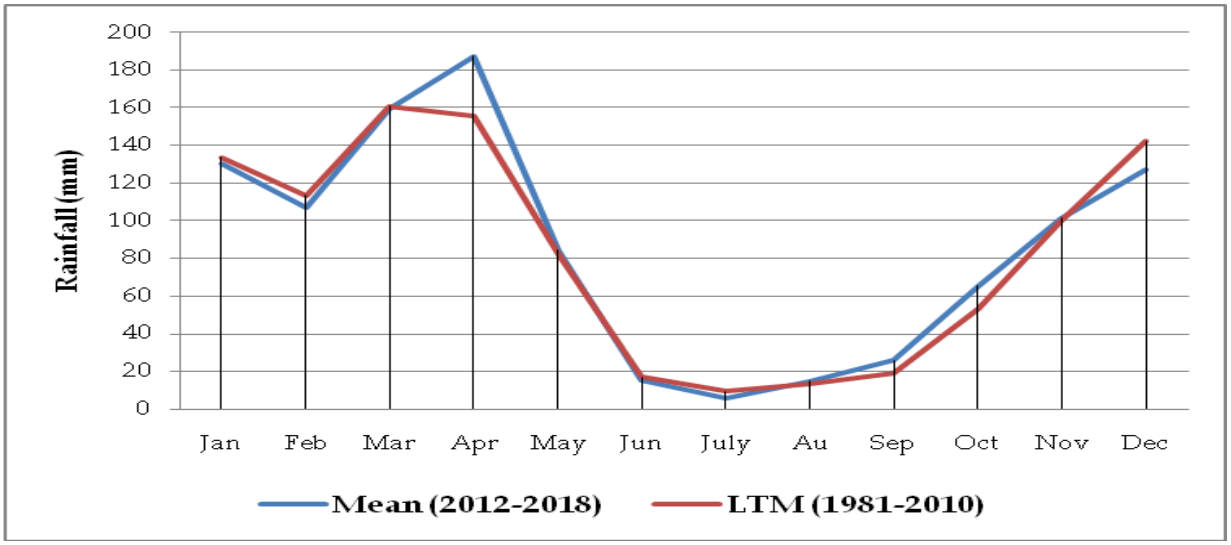
Monthly rainfall averages in Table 3.6 are averages of all stations in Tanzania. For the period of 30 years (1981-2010) the highest mean monthly total rainfall was 160.9 mm, which was recorded in March and the overall period mean was 83.3 mm. On the other hand, the period of seven years from 2012 to 2018, Tanzania received, an average of **85.4** mm of rainfall per month with the maximum observed in April, which accumulated to **187.4** mm.

Table 3. 6: Monthly Average and Monthly Long-Term Average Rainfall

Year	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Mean
2012	86.2	95.4	93**.0**	151.5	93.8	24.1	2.6	17.9	14.9	63.9	92.6	138.4	72.9
2013	144.2	63.2	196.0	147.8	62.8	0.4	9.0	13.1	33.0	23.2	95.2	142.7	77.6
2014	108.7	140.9	185.3	180.7	60.2	15.4	4.5	20.6	42.8	61.9	105.3	117.9	87.0
2015	123.0	57.7	122.8	171	100.3	9.2	5.1	9.4	11.0	63.3	164.3	132.2	80.8
2016	191.8	131.2	140.0	213.6	41.1	9.2	2.2	8.3	14.1	27.8	64.6	66.6	75.9
2017	89.3	172.6	178.7	189.9	138.5	15.8	13.1	15.0	33.5	98.4	134	132.2	100.9
2018	169.6	87.3	200.4	257.2	93.9	33.8	4.0	18.8	31.5	119.0	55.3	163.4	102.8
Mean													
(2012-2018)	**130.4**	**106.9**	**159.5**	**187.4**	**84.4**	**15.4**	**5.8**	**14.7**	**25.8**	**65.3**	**101.6**	**127.6**	**85.4**
LTM													
(1981-2010)	**133.9**	**113.4**	**160.9**	**155.6**	**82.5**	**16.7**	**9.3**	**13.3**	**18.7**	**53.0**	**99.8**	**142.3**	**83.3**

Source: Tanzania Meteorological Agency (TMA)

Chart 3. 2: Monthly Average Rainfall and Monthly Long-Term Average Rainfall



Source: Tanzania Meteorological Agency (TMA)

3.5 Hydrographical Characteristics

3.5.1 Lakes, Rivers and Streams

Tanzania shares six international lakes and five international rivers including three of the largest African river basins, namely:- Nile, Congo and Zambezi, and seven international aquifers. Predictions of changes of lake levels and hydrological basins due to climate change in Tanzanian have indicated a potential decline of about 0.1-1.2 metres (VPO, 2019). From the assessments, the highest changes of about 3 metres are predicted for Lake Rukwa.

These assessments also indicated that one percent decrease of annual rainfall may result in 0.6 - 5.0 percent reduction in average discharge; 0.6-4.1 percent minimum discharge, 0.4-7.5 percent maximum discharge, and 0 - 1.6 percent of Zero Flow Duration. The largest discharge decreases are predicted for Internal Drainage and Lake Victoria while lowest decreases are predicted for Kikuletwa, Ruhuhu and Rufiji (except Great Ruaha). Predicted rainfall increases expected from some Global Circulation Models (GCMs) indicate future discharge increases of 8-41 percent (average discharge), 6-30 percent (minimum discharge), 0.4-45 percent (maximum discharge) and decrease of 6-16 percent (Zero Flow Duration) (VPO, 2019).

Figure 3. 1: Bismarck rocks showing the drop in water level of Lake Victoria

Source: VPO 2019

3.5.2 Land degradation

Land degradation in Tanzania like in many other parts in developing countries particularly in Africa, occurs as a consequence of several human decisions, actions as well as through natural processes, and often magnified by the impacts of climate change and biodiversity losses. These decisions, actions or processes are the driving forces which cause the gradual or rapid deterioration of the natural environment which in turn impacts adversely on people especially in rural areas who almost entirely depend on natural resources for their survival.

The frequency of occurrence of climate extreme events (e.g. droughts, heavy precipitations and associated floods) has been increasing in Tanzania in recent years. The severity of drought is more pronounced in the semi arid areas especially some parts of central corridor regions of Dodoma, Shinyanga, Singida , and Tabora. These regions are characterized by extreme seasonal conditions with relatively low rainfall, a long dry seasons and temperature fluctuations which cannot reliably favor agricultural activities. Frequent droughts in these areas limit regeneration of vegetation thus leave the land bare, making it susceptible to agents of soil erosion such as wind and water. (VPO, 2014).

Figure 3. 2: Evidence of severe gully erosion in Bunda district

Source: VPO 2014

The analysis of land degradation status is presented in Tables 3.7. Generally, it is indicated that, the highly degraded land area in the country has increased from 13.5 percent in 1980 to 16.02 percent in 2012. The degradation has significantly changed at a rate of 18.3 percent. Similarly, the moderate degraded areas have also increased from 30.9 percent to 33.55 percent with a rate change of 8.95 percent.

Table 3. 7: Land degradation status from 1980 – 2012

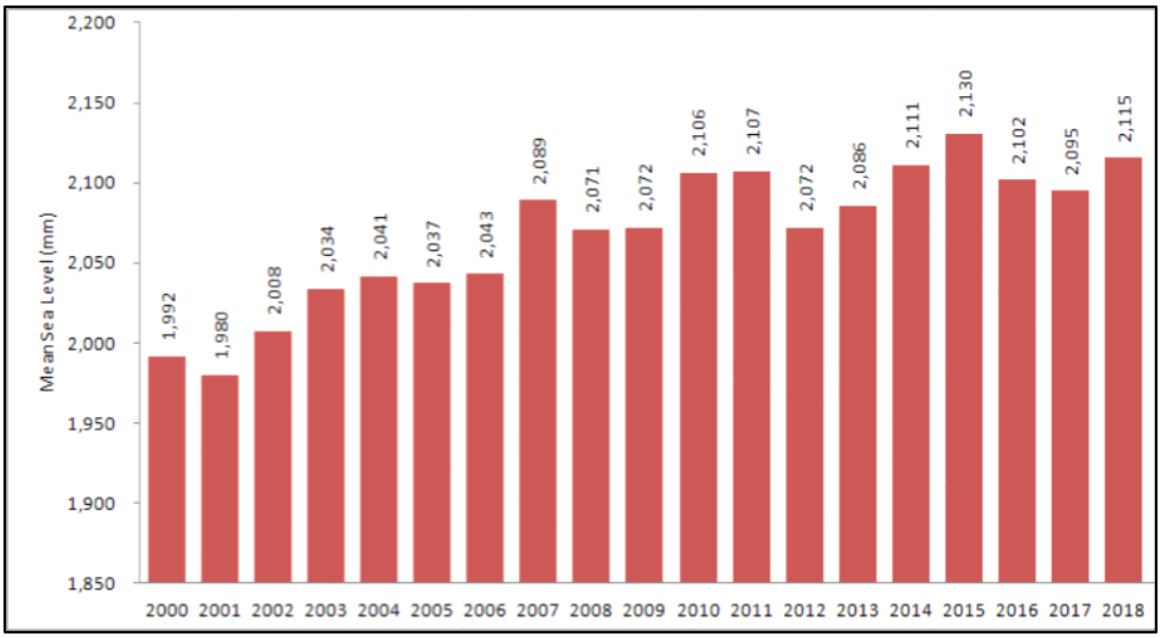
	Land Degradation				Rate of Change	
	Year: 1980		Year: 2012		1980-2012	
	Ha	%	Ha	%	Ha	%
Highly degraded	12,785,136	13.54	15,124,599	16.02	2,339,463	18.29
Moderately graded	29,166,276	30.90	31,671,735	33.55	2,505,459	8.59
Non-degraded	52,440,086	55.56	47,595,164	50.42	-4,844,922	-9.24
TOTAL	**94,391,498**	**100.00**	**94,391,498**	**100.00**		**-**

Source: VPO, 2014

3.6 Sea Level Rise

Sea level rise impacts are increasingly manifested by accelerated coastal erosion in many parts of the coastal areas and in some cases destruction of mangroves caused by strong sea waves. It has also lead to intrusion of sea water into fresh water wells and crop fields. Thus sea level rise can be among the most challenging climate change issues since it threatens the destruction of key coastal infrastructure and costal livelihood of coastal countries.

Chart 3. 3: Mean Sea Level (mm) 2000 – 2018



Source: University of Dar es Salaam, IMS; Zanzibar station

Chart 3.3 indicates that, despite occasional declines over time, there is an increase of the sea level from 2000 to 2018. The lowest recorded value for the mean sea level was 1,980 mm in 2001 and the highest was 2,130 mm in 2015. This is an increase of 150 mm of the sea level over the period of 15 years.

3.7 Occurrence of Natural Extreme Events and Disasters

In recent years, Tanzania has experienced an increase in frequency and intensity of extreme events such as strong wind, heavy rainfall, hailstorm and higher temperatures. These extremes are normally associated with devastating socio-economic impacts including loss of life and properties, and destruction of infrastructure.

The last four years, 2015, 2016, 2017 and 2018 have also been characterized by record breaking extreme events, consistent with global observation and trends as documented in IPCC report. For example in November 4th 2015, Tukuyu Meteorological Station recorded 327.8 mm of rainfall in 24 hours, which is the highest ever-recorded 24 hours rainfall since the establishment of the station in 1928. On 9th April 2016, Mbambabay, Ruvuma region recorded 247.6 mm of rainfall in 24 hours, which is the highest amount on record since the station was established in 1951. On 8th May 2017, Tanga station recorded 316 mm of rainfall in 24 hours, the highest ever, since the establishment of the station in 1968. The details of natural extreme events and disaster are shown in appendix 1.

CHAPTER FOUR

Climate Change Impacts and Vulnerability

4.1 Introduction

In recent years Tanzania has experienced an increase in frequency and intensity of extreme events such as strong wind, heavy rainfall, hailstorm and higher temperatures.

Socio-economic development and livelihoods for most of the developing countries including Tanzania are strongly linked to natural resources and rain-fed agriculture. In this regards, initiatives and efforts towards poverty reduction and sustainable food security are significantly affected by trend and pattern of climate change extremes. Climate extremes therefore pose a serious threat to achievement of various socio-economic development strategies and plans. Climate change impacts on different sectors are discussed below:-

4.1.1 Agriculture

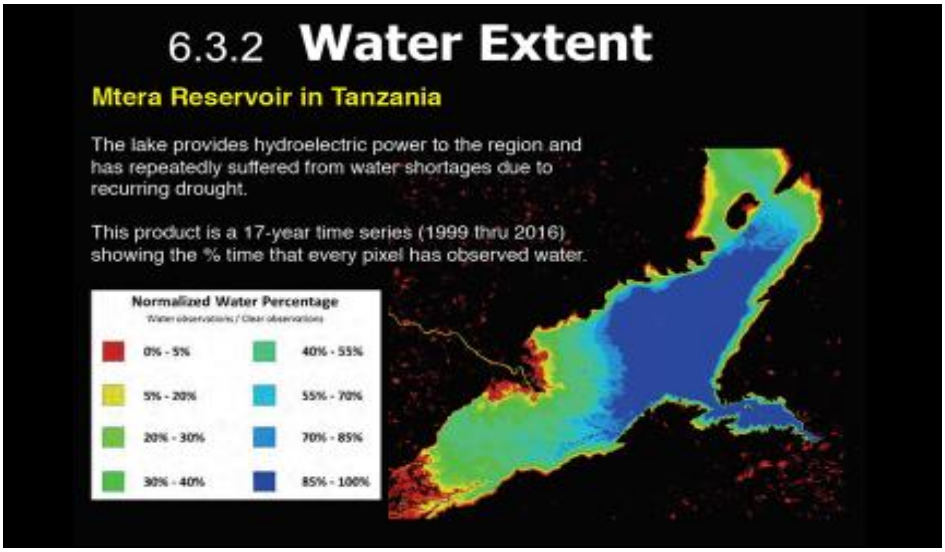
According to the State of Environment Report, 3 of 2019, the agriculture sector in Tanzania is particularly vulnerable to climatic change because it is customarily dependent on rainfall. Since more than 60 percent of Tanzanian population directly rely on agriculture for their livelihoods; thus, 10 percent decrease in rainfall would make most of areas unsuitable for cultivation. Prevalence of crop pest and diseases is also reported to have increased, posing more challenge to agriculture.

4.1.2 Water Resources

Water is critical resource for both ecosystem and human uses, and it is affected by climate change both in short and long term. Warmer temperatures speed evaporation of water resources from water bodies causing dwindling of water supplies. On the other hand, excessive rainfall increases the frequency and intensity of flooding which may lead to soil erosion and damage to infrastructure. Figure 4.1 presents case studies of Mtera Reservoir located in Iringa and Dodoma and Lake Salunga located in Dodoma to show impacts of climate change on water resources. Analysis of change of water resources is done using Data Cube

approach from 1999 to 2016 for Mtera Reservoir and from 2001 to 2017 for Lake Salunga.

Figure 4. 1: Change of Water Levels for Mtera Reservoir Located in Iringa and Dodoma, 1999 - 2016



As it is indicated in Figure 4.1 water levels at Mtera reservoir has decreased significantly over time with large part of the reservoir retaining only about 20 - 30 percent of water resources it used to hold. This decline of water resources is an evidence of impacts of climate change, mainly due to erratic rainfall patterns and long spells of droughts.

Figure 4. 2: Change of Water Levels for Lake Sulunga Located in Dodoma, 2001 - 2017

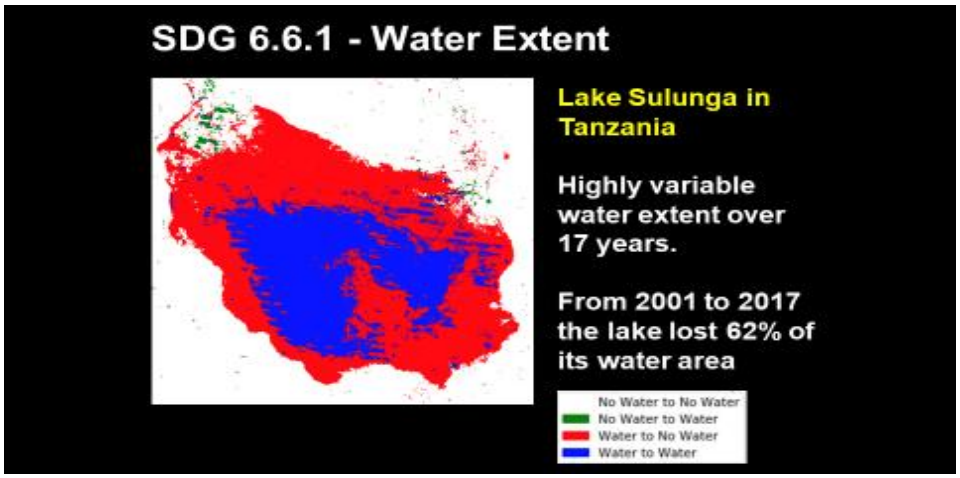


Figure 4.2 indicates significant transformation of the Lake Salunga over the period of 16 years from 2001 to 2017. Over half of the lake has transformed from water to no water during this period of time.

4.1.3 Human health

According to the Intergovernmental Panel on Climate Change (IPCC, 2007), extreme temperatures can lead directly to loss of life, while climate-related disturbances in ecological systems can indirectly impact the incidence of infectious diseases.

In Tanzania, increased temperatures and changes in rainfall patterns as a result of climate change are widely recognized to entail potentially serious consequences for human health. For instance, studies show significant relationship between temperature and the incidence of cholera in the country whereby for a one degree Celsius temperature increase, the initial relative risk of cholera increases by 15 to 29 percent (VPO, 2019).

CHAPTER FIVE

Mitigation and Adaptation Measures

5.1 Introduction

Mitigation and adaptation processes are important part of the sequence of climate change. Mitigation aims to decrease emissions of GHGs, while climate change adaptation is about carrying out adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

5.2 Climate change mitigation

Despite its negligible GHG emissions, Tanzania is participating in mitigation activities to contribute to its sustainable national development. In its INDC, Tanzania states its goal to embark on a climate resilient development pathway that will reduce GHG emissions by 10 percent to 20 percent by 2030, relative to the projected 2030 business-as-usual emissions of 138-153 $MtCO_2e$ (INDC, 2019).

Various initiatives have been undertaken at the national level and local levels by various stakeholders to mitigate emissions of GHGs. These initiatives are included in national policies, legislations, regulations, strategies, plans and guidelines such as:- The National Energy Policy (2015); The National Petroleum Policy of Tanzania (2015); Petroleum Act (2015); Paris Agreement on Climate Change (2018); National Framework for Climate Services (2018); and the National Climate Change Strategy (2012).

5.3 Climate change adaptation

The overall objective of adaptation measures is to enhance adaptive capacity to climate change. The country has developed and implemented programmes and projects including: Adaptation Fund project implemented in the Coastal regions of Tanzania (2017); Developing Core Capacity to Address Adaptation to Climate Change in Productive Coastal Zones of Tanzania (2012- 2018); Implementation of

Concrete Adaptation Measures to Reduce Vulnerability of livelihood and economy of Coastal Communities of Tanzania (2012-2018); Mainstreaming Environmental and Climate Change into development plans and national policies 2012-2015; and Africa Adaptation Programme project (2010- 2012).

Implementation of these initiatives has enabled the country to build resilience in various areas of the country to climate change impacts including: construction of 780 m sea wall at Barack Obama Road; Construction of 500 m wall at Mwalimu Nyerere
Memorial College in Kigamboni; reconstruction of 860m sea wall in Pangani; Restoration of 1,000 ha of degraded mangrove areas in Rufiji, and Restoration of 3,000 m2 of coral reef in Sinda Kigamboni.

Figure 5. 1: Sea wall along Barack Obama road

Source: VPO 2019

The Government has also established the National Carbon Monitoring Centre at Sokoine University of Agriculture (SUA) in Morogoro. The centre is responsible for developing, maintaining, analyzing and updating carbon database which facilitate taking stock of country contribution in sequestering carbon dioxide. Moreover; Tanzania developed the Forest Reference Emission Level in 2018 which makes the country to qualify and benefit from Reducing Emissions from Deforestation and Forest Degradation (REDD) financing mechanism (VPO, 2019).

Other initiatives include, National REDD Framework for Reducing Emissions from Deforestation and Forest degradation; Implementation of Dar es Salaam

Rapid Transit (DART) project; and Reduction of greenhouse gas emissions through tree planting campaigns (1.5 million trees for each district); and production of efficient firewood and charcoal cooking stoves.

Also Tanzania has promoted and encouraged small and medium scale irrigation schemes, development of drought tolerant seeds, water harvesting, use of weather data and weather forecasts and strengthening early warning systems.

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APPENDICES

Appendix 1: Occurrence of natural extreme events and disasters

Type of Natural Extreme Event	Date of occurrence	Location	
		Region	District
Floods	2018	Dar Es Salaam	Kinondoni, Ilala, Temeke, Kigamboni & Ubungo
Floods	2018	Dodoma	Chemba
Floods	2018	Arusha	Longido
			Arusha CC
			Meru
			Karatu
			Monduli
Floods	2018	Kilimanjaro	Same DC
			Same DC
			Hai
			Mwanga
			Moshi Vijijini
Floods With Strong Winds	2018	Tanga	Handeni
			Lushoto
			Korogwe
			Tanga Dc
Floods	2018	Morogoro	Kilosa
Anthrax Floods	2018	Manyara	Simanjiro
			Kiteto
			Kiteto
			Hanang
			Babati
			Mbulu
Floods	2018; 2019	Tabora	Kaliua
			Sikonge
			Nzega
Floods	2018	Singida	Mkalama
			Singida
			Iramba
			Ikungi
Floods	2018	Pwani	Mafia
			Rufiji
Heavy Rainfall With Strong Winds	2018	Kagera	Missenyi
			Bukoba Mc
Floods With Strong Winds	2018	Kigoma	Ujiji
Heavy Rainfall With Strong Winds	2018	Mtwara	Nanyamba Mji
Floods With Strong Winds	2018	Katavi	Mlele
			Mpanda (M)

Type of Natural Extreme Event	Date of occurrence	Location	
		Region	District
			Mpanda (V)
Fire	2018		Nsimbo
Fire	2018	Rukwa	Nkasi
Heavy Rainfall With Strong Winds	2018, 2019	Rukwa	Nkasi
			Nkasi
Fire	2018		Sumbawanga Dc
Lightning	2018		Sumbawanga Dc
Heavy Rainfall, Strong Winds And Lightning	2018		Sumbawanga Dc
Floods	2018	Mwanza	Misungwi
			Misungwi
Marine Accident	2018	Mwanza	Ukerewe
Floods	2018	Shinyanga	Shinyanga Region
Floods	2018	Geita	Chato
			Geita Dc
			Geita Tc
Lightning	2018	Geita	Geita Tc
Flood and Earthquake	2018	Geita	Mbogwe
			Nyang'hwale
			Bukombe
Strong Winds	2018	Lindi	Liwale
			Nachingwea

Source: PMO 2019

Appendix 2: Impact of natural disasters and people affected in Tanzania 1998 - 2017

Year	Hazard	People Affected	People killed	People Injured	People Homeless	Physical Losses	Estimated Economic Losses (TZS)
1998	Floods		66				
2000	Floods	2761	32			86 houses destroyed	
2000	Drought						
2000	Rodent Infestation	12737				4795 acres of crops destroyed	599,375,000/-
2001	Floods		12	10	197		
2001	Floods	209	7	10		32 houses were damaged	10,553,500/-
2001/2002	Rodent Infestation	76,420				28,173 acres of crops were damaged	3,521,625,000/-
2002	Floods	165				65 acres of crops and 20 houses were damaged	6,200,000/-
2002	Earthquake		2	5		1326 houses affected	
2003	Cyclone, Heavy Rainfall		2			13 houses were damaged 596 livestock died	20,000,000/-
2003/2004	Rodent Infestation	160,000				1392 acres of crops were damaged	174,000,000/-
2003/2004	Drought	316,521					
2004	Heavy Rainfall and Strong Wind					97 houses and food were destroyed	15,000,000/-
2004/2005	Rodent Infestation	255,000				101,400 acres of crops were damaged	12,675,000,000/-
2005/2006	Drought					4,871 cattle, 1,974 goat and sheep died	361,000,000/-
2005/2006	Army worm Infestation	321,000				27,974 different crops of grass type were damaged	3,496,750,000/-
2006	Cyclone	225				5 classrooms and 2 offices were damaged	97,722,000/-
1880, 1917, 1921, 1940, 1966, 1967, 2007 and 2008	Volcano eruption at Oldonyo Lengai hills					Environment was destructed	
2008	Floods		74				
2008/2009	Drought						
2008/2009	Drought						

Year	Hazard	People Affected	People killed	People Injured	People Homeless	Physical Losses	Estimated Economic Losses (TZS)
2009	Landslides		24			15kilometre road was damaged, 15 Ndiva (Irrigation reservoirs) were damaged, 60 cows died	
2009	Floods	25,637	2			5,981 houses, 4 schools and number of dug wells were damaged	
2009/2010	Drought					Farms with crops dried	
2010/2011	Drought					Farms with crops dried	
2011	Floods	6,643				2731.5 hetres of farms were destroyed, 6 bridges, 677 houses and roads were damaged	
2011	Floods	5,000	41				
2013/2014	Drought					People and Livestock were affected	
2014	Floods		10			Houses and roads were damaged	
2014/2015	Drought					People and Livestocks were affected	
2015	Hail storm, strong winds and heavy rainfall		47		3,500	634 houses were damaged, 67 cows and 236 goats were killed	
2015	Floods		8			Houses and roads were damaged	
2015/2016	Drought						
2016	Earthquake		17	440		2,072 houses were totally damaged, 14,595 houses were partially damaged and 2,191 public buildings were damaged	
	Total	**1,182,318**	**344**	**465**	**3,697**		

Source: PMO 2019

Appendix 3: FDES Climate Change Statistics Indicators

FDES Climate Change Statistics

Core Set/Tier 1; Regular Text – Tier 2; ***Italicized Text – Tier 3)***

Climate Process Drivers

Sub-component 1.3: Environmental Quality

1.3.1.1 Air Quality

1.3.1.b: Global atmospheric concentrations of greenhouse gases

1.3.1.b.1 Global atmospheric concentration level of carbon dioxide (CO_2)

1.3.1.b.2 Global atmospheric concentration level of methane (CH_4)

Sub-component 3.1: Emissions to Air

3.1.1 Emissions of greenhouse gases

3.1.1.a: Total emissions of direct greenhouse gases (GHGs), by gas:

3.1.1.a.1: Carbon dioxide (CO_2)

3.1.1.a.2: Methane (CH_4)

3.1.1.a.3: Nitrous oxide (N_2O)

3.1.1.a.4: Perfluorocarbons (PFCs)

3.1.1.a.5: Hydrofluorocarbons (HFCs)

3.1.1.a.6: Sulphur hexafluoride (SF_6)

3.1.1.b: Total emissions of direct greenhouse gases (GHGs), by gas:

3.1.1.b.1: Sulphur dioxide (SO_2)

3.1.1.b.2: Nitrogen oxides (NO_x)

3.1.1.b.3: Non-methane volatile organic compounds (NM-VOCs)

3.1.1.b.4: Other

3.1.2: Consumption of ozone depleting substances

3.1.2.a: Consumption of ozone depleting substances (ODSs), by substance:

3.1.2.a.1: Chlorofluorocarbons (CFCs)

3.1.2.a.2: Hydrochlorofluorocarbons (HCFCs)

3.1.2.a.3: Halons

3.1.2.a.4: Methyl chloroform

3.1.2.a.5: Carbon tetrachloride

3.1.2.a.6: Methyl bromide

3.1.2.a.7: Other

Climate Change Evidence

Sub-component 1.1: Physical Conditions

1.1.1: Atmosphere, climate and weather

1.1.1.a: Temperature

1.1.1.a.1: Monthly average

1.1.1.a.2: Minimum monthly average

1.1.1.a.3: Maximum monthly average

1.1.1.b: Precipitation (also in 2.6.1.a)

1.1.1.b.1: Annual average

1.1.1.b.2: Long-term annual average

1.1.1.b.3: Monthly average

1.1.1.b.4: Minimum monthly value

1.1.1.b.5: Maximum monthly value

1.1.2: Hydrographical characteristics

1.1.2.e: Seas

1.1.2.e.4: Sea level

Sub-component 4.1: Natural Extreme Events and Disasters

4.1.1: Occurrence of natural extreme events and disasters

4.1.1.a: Occurrence of natural extreme events and disasters

4.1.1.a.1: Type of natural extreme event and disaster (geophysical, meteorological, hydrological, climatological, biological)

4.1.1.a.2: Location

4.1.1.a.3: Magnitude (where applicable)

4.1.1.a.4: Date of occurrence

4.1.1.a.5: Duration

Sub-component 1.1: Physical Conditions

Topic 1.1.2: Hydrographical characteristics

1.1.2.a: Lakes

1.1.2.a.1: Surface area

1.1.2.a.2: *Maximum depth*

1.1.2.b: Rivers and streams

1.1.2.b.1: Length

1.1.2.c: Artificial reservoirs

1.1.2.c.1: *Surface area*

1.1.2.c.2: *Maximum depth*

1.1.2.e: Seas

1.1.2.e.5: *Area of sea ice*

1.1.2.g: Glaciers

1.1.4: Soil characteristics

1.1.4.b: Soil degradation

1.1.4.b.2: Area affected by desertification

Sub-component 1.2: Land cover, Ecosystems and Biodiversity

1.2.1: Land cover

1.2.1.a: Area under land cover categories

1.2.2: Ecosystems and biodiversity

1.2.2.a: General ecosystem characteristics, extent and pattern

1.2.2.a.1: Area of ecosystem

1.2.2.b: Ecosystems' chemical and physical characteristics

1.2.2.b.2: *Carbon*

1.2.2.c: Biodiversity

1.2.2.c.1: Known flora and fauna species

1.2.2.c.2: Endemic flora and fauna species

1.2.2.c.3: Invasive alien flora and fauna species

1.2.2.c.4: Species population

1.2.2.c.5: *Habitat fragmentation*

1.2.3: Forests

1.2.3.a: Forest area

1.2.3.a.1: Total

1.2.3.a.2: Natural

1.2.3.a.3: Planted

1.2.3.a.4: Protected forest area (also in 1.2.2.d)

1.2.3.a.5: Forest area affected by fire

1.2.3.b: Forest biomass

1.2.3.b.1: Total

1.2.3.b.2: *Carbon storage in living forest biomass*

Sub-component 1.3: Environmental Quality

1.3.3: Marine water quality

- 1.3.3.b: Organic matter
- **1.3.3.b.1: Biochemical oxygen demand (BOD)**
- 1.3.3.b.2: Chemical oxygen demand (COD)
- 1.3.3.f: Physical and chemical characteristics [of marine water bodies]
- 1.3.3.f.1: *pH/Acidity/Alkalinity*
- 1.3.3.f.2: Temperature
- 1.3.3.f.3: *Total suspended solids (TSS)*
- 1.3.3.f.4: *Salinity*
- 1.3.3.f.5: Dissolved oxygen (DO)
- 1.3.3.f.6: *Density*
- 1.3.3.g: Coral bleaching
- **1.3.3.g.1: Area affected by coral bleaching**

Sub-component 2.3: Land

2.3.1: Land use

2.3.1.a: Area under land use categories

2.3.2: Use of forest land

- 2.3.2.a: Use of forest land
- **2.3.2.a.1: Area deforested**
- 2.3.2.a.2: Area reforested
- 2.3.2.a.3: Area afforested
- 2.3.2.a.4: *Natural growth*

Sub-component 4.1: Natural Extreme Events and Disasters

4.1.2: Impact of natural extreme events and disasters

4.1.2.a: People affected by natural extreme events and disasters

- **4.1.2.a.1: Number of people killed**
- 4.1.2.a.2: Number of people injured
- 4.1.2.a.3: Number of people homeless
- 4.1.2.a.4: Number of people affected

4.1.2.b: Economic losses due to natural extreme events and disasters

4.1.2.c: Physical losses/damages due to natural extreme events and disasters

4.1.2.d: Effects of natural extreme events and disasters on integrity of ecosystems

4.1.2.d.1: *Area affected by natural disasters*

4.1.2.d.2: *Loss of vegetation cover*

4.1.2.d.3: *Area of watershed affected*

4.1.2.d.4: *Other*

Sub-component 5.1: Human Settlements

5.1.3: Housing conditions

5.1.3.c: Population living in hazard-prone areas

5.1.3.d: Hazard-prone areas

Sub-component 5.2: Environmental Health

5.2.3: Vector-borne diseases

5.2.3.a: Vector-borne diseases

5.2.3.a.1: Incidence

5.2.3.a.2: Prevalence

5.2.3.a.3: Mortality

5.2.3.a.4: *Loss of work days*

5.2.3.a.5: *Estimates of economic cost in monetary terms*

5.2.4: Health problems associated with excessive UV radiation exposure

5.2.4.a: Problems associated with excessive UV radiation exposure

5.2.4.a.1: *Incidence*

5.2.4.a.2: *Prevalence*

5.2.4.a.3: *Loss of work days*

5.2.4.a.4: *Estimates of economic cost in monetary terms*

Mitigation and Adaptation

Sub-component 2.2: Energy Resources

2.2.2: Production, trade and consumption of energy

2.2.2.a: Production of energy

2.2.2.a.3: Production from renewable sources

Sub-component 6.1: Environment Protection and Resource Management Expenditure

6.1.1: Government environment protection and resource management expenditure

6.1.1.a: Government environment protection and resource management expenditure[on climate change mitigation activities]

6.1.1.a.1: Annual government environment protection expenditure

6.1.1.a.2: Annual government resource management expenditure

6.1.2: Corporate, non-profit institution and household environment protection and resource management expenditure

6.1.2.a: Private sector environment protection and resource management expenditure [on climate change mitigation activities]

6.1.2.a.1: Annual corporate environment protection expenditure

6.1.2.a.2: *Annual corporate resource management expenditure*

6.1.2.a.3: *Annual non-profit institution environment protection expenditure*

6.1.2.a.4: *Annual non-profit institution resource management expenditure*

6.1.2.a.5: *Annual household environment protection expenditure*

6.1.2.a.6: *Annual household resource management expenditure*

Sub-component 6.2: Environmental Governance and Regulation

6.2.2: Environmental regulation and instruments

6.2.2.a: Direct regulation

6.2.2.a.1: List of regulated water pollutants and description (e.g. by year of adoption and maximum allowable levels) [related to climate change]

6.2.2.a.2: Description (e.g. name, year established) of licensing system to ensure compliance with environmental standards for businesses or other new facilities [related to climate change]

6.2.2.a.3: Number of applications for licenses received and approved per year [related to climate change]

6.2.2.a.4: List of quotas for biological resource extraction

6.2.2.a.5: Budget and number of staff dedicated to enforcement of environmental regulations [related to climate change]

6.2.2.b: Economic instruments [related to climate change]

6.2.2.b.1: *List and description (e.g. year of establishment) of green/environmental taxes*

6.2.2.b.2: *List and description (e.g. year of establishment) of environmentally relevant subsidies*

6.2.2.b.3: *List of eco-labelling and environmental certification programmes*

6.2.2.b.4: Emission permits traded

6.2.3: Participation in MEAs and other global environmental conventions

6.2.3.a: Participation in MEAs and other global environmental conventions

6.2.3.a.1: List and description (e.g. country's year of participation) of MEAs and other global environment conventions [related to climate change]

Sub-component 6.3: Extreme Events Preparedness and Disaster Management

6.3.1: Preparedness for natural extreme events and disasters

6.3.1.a: National natural extreme event and disaster preparedness and management systems

6.3.1.a.1: Existence of national disaster plans/programmes

6.3.1.a.2: Description (e.g. number of staff) of national disaster plans/programmes

Appendix 4: Sustainable Development Goals

Goal 1. End poverty in all its forms everywhere

Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Goal 3. Ensure healthy lives and promote well-being for all at all ages

Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Goal 5. Achieve gender equality and empower all women and girls

Goal 6. Ensure availability and sustainable management of water and sanitation for all

Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all

Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Goal 10. Reduce inequality within and among countries

Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

Goal 12. Ensure sustainable consumption and production patterns

Goal 13. Take urgent action to combat climate change and its impacts

Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development