SWAZILAND GOVERNMENT
MINISTRY OF TOURISM AND ENVIRONMENTAL AFFAIRS

SWAZILAND'S SECOND NATIONAL COMMUNICATION TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

Funding for this document was provided by the Global Environmental Facility (GEF) the financial entity of the financial mechanism of the United Nations Framework Convention on Climate Change UNFCCC through the United Nations Development Programme (UNDP) Country Office as it agent. The Department of Meteorology under the Ministry of Tourism and Environmental Affairs was the Executing Body for the preparation of this document.

FINAL REPORT

FOREWORD

On behalf of the kingdom of Swaziland it is a privilege and a great honour for me to present Swaziland's Second National Communication to the Conference of Parties to the United Nations Framework Convention on Climate Change.

Swaziland ratified the United Nations Framework Conventions on Climate Change (UNFCCC) in 1996 and since then, the country has been working towards the achievement of the objectives of the convention.

Like all parties to the convention, Swaziland is obligated to submit national communications' as per requirement of the UNFCC. The first national communication of Swaziland was submitted to the UNFCCC in 2002. This Second National Communication is a follow-up to the first national communications and continues the work under the Convention.

Swaziland as a developing country is not immune to the adverse effects of climate change which have impacted immensely on the country's main economic sectors such as agriculture, industry and forestry. For Swaziland, adaptation is not an option but is a necessity; however, there is still need for strengthening institutional and human resources for the country to adapt to the impacts of climate change. Swaziland do have mitigation potential in some sectors like energy and waste but funding remains the limiting factor towards exploiting such opportunities. With all the above highlighted limitations, the Kingdom of Swaziland is keen to continue participating actively on the different national and international activities on climate change.

The Hon. Macford Sibandze

Minister of Tourism and Environmental Affairs

ACKNOWLEDGEMENTS

Swaziland's Second National Communication to the United Nations Framework Convention on Climate Change has been prepared in accordance with Article 4, paragraph 1, and Article 12, paragraph 1, of the United Nations Framework Convention on Climate Change (UNFCCC), which calls for each Party to report to the Conference of Parties (COP) information on its emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol (Greenhouse Gas Inventories); national or, where appropriate, regional programmes containing measures to mitigate, and to facilitate adequate adaptation to climate change (general description of steps taken or envisaged by the Party to implement the Convention); and any other information that the Party considers relevant to the achievement of the objective of the Convention.

The structure of the Communication is based on the Guidelines for preparation of National Communications from Parties not included in Annex I to the Convention (Decision 17/CP.8).

This Second National Communication (SNC) is presented by the SNC Project Team, managed and supervised by Mr. Emmanuel Dlamini (UNFCCC Focal Point and Designated National Authority (DNA)), in the Ministry of Tourism and Environmental Affairs (MTEA). It is based on contributions from the SNC Technical Working Groups consisting of F.D. Yamba (Team Leader), M. Mathunjwa (Energy Sector), J. Matondo (Water Sector & Industrial Processes), A. Dlamini (Agriculture Sector), A.M. Manyatsi (Land Use Change & Forestry), B. Dlamini (Waste Sector), N. A. Sukati (Health) and W. S. Madonsela-Kamalandua (Socio-Economic Review) and Ms. Duduzile Nhlengethwa-Masina (Project Manager).
The consolidation of the various Thematic Working Groups reports was done by R. Brown (Team Leader), A. Remmelzwaal and W.M. Dlamini. Report review and language editing was done by J. B. Rwanika and J. K. Mutsigwa (ITECH PRO) under close collaboration with the UNFCCC Focal Point Mr. Emmanuel Dlamini. Valuable inputs were provided by stakeholders consulted through workshops and meetings and they are acknowledged as well.

Lastly the inputs and efforts of H.P Sikhosana and S.C Nzalo on doing the final editing and graphic design of the document are also acknowledged.

The SNC Project was financed through the Global Environmental Fund (GEF), the financial Entity of the UNFCCC. The United Nations Development Programme (UNDP), as the GEF financial agent, through Swaziland Country Office provided management of the project while the implementation was through the Ministry of Economic Planning and Development. The Department of Meteorology (MET) under the Ministry of Tourism and Environmental Affairs (MTEA) was the executing agency. Special appreciation goes to the Technical Working Groups, development partners as well as everyone who contributed in one way or another in the preparation of the Second National Communication. The views and opinions expressed in the report do not necessarily reflect the opinion of the United Nations.

EXECUTIVE SUMMARY

Background

The preparation of the Second National Communication used the guidelines based on methodologies developed by the Intergovernmental Panel on Climate Change (IPCC). The National Communication is composed of the following chapters in accordance with the UNFCCC guidelines for the preparation of Non-Annex 1 national communication:

- National Circumstances
- National GHG Inventory
- Vulnerability and Adaptation to Climate Change
- Mitigation Options Analysis
- Policies and Measures to ensure the fulfillment of the UNFCCC Objectives
- Other Information relevant to the implementation of the Convention
- Gaps, Constraints, and Related Financial, Technical and Capacity Needs

National Communication Process

The Second National Communication preparation was coordinated by the Department of Meteorology (MET), which is the National Climate Change Focal Point. To support the preparation of the National Communication, several Technical Working Groups (TWGs) were established to source and interpret information and data about the impact of climate. Contributions were made by TWGs consisting of the following thematic areas; Energy; Water and Industrial Processes; Agriculture; Land Use Change and Forestry; Waste; Health; and Socio-Economic Review. The Thematic Working Groups worked under the guidance of the present coordinator.

In September 2010 the Ministry of Tourism and Environmental Affairs (MTEA) through the Department of Meteorology (MET) established a multi-sectoral National Climate Change Committee which comprised of various Government ministries. The Committee is responsible for developing and coordinating programmes and projects aimed at addressing climate change in line with the country's development priorities. Stakeholder participation in the national climate change adaptation debate has been slow since the Convention was ratified by Swaziland in 1996. It is hoped that the existence of the Committee will strengthen the capacity of the relevant stakeholders to fulfil the country’s mandate under the Convention, whilst also help in mobilising financial and technical support to fulfil Swaziland’s commitment under the Convention.

Geographic Settings

The Kingdom of Swaziland is a landlocked and mountainous country situated in the south-eastern part of the African Continent, bounded by the Republic of South Africa on the north, west and south and by the Republic of Mozambique to the east. The country covers a land area of 17,364 km^2 and has an elevation range of 600-1,860 masl.

The Climate

The general climatic characterization of Swaziland is subtropical with wet hot summers (about 75% of the annual rainfall in the period from October to March) and cold dry winters (April-September). The physiographic zones show clearly different climatic conditions, ranging from sub-humid and temperate in the Highveld to semi-arid and warm in the Lowveld.

Swaziland lies at the transition of major climatic zones, being influenced by air masses from different origin: equatorial convergence zone (summer rains), subtropical eastern continental moist maritime (onshore flow with occasional cyclones), dry continental tropical and marine west Mediterranean (winter rains, with rare snow).

Mean annual rainfall ranges from about 1,500 mm in the northern Highveld to 500 mm in the southern Lowveld. Precipitation varies considerably from year to year, which either may lead to periods of flash flooding or drought. Drought is an inherent feature of the current semi-arid climate.

Mean annual temperature varies from 17°C in the Highveld to 22°C in the Lowveld. These temperatures are zonal averages, with some variation across zones.

The Economy

Swaziland's economy is highly dependent on South Africa with the Lilangeni pegged to the Rand. South Africa accounts for 90% of Swaziland imports. Swaziland's exports to South Africa amounts to 60% and she imports 80% of her electricity from South Africa. Until 2010 the Southern Africa Customs Union (SACU) returns used to account, on average, for 60% of total government annual revenue and have since been reduced to below 60%. The manufacturing sector has diversified since the mid-1980s. Sugar remains important foreign exchange earner. In 2007, the sugar industry increased efficiency and diversified in response to a 17% decline in EU sugar prices. The agricultural sector's share of GDP decreased from over 30% at independence to 13% in 1989 and to 10% in 2009. However, agriculture is more important for Swaziland's population and national economic development than its contribution to GDP suggests. Agricultural output forms the raw material base for about one third of value added goods within the manufacturing sector and contributes substantially to national export earnings. Livestock production is a major agricultural activity with small farmers owning about 77% of the total cattle population. The number of livestock has been declining in recent years due to droughts and overgrazing of rangelands resulting in less productivity, and to some extent also because of the population increases and thereby increasing demand for resources.

Despite a relatively high per capita income of $5,708 (IMF, 2010), giving it a ranking of 106 out of 181 countries and therefore categorized as a lower middle income country, Swaziland faces socio-economic challenges akin to a least developed country. According to the Poverty

Reduction Strategy and Action Plan (GOS, 2008), 69% of the population live in poverty (less than $1 US income per day). Food insecurity is high, with 25-50% of the population dependent on food aid. Real GDP growth since 2001 has averaged 2.8 percent, nearly 2 percentage points lower than growth in other SACU member countries.

Population

The population of Swaziland in 2007 was estimated at just over 1 million, with an annual growth rate of 0.9%. There is a concern over the HIV prevalence and rate of infection among the populace. The Demographic and Health Survey 2006-2007, the first survey to provide population-based prevalence estimates for HIV, showed that HIV adult prevalence was 26% (31% in adult women and 20% in adult men).

National Inventory of Anthropogenic Emissions

In 2000, total GHG emissions were estimated at 19.8 million tonnes of CO_2 equivalent. Results of this inventory indicate that Swaziland is a net source for GHGs, a change from the 1994 GHG Emission, where Swaziland was a sink.
The highest GHG in Swaziland are HFCs which contributed 45.8% to total national GHG emissions expressed in CO_2 equivalent in 2000, followed by N_2O, 33.1% and, CO_2, 14.3%. CH_4 contributed 6.8% which is insignificant in comparison to the overall GHG emissions in the country.

When considering the GHG emissions by sectors, Industrial processes accounted for 45.8% (mostly HFCs) followed by Waste 33.7%, Agriculture 8.2%, Energy 6.7% and land use change 5.6%. Total GHG emissions in 2000, not considering uptake by sinks, amounted to 18,658.01Gg CO_2 equivalent.

Climate Analysis

Two methods were used to do climate projections. The climate projections were carried out for two future periods: Future A[1] and Future B[2]. the two methods were: Climate Change Explorer tool and an ensemble of 7 Global Circulation Models (GCMs). The models didn't agree on the predicted rainfall for the Future A period but they were in agreement in the Future B period. The Climate Change Explorer tool predicted a decrease in rainfall in the Future A period while the ensemble of 7 GCMs predicted an increase in rainfall in the same period. Both models predicted an increase in rainfall in the Future B period.
Temperature analysis of historical observations showed a significant increase in the observed annual mean temperature which led to increases of way above 3 ˚C in the period from 1961 to 2000 in all agro-ecological zones. Both modelling methods indicated that temperatures will continue to rise and the Future B period has a relatively higher rate of warming than Future A.

[1] Future A is the time period from January 1, 2046 to December 31, 2065.
[2] Future B is the time period from January 1, 2081 to December 31 , 2100

Over the period covering 1960-2005, most stations indicate significant increases in both mean minimum and mean maximum temperatures. Trends in rainfall indices were much more heterogeneous than those for temperature, whilst there were statistically significant increases in some intensity related indices at specific locations and for specific periods.

Land Use, Land Use Change and Forestry

It has been predicted that there would be an increase in temperature in all agro-ecological zones and that there will be no significant change in the total annual rainfall. High temperatures are likely to lead to high evaporation and high water demand by forest plantations and indigenous forests. The country may be much drier posing potential changes to eco-systems. The drier Acacia savanna is likely to be dominant. Invasion by alien plant species and bush encroachment is most likely to increase. Frequent outbreak of forest fires is most likely to occur in linear year to year intervals.

Agriculture

In Swaziland, climate change will affect production of crops differently depending on the crop type, the agro-ecological zone and the planting time period for the particular crop. Maize yields are most likely to be high when planted in the first week of December rather than when planted in mid-October when there is enough rain. Increased maize yields are most likely from the Middleveld than in any other region. Beans yields are predicted to be high when planted in October than in January. Sorghum yields are most likely to be high when planted in January than when planted in mid-October. High yields for sorghum and beans are expected from the Highveld than in the other regions.

Dairy animals are expected to perform better in the Highveld and wet Middleveld particularly during the winter months. Adaptation to climate change may include shifting planting periods, growing of drought tolerant crops, and raising suitable crops in appropriate regions.

Biodiversity

The vast area of Swaziland’s grassland and Lebombo bushveld is likely to be affected by climate change although with varying degrees of severity if the moderate case scenario (A1B) conditions prevail. Both vegetation types will likely lose more than half of their current bioclimate area. This has significant implications on biodiversity and people’s livelihoods with most of the country’s current vegetation types and species experiencing notable declines.

Simulation modelling indicates that habitat for a majority of the endangered birds and mammals would decline dramatically. Analysis of the spatial distribution of most of the species of birds suggests most species are mostly likely to be critically endangered by the middle of the 21st century as a result of climate change. This may further be exacerbated by the combined effects of continued habitat destruction and over-harvesting among other threats. Furthermore, considering the spatial distribution patterns of mammals and amphibians, which tend to be grouped into Lowveld and Highveld species, will have dire consequences on the country’s faunal diversity. This is more the case because the novel warmer bio climates occur in the country's protected areas and faunal hotspots.

Adaptation measures recommended include among others; improving the understanding of the impacts of climate change on biodiversity; increasing awareness of climate change impacts and capacity to respond, minimising the impacts of climate change on aquatic and semi-aquatic species, communities and ecosystems, indigenous terrestrial species; impact of alien and invasive organisms on biodiversity in future climates; and factoring the impacts of climate change on biodiversity into natural resource management and land-use planning.

Water Resources

The projected runoff change is negative in Usuthu, Mbuluzi and Ngwavuma catchments except for the Komati catchment. The median future stream flow lies below the present flows especially during the winter months in the three catchments except the Komati catchment. However, the decreases and increase in the stream flows in the four catchments fail to attain statistical significance at the 5% level.

It has also been established that the present stream flow lies within the 95% confidence interval of the projected flows in all the catchments which emphasizes the lack of statistical significance in the simulated runoff change. It can therefore, be concluded that, the water resources sector is less vulnerable to climate change at the 5% significance level. Adaptation strategies proposed include implementation of efficient water use, strengthening of stream flow observation, early warning systems, implementation of integrated water resources management and rain water harvesting.

Health

Climate change will affect the basic requirements for maintaining healthier nation, clean air and water, sufficient food and adequate shelter. Catastrophic weather events, variation in weather systems that affect food and water supplies, ecosystem changes are all associated with global warming and pose health risks. Climate and weather risk may result in increased deaths due to heat waves, and natural hazards such as floods, vector-borne diseases such as malaria and other existing and emerging infectious diseases.

Projections of Greenhouse Gas Emissions

GHG emissions from all sectors (energy, industrial processes, agriculture, waste, and Land Use, Land Use Change and Forestry) are projected to be at 25.4 million tonnes of CO_2 equivalent and are expected to increase to 33.4 million tonnes of CO_2 equivalent by the 2030 as the country tries to avert overarching challenges related to poverty and food security. Stringent implementation of identified mitigation measures under energy and Land Use, Land Use Change and Forestry (LULUCF) would gradually contribute to moving Swaziland from a carbon source to a carbon sink after 2030. Mitigation measures considered include fuel switch from coal to sugarcane trash in the sugar industry, strengthening and promoting renewable energy sources, efficient energy system and ethanol blending under the energy sector. Under LULUCF, measures considered include reforestation, regeneration, and bio-electricity. The trend to attain a carbon sink status could also be enhanced through conservation farming.

Achieving the Objectives of the UNFCCC

Since the publication of its First National Communication, Swaziland has undertaken a number of activities that can broadly be presented as addressing the needs of climate change and these include the establishment of National Climate Change Committee (NCCC) and Designated National Authority (DNA) to handle and manage CDM Projects applications and processes, and conducting various programmes on public awareness at grassroots level.

Besides establishment of the NCCC and DNA, Swaziland is working toward developing a climate change strategy and action plan with financial support from the UNDP Country Office. The expected result is creating a platform for developing a legislative instrument for mainstreaming climate change in national development policies and programmes. Further, a number of policies with climate change considerations have been integrated in recent policies and strategies. These include food security and agricultural sector policies, biodiversity conservation and management policy, natural disaster and emergency policy, national biofuels strategy and action plan, national energy policy implementation strategy, and adaptation and mitigation measures in national action plans.

One notable activity related to technology transfer was the undertaking of a Technology Needs Assessment (TNA) in 2010. The objective of this exercise was to identify and evaluate climate change mitigation and adaptation technologies and measures that are in line with national development priorities in Swaziland.

The TNA found that there are mitigation and adaptation measures available to address the key impacts of Climate Change. Information gaps were noted on education, training and public awareness and efforts have been made to strengthen the capacity of the Ministry of Education and Training to lead and coordinate the integration of climate change in the school curricula. Priorities aimed at strengthening national capacity in assembling and interpreting climate data and information were identified. The National Capacity Self-Assessment (NCSA, 2005) identified a number of challenges which should form the basis for follow up when developing new programmes. Swaziland has been actively participating in the UNFCCC process through mainly financial support by the UNFCCC to participate fully on some of the UNFCCC programmes such as the adaptation panel and the Nairobi Framework Programme on adaptation and the Poznan technology transfer programme.

Constraints, Gaps and Related Financial, Technical and Capacity Needs

Swaziland faces pressing social and economic challenges which weaken her ability to set aside resources for implementing climate change projects. The country is classified as a lower income country and is thus seen not to lack resources to undertake climate projects without external assistance. The country has poverty rate of 69% and does not have the capacity to fund climate projects without external assistance. Mobilising financial support require both human and technical capacity which remains a challenge.

It is therefore critical that technical capacity and human resource development are undertaken to strengthen the existing weakest links. This includes capacity in data collection and systematic observation, systematic research and development in climate change including downscaling models. Due to the lack of activity data, estimates were used and these seem to be overestimated.

This National Communication has identified areas wherein data and information have to be improved (e.g. waste, health sector, water resources, agriculture, energy, and more importantly industry). To support the preparation of the National Communication, several technical working groups were established to source and interpret information and data about the impact of climate. It emerged that the capacity and skills available locally were gradually being developed as all thematic group work was done by Nationals.

Moreover, it was equally noted that the baseline information to model, analyse or interpret climate impacts was still a challenge that need to be further considered in the third and subsequent National Communications. Hence, national research institutions need to upgrade their capacities to ensure that future National Communication Reports are conducted based on readily available, useful, relevant data and information. In this regard, there is a need to mobilise support that National Institutions (private and public) to coordinate and strengthen their technical and human capacity.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS AND TERMS

Abbreviations for Chemical Compounds

CH_4	Methane
N_2O	Nitrous oxide
CO_2	Carbon dioxide
CO	Carbon monoxide
NO_X	Nitrogen oxides
NMVOC	Non-methane volatile organic compound
NH_3	Ammonia
CFCs	Chlorofluorocarbons
HFCs	Hydrofluorocarbons
PFCs	Perfluorocarbons
SF_6	Sulfur hexafluoride
CCl_4	Carbon tetrachloride
C_2F_6	Hexafluoroethane
CF_4	Tetrafluoromethane

Standard Equivalents, Units and Factors

1 tonne	1 megagram
1 kilotonne	1 gigagram
1 megatonne	1 teragram
1 gigatonne	1 petagram
1 kilogram	2.2046 lbs
1 hectare	10,000 m^2
1 calorie	4.1868 Joules
1 atmosphere	101.325 kPa
Bt	billion tons
dm	dry matter
E	Emalangeni
g	gram
Gg	gigagrammes
GW	gigawatts
GWh	gigawatt-hours
ha	hectare
J	joule
ℓ	litre

ℓ/s	litres per second
mm	millimetres
m^3	cubic metre
masl	metres above sea level
mcm	million cubic metres
Mt	million tons
MW	megawatt
MWh	megawatt-hours
^oC	degree Celsius
t	metric ton

Acronyms

AEZ	Agro Ecological zones
CBS	Central Bank of Swaziland
CCCMA	Canadian Centre for Climate Modeling and Analysis
CCCMA_ CGCM3	Canadian Centre for Climate Modeling and Analysis -The Third Generation Coupled Global Climate Model
CDM	Clean Development Mechanism
CFLs	Compact Fluorescent Lamps
CNRM	Centre National de Recherché Meteorologique
COMAP	Comprehensive Mitigation Analysis Process
COP	Conference of Parties
CP.8	Conference of the Parties (The 8^{th})
DNA	Designated National Authority
DSSAT	Decision Support System for Agrotechnical Transfer
E	Emalangeni
FNC	First National Communication
GCM	Global Circulation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GFDL	Geophysical Fluid Dynamics Laboratory
GHGs	Greenhouse Gases
GIS	Geographic Information System
GOS-NMS/SNC	Government of Swaziland-National Meteorological Service/Second National Communication
GWP	Global Warming Potential
HDI	Human Development Index
HIV/AIDS	Human Immuno deficiency Virus/Acquired Immuno Deficiency Syndrome
IPCC	Intergovernmental Panel on Climate Change
LEAP	Long Range Energy Alternative Planning
LGP	Length of Growing Period

LPG	Liquid Petroleum Gas
LULUCF	Land use, land use change and forestry
MASL	Metres above sea level
MET	Department of Meteorology
MIASMA	Modeling Framework for Health Impact Assessment of Man-Induced Atmospheric Changes
MNRE	Ministry of Natural Resources and Energy
MOAC	Ministry of Agriculture and Cooperatives
MTEA	Ministry of Tourism and Environmental Affairs
NCCC	National Climate Change Committee
NCSA	National Capacity Self-Assessment
NMVOC	Non-Methane Volatile Organic Compounds
NOAA	National Oceanic and Atmospheric Administration
OECD	Organization for Economic Co-operation and Development
QA/QC	Quality Assurance/Quality Control
SACU	Southern Africa Customs Union
SADC	Southern Africa Development Community
SAPP	Southern African Power Pool
SEC	Swaziland Electricity Country
SNC	Second National Communication
SNL	Swazi Nation Land
SSA	Swaziland Sugar Association
TDL	Title Deed Land
TNA	Technology Needs Assessment
TWGs	Technical Working Groups
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UV	Ultra Violet
V&A	Vulnerability Assessment

Glossary

Activity:
A practice or ensemble of practices that take place on a delineated area over a given period of time.

Activity data:
Data on the magnitude of a human activity resulting in emissions or removals taking place during a given period of time. Data on energy use, metal production, land areas, management systems, lime and fertilizer use and waste arising are examples of activity data.

Biological treatment of waste:
Composting and anaerobic digestion of organic wastes, such as food waste, garden/park waste and sludge, to reduce volume in the waste material, stabilisation of waste, and destruction of pathogens in the waste material. This includes mechanical-biological treatment.

Biomass:
(1)The total mass of living organisms in a given area or of a given species usually expressed as dry weight. (2) Organic matter consisting of or recently derived from living organisms (especially regarded as fuel) excluding peat. Includes products, by-products and waste derived from such material.

Blowing agent (for foam production):
A gas, volatile liquid, or chemical that generates gas during the foaming process. The gas creates bubbles or cells in the plastic structure of foam.

Bootstrap technique:
Bootstrap technique is a type of computationally intensive statistical methods which typically uses repeated re-sampling from a set of data to assess variability of parameter estimates.

Calcium carbide:
Calcium carbide is used in the production of acetylene, in the manufacture of cyanamide (a minor historical use), and as a reductant in electric arc steel furnaces. It is made from calcium carbonate (limestone) and carbon containing reductant (e.g., petroleum coke).

Carbon dioxide equivalent:
A measure used to compare different greenhouse gases based on their contribution to radiative forcing. The UNFCCC currently (2005) uses global warming potentials (GWPs) as factors to calculate carbon dioxide equivalent.

Category:
Categories are subdivisions of the four main sectors: Energy; Industrial Processes and Product Use (IPPU); Agriculture, Forestry and Other Land Use (AFOLU); and Waste. Categories may be further divided into subcategories.

Chlorofluorocarbons (CFCs):
Halocarbons containing only chlorine, fluorine, and carbon atoms. CFCs are both ozone-depleting substances (ODSs) and greenhouse gases.

Country-specific data:
Data for either activities or emissions that are based on research carried out on sites either in that country or otherwise representative of that country.

Emission factor:
A coefficient that quantifies the emissions or removals of a gas per unit activity. Emission factors are often based on a sample of measurement data, averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions.

Emissions:
The release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time.

Energy recovery:
A form of resource recovery in which the organic fraction of waste is converted to some form of usable energy. Recovery may be achieved through the combustion of processed or raw refuse to produce steam through the pyrolysis of refuse to produce oil or gas; and through the anaerobic digestion of organic wastes to produce methane gas.

Enhanced coal bed methane (recovery):
Increased CH4 recovery produced by the injection of CO_2 into coal seams.

Estimation:
The process of calculating emissions and/or removals.

Evaporative emissions:
Evaporative emissions fall within the class of fugitive emissions and are released from area (rather than point) sources. These are often emissions of Non-Methane Volatile Organic Compounds (NMVOCs), and are produced when the product is exposed to the air – for example in the use of paints or solvents.

Expert judgement:

A carefully considered, well-documented qualitative or quantitative judgement made in the absence of unequivocal observational evidence by a person or persons who have a demonstrable expertise in the given field.

Feedstock:
Fossil fuels used as raw materials in chemical conversion processes to produce primarily organic chemicals and, to a lesser extent, inorganic chemicals.

Fluorocarbons:
Halocarbons containing fluorine atoms, including chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

Flux:
(1) Raw materials, such as limestone, dolomite, lime, and silica sand, which are used to reduce the heat or other energy requirements of thermal processing of minerals (such as the smelting of metals). Fluxes also may serve a dual function as a slagging agent.
(2) The rate of flow of any liquid or gas, across a given area; the amount of this crossing a given area in a given time, e.g., "Flux of CO_2 absorbed by forests".

Fossil carbon:
Carbon derived from fossil fuel or other fossil source.

Fuel:
Any substance burned as a source of energy such as heat or electricity. See also Primary Fuels and Secondary Fuels.

Fuel combustion:
Within the Guidelines fuel combustion is the intentional oxidation of materials within an apparatus that is designed to provide heat or mechanical work to a process, or for use away from the apparatus.

Fuelwood:
Wood used directly as fuel.

Fugitive Emissions:
Emissions that are not emitted through an intentional release through stack or vent. This can include leaks from industrial plant and pipelines.

Global warming potential:
Global Warming Potentials (GWP) are calculated as the ratio of the radiative forcing of one kilogramme greenhouse gas emitted to the atmosphere to that from one kilogramme CO_2 over a period of time (e.g., 100 years).

Good Practice:

Good Practice is a set of procedures intended to ensure that greenhouse gas inventories are accurate in the sense that they are systematically neither over- nor underestimates so far as can be judged, and that uncertainties are reduced so far as possible. Good Practice covers choice of estimation methods appropriate to national circumstances, quality assurance and quality control at the national level, quantification of uncertainties and data archiving and reporting to promote transparency.

Hydrocarbon:

Strictly defined as molecules containing only hydrogen and carbon. The term is often used more broadly to include any molecules in petroleum which also contains molecules with S, N, or O An unsaturated hydrocarbon is any hydrocarbon containing olefinic or aromatic structures.

Hydrochlorofluorocarbons (HCFCs):

Halocarbons containing only hydrogen, chlorine, fluorine and carbon atoms. Because HCFCs contain chlorine, they contribute to ozone depletion. They are also greenhouse gases.

Hydrofluorocarbons (HFCs):

Halocarbons containing only hydrogen, fluorine and carbon atoms. Because HFCs contain no chlorine, bromine, or iodine, they do not deplete the ozone layer. Like other halocarbons, they are potent greenhouse gases.

Hydrofluoroethers (HFEs):

Chemicals composed of hydrogen, fluorine and carbon atoms, with ether structure. Because HFES contain no chlorine, bromine, or iodine, they do not deplete the ozone layer. Like other halocarbons, they are potent greenhouse gases.

Key category:

A key category is one that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emissions and removals, the trend in emissions and removals, or uncertainty in emissions or removals. Whenever the term key category is used, it includes both source and sink categories.

Land cover:

The type of vegetation, rock, water etc. covering the earth's surface.

Landfill gas:

Landfill gas is a gaseous fuel composed of mainly methane and carbon dioxide and is formed after anaerobic digestion of municipal solid waste. Municipal solid waste contains significant portions of organic materials which are deposited, compacted and covered in a landfill. In the landfills, anaerobic bacteria thrive in the oxygen-free environment, resulting in the decomposition of the organic materials and the production of primarily carbon dioxide and methane. Carbon dioxide is likely to leach out of the landfill because it is soluble in water.

Methane, on the other hand, which is less soluble in water and lighter than air, is likely to migrate directly to the atmosphere.

Lubricants:
Lubricants are hydrocarbons produced from distillate or residue, and they are mainly used to reduce friction between bearing surfaces. This category includes all finished grades of lubricating oil, from spindle oil to cylinder oil, and those used in greases, including motor oils and all grades of lubricating oil base stocks.

Manure:
Waste materials produced by domestic livestock which can be managed for agricultural purposes. When manure is managed in a way that involves anaerobic decomposition, significant emissions of methane can result.

Non-energy products:
Primary or secondary fossil fuels which are used directly for their physical or diluent properties. Examples are: lubricants, paraffin waxes, bitumen, and white spirits and mineral turpentine (as solvent).

Non-energy use:
Within the Guidelines this term refers to the use of fossil fuels as Feedstock, Reductant or Non-energy products. However, the use of this term differs between countries and sources of energy statistics. In most energy statistics, e.g., of the International Energy Agency (IEA), fuel inputs of reductants to blast furnaces are not included but accounted for as inputs to a fuel conversion activity transforming coke and other inputs to blast furnace gas.

Non-Methane Volatile Organic Compounds (NMVOCs):
A class of emissions which includes a wide range of specific organic chemical substances. Non-Methane Volatile Organic Compounds (NMVOCs) play a major role in the formation of ozone in the troposphere (lower atmosphere). Ozone in the troposphere is a greenhouse gas. It is also a major local and regional air pollutant, causing significant health and environmental damage.
Because they contribute to ozone formation, NMVOCs are considered "precursor" greenhouse gases. NMVOCs, once oxidized in the atmosphere, produce carbon dioxide.

Open burning of waste:
The combustion of unwanted combustible materials such as paper, wood, plastics, textiles, rubber, and other debris in the open or at an open dump site, where smoke and other emissions are released directly into the air without passing through a chimney or stack. Open burning can also include incineration devices that do not control the combustion air to maintain an adequate temperature and do not provide sufficient residence time for complete combustion.

Oxidation:
Chemical reaction of a substance by combining it with oxygen.

Ozone-depleting substances (ODS):
A compound that contributes to stratospheric ozone depletion. Ozone-depleting substances (ODS) include CFCs, HCFCs, halons, methyl bromide, carbon tetrachloride, and methyl chloroform. ODS are generally very stable in the troposphere and only degrade under intense ultraviolet light in the stratosphere. When they break down, they release chlorine or bromine atoms, which then deplete ozone.

Perfluorocarbons (PFCs):
Synthetically produced halocarbons containing only carbon and fluorine atoms. They are characterized by extreme stability, non-flammability, low toxicity, zero ozone depleting potential, and high global warming potential.

Primary fuels:
Fuels which are extracted directly from natural resources. Examples are: crude oil, natural gas, coals, etc.

Process emissions:
Emissions from industrial processes involving chemical transformations other than combustion.

Quality Assurance (QA):
Quality Assurance activities include a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process to verify that data quality objectives were met, ensure that the inventory represents the best possible estimate of emissions and sinks given the current state of scientific knowledge and data available, and support the effectiveness of the quality control (QC) programme.

Quality Control (QC):
Quality Control is a system of routine technical activities, to measure and control the quality of the inventory as it is being developed. The QC system is designed to: (i) Provide routine and consistent checks to ensure data integrity, correctness, and completeness; (ii) Identify and address errors and omissions; (iii) Document and archive inventory material and record all QC activities. QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardised procedures for emission calculations, measurements, estimating uncertainties, archiving information and reporting. More detailed QC activities include technical reviews of source categories, activity and emission factor data, and methods.

Removals:
Removal of greenhouse gases and/or their precursors from the atmosphere by a sink.

Reporting:
The process of providing results of the inventory.

Secondary fuels:
Fuels manufactured from primary fuels. Examples are: cokes, motor gasoline and coke oven gas, blast furnace gas.

Sequestration:
The process of storing carbon in a carbon pool.

Sink:
Any process, activity or mechanism which removes a greenhouse gas, an aerosol, or a precursor of a greenhouse gas from the atmosphere.

Source:
Any process or activity which releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere.

Uncertainty:
Lack of knowledge of the true value of a variable that can be described as a probability density function characterizing the range and likelihood of possible values. Uncertainty depends on the analyst's state of knowledge, which in turn depends on the quality and quantity of applicable data as well as knowledge of underlying processes and inference methods.

CHAPTER 1

Introduction

Swaziland rectified the UNFCCC in 1996. Since then the country have been contributing to the attainment of the ultimate objective of the UNFCCC and have been legally obligated to adopt and to implement relevant measures in order to stabilise greenhouse gas concentrations in the atmosphere at a level that would present dangerous anthropogenic interference with the climate system. As a non-Annex 1 Party to the convention, the country is committed to prepare and submit (in accordance to Article 4 paragraph 1a and b and article 12 of the convention) greenhouse gas inventories, mitigation options of GHG emissions, assessment of its vulnerability to the effects of climate change and adaptations options to the COP through the UNFCCC secretariat.

Swaziland signed and further rectified the United Nations Framework Convention on Climate Change (UNFCCC) in 1996. "The ultimate objective of the UNFCCC and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provision of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a substantial manner" (UNEP/IUC, 1998).
Articles 4 paragraph 1 (a) and (b) and 12 commit all parties to the UNFCCC to prepare and submit an inventory of GHGs, mitigation options of GHG emissions, an assessment of its vulnerability to adverse effects of climate change and adaptation measures to the Conference of Parties through the UNFCCC Secretariat.

The 1996 IPCC Guidelines were used for GHG emissions inventory and the reporting is according to Decision 17/CP.8. The Second National Communication is composed of the following sections in accordance with the UNFCCC guidelines for the preparation of Non-Annex 1 national communication:

- National Circumstances
- National GHG Inventory
- Vulnerability and Adaptation to Climate Change
- Mitigation Options Analysis
- Policies and Measures to ensure the fulfillment of the UNFCCC Objectives
- Other Information relevant to the implementation of the Convention
- Gaps, Constraints, and Related Financial, Technical and Capacity Needs

The Second National Communication preparation was coordinated and supervised by the Department of Meteorology (MET), which is the Swaziland's Climate Change Focal Point. Input from stakeholders such as the Ministry of Agriculture, the Ministry of Natural Resources and Energy, the Department of Forestry, the Ministry of Commerce, Industry and Trade, the University of Swaziland, the Swaziland Water Services Corporation were key in the preparation of the Second National Communication. This second National Communications is a follow up and builds upon work done and reported in the first National Communications submitted to the UNFCCC in 2002.

CHAPTER 2

National Circumstances

2.1. Geographic setting

The Kingdom of Swaziland is a landlocked and mountainous country situated in the South-Eastern part of Africa between 25°C and 28°C latitude south and 30° and 33° longitude east. The country covers a land area of 17,364 km^2 and is bounded by the Republic of South Africa on the north, west and south and by the Republic of Mozambique to the east (Figure 2.1). Although small in size, Swaziland is characterized by a great variation in landscape, geology, soils, climate and biodiversity.

Figure 2.1: *Map of Swaziland*

Swaziland is located at the transition of the South African Plateau (reaching over 1500m) to the Mozambican coastal plain. The western part of the country lies in the escarpment zone, the eastern part on the coastal plains. The Lubombo Range separates the Swaziland coastal plain from the Mozambique coastal plain.

Swaziland is classified into six Physiographic Zones (Table 2.1 and Figure 2. 2), taking into account elevation, landforms, geology, soils and vegetation: Highveld, Upper Middleveld, Lower

Middleveld, Western Lowveld, Eastern Lowveld and Lubombo Range (Remmelzwaal, 1993; Murdoch, 1970). The six zones are subdivided according to soil and terrain characteristics.

The Highveld is the upper part of the overall escarpment and consists of a complex of steep slopes between low and high levels, dissected plateaux, plateau remnants and associated hills, valleys and basins. The Upper Middleveld consists of strongly eroded plateau remnants and hills at an intermediate level of overall escarpment, but also contains structurally defined basins in relatively protected positions, which are only weakly eroded, e.g. the Ezulwini Valley. The Lower Middleveld is basically the piedmont zone of the escarpment, characterized by generally strongly eroded moderate foot slopes.

The Lowveld plain consists of largely sedimentary and volcanic Karroo beds versus the igneous and metamorphic rocks of Highveld and Middleveld. The Lowveld is subdivided into the Western Lowveld on sandstone predominantly and the Eastern Lowveld on basalt exclusively. The Lubombo Range is basically an eroded cuesta (tilted plateau) with a steep escarpment on the western side and a gradual dip slope of about 1:20 descending east.

Physiographic Zone	Area (ha)	Altitude (msl)	Landform & Topography	Geology	Vegetation Type
Highveld	568,000	900-1,400	Steep hills on steeply dissected escarpment, transitions to plateaux; 30% serious erosion	Granite (dominant) with gneiss, lava	Short sour grassland with forest patches
Upper Middleveld	242,000	600-800	Mod steep hills with plateau remnants and basins; 50% serious erosion	Granodiorite & granite with gneiss, shale	Tall grassland with scattered trees & shrubs
Lower Middleveld	242,000	400-600	Rolling piedmont plains with basins and isolated hills ; 20% serious erosion	Gneiss (dominant) with granite/diorite	Broad-leaved savanna & hillside bush
Western Lowveld	341,000	250-400	Undulating plain; 10% serious erosion	(Sandstone/ shale, with dolerite intrusions)	Mixed broad-leaved & Acacia savanna
Eastern Lowveld	196,000	200-300	Gently undulating plain; 5% serious erosion	Basalt	Acacia savanna (dry)
Lubombo Range	148,000	250-600	Undulating plateau (cuesta) with steeply dissected escarpment; 5% serious erosion	Ignimbrite	Hillside bush and plateau savanna

Table 2.1 Physiographic Zones of Swaziland with Landforms, Geology and Vegetation

Note: *Altitude covers average range, does not include minor parts with extreme altitudes; Source: Remmelzwaal, 1993; vegetation units after Sweet & Khumalo, 1994; erosion (GOS/FAO, 1997).*

Land Degradation

Land degradation is recognised as a very serious problem in Swaziland and a critical issue for continued sustainable social and economic development and poverty alleviation. The most conspicuous form of land degradation in Swaziland is soil erosion (gully, rill and sheet erosion), but also degradation of natural vegetation and forests is commonly observed.

Climate change is expected to have a further negative effect on land degradation through reduction of vegetation cover and changes in species composition (GOS-NMS/SNC, 2010b), as well as through increased deforestation, desertification and disaster hazards.

Mineral Resources

The geology of Swaziland is complex and diverse; the oldest igneous formations of the basement complex are 3.550 million years old and belong to the oldest rock on earth (GOS, 1982). Minerals of economic importance include asbestos, iron, soapstone, green chert, gold, tin, diamonds and various other base metals such as copper, nickel and chromium, several of which have been mined in the past. Coal layers are of economic value, with an estimated 1.017 million tonnes probable and potential reserve.

Land Tenure

Land tenure in Swaziland has two main categories: communal land held in trust by the King, called Swazi National Land (SNL - about 74%), and land that is private, or under Title Deed Land (TDL - about 26%). Two other minor categories exist of less than a percent, namely crown land and concession land. The TDL area is largely used for industrial timber plantations, livestock production and sugarcane cultivation, and does also include urban areas. The majority of SNL is used for communal extensive grazing and subsistence crop production, and human settlement. Unlike TDL, SNL cannot be used as collateral; consequently farmers on SNL generally remain challenged regarding financial access to commercial finance.

Under the 2005 Constitution, all people have equal access and rights to land. The pressure on land is driven by the growing population and the demand for more land for competing land uses, e.g. agriculture and residential in peri-urban areas, forestry and grazing in the Highveld, transport, tourism, sugarcane and biodiversity conservation in the Lowveld. Mechanisms for land distribution and administration remain underdeveloped to adequately deal with the multifaceted physical planning challenges.

Agro-Ecological Characterization

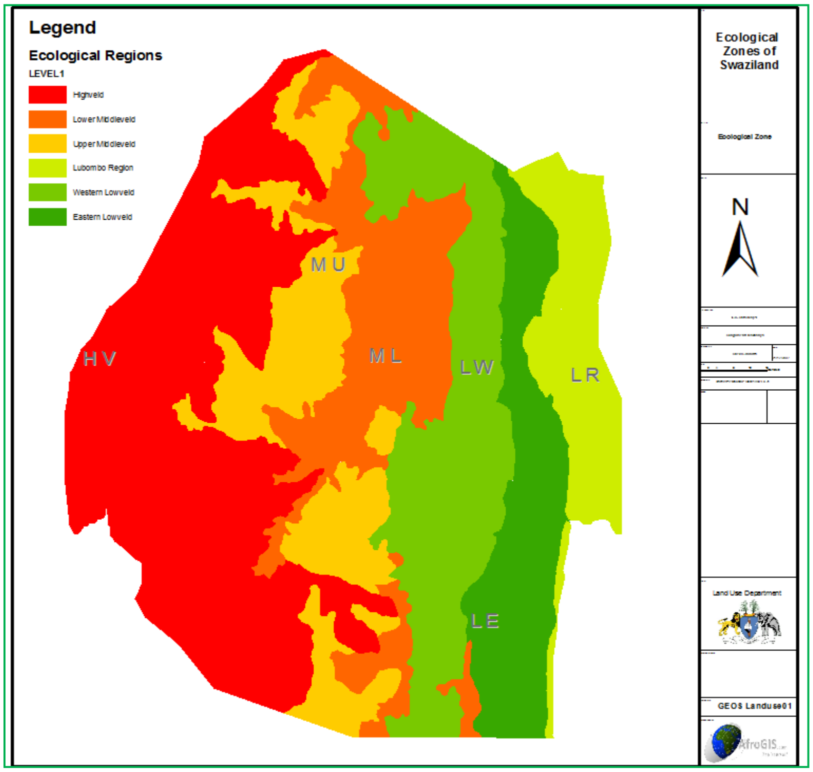


Figure 2.2: *Agro- Ecological Zones of Swaziland*

Combining climatic data with the soil and terrain characteristics of the physiographic zones has led to the definition and mapping of the agro-ecological zones (AEZ) of Swaziland (GOS/FAO, 1994). Figure 2.2 show the six main zones which have been subdivided at two levels into smaller units. In the AEZ procedure (FAO, 1996) locally defined agro-climatic moisture and thermal zones are superimposed on physiographic zones. The moisture zones are classified on basis of the annual rainfall totals and the length of growing period expressed at an 80% reliability level as dependable annual rainfall.

The agro-climatic characterization provides essential climatic information for crop production but is also relevant to the occurrence of natural vegetation zones.

The AEZ methodology provides a framework for the organization and evaluation of land resource data, including topography, soils, vegetation, land suitability and land uses.

The framework is relatively rigid with respect to landforms, geology and soils, however flexible for climatic trends; it can be used to accommodate spatial shifts resulting from observed or projected climate change.

The Organisation for Economic Co-operation and Development (OECD) highlights the FAO AEZ approach, which is used to quantify the regional impact and geographical shifts in agricultural land and productivity potentials (Pingali, 2004). The AEZ approach analyses the implications for food security resulting from climate variability and change.

Drylands of Swaziland

Drylands are particularly vulnerable to the effects of climate change; hence adaptation is essential in dryland management (GOS/UNDP, 2003). In Swaziland drylands cover 944,000 ha or 54% of the country and encompass all of the Lower Middleveld, Eastern and Western Lowveld, as well as parts of the Lubombo Range and Upper Middleveld (Figure 2.2).

Figure 2.3 show the subdivision of the Dryland Zones of Swaziland with the corresponding length of growing period (LGP), precipitation and potential evapotranspiration.

The driest zone in Swaziland is the moist semi-arid zone, found in the southern Lowveld. The intermediate dry sub-humid II zone occurs mainly in the northern Lowveld. The most humid part of the Drylands is the dry sub-humid I zone, covering the Lower Middleveld, most of the Lebombo and a small part of the Upper Middleveld.

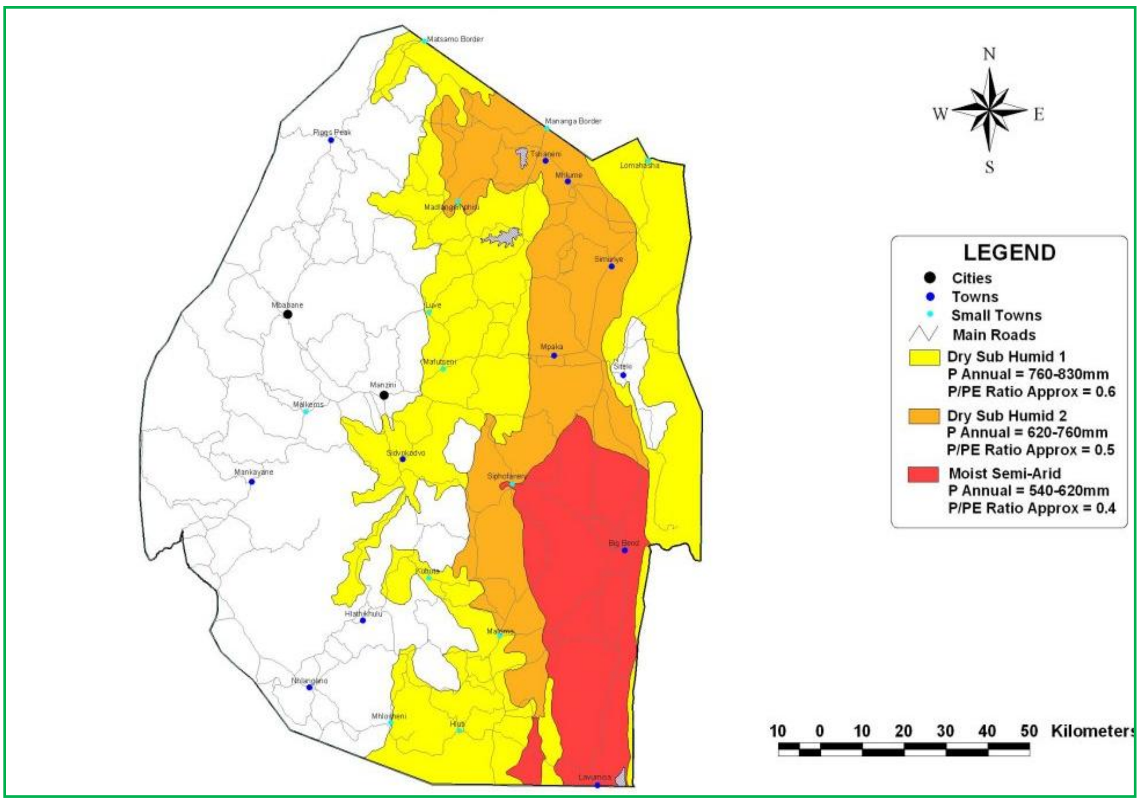


Figure 2.3: *Dryland Zones of Swaziland*

Land Use, Land Use Change and Forestry, and Conversions

Land use, land use change and forestry (LULUCF) activities are important for estimating emissions (source) and removals (sink) of greenhouse gases (GHGs) resulting from interventions in land management. The type of human forestry has a strong impact on whether the land is or becomes a net source or sink of atmospheric GHGs, which in turn contributes to climate change.

Issues on LULUCF are particularly relevant to Swaziland, with an emphasis on development perspectives. Despite concerns that agricultural land is in short supply, substantial tracts of land with agricultural potential remain under-utilized (FAO/WFP, 2008). Moreover, evidence suggests that an increasing proportion of arable land is no longer used; most likely as the combined result of recurrent droughts (or climate change), weakened labour force due to the effects of HIV/AIDS , land conversions and economic challenges.

In peri-urban areas, rainfed arable land, together with land used for grazing, is converted to residential use, both formal and informal, however not at dramatic scale. Changes in land use for industrial timber plantations or for conservation have been minor in recent years.

Land considered suitable for cultivation in Swaziland is generally estimated at 20% of the country’s total land mass (about 350,000 ha).

The estimated area under cultivation was 236,000 ha (including fallow land), in the late 1980s. Since then, land area used for rainfed production has been decreasing and a noticeable shift towards irrigated agriculture.

Ecosystem conversion from 1985 to 2000 into plantation forestry, irrigated agriculture, urban, dams, etc was estimated at 2,900 ha annually (GOS-SEA, 2001). As conversions to forestry have decreased after 1990, the annual amount is modified to 2,000 ha for the period 1990-2020.

Land under irrigation is increasing annually with 1,000-1,500 ha, mainly driven by the expansion of the sugar industry (SSA, 2009) although alternative uses are now being considered as in future the production of sugarcane in Swaziland may become less profitable or water insufficient.

Land use Category	1990	2000	2010	2020
Land use: Forestry, Ranching, Communal Grazing, Conservation equals Landcover: Forest, Woodland, Savanna, Bushland, Grassland				
Industrial Forestry large scale	135,000	121,000	107,000	100,000
Plantation Forestry small scale, mainly wattle	26,000	28,000	30,000	32,000
Ranching	340,000	349,000	344,000	344,000
Ext. Comm. Grazing: no-slight degradation	650,000	673,000	676,000	639,000
Ext. Comm. Grazing: moderate degradation	70,000	75,000	80,000	85,000
Ext. Comm. Grazing: severe degradation	110,000	115,000	120,000	125,000
Ext. Comm. Grazing: wasteland	30,000	35,000	40,000	45,000
Conservation, Parks	58,000	69,000	84,000	94,000
Subtotal land use /landcover	*1,419,000*	*1,465,000*	*1,481,000*	*1,464,000*
Land use Crop Agriculture (gross) equals Landcover Cultivated Land (gross arable land)				
Crop Agriculture Irrigated	45,000	57,000	70,000	90,000
Crop Agriculture small scale rainfed	210,000	150,000	110,000	100,000
Crop Agriculture large scale rainfed	50,000	30,000	20,000	10,000
Subtotal land use /landcover Crop agriculture	*305,000*	*237,000*	*200,000*	*200,000*
Land use Residential, Dams etc. equals landcover Urban (built-up), Dams				
Residential/Industrial	8,000	12,000	16,000	20,000
Dams	4,000	8,000	12,000	16,000
Not classified (unaccounted/balance)	0,000	14,000	29,000	36,000
Total	**1736,000**	**1736,000**	**1736,000**	**1736,000**

Table 2.2: *Estimated and Projected Land Use, Land Use Change and Forestry Conversions (1990-2020).*

Main Sources: GOS/FAO, 1994a (with some minor modifications to accommodate wattle); GOS-MOAC, 2006; GOS-CSO, 1900-2004; CBS Annual Reports 1995-2009; SSA Annual Reports 2000-08; FAO/GOS-MOAC, 2006; GOS-MOA, 2008; FAO, 2010. Most figures rounded off, extreme values eliminated, if needed averaged for nearest 2-4 years, extrapolated for 2010, estimated for 2020.

2.2. Climate

The climate of Swaziland is mainly subtropical with hot and wet summers (about 75% of the annual rain in the period from October to March) and cold and dry winters.

The physiographic zones show clearly different climatic conditions, ranging from sub-humid and temperate in the Highveld to semi-arid and warm in the Lowveld.

The Swaziland Meteorological Services was established in 1991 and since then some of their stations have not yet accumulated long-term data considered suitable for climate data analysis. Normally, climate data accumulated over 30 years is considered viable for statistical analysis. Financial resources remain a constraint toward improving the distribution of the country's weather observation station network.

Mean annual rainfall ranges from about 1,500 mm in the northern Highveld to 500 mm and below in the southern Lowveld. Precipitation varies considerably from year to year, which either may lead to periods of flash flooding or drought.

Mean annual temperature varies from 16°C in the Highveld to 22°C in the Lowveld. These temperatures are zonal averages, with some variation across zones. Highest January mean maximum temperatures are recorded in the Eastern Lowveld (34°C at Lavumisa at 200 masl), and lowest in the Highveld (22°C at Usutu at 1450 masl). The lowest July mean minimum temperature of 5°C occurs at Usutu, the highest of 10°C at Lavumisa. Frost is recorded in all physiographic zones, frequently in Highveld and Upper Middleveld but only rarely in the Lowveld. The lowveld tends to be much hotter during the day, recording about 40°C at times and much cooler at night with minimum temperature close to zero.

Physiographic Zone	Mean Temperature (°C)			Mean Annual Rainfall (mm)		Köppen Classification
	Annual	January	July	Mean Annual	80% Dependable	
Highveld	17	20	12	850-1,500	700-1,200	Cwb
Upper Middleveld	20	24	15	800-1,000	650-850	Cwa
Lower Middleveld	21	25	16	650-800	500-700	Cwa
Western Lowveld	22	26	18	625-725	425-550	BSh
Eastern Lowveld	22	27	17	550-625	400-500	BSh
Lubombo Ridge	21	26	17	700-825	500-750	Cwa

Table 2.3: *Climatic Characterisation by Physiographic Zone. Source: GOS/FAO, 1994a, 1997*

According to the Köppen classification the Highveld has a Cwb climate, which is defined as warm temperate rainy (C), with a dry season in winter (w) and a cool summer (b: warmest month below 22°C). The Upper Middleveld, Lower Middleveld and Lebombo fall into a Cwa climate, same as Highveld but with a hot summer (a: warmest month over 22°C). The Western and Eastern Lowveld have a Bsh climate, a dry and hot steppe climate. Further north along the Mozambican coast the climate changes to tropical (Aw), further south in KwaZulu Natal to rainfall all year round (Cf).

2.3. Population and Health

The population of Swaziland was estimated at just over 1 million in 2007, with an annual growth rate of 0.9% (GOS-CSO, 2010). Table 2.4 shows that the population has been in general decline since independence. The distribution between male and female is 47.3% versus 52.7%. The overall national level of HIV prevalence is a source of concern. Over half of Swaziland's population is below 20 years old and there are estimated to be 144,000 orphans and vulnerable children (OVCs) (GOS/NERCHA, 2006). There was a significant mortality increase for Swaziland between 1997 and 2007.

Census Year	Total	Annual Growth (%)
1966	374,697	4.8
1976	494,534	2.8
1986	681,059	3.2
1997	929,718	2.9
2007	1,018,449	0.9

Table 2.4: *Population and Annual Growth Rate (1966-2007). Source: GOS-CSO (2010) Population and Housing Census 2007*

Investment in health is a prerequisite for the long-term goal of poverty reduction and is recognised in the Poverty Reduction Strategy and Action Plan 2005-2015 (PRSAP) which considers poverty as both a cause and consequences of ill health. Poverty and chronic diseases are interconnected (WHO, 2007).

All countries are vulnerable to climate-sensitive disease conditions or outcomes. Out-patient records show the prevalence of four common ailments affecting Swaziland that is diarrhoea, malaria, bilharzias, and malnutrition.

2.4. Government Structure

In September 2010 the Ministry of Tourism and Environmental Affairs established a multi-sectoral National Climate Change Committee (NCCC) comprised of various governments' ministries. The NCCC is responsible for developing and coordinating programmes and projects aimed at addressing climate change in line with the country's development priorities. The NCCC provides the National Climate Change Focal Point with periodical updates of national inventories of anthropogenic emissions of harmful gases (GHGs) by sources and removals by sinks.

In addition, the committee will carry out education and public awareness campaigns on climate change and act as the interface between National Climate Change Focal Point (NCCFP) and the Climate Change Unit, while guiding the establishment of a technical board comprising of representatives from NGOs and the private sector.

The Department of Meteorology is also the Designated National Authority (DNA) for the Clean Development Mechanism (CDM). A DNA is the body granted responsibility by a Party (to the Convention) to issue written approval of project in which participation is voluntary and projects must contribute to the country's sustainable development. CDM is a market mechanism for carbon trade between developed and developing countries under the Kyoto Protocol which Swaziland ratified and came into force on the 16th April 2006. Establishment of a DNA is a pre-requisite for participation by a Party in the CDM. The DNA acts as a focal point for the CDM project approval process. The DNA function as "one-stop-shop" for CDM project developers interested in developing CDM projects in the country.

2.5. Economy

Swaziland is categorized as a lower middle income country with per capita income of $5,708 (IMF, 2010). In view of the level of poverty, the country is faced with socio-economic challenges that are similar to those faced by least developed countries.

Swaziland achieved steady progress in its development indices since independence, increasing its Human Development Index (HDI) to a peak in 1995, followed by a decline and relative low in 2005, but again followed by a modest rise till 2010 (UNDP, 2010a) (Table 2.5). The decline from 1995-2005 is the result of a deteriorating national health indices which has shown improvement post 2005 whilst the indicators for education and income have shown a steady rise (UNDP, 2010a).

Year	1990	1995	2000	2005	2006	2007	2008	2009	2010
HDI	0.511	0.523	0.490	0.474	0.477	0.482	0.487	0.492	0.498

Table 2.5: *Human Development Index (1990-2010). Source: UNDP, 2010a.*

Swaziland is highly dependent on South Africa, not only is the Swazi Emalangeni pegged to the South African Rand but South Africa accounts for 90% of Swaziland's imports, 60% of its exports, and 80% of its electricity. Most importantly the Southern Africa Customs Union (SACU) until 2010 used to account for an average of 60% of total government annual revenue but was reduced to below 60%. The trends of key economic indicators over the period 2000-2009 are shown in Table 2.6. The economy witnessed rapid growth from the early 1970s to the early 1990s. However after the emergence of South Africa from economic isolation and relocation of investments from Swaziland to South Africa, the economic performance deteriorated. Gross Domestic Product (GDP) grew by an annual average of 7.6% in the decade 1968-1978 and 5.8% in the period 1979-1989. In the period 1990-2000 the rate declined to 3.4% with the downward trend continuing. After a temporary growth from 2003 till 2007, the expansion of economic activity again lost momentum, with growth dropping to 1.2% in 2009 and negative projection for 2010 (CBS, 2010).

Indicator	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Real GDP	8,689	8,791	8,964	9,174	9,436	9,683	10,012	10,365	10,612	10,740
Real GDP growth (%)	1.8	1.2	1.8	2.2	2.9	2.5	3.3	3.5	2.4	1.2
GDP per Capita	10,544	11,324	12,220	12,972	14,154	14,590	17,418	21,126	24,277	25,836
Inflation (%)	7.3	7.5	11.7	7.4	3.4	4.8	5.3	8.1	12.6	7.5
External Debt	2,710	3,498	3,031	2,742	2,733	2,750	3,077	3,393	4,135	3,327
Debt Service (% GDP)	1.8	1.6	2.1	2.0	2.3	1.5	1.6	1.4	1.8	2.1
Stock of Foreign Direct Investment	4,057	4,302	5,248	4,787	5,238	4,972	5,764	6,056	5,043	5,971
GDP at market prices (nominal)	10,580	11,661	12,904	14,025	15,636	16,433	19,962	21,515	24,947	26,788

Table 2.6: *Key Economic Indicators (2000-2009 in million Emalangeni)*

The financial outlook for 2009/10 indicated a budget deficit of E1.28 billion or 5% of GDP. Estimates for 2010/11 indicate a worsening position with the overall budget deficit projected to reach E3.65 billion or 13% of GDP (CBS, 2009 & 2010). The negative turnaround in the fiscal position is a result of a 62% fall in SACU receipts totalling E2.0 billion in 2010/11 compared with E5.2 billion received in 2009/10. Total revenue is projected at E6.6 billion indicating a massive decline of 31% from the previous year's budget.

Sector contributions to GDP over the period 2003-09 are listed in Table 2.7. It shows that there is a gradual but continuing decrease of the contribution from traditional sectors such as agriculture and manufacturing. Nevertheless, to the extent that a large portion of the manufacturing sector is agro-based (mainly sugar, wood pulp and citrus canning), the base of the economy is therefore still agricultural.

Sector	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Agriculture, hunting, forestry and fishing	11.7	11.0	11.3	10.7	10.5	10.4	10.0
Mining and quarrying	0.3	0.3	0.2	0.2	0.1	0.1	0.1
Manufacturing	38.5	37.8	37.1	36.4	36.1	35.8	34.3
Electricity, gas and water supply	1.2	1.2	1.2	1.2	1.2	1.2	1.3
Construction	3.6	4.1	4.2	4.0	4.0	3.8	3.6
Wholesale, retail, hotel and restaurants	8.9	9.4	10.0	10.8	11.5	11.7	12.2
Transport and communication	8.0	8.3	9.2	9.4	9.4	9.8	10.2
Financial intermediation	3.5	3.5	3.5	3.6	3.6	3.6	3.8
Real estates and renting	6.9	6.8	6.7	6.7	6.7	6.9	7.0
Public administration	17.0	17.1	16.0	16.3	16.5	16.4	17.1
Other community and social activities	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total value added	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 2.7: *Percentage Sector Contribution to GDP at Basic Prices (2003-2009). Source: GOS-CSO & MOF, CBS*

2.6. Agriculture

Over the past decade, the country has been affected by a large variation in rainfall resulting in recurring drought events. Preliminary analysis suggests that climate change will have an increasingly adverse effect on agricultural production, particularly on smaller households. Land degradation, erosion and uncontrolled bushfires contribute further to the vulnerability of the 78% of the population that reside in rural communities. The result is chronic food shortages with many households depending on food aid (UNDP, 2010).

Before the 1980s Swaziland was largely self-sufficient in its cereal production. In the 1990s Swaziland produced about 60 percent of its own staple food (maize) requirements, but since 2001 this has in average fallen under 40 percent. In 2007/08 650,000 beneficiaries received emergency food relief, of which most were covered under free food distribution.

Agriculture is more important for Swaziland's population and national economic development than its contribution to GDP suggests. Agriculture plays a key role in the lives of the majority of the population, since over 70% of the population and households rely on agricultural output as a major source of income and food security, either as small-scale producers or as recipients of income from employment (about 20,000 people) on medium and large-scale farms and estates.

Maize is the most important subsistence crop on SNL, followed by groundnuts, pumpkins, beans, sweet potatoes and vegetables. Sorghum, cowpeas, jugo beans, melons, watermelons, cassava, bananas, peaches and avocados are also produced, but in limited quantities. Although most of these crops are economically not very important, they contribute to the agricultural diversification pattern in Swaziland and hence to food security and nutrition.

Livestock production is a major agricultural activity in Swaziland, with small farmers owning about 77% of the total cattle population. The number of livestock has been declining in recent years due to drought and overgrazing of rangelands resulting in less productivity, and to some extent also because of allocation of land for human settlement and agricultural schemes as the population grows, which in turn increase the demand for resources.

Cattle are the main livestock; other animal species raised in Swaziland are goats, sheep, pigs, equines and poultry. The contribution of the livestock sub-sector to the agricultural sector GDP is about 4% (Table 2.8). Beef and other livestock products contribute about 1% to total exports.

In Swaziland there are two broad livestock production systems, namely the commercial system and the traditional system. The traditional SNL sector manages about 86% of cattle and 95% of small stock whereas the commercial TDL system carries the rest; the stocking rate on SNL is two times larger than on TDL. Cattle population indicates a continuous increase from 600,000 in 2003 to a peak of 658,000 in 2006, followed by a decrease to 634,000 in 2008 (CBS, 2010). Goats are the main small stock, numbering about 300,000 in 2000 increasing to 500,000 in 2008. In recent years, poultry has also increased.

Livestock Type	Number of Animals
Dairy Cattle	3,292
Non-dairy Cattle	588,288
Sheep	15,755
Goats	297,756
Horses	1,448
Mules & Asses	11,880
Swine	36,826
Poultry	1,703,415
Total	2,658,660

Table 2.8: *Livestock Census (2000). Source: GOS-MOAC, 2000. Livestock Census*

The contribution of the fisheries sector in general to the national economy is negligible because of the limited amounts of fish in the country. However, aquaculture is making a contribution to food security by improving the nutritional status of the population and income generation. Aquaculture is encouraged by the government. There are fishponds located all over the country. The most common fish farmed in Swaziland are Oreochromis mossambicus (Tilapia) and Clarias Gaiepinus (Catfish). Rainbow trout (Salmo giardeneri) and the Common carp (Cyprinus carpio) are also cultured. The tilapia is sourced locally, while other species are imported from South Africa. In 2007, there were about 40 community ponds around the country stocked with tilapia and catfish.

2.7. Forestry

There are two main types of forestry, namely industrial and community forestry. Industrial forestry is aimed at commercial production, whereas community forestry is largely a subsistence activity, although there is an important trade element.

Figure 2.4: *Forest plantations showing chopped wood at Peak Timber in Pigg's Peak. Picture by: Swazi photo pro.*

Swaziland has a large industrial forestry sector as climatic conditions, particularly in the Highveld, are very conducive for the commercial growing of a specific variety of trees. Trees for commercial production were first planted in 1949, and areas under plantation forest have since steadily expanded until about 1990, covering about 8% of the country.

The commercially grown plantation species are pine (predominantly Pinus patula, but also P. radiata, P. taeda and P. elliottii) and eucalyptus (mainly Eucalyptus salinga and E. grandis), covering about 80 and 20 percent respectively of the planted area.

2.8. Biodiversity

Several vegetation mapping exercises have been executed over the past 50 years (Sweet and Khumalo, 1994). Degradation of natural forests and woodlands is commonly observed in Swaziland. Some of these categories, in particular grassland and bushland, overlap with rangelands which also show degradation.

Uncontrolled veld fires further contribute to forest degradation. Table 2.9 indicates the extent of veld fires which occurred in 2007. In average about 400,000 ha or almost a quarter of the country is annually burnt.

Year	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	Average
Burnt Area (ha)	384,124	517,044	457,860	406,562	256,652	434,935	327,217	397,771
Total Land Area (%)	22	30	26	23	15	25	19	23

Table 2.9: Burnt Area from Veld Fires in Swaziland (2000-2007).Source: Dlamini, W.M. (2010, 2010a)

The driving forces behind the deforestation and degradation in the natural forest and woodland areas are a complex of factors including population growth, pressure on land for agriculture and grazing, land conversions, growing poverty (EC, 2006). Lack of capacity to manage the indigenous forests has led to uncontrolled extraction of timber and non-timber forest products, including fruits, edible plants and vegetables, fuelwood, wood for utensils and craft, medicinal plants.

Severe bush encroachment is found in some of the commercial TDL ranches as there are less seasonal fires and relatively little wood extractions compared to SNL. In contrast to the observed signs of degradation, there may be new and more positive developments relating to the status of forest resources. As mentioned in the previous section, a reduced pressure on forest resources, resulting from decreasing livestock in at least part of the rural areas, together with improved natural resource management is contributing to re-afforestation of degraded forest resources.

The four recognised ecosystems of Swaziland are (1) montane grasslands, (2) savanna-woodland mosaic, (3) forests, and (4) aquatic systems (Figure 2.4). The savanna-woodland mosaic is the dominant ecosystem, covering the central and lower parts of the country, followed by the montane grasslands predominantly in the Highveld and the two other as minor systems. The savanna-woodland mosaic ecosystem is further sub-divided into three habitats, namely sour bushveld, Lowveld bushveld, and Lebombo bushveld. The savanna ecosystem is currently the best protected (5%), while just 2% of each of the other three ecosystems is protected. Swaziland is extremely rich in biodiversity. Plants and animals are not uniformly distributed across the four ecosystems. Furthermore, species composition varies greatly between ecosystems.

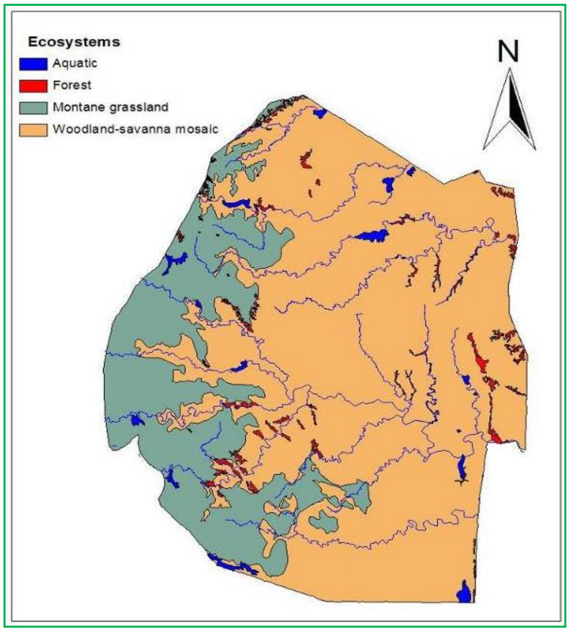


Figure 2.4: *Ecosystem Map of Swaziland*

The decline in biological diversity is most visible in two groups, large mammals and indigenous flora, but affects the entire spectrum. Main causes are loss of habitat, over-exploitation and invasive alien species. Habitat destruction is the result of agricultural expansion - at present mainly irrigation (sugarcane) - commercial forestry, road construction, industrial and urban development, and various other activities. Hunting, poaching, ignorance and lack of law enforcement contribute to over-exploitation. It is predicted that in the long-term climate change and desertification will have a severe impact on biodiversity, in particular in the savannah-woodland mosaic and aquatic ecosystems (GOS-NMS/SNC, 2010b).

2.9. Water Resources

All rivers in Swaziland are international rivers and the water that Swaziland can utilise from them is limited by agreements with South Africa and Mozambique. A Tripartite Permanent Technical Committee addresses international water right issues.

As a member state, Swaziland recognises the 1995 and 2004 revised SADC Protocol on Shared Watercourse Systems, which resulted from the Dublin Conference and Agenda 21. The water sources in Swaziland are surface waters (rivers, reservoirs), ground water and atmospheric moisture. The seven river catchment or drainage systems in Swaziland are the Komati, Lomati, Mbuluzi, Usutu, Ngwavuma, Pongola and Lubombo. Several of these rivers rise in South Africa and all flow eventually to Mozambique.

Water is a relatively scarce resource in the country and the use of the available water is skewed in favour of irrigation, which utilises about 95.3% of the surface water resources – the balance being used for industry (1.2%), livestock (1.2%) and domestic urban (1.4%) and domestic rural (0.9%).[3]

Most of the irrigation activities are located in the Lowveld, which is the dryer part of the country, with low levels of annual rainfall making it more prone to drought.The late onset of the rainfall season in this region, the shortened rains period and severe dry spells during the critical crop growth stages often cause crop failure. The industrial forestry sector is also using large amounts of water, however directly derived from rain and substantially reducing runoff. It can be observed irrigation is the major user of water in the country which accounts for 96.6% and the crops that are grown are sugarcane, citrus fruits, pineapples, vegetables and cotton. Most of the irrigation activities are located in the Lowveld region which also receives the lowest rainfall as explained earlier. Swaziland has been experiencing frequent droughts especially in the Lowveld region. Swaziland area is categorized into three drought risk zones namely little/none, moderate and severe. The northwest Highveld region is in the little/none drought risk zone. This is consistent with the position that the region receives the highest amount of rainfall (1200–1500 mm).

The south west Highveld, Middleveld and Lubombo regions are in the moderate drought risk zone, with annual rainfall values ranging from 700-1200 mm. The Lowveld region coincides with the severe drought risk zone, with annual rainfall ranging from 500-700 mm.

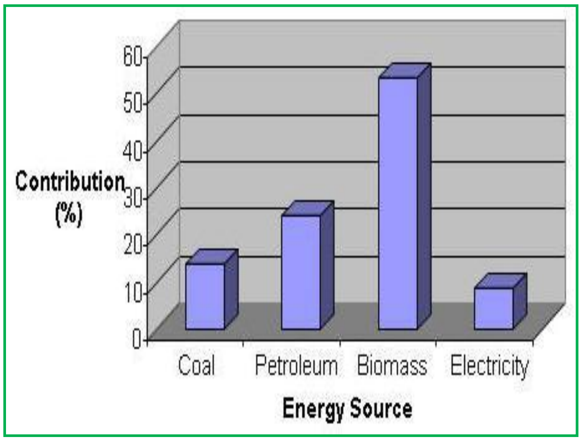
2.10. Energy

The figure below shows the different sources of Energy in Swaziland. Swaziland imports over 80% of electricity from South Africa's Electricity Supply Commission (ESKOM).

The biomass is from the local agriculture and forestry sectors of the economy and is almost exclusively used to power industrial processes in the sugarcane producing and timber producing sectors.

Most of the coal and electricity are used by industrial consumers, companies, town and urban dwellers; whereas most rural households use fuel wood as their main source of energy which is collected from within the area surrounding the homestead. The energy contributions are illustrated in Figure 2.5.

[3] Source: Department of Water Affairs – Figures relate to 2000.



According to the National Energy Policy Implementation Strategy 2009 (MNRE, 2009), in 1995, bagasse (33%) gave the largest contribution to the energy supply. Bagasse is a waste product of the sugar industry in Swaziland. It is used by the industries for electricity and steam generation. The electricity is used in the sugar plants and also distributed to surrounding company towns, but no electricity is sold to the national grid presently.

Figure 2.5: *Energy Contribution (2000)*

gest consumer of energy (41% of the total energy demand), followed by households at 21%, the agricultural sector with 16% and the transport sector with 15%. Industry uses electricity, petroleum products, coal and biomass (Figure 2.6). Household energy comprises of a mix of electricity for lighting and appliances, LPG, paraffin and biomass for cooking (Table 2.10). In agriculture electricity is used for irrigation and appliances and petroleum products for machinery and vehicles.

Diesel is also now being purchased from international markets and imported through Mozambique. Petrol is mainly used for vehicle transportation while a very small amount is used for other uses such as small electricity generators and brush cutting equipment. Diesel is also used for motor vehicle transportation and rail transportation, and some is used in diesel generators, boilers and incinerators.

Kerosene has traditionally been used for domestic use in lighting and cooking, but in recent years has also been used by light industry in firing boilers.

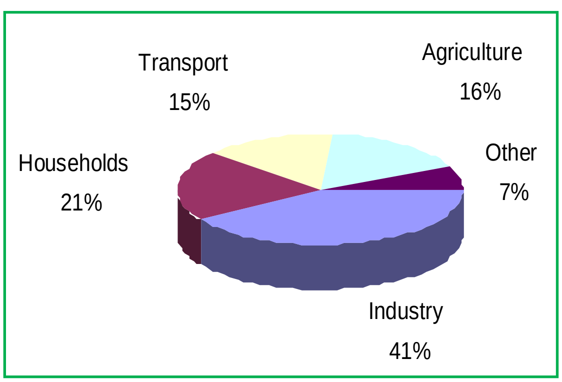


Figure 2.6: *Energy Demand (2005)*

Swaziland's main electricity production is by hydro generation with a production capacity of 70.1 MW. It also has 10 MW diesel generating capacity. Total energy supplied in 2007 amounted to 841 GWh of which 93.7 GWh was sourced from Mozambique. Swaziland imports 100% of her petroleum products. Swaziland produces anthracite coal for export to South Africa and Europe. Most of imported coal is used mainly in the industrial, agriculture, commercial and institutional sectors, while some is for domestic use.

The two main renewable sources of energy in Swaziland are biomass and hydroelectric power. Biomass fuels are available from the sugar and forestry industries whilst fuelwood is harvested from forests often by rural communities dependent upon it for their cooking and lightening energy needs.

The sugar industry uses both bagasse and wood chips to produce heat for internal production processes and electricity generation to energise the same processes. Other initiatives are evolving on the use of cane trash and tops as fuel for co-generation of electricity. Swaziland also produces hydroelectric power through four hydroelectric schemes, contributing about 23% of energy supply in the country.

Fuelwood use in rural and urban areas remains an important energy source and a significant GHG source (1410 Gg/year in 2004). Fuelwood and wood waste (26%) was the second largest contributor to the Swaziland energy supply. The wood fuel mainly comes from indigenous forests and savannah woodlands and to some extent from forest plantations and woodlots. The fuelwood is consumed in households, and the wood waste from the timber is used by industries for electricity and heat generation.

Between 1992 and 1995 the Ministry established an extensive solar pilot project mainly to electrify clinics and schools. Several street lighting, solar water heating and vaccine refrigeration systems were also installed through the project. The project also installed four PV water pumping schemes in the different regions of the country.

Hydropower is the major source of nationally produced electricity with installed capacity. The Swaziland Electricity Company has conducted several studies for expanding the hydropower capacity. Two possible sites (Lower Maguduza with a capacity of 20 MW and one on the Ngwempisi River with a potential 120 MW) have been earmarked.

	Cooking		**Lighting**	
	Total	%	Total	%
Electricity	44,999	21.2	74,872	35.3
Paraffin	17,808	8.4	26,600	12.5
Gas	31,264	14.7	1,085	0.5
Candle			106,308	50.1
Solar			427	0.2
Coal	2,217	1.0		
Wood	112,890	53.2	638	0.3
Other	560	0.3	219	0.1
Not Reported	2,457	1.2	2,046	1.0

Table 2.10: *Number of People using Domestic Sources of Energy for cooking and lighting (2007). Source: GOS-CSO, 2010.*

2.10. Industry, Mining & Transport

The major minerals in the country include asbestos, coal, quarried stone, soapstone, kaolin, talc, silica, green chert and others. Maloma Colliery is the only active coal mine.

The transport system in Swaziland is based principally on road transport. Nearly all passengers are conveyed by road on public transport[4], as are a major portion of the goods transported within Swaziland. The bulk of road freight operations continue to be carried out by multinational companies based in Swaziland, with only a few Swazi companies. There are 11 border posts used by freight operators, of which 9 are in South Africa and 2 in Mozambique. Over 90% of goods transported by road in cross-border movements go to South Africa.

Swaziland's rail network is about 300 km long[5]. The Railways Act of 1962 established the parastatal Swaziland Railway to provide transport services for import and export of goods as well as transit cargo. There is very little rail passenger service, although tourist trains have been increasing over the last few years. Airlink Swaziland, a joint venture between the Government and South African Airways, is the only airline currently operating. There is no significant air freight operation. Swaziland has one international airport, at Matsapha, and there are two other state-owned and nine privately-owned airstrips. The construction of the new airport, Sikhuphe, is already in progress and close to completion.

The country has well-serviced industrial sites located strategically in close proximity to border posts. The industry constitutes mostly of agro-processing including sugarcane, cotton, wood pulp livestock and canned fruit, production of soft drinks concentrates beverages, textiles, tourism and other manufacturing. Manufacturing involves textile and garment production that offers wide range of services and products including weaving, knitting, dyeing and finishing and employs relatively 15,000 Swazis.

[4] The majority of the population uses public transport.

[5] Rail transport in Swaziland began in 1964 with the opening of the line linking the Nqwenya iron ore mine at KaDake on the border with Mozambique. Operations continued until the mine ceased activities in 1980.

CHAPTER 3

National Greenhouse Gas Inventory

3.1. Introduction

The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories were used as the basis for conducting the inventory. Estimates for GHG emissions were based on the suggested methodology of the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 1996) and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000). Table 3.1 below provides a summary of the global warming potentials (GWPs) of the gases.

Gas	CO_2	CH_4	N_2O	HFC-134a	CF_4	SF_6
GWP	1	21	310	1300	6500	23900

Table 3.1: *Global Warming Potential (GWP) For Gases Source: IPCC, 2007b (http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html)*

The 1996 Revised Guidelines also provide information for the reporting of the following precursors: nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO) and sulphur dioxide (SO_2). Greenhouse gas emission and removal estimates are divided into main sectors, which are groupings of related processes, sources and sinks.

The Second National Communication is reporting on the following sectors:

- Energy
- Industrial Processes
- Agriculture
- Land Use, Land Use Change and Forestry
- Waste

3.2. Inventory Methodology

The calculated emissions and removals of GHGs for 2000 were based on the Revised 1996 IPCC Guidelines (IPCC, 1996a). The source categories included energy, industrial processes, agriculture, land use change and forestry, and waste. Tier 1 method was used for all the sector computation, except for open burning in rural areas under waste sector, where IPCC 2006 guidelines were used.

The UNFCCC Software Module 1.3.2 was used for this purpose. Given in Table 3.2 are the main sources of data for the GHG Inventory.

	Sector	Data Sources
1	Energy	Energy stakeholder statistics, Department of Energy
2	Industry	Swaziland Environment Authority, SIPA and Government Ministries
3	Agriculture	Ministry of Agriculture, Daily Board, Central Statistical Office, Swaziland Sugar Association
4	Waste	Swaziland Water Services Corporation, Matsapha Landfill Environmental Audit, Surveys
5	Land Use, Land Use Change and Forestry	Forestry Department and commercial companies

Table 3.2: *Sources of GHG data*

Quality Assurance (QA) and Quality Control (QC) is an important part of inventory development in order to perform sector specific quality control checks for verifying inventories. Estimates of uncertainties are needed for relevant source and sink categories, greenhouse gases, inventories totals as a whole and their trends. In Swaziland, this activity has not been performed in the past so far due to lack of an institutional capacity for GHG inventory reporting and preparation. However, such institutional capacity is gradually being developed. Its reinforcement will contribute to fulfil this activity in the near future and it is envisaged that it will be performed in the 3rd National Communication.

3.3. National GHG Inventory Summary

For the year 2000, Swaziland contributed 19,763Gg or 19.673 million tonnes of CO_2 equivalent GHGs to the atmosphere. Table 3.3 summarises emissions of CO_2, CH_4 and N_2O, HFCs, PFCs and SF_6 for all sectors presented in terms of CO_2 equivalent. Table 3.3 summarises Swaziland's national emissions and removals for the year 2000, with proper notations as required by Decision 17/CP.8. Table 3.4 shows Summary of GHG Emissions by Source.

Source	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Energy	1,172.33	121.17	40.30				1,333.80
Industrial Processes				9,053.20		10.30	9,063.50
Agriculture		849.41	753.50				1,602.91
Land Use, Land Use Change and Forestry	1,102.19	2.94					1,105.13
Waste	559.06	366.82	5,731.90				6,657.78
Total	**2,833.58**	**1,340.34**	**6,525.70**	**9,053.20**	**0.00**	**10.30**	**19,763.12**

Table 3.3: *Summary of GHG Emissions by Source*

The major GHG emission was HFCs which contributed about 45.8% to total national GHG emissions expressed in CO_2 equivalent in 2000, followed by N_2O, 33.1% and, CO_2, 14.3%. CH_4 contributed about 6.8% of the overall GHG emissions in the country. Industrial Processes accounted for 45.8% followed by Waste 33.7%, Agriculture 8.2%, Energy 6.7% and Land Use Change and Forestry 5.6%. Swaziland's major contribution of GHG emissions is industrial processes. This observation could be due to the refrigeration assembly facility in the country. However, a better certainty will emerge upon completion of the 3rd National Communication. It is expected that enough activity data will be available thus permitting to ultimately draw firmer conclusions. After Industrial Processes, Waste is ranked second mainly due to the inclusion of CO_2 emissions from open burning.

Greenhouse Gas Source and Sink Categories	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions)	2,833.58	1,340.36	6,525.7	9,053.2		10.3	19,763.14
I. Energy	**1,172.33**	**121.17**	**40.3**				**1,333.8**
I.1. *Fuel Combustion (Sectoral Approach)*	1,172.33	81.69	40.3				1,294.32
1. Energy Industries	2.21	0	0				2.21
2.Manufacturing Industries and Construction	464.38	13.65	27.9				505.93
3. Transport	553.48	1.89	0				555.37
4. Agriculture	14.69	0	0				14.69
5. Other (include household and commercial)	137.57	66.15	12.4				216.12
I.2. *Fugitive Emissions from Fuels*		39.48					39.48
1. Solid Fuels		39.48					39.48
2. Oil and Natural Gas	NO	NO					
II. Industrial Processes				**9,053.2**		**10.3**	**9,063.5**
A. Mineral Products	NO	NO					
B. Chemical Industry	NO	NO					
C. Metal Production	NO	NO					
D. Other Production	NO						
E. Production of Halocarbons and SF_6				NO	NO	NO	
F. Consumption of Halocarbons and SF_6				9,053.2		10.3	9,063.5
G. Other							
III. Solvent and Other Product Use							
IV. Agriculture		**849.41**	**753.5**				**1,602.91**
A. Enteric Fermentation		434.55					434.55
B. Manure Management		15.41					15.41
C. Rice Cultivation		0.0084					0.0084
D. Agricultural Soils			629.3				629.3
E. Prescribed Burning of Savannas		232.47	43.4				275.87
F. Field Burning of Agricultural Residues		166.97	80.8				247.77
G. Other							
V. Land Use, Land Use Change and Forestry	**1,102.19**	**2.94**	**0**				**1,105.13**
VI. Waste	**559.06**	**366.84**	**5,731.9**				**6,657.8**
A. Solid Waste Disposal on Land		206.01					206.01
B. Wastewater Handling		160.81					160.81
C. Waste Incineration	559.06	0.0156	5,363				5,922.08
D. Indirect emissions			368.9				368.9
VII. Other *(please specify)*							
Memo Items:							
International Bunkers	NE	NE	NE				
Aviation	NE	NE	NE				
Marine	NE	NE	NE				
Multilateral Operations							

Table 3.4: *Detailed Summary Report for CO_2 equivalent Emissions*

It is worth noting that CO_2 emissions from open burning were computed based on the 2006 IPCC Guidelines, and specific activity data pertaining to this sector are yet to be systematically collected, formatted and reported.

	NOx (Gg)		CO_2 (Gg)		NMVOC (Gg)		SO_2 (Gg)	
	2000		**2000**		**2000**		**2000**	
Energy	11.43		155.68		13.35		6.22	
Industrial Processes	0.21		0.78		93.67		4.204	
Agriculture	14.21		456.90		NO		NO	
Land Use Change	0.03		1.2					
Waste	NO		NE					

Table 3.5: *Indirect GHG Emissions*

Indirect GHG emissions are emissions that are a consequence of the activities of the reporting sector, but occur at sources owned or controlled by another entity. This would include, for example, indirect GHG emissions from consumption of purchased electricity, heat or steam or other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities, outsourced activities, waste disposal etc.

3.4. GHG Inventory by Sector

3.4.1. Energy

Energy – related activities have a minor share of GHG emission in Swaziland, estimated at 6.7% of total GHG emissions. Emissions from this sector came from fuel combustion (97%) and fugitive emissions (3%) arising from coal mining activities. The largest contribution from the subsector on fuel combustion came from transport (43%), followed by manufacturing (39%), and others (17%). Agriculture is 1% and energy industries are negligible. Other includes households and commercial.

3.4.2. Industrial Processes and Product Use

Industrial Processes and Product Use (IPPU) covers greenhouse gas emissions occurring from industrial processes, from the use of greenhouse gases in products, and from non-energy uses of fossil fuel carbon. Greenhouse gas emissions are produced from a wide variety of industrial activities. During these processes, many different greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs) and per fluorocarbons (PFCs), are produced.

Activities leading to greenhouse gas emissions in this sector include the following; mineral products, chemical industry, metal production, production of pulp and food, production of halocarbons and sulphur hexafluoride, consumption of halocarbons and sulphur hexafluoride, solvent and other product use, paint application, degreasing and dry cleaning, chemical products, manufacture and processing and other GHG emissions from the use of anaesthetic, and propellant.

Figure 3.1*: A portion of Matsapha Industrial Site. Picture by: Swazi Photo Pro.*

Swaziland does not have cement, chemical and metal production industries. Under mineral production, all activities related to the use of asphalt (roofing and road paving, glass production, pulp and paper, food and beverages, and production of concrete blocks were taken into account in estimating indirect GHG emissions (NMVOC, NO_X ,CO, SO_2). Swaziland does not produce halocarbons and sulphur hexafluoride and therefore only GHG emissions related to the consumption of halocarbons and sulphur hexafluoride in the repair and assembly of refrigerators, foam blowing, fire extinguishers, aerosols and solvents were reported.

GHG emissions from consumption of the later was estimated at 9053.2 Gg CO_2 equivalent, representing 45.8% of total GHG emission for Swaziland. Total NMVOC from road paving with asphalt and food and beverages were estimated at 93.2 Gg. It can be observed that GHG emissions from consumption of HFCs appear to be apparently high. The activity data for these activities were obtained from information collected from the Customs Authorities. It is proposed that more work need to be done on this section of the 3rd National Communication to clarify the high levels of GHG emissions from this sector.

3.4.3. Agriculture

For the year 2000, Agriculture was the highest contributor of indirect NO_X with 14.21 Gg followed by energy with 11.43 Gg, respectively. Similarly, Agriculture was the highest contributor of indirect CO_2 with 456.9 Gg followed by energy with 155.7 Gg, respectively. Industrial processes was the highest contributor of indirect NMVOC with 93.67 Gg followed by energy with13.35 Gg. Energy topped as the highest contributor of indirect SO_2 with 6.22 Gg followed by industrial processes with 4.2 Gg. The total GHG emissions from agricultural activities in Swaziland during 2000 were estimated at 1602.91 Gg CO_2 equivalent.

The subsectors were enteric fermentation, manure management, rice cultivation, prescribed burning of savannas, and field burning of agricultural residues. The major gases were CH_4 and N_2O. The largest contribution came from agriculture soils (39%), followed by enteric fermentation (27%), prescribed burning (17%), and field burning (16%) (Figure 3.1). Manure management was negligible at 1%.

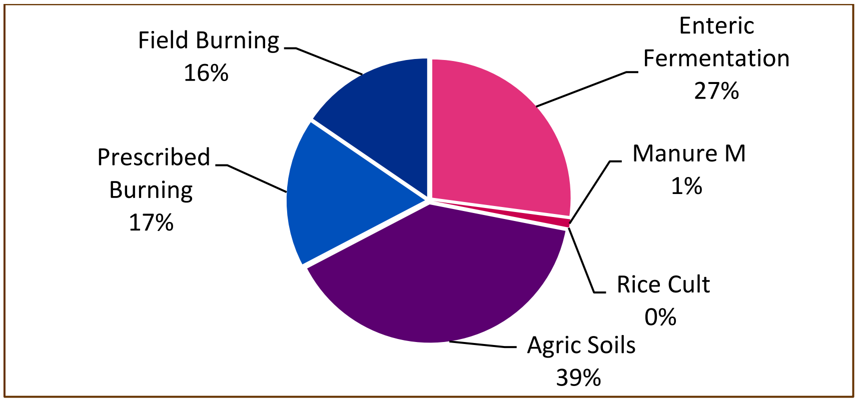


Figure 3.1: *Share of Agriculture sector in GHG emissions*

Almost all N_2O emissions in agriculture sector were emitted from agriculture soils (83.5%), followed by field burning of agricultural residues (10.7%). Enteric fermentation was the highest contribution for CH_4 with 51.0%, followed by field burning of agriculture residue with 27.4%. Emissions of indirect GHGs of CO and NO_X were estimated at 101.12 Gg for the later and all coming from prescribed burning of savanna, and 2.48 Gg for the former with 69% contribution from prescribed burning of savannah and 31% from manure management, respectively.

3.4.4. Land Use, Land Use Change and Forestry

GHG emissions under Land Use, Land Use Change and Forestry were calculated from onsite burning, onsite decay, offsite burning, commercial harvest, liming of soils, changes in soil carbon in minerals, carbon loss from organic soils and having a total of 3845.29 Gg. CO_2 uptake representing Swaziland's sink come from carbon uptake by trees and in abandoned areas and was estimated at 2707.4 Gg (Table 3.6).

Source	Annual Emissions CO_2 Gg	Annual Uptake CO_2 Gg	Balance Gg
On site burning	31.35		
On site decay	105.20		
Off site burning	51.70		
Commercial harvest	3,508.30		
Liming of soil	0.51		
Change in soil carbon in mineral soil	47.40		
Carbon loss from organic soils	100.83		
Total Sources	3,845.29		
Sinks			
Carbon uptake by trees		2,568.80	
Carbon uptake in abandoned areas		138.60	
Total Sinks		2,707.40	
Balance			1,105.2

Table 3.6: *Summary of GHG Emissions and Removals (2000)*

The Land Use, Land Use Change and Forestry sector was a net source of CO_2 by 1105.2 Gg. The highest contribution of CO_2 emissions came from commercial harvest estimated at 3508.3 Gg representing 92% of total CO_2 emissions from the sector, followed by onsite decay, and carbon loss from organic soils, each representing around 2.6%. The minimum contribution came from offsite burning, change in soil carbon in mineral soils and liming of soils all estimated at 85.3 Gg representing 2.2% of total CO_2 emissions. The largest contribution of carbon uptake come trees including commercial plantations representing 95% of total CO_2 uptake and remaining 5% attributed to carbon uptake in abandoned areas.

3.4.5. Waste

The 1996 IPPC guidelines for solid waste disposal on land for both managed waste and unmanaged waste disposal, combined waste water handling (to include domestic, commercial and industrial waste, water), pit latrines, and indirect emissions from sewerage systems were used to estimate GHG emissions (CH_4 and N_2O from sewerage sludge).

The 2006 IPCC guidelines were used to estimate GHG emissions (CH_4, N_2O and CO_2) from open burning of wastes in both urban and rural areas. The 2006 IPCC Guidelines were used in view of availability of data in the required format.

In the year 2000, GHG emissions from the waste sector was estimated at 6,657.8 Gg CO_2, representing 33.7% of total GHG emissions of Swaziland. The largest contribution came from incineration predominantly opening burning of waste with a share of 89%, followed by indirect emissions from mainly N_2O, solid waste (3%), and waste water (2%) (Figure 3.2).

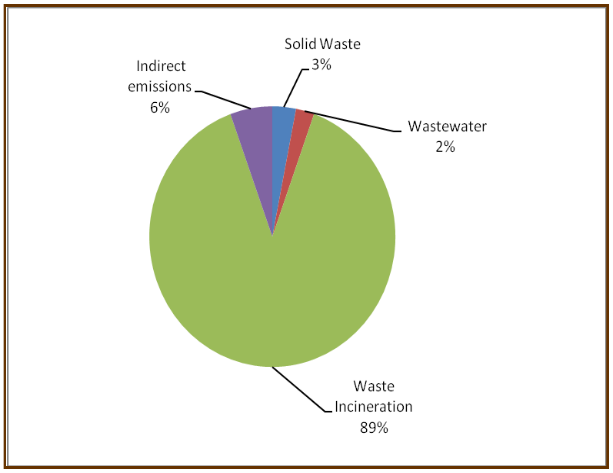


Figure 3.2: *Share of Waste Sector in GHG Emissions*

The high value of contribution from waste incineration is due to inclusion of GHG emissions from open burning of waste from both rural and urban areas of Swaziland. This source is not normally considered in most national inventories from developing countries, especially in Africa, where this practice is prevalence. However, it should be noted that data used for this computation for this subsector has high uncertainty level

3.5. Comparison between the Current and Previous Inventories

The previous national GHG inventory was prepared for the base year of 1994 as part of Swaziland's First National Communication (FNC). Computation of 1994 GHG national inventory was compared to that of 2000 and the comparison is presented in the table below (Table 3.7).

Year	Total with emissions from LULUCF	Total without emissions from LULUCF	Energy	Industrial processes	Agriculture	Land Use Change and Forestry	Waste
1994	4,285.88	7,538.61	1,055.95	4,902.69	1,233.49	(3,252.73)	346.48
2000	19,763.14	18,658.01	1,333.8	9,063.5	1,602.91	1105.13	6,657.8

Table 3.7: *GHG emissions by sector (Gg CO_2 equivalent)*

The main finding of the comparison is that between 1994 and 2000, total GHG emissions apparently increased by 361.1%. This increase is due to inclusion of CO_2 emissions from open burning of waste under waste sector, which was not considered in the 1994 inventory. Table 3.8 shows GHG emissions by gas.

Base Year	Total	CO_2	CH_4	N_2O	HFCs	SF_6
1994	7543.36	873.871	1,351.71	415.09	4,902.69	NE
2000	19,763.14	2833.58	1340.36	6,525.7	9,053.2	10.3

Table 3.8: *GHG Emissions by Gas (Gg CO_2 Equivalent)*

3.6. Gaps, Further Work and Improvements

Challenging issues which need to be further investigated in future National Inventory Reporting include data collection and archiving, reporting and associated Quality Assurance/Quality Control (QA/QC) and understanding of uncertainties in assessments for energy, industrial processes, waste and agriculture. Equally, activity data for estimation of GHG emissions from open burning will require further focused work to understand the apparently high uncertainty levels. To address this challenge requires further strengthening of institutional capacity building for inventory planning, preparation and management of GHG inventories.

The institution framework should entail establishment of a focal point either public or private which will be responsible for data collection and archiving, and inventory calculations on a consistent basis. The focal point shall also provide a guide on mobilising resources (human and financial) and technical guidance to support climate change data base management system. The institution can further implement QA/QC frameworks in their systems and at various institutions where data sources are being obtained.

RECOMMENDATION 1

For conducting the national inventory, there is need for quality data in all the sectors for both emission sources and sinks. It is therefore recommended to establish good databases in all the sectors and to further strengthen current databases to ensure the availability of quality data for conducting inventories in all the sectors in future studies. There is also need for educating relevant stakeholders, companies and businesses on the need and importance of keeping and archiving data useful for conducting inventories.

CHAPTER 4

Vulnerability Assessment and Adaptation Measures

4:1: Data Used for Climatological Analyses

This report details some of the most extensive changes noted in the historical records (trends) of climate in Swaziland as well as those changes projected for the future 2046-2065 and 2081-2100 periods using two different methods: a suite of 7 downscaled GCMs and Climate Change Explorer tool. These trends and future projections were then used to model and suggest the potential impacts on agriculture, water resource and industrial processes, biodiversity, health and land use and forestry.

4.1.1 Station data

Both the historical trends and future projections were derived from daily (maximum and minimum) temperature and rainfall measurements for the period from 1961 to 2000 from 22 synoptic weather stations within and surrounding Swaziland, see Figure 4.1. However, in the analysis done using the Climate Change Explorer tool, only stations inside Swaziland were considered. The data was supplied by the National Meteorological Service of Swaziland and the database of the Centre for Climate and Water Research of South Africa. A list of the 22 stations, as well as their geographical locations, is provided in **Error! Reference source not found.**. Whilst there were more stations than these available, a minimum of 10 years of daily data post-1979 was required for the statistical downscaling and this restricted our analysis to these 22 stations.

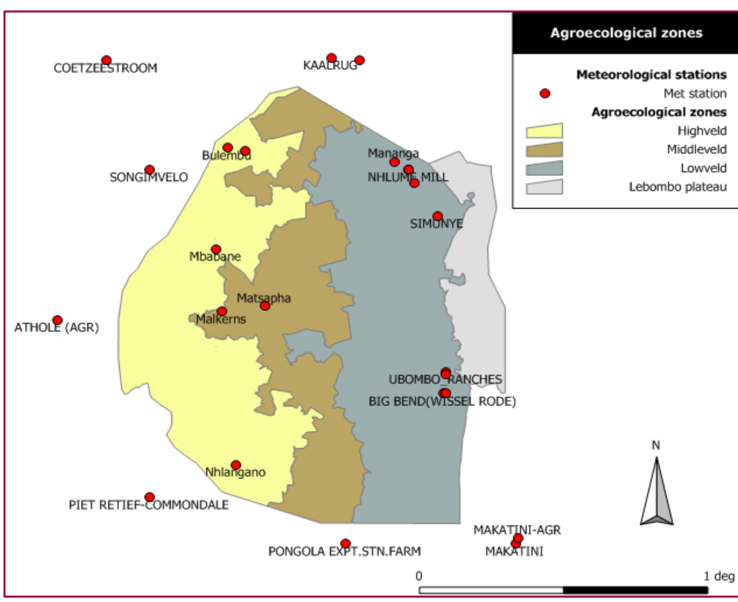


Figure 4.1

Location of synoptic stations used in the analysis of historical trends and for downscaling the future climate and agro-ecological zones of Swaziland. (Data courtesy of Swaziland Meteorological Services, Centre for Climate and Water Research and the Swaziland Central Statistics Office)

The stations are spread across Swaziland, however, due to lack of data in the Lubombo Plateau and other regions, South African stations bordering the country were used to fill the gaps for the method using a suite of 7 GCMs. The data from each station underwent rigorous quality control including checking for unrealistic values as well as tests for homogeneity.

Station ID	Station Name	Latitude (^{0}S)	Longitue (^{0}E)	Elevation (m)
0408704_W	PIET RETIEF COMMONDALE	27.23	30.9	1066.0
0410144_S	PONGOLA EXPT.STN.FARM	27.4	31.58	308.0
0411294_S	MAKATINI	27.4	32.17	69.0
0411323_W	MAKATINI AGR	27.38	32.18	63.0
0444126_A	ATHOLE (AGR)	26.58	30.58	1371.0
0446741_S	BIG BEND(WISSEL RODE)	26.85	31.92	100.0
0446766_S	UBOMBO_RANCHES	26.77	31.93	106.0
0481692_W	SONGIMVELO	26.03	30.9	846.0
0483512_S	NHLUME MILL	26.03	31.8	280.0
0483545_S	MHLUME 428	26.08	31.82	249.0
0483702_S	SIMUNYE	26.2	31.9	233.0
0518428_A	COETZEESTROOM	25.63	30.75	1636.0
0520037_S	KAALRUG	25.62	31.53	366.0
0520218_A	HOECHST.	25.63	31.63	274.0
33309100	Bigbend	26.85	31.93	98
11109004	Bulembu	25.95	31.17	1181
22209062	Malkerns	26.55	31.15	740
33309104	Mananga	26.00	31.75	293
22209060	Matsapha	26.53	31.3	646
11109000	Mbabane	26.32	31.13	1182
33309105	Mhlume	26.03	31.8	267
11109014	Nhlangano	27.11	31.2	1036
33309120	Ubombo	26.78	31.93	125

Table 4.1*: CCWR and Swaziland NMS synoptic weather stations for which daily rainfall and temperature measurements from 1961 to 2000 were acquired. Shaded stations are South African stations that were not used in the analysis made by the Climate Change Explorer tool.*

To assess changes in climate the suite of seasonal and annual indices, from the 7 models were calculated at each of 9 stations provided by NMS Swaziland. These indices represent a broad range of rainfall and temperature characteristics that capture most aspects of the climate that are likely to be affected by climate change. Average trends between 1960 and 2005 were calculated for each index, geographically located, and then interpolated (kriged) to a 0.25° grid. For the Climate Change Explorer analysis, calculations were made in each agro-ecological zone and these were used to deduce trend lines.

4:2 Climate Change in Swaziland

4:2:1 Introduction

Under this section, information is provided on changes in observed climatological variables in the country mainly temperature and rainfall in the 40 year period from 1961 to 2000. It also gives information on the projected changes caused by anthropogenic climate change over two specific periods classified as Future A and Future B. Future A covers the mid-century period from 2046 to 2065 and Future B covers the late-century period from 2081 to 2100. In addition to the observed and projected information, this section is also based on the 4th Assessment report of the intergovernmental panel on Climate Change (AR4) (IPCC, 2007) and other studies.

The issue of uncertainty could not be ruled out as regional and national climate projections are limited by sources of uncertainty. These sources are: - uncertainties in the future emissions of GHG, uncertainties in the science and limited understanding of limited regional climate dynamics, uncertainties introduced when interpolating data points to grid boxes and uncertainties introduced by downscaling of GCMs. For that reason confidence on the results in this section is limited especially in the magnitude of the projected changes although the sign and pattern of change can be interpreted with better confidence.

4.2.2 Observed Trends in Temperature and Rainfall for the Period from 1961 to 2000.

Generally, the temperature indexes showed a consistent trend which followed the global trend for all four seasons (please note: MAM and SON seasons are not shown in Figure 4.2 although analysis for these seasons were made) as shown in Figure 4.2 showing distinct increases in all the three agro-ecological zones. From this figure it is clear that in most parts of the country, significant increases in both mean minimum and mean maximum temperatures are evident except for minimum temperature at Bulembu station during JJA and for maximum temperatures at Nhlangano and Mananga during DJF. Highest recorded trends for temperature were greater than 0.12°C per year at Mbabane during JJA, resulting in an increase of approximately 5°C during the 40 year period (smaller increases of 3°C and 2.6°C are noted for the MAM and SON seasons). These are very high increases, yet the record at Mbabane is one of the most consistently and reliably reported within Swaziland therefore there is some confidence in such findings. Similar changes were noted from the results of the analysis done by the Climate Change Explorer tool. The two methods were in high agreement with both the sign and magnitude of the changes.

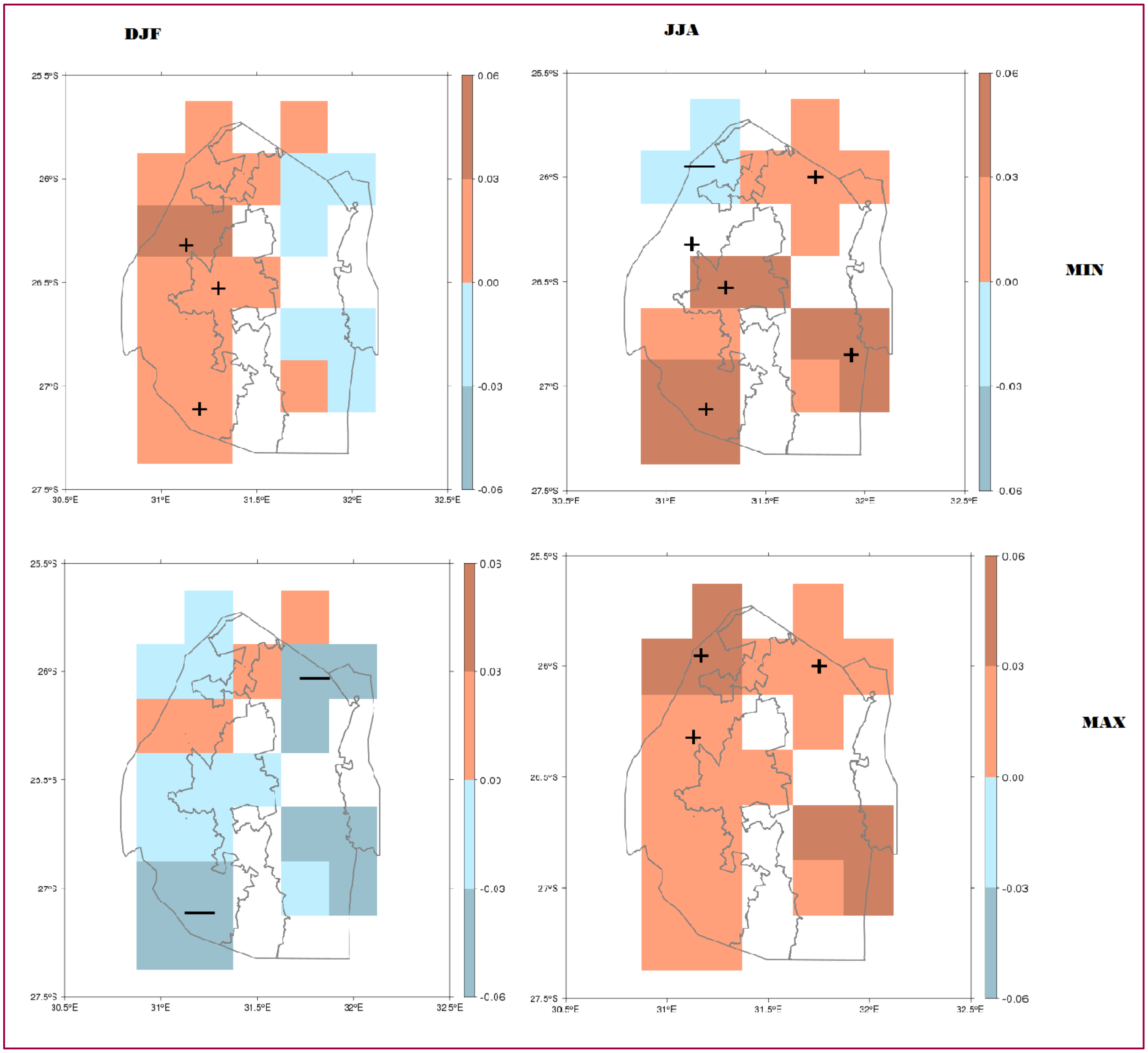


Figure 4.2*: Observed Trends in minimum temperatures (top) and maximum temperatures (1961-2000) for the DJF and JJA seasons (in ˚C year^{-1}). "+/-" indicates positive/negative trends significant at the 90 % confidence level.*

In addition to the observed increasing trends in both minimum and maximum temperatures, similar increases were also noted in both coldest nights and hottest days with coldest nights getting warmer and hottest days getting hotter. Spatially extensive and statistically significant increases in the duration of the longest (90th percentile) heat waves were also noted, with the largest increases occurring during JJA and SON at Mhlume and Ubombo in the Lowveld zone. In general the frequency of cold nights (and frost where it occurs) has decreased whilst the frequency of hot nights has increased. Highest increases in the number of hot nights occurred at Mbabane, where the frequency increased by 27% between 1961 and 2004 during JJA season.

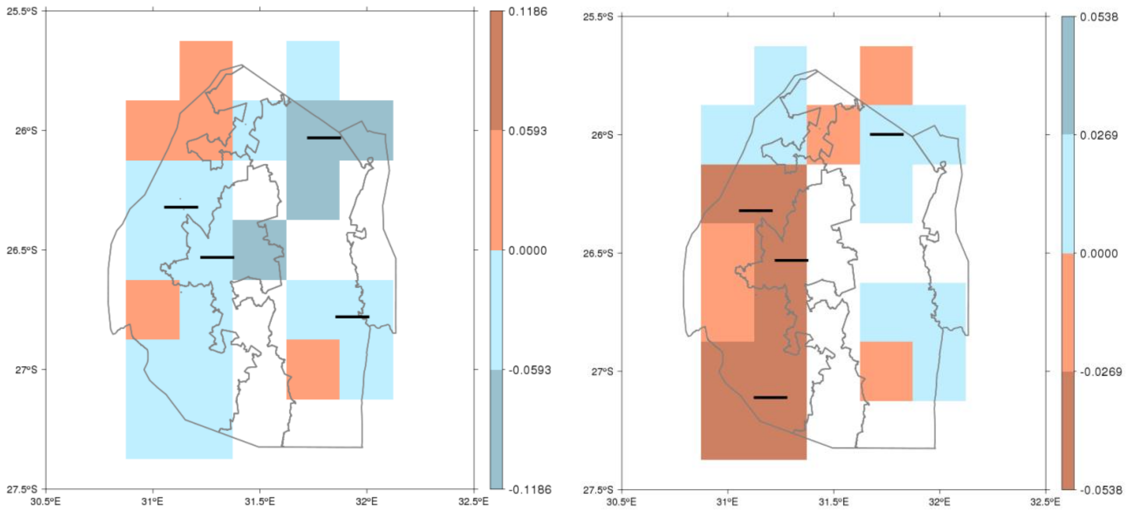


Figure 4.3: *Trends (1961-2000) during DJF: Left: average dry spell length (days year^{-1}); Right: Trends (1961-2000) in 20th percentile rainfall amount (mm day^{-1}).*

Due to the high variability in weather patterns across the country, detecting trends in rainfall is more challenging. This is mainly because unlike temperatures, analysis of rainfall requires a dense network of stations as two nearby areas in the country have completely different rainfall observations. For example, it can be completely dry in central Mbabane but can be raining in Motjane, 15 km away. Another contributing factor to this challenge is the fact that in the case of rainfall, a single extreme rainfall event can contribute a significant portion of the annual rainfall. This explains the more heterogeneous trends in rainfall. This study found that there are statistically significant increases in the rainfall intensity indices at specific locations and for specific periods especially for the DJF period indicating increases in the season's rainfall intensity. An analysis of the trends in average dry spell length and the median wet spell length indicated that there were more DJF days with rain in the later part of the 40 years. This explained the decreases in temperatures during the DJF season noticed above as more rain implies more cloud/evaporative cooling, and less sunlight reaching the surface during the day.

Analysis of the start and end of the rainy seasons cannot be presented by the downscaled indices, therefore after consultations with NMS Swaziland, development of indexes related to the start, end and duration of the season, based on rainfall was done and an assumption that the season have to start when 35mm of rain fell in 10 days after August 1st and ended when less than 40mm fell in 30 days. Very few spatially extensive and significant changes were detected in the seasonal boundaries, however towards the end of the study period (after 1980), such changes become significant indicating that rains have been delayed in the later part of the study period. On the other hand, rainfall cessation was found to have been occurring earlier over most of the country except southeast in Bigbend (Lowveld) and in the northwest near Bulembu (Highveld). It was also found that the rainfall season has been decreasing in length over central regions (most significantly at Matsapha) and increasing in the southeast and northwest parts of the country.

4.2.3 Climate Change Projections (Future Climate of Swaziland)

Climate change projections were deduced from two methods: statistically downscaled ensemble of 7 GCMs and Climate Change Explorer. The 7 GCMs were downscaled to each of the station locations presented in Table 4.1 and the list of the GCMs is found in Table 4.2. In both methods, all GCMs were forced with the SRES A1B emissions scenario. The statistical downscaling used in this report is based on Self Organising Maps, the results of which have been used by the IPCC over Africa as detailed in Hewitson and Crane (2006). The Climate Change Explorer tool was based on three GCMs. The three GCMs used in this case were Canadian Centre for Climate Modelling and Analysis (CCCMA), Centre National de Recherché Meteorologique (CNRM), and NOAA Geophysical Fluid Dynamics Laboratory (GFDL). The Climate Change Explorer outputs were used to assess vulnerability to climate change for forest and land use change and agriculture sectors, whilst the GCM ensemble was used for biodiversity and water resources sectors.

Owner	**Country**	**ID**
Canadian Centre for Climate Modelling & Analysis	Canada	CGCM3.1 (T63)
Météo-France/ Centre National de Reserchers Météerogiques	France	CNRM-CM3
Meteorological Research Institute	Japan	MRI-CGCM2.3.3
Max Planck Institute for Meteorology	Germany	ECHAM5/MPI-OM
US Dept. of Commerce/ NOAA/Geophysics Fluid Dynamic Lab	USA	GFDL-CM2.1
Meteorological Research Institute of the University of Bonn Meteorological Research Institute of KMA	Germany/ Korea	ECHO-G
Institute Pierre Simon Laplace	France	IPSL-CM4

Table 4.2*: The 7 downscaled GCMs and their origin.*

In both methods, projections were made for two periods: 2046-2065 representing the mid-century and 2080-2100 representing late century. Both methods had flaws. The downscaling process of the ensemble of GCMs introduced some noise and the noise to signal ratio was significant. However these GCMs could still be used for climate projections since they were able to reproduce the past climatic trends. The Climate Change Explorer tool considered Swaziland as a single grid point and therefore it was interpolated across the country which introduced uncertainties. Due to these problems, both methods were used for climate projections and results were compared where necessary.

4.2.3.1 Rainfall

The projections from the ensemble of 7 GCMs suggests that rainfall can be expected to increase over most of Swaziland during all seasons, though no significant change is projected over the Lowveld and Lubombo Plateau during winter (JJA). Highest increases are projected during the DJF period over the whole country and towards the east during other seasons for both periods (2046 to 2065 and 2081 to 2100). Climate Change Explorer suggested a decreasing trend in rainfall for the period from 2046 to 2065 and an increase in rainfall in the period from 2081 to 2100. Because of the disagreement between the two methods in the period from 2046 to 2065, further research is recommended. Both methods suggested an increase in droughts for both periods and an increase in flooding in the late century.

4.2.3.2 Temperatures

Both minimum and maximum temperatures are projected to increase in all seasons and all regions/zones in the country by both methods used. Both methods were in agreement with temperature increase and they clearly demonstrated that temperatures are expected to rise by 1.5 – 2.5°C by the 2046-2065 period. Largest increases are more extensive over the Highveld and northern Lowveld, before the onset of the rains.

RECOMMENDATION 2

Further analysis is recommended in the previous climate projections especially because of the disagreement in results between the two methods. Lack of useful data was one of the biggest limitations in conducting studies, establishment of a good observational network is therefore recommended for strengthening future studies and for filling data gaps. However, given the sparse coverage of weather stations in the country, calibration of satellite weather observations using the few available ground-based stations can be an immediate solution to the limiting factor of lack of observational data.

4.3 Impacts and Vulnerability Assessment and Adaptation Measures

The results of the two methods used in climate projections were used to drive assessments of present impacts and to project future impacts of climate change scenarios on sectors based on sector analysis and expert judgement. The assessment of impacts of climate change on agriculture was based on the Decision Support Systems for Agro Technology Transfer Software (DSSAT) which requires data input of daily precipitation, maximum and minimum temperatures, and solar radiation (Thorpe, 2008).

Different sectors will change differently in response to changes in temperature and rainfall. Analysis results of changes in all the sectors are outlined below.

4.3.1 Agriculture

Simulations were done for the three crops: maize, sorghum and beans. These crops were chosen because of various reasons. Maize is the staple food crop in Swaziland and almost every subsistence farmer in the rural community grows maize. Sorghum is a cereal crop that is drought tolerant and has potential to substitute maize under periods of drought especially in the arid Lowveld region. Beans are a major source of protein and they are mostly intercropped with maize as a nitrogen fixing crop. Crop production conditions such as pest control, fertilization, weeding, and disease control were optimally considered in these simulations. Analysis were made using Climate change Explorer.

In general, crops sensitive to water logging will likely perform poorly when grown between November and April because of possibility of occurrence of higher rainfall, whereas, crops grown between April and October may possibly perform poorly due to water shortages. Results of the analysis showed that climate change in Swaziland will affect crops differently. This will depend on the region and period of planting. For the period from 2046 to 2065 maize yields will likely be highest when planted in first week of December than when planted in mid-October. On the other hand, if maize is planted in February, maize yields will probably be reduced by at least 50% from the December planted maize. Figure 4.5 shows the projected maize yields for maize crops planted in different times for the period from 2046 – 2065.

Figure 4.4*: Maize fields at different growth stages in Nsangwini (Hhohho) in mid-December. Pictures by: Hlobsile Sikhosana.*

Regarding beans production, model results showed that beans yields are expected to decrease in Big Bend and Pigg's Peak for the period from 2046 to 2065 and from 2081 to 2100. The biggest decrease (-61%) will probably be experienced in Big Bend with beans planted in January in the period 2081 – 2100. Only Matsapha prediction has indicated possible increased

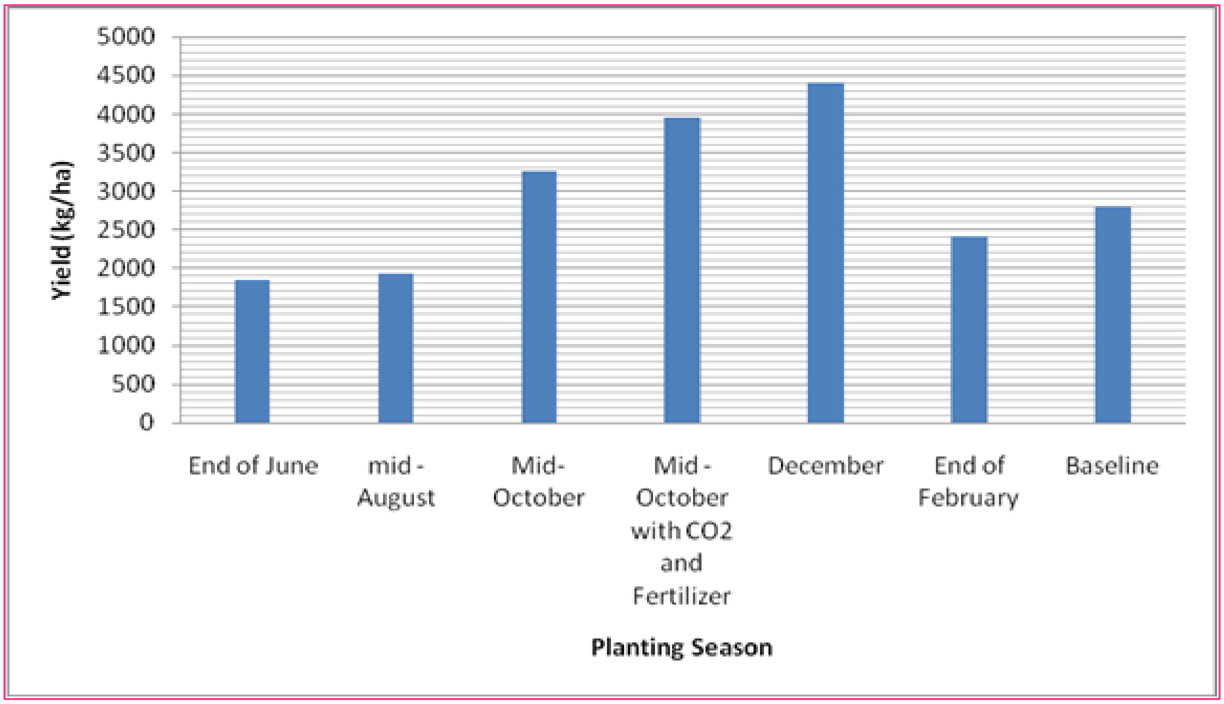


Figure 4.5: *Projected yields for maize planted at different planting periods is Swaziland simulated for 2046 – 2065.*

yields in the period 2046 -2065 and 2081 – 2100. A highest yield increase of +56% is expected for beans planted in October for Matsapha in the period 2046 – 2065. The results have also shown that in general, beans yields will be highest in Piggs Peak and lowest in Big Bend. In 2046 to 2065, yields of about greater than 4800 kg/ha are predicted for Piggs Peak when beans are planted in October. This is two times higher than that of Matsapha, and at least 6 times more than the yields predicted for Big Bend. Higher yields for beans planted in October than in January are also predicted.

Sorghum yields will be higher when planted in January than when planted in mid October. High yields for sorghum and beans will be obtained when planted in the Highveld than in the other regions. Projected results show a possible decrease in sorghum production when planted in January. These decreases in sorghum yields ranges from -17% to -1%. Sorghum planted in mid-October have in general possible higher yield than sorghum planted in January. Possible highest changes in sorghum yields will be obtained in Pigg's Peak in the period from 2081 to 2100.

Livestock could not be supported by the DSSAT system and they were projected using expert judgment based on growth and performance requirements for the livestock. The judgments were based on known climatic requirements of the livestock. According to the expert judgement, dairy animals are expected to perform better in the Highveld and wet Middleveld particularly during the winter months.

Figure 4.5*: cattle grazing in Nsangwini (Hhohho) showing signs of erosion caused by cattle tracks (left) and cattle grazing in Hawane. Pictures by: Hlobsile Sikhosana.*

Livestock production will likely be affected by fodder availability, particularly from the natural pastures. When weather conditions are dry and cold, forage growth is inhibited. The simulated climatic data have shown that precipitation will possibly be below normal during the periods April to November, this imply that there will be poor forage growth, thus affecting cattle productivity. Also as discussed, projected environmental temperatures are expected to be higher than normal during the period October to March, thus raising maximum daily temperatures to above comfort zones of both beef and dairy cattle. Dairy cattle is more likely to be adversely affected than beef cattle as they have a lower comfort zone range, 5 – 25ºC, and a lower maximum temperature, 25ºC, for productivity inhibition.

Adaptation to climate change for crop production (Table 4.2) may include shifting planting periods, growing of drought tolerant crops, and raising suitable crops in appropriate regions. Adaptation in livestock production may include raising dairy cattle mainly in the Highveld and wet Middleveld where it is cooler. During the period, March to September, temperature forage species could be grown under irrigation for the dairy herds to obtain maximum yields. Beef production could be better suited for the dry Middleveld and Lowveld because these animals have a higher maximum temperature for performance inhibition.

Measure	Description
Crop Production	Shifting planting periods involving research for planting dates and other management factors.
	Drought resistant crops through diversifying cropping pattern and focussing on drought tolerant crops, through selection, testing and introducing crops such as cassava, pigeon pea, sisal, herp, sorghum, oil seeds such as cotton, sunflower and groundnuts and leguminous crops.
	Regional suitability production through introducing sustainable land resource planning and management based on updated AEZ and crop suitability models, through concentrating rainfed agriculture production in particular maize, in areas with reliable rainfall(Highveld, Middleveld)
Livestock Production	Locational change of livestock production through redistributing livestock according to suitability of AEZ by selecting animal according to their tolerance to changed climatic conditions for example concentrate beef cattle in lower, Middleveld and Lowveld because they have a high maximum temperature for performance inhibition, and concentrate daily cattle mainly in the Highveld and upper Middleveld where it is cooler
	Irrigation support through developing small dams primarily for livestock and domestic water with supplementary irrigation for horticulture.

Table 4.3: *Adaptation Measures for Crop and Livestock*

4.3.2 Water Resources

Vulnerability assessment to water resources was done using a Watbal rainfall-runoff model was used to estimate stream flow in each of the four catchments. The model was first calibrated in order to obtain optimal parameters using historical records of precipitation, potential evapotranspiration (PET) and stream flow in each catchment as input variables. A similar calibration was carried out using output precipitation and derived PET from 12 objectively Ensemble GCM simulations, with respect to observed (1961–2000) and future (2061–2100) (Tebaldi et. al., 2005).

From the results it was evident that the derived stream flow was biased towards higher flow at the beginning of the rainfall season (October–December) and towards slightly lower flows thereafter up to around April in the Komati catchment. In the Mbuluzi catchment the simulated stream flow was higher from October to December and it was lower thereafter until around July. In the Ngwavuma catchment simulated stream flow is higher from October to December and lower thereafter until around July. In the Usuthu catchment the simulated stream flow is higher from October to December and low flows thereafter until around July. These are apparent biases even though the modelled stream flow in the four catchments captures a realistic annual cycle, which demonstrates that useful inferences can still be made from these data.

Figure 4.6: *A portion of Maguga dam, one of the dams constructed as an adaptation measure in the water resource sector.*

The projected runoff change is negative in Usuthu, Mbuluzi and Ngwavuma catchments except for the Komati catchment. The median future stream flow lies below the present flows especially during the winter months in the three catchments except the Komati catchment. However, the decreases and increase in the stream flows in the four catchments fail to attain statistical significance at the 5% level. It has also been established that the present stream flow still lies within the 95% confidence interval of the projected flows in all the catchments which emphasize the lack of statistical significance in the simulated runoff change.

Number	Measure	Description
1	Implementation of water use	Reduction of water consumption at all levels through efficient water utilisation using water demand managements
2	Strengthening of early warning systems	Systems installed to predict and prevent effects of floods, droughts and tropical cyclones as well as for indicating the planning dates to coincide with the beginning of the rainy season for water related infrastructure
3	Implementation of integrated water resources management	Integrated water resource management carried out in the country with establishment of river basin authorities and focusing on sectoral integration that takes into account competing and conflicts among various users and, geographical and economic social and environmental considerations
4	Rain water harvesting	Introduced as a source of water for domestic, livestock and irrigation leading to increased crop production and food security especially under climate change

Table 4.4*: Recommended Adaptation Measures in the water resource sector.*

4.3.3 Biodiversity

Biodiversity vulnerability assessments were conducted using the climate envelope approach which was used to model the baseline relationship between vegetation units (habitats), birds, and trees and to predict the future distributions of these under conditions of changes in climate. The full set of 19 bioclimatic variables were derived using data collected from various stations in the country for the baseline data which was then used to predict biodiversity changes in response to climatic changes. The data used to predict the vulnerability and possible impacts of climate change was based on inputs from the results of the GCMs simulations mentioned earlier.

All the datasets were then combined in a BN using the software Netica and modelled spatially in the GIS software ArcGIS 9.3 (Environmental Systems Research Institute) following the schematic framework indicated in Figure 4.7.

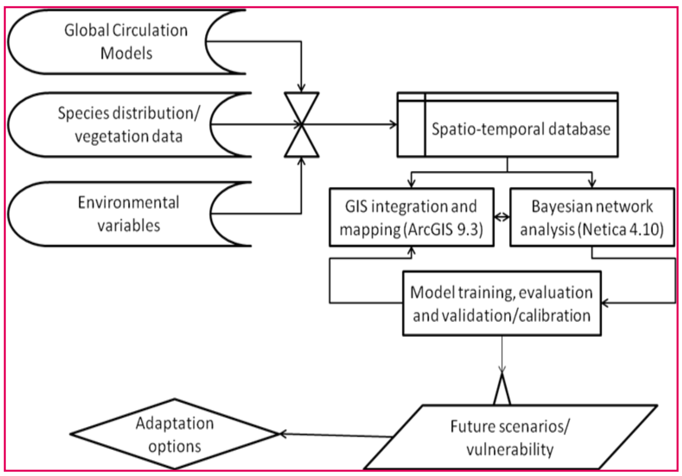


Figure 4.7: *Schematic for biodiversity vulnerability and adaptation assessments in Swaziland*

The results of the impacts analysis revealed that from 2046 to 2065, if the moderate case scenario conditions prevail, the vast area of Swaziland's grassland and Lebombo bushveld should begin to be affected albeit with varying degrees of climate change severity, with differing effects on their constituent species for the different vegetation types. Both vegetation types will likely to certainly lose more than half of their current bioclimatic area. This has significant implications on biodiversity and people's livelihoods as most of the country's current vegetation types and species are likely to experience notable declines. Moreover, the shift of the rainy season and the increase in temperatures could also have significant impact on ecosystem health as a result of forest fires.

Using predicted changes in Swaziland's bioclimate, expert judgements were undertaken to assess the effects of climate change on flora and fauna vulnerability. For example within the lebombo bushveld, there are 7 species of plants (e.g. encephalartos lebomboensis, encephalartos aplanatus, encephalartos sentocisus, encephalartos umbeluziensis euphorbia keithii, celtis mildbraedii and aloe keithii) and 3 species of vertebrates (platysaurus lebomboensis, leptotyphlops telloi and cordylus warreni) that are endemic to this area (including South Africa and Mozambique) which will be severely impacted or even driven to local extinction as result of the effects of climate change. The species that are most vulnerable to extinction will be those with small populations, slow rates of dispersal, restrictive elevation, climate requirements, and/or those whose habitat is limited or occurs in patches.

Figure 4.8: *Encephalartos lebomboensis commonly known as the Lebombo cycad, one of the species that would be severely impacted by changes in climatic conditions. Source:- http://www.plantzafrica.com/plantefg/encephlebomb.htm*

Simulation modelling indicates that habitat for a majority of the endangered birds and mammals would decline dramatically. However, analysis of the spatial distribution of most of the species of birds suggests that they are most likely to be critically endangered by the middle of the 21st century as a result of climate change. Further, this is likely to be exacerbated by the combined effects of continued habitat destruction and over-harvesting, among other threats.

Furthermore, considering the spatial distribution patterns of mammals and amphibians, which tend to be grouped into Lowveld and Highveld species, will have dire consequences on the country's faunal diversity.

To mitigate the effects of such impacts will require policies (Table 4.3) and measures to be implemented. Some of the policies recommended include: restructuring the management of biodiversity, strengthening the national commitment to conserve Swaziland's biodiversity, investing in the protection of ecosystems and their services, building innovative and adaptive biodiversity governance systems, and meeting the mitigation challenge. some of the measures recommended include: improving the understanding of the impacts of climate change on biodiversity, increasing awareness of climate change impacts and capacity to respond, minimising the impacts of climate change on aquatic and semi-aquatic species, communities and ecosystems, indigenous terrestrial species, impact of alien and invasive organisms on biodiversity in future climates, and factoring the impacts of climate change on biodiversity into natural resource management and land-use planning.

Measure	Description
Policy direction	Restructuring the management of biodiversity
	Strengthening of the national commitment to conserve Swaziland biodiversity
	Investment in protection of ecosystems and their services
	Building of innovative and adaptive biodiversity governance systems
	Mitigation options
Adaptation options	Improvements of the understanding of the impacts of climate change on biodiversity
	Awareness of climate change impacts and capacity to respond strategy
	Minimising the impacts of climate change on aquatic and semi aquatic species, communities and ecosystems, and indigenous terrestrial species
	Impact of alien and invasive organisms on biodiversity in future climates and factoring the impacts of climate change on biodiversity into natural resource management and land use planning

Table 4.5.: *Policy Direction and Adaptation Measures*

4.3.4 Forest and Land Use Change

The expected increase in temperatures with extreme values for minimum and maximum temperatures for all weather stations, may lead to events such as floods, cold waves, drought and extreme heat. They may also increase the number of days with dry spells, and a reduction in the number of days with rainfall, however, these days will have rainfall of heavy intensity. These events are likely to exacerbate management problems relating infrastructure (human settlements and water supply) and indigenous forest and forest plantations.

The pattern of distribution of human settlement in Swaziland is such that they are concentrated in areas of high economic potential, in proximity to major transport routes, and in places that enjoy hospitable climatic regimes. Changes in climatic conditions may have severe impacts not only on the pattern of distribution of human settlements, but also on the quality of life in particular areas. The Lowveld may be too hot and uncomfortable for human settlement.

This may possibly lead to people migrating to areas in the Highveld, which will be having conditions similar to the present day Lowveld. Such movement would bring social disorder and high population pressure in the Highveld, leading to possible overexploitation of natural resources. Climate change may severely affect the tourism industry. Tourism accounts for 2.8 % of GDP in the country. The extreme high temperatures may discourage tourists from visiting the country.

Figure 4.9: Area showing different land uses (settlements, farming and grazing) in Nsangwini (Hhohho). Picture by Hlobsile Sikhosana.

With possible increased temperatures, evaporation from dams and reservoirs will be very high, as well as water demand by crops. There may be less water available for irrigation. This may lead to reduction of area under irrigation and or change of crop to that with low water demand. The Highveld is currently suitable for growing temperate crops and trees. With increase in temperatures, the areas may not be suitable for growing temperate crops, but may be suitable for growing tropical and subtropical crops.

Results of the sector analysis on indigenous forest and forest plantation revealed that the expected increase in temperature in all agro-ecological zones of Swaziland may lead to high evaporation and high water demand for forest plantations and indigenous forests. The likely impact of climate change to indigenous forest and biodiversity may include, invasion by alien species and bush encroachment, frequent fires due to a combination of high temperatures and poor fire management practices, conversion of grasslands to trees and savannas and scarcity of natural resources for cultural events, traditional medicine and craft.

The forest plantations cover about 114,000 ha in Swaziland, and the plantations are found mainly in the Highveld where temperatures are relatively low, with high rainfall. Climate change may bring about high increase in temperatures, leading to conditions in the present day Highveld changing to be hotter and drier. The high temperatures may also lead to high evaporation, and high demand for water. The moisture may not be enough for the growth of the trees, leading to reduced growth rate. This may lead to low biomass production, affecting the wood and timber production. There may be likely change in the location for optimum growing of some tree species. Pine trees may be mostly affected by the increase in temperature, as the temperatures may be too high for their optimum growth in the Middleveld.

There may be shifts in species composition. Currently the dominant species for forest plantations are Eucalyptus and pine trees. New species may have to be introduced in the country to withstand the effects of climate change. Alien species are likely to invade the forest plantations. There is likely to be change in biodiversity within the forests. The high temperatures are likely to bring about increase in occurrence of pests and other pathogens, affecting the timber and wood production. The dry conditions and high temperatures are likely to increase the incidence and severity of forest fires.

The possible impacts of climate change to forest plantations include, change in the location and optimum growing size of species, more frequent outbreak of fires, shifts in species composition and size of forest estates, increase or decrease in production of wood or non-timber products per unit area, change in the type, location and intensity of pests and other pathogens, increase or decrease in amount of carbon stored in forest ecosystem, disturbance of ecosystem functions such as nutrient retention, litter decaying, flowering and leaf-fall, change in biodiversity, invasion of alien species into natural ecosystem, reduced growth rates, severe drought conditions.

Adaptation to climate change requires establishing objectives for the future Land Use, Land Use Change and Forestry. The first step entails development of policies and programs to facilitate the creation and implementation of adaptive management response strategy to climate change. Some of the critical adaptation strategies and their corresponding costs can be further developed are summarised in Table 4.5.

Number	Strategy	Description
1	Natural forests and woodlands sustainable forest management.	Sustainable forest management developed and introduced to communities and all stakeholders
2	Commercial forest management practices.	Commercial forest companies and individual growers develop and introduce forest management practices that maintain biodiversity.
3	Sustainable expansion of industrial forest areas	Sustainable expansion of industrial forest areas in those locations in the Highveld with sufficient rainfall and low potential for other agricultural use.
4	Integrated fire management framework	Integrated fire management framework involving assessment of laws and policies, fire prevention and education, fire preparedness and response, ecosystem restoration, recovery and maintenance and adaptive management, research and information.
5	Alien invasive plant species comprehensive program	Alien invasive plant species comprehensive program using a variety of methods, including mechanical clearing, the use of herbicides and biological control.
6	Community based forest management program	Sustainable utilisation and rehabilitation practices introduced at community level to ensure availability of all culturally important tree and plant species.
7	Selection of suitable tree species suitable for each ecological zone	Proper selection of suitable tree species on the basis of community needs for each of the ecological zones with research for specific tree species meeting specific situations.
8	Improved infrastructure design	Improved infrastructure design for roads, bridges, dams and water reservoirs, and for housing to provide some comfort under possible increased temperatures.

Table 4.5: *Critical Adaptation Strategies*

4.3.5. Health

The report on V&A under the Health Sector provides information on observable health effects of climate change. In order to establish possible linkage between historical rainfall and temperature variations vis-a-vis occurrences of bilhazia, diarrhoea, malaria, deaths from drowning and lightening fatalities, data collection was found necessary. Due to paucity of data it was not possible to establish such linkages. In this connection a model, MIASMA (Modelling Framework for Health Impact Assessment of Man-Induced Atmospheric Changes) was identified for the purpose of assessing the effect of climate change on human health concerns focusing on vector-borne diseases like malaria and blindness, thermal heat mortality and UV related skin cancer. Efforts are being done to collect relevant data for feeding into the model. In the 3rd National Communication, this sector will be given special priority to complete what has been started and not completed.

RECOMMENDATION 3

Projections of impacts in the different sectors were done using outputs from two different projections (some using the Climate Change Explorer tool output and some using the ensemble of 7 GCMs output). These two methods were not in agreement especially in the period from 2046 to 2065. Use of the same projections is recommended for uniformity and comparison. It is also recommended to further analyse the expected impacts of changes in climatological conditions to the health sector using certain climatological dependant diseases as a case study like malaria. Further analysis on the water and forestry and land use sectors using clear (well explained), competent and feasible methodologies is also recommended. Analysis of the costs of implementing adaptation options are recommended.

CHAPTER 5

Mitigation Options Analysis

5.1. Projections of Greenhouse Gas Emissions

5.1.1. Introduction

As part of the preparation of the Second National Communication, an in depth study was undertaken involving analysis of current conditions which formed the business-as-usual or baseline conditions and analysis of various available mitigation options including policy considerations. The main focus of the study was to develop baseline scenarios in energy, industrial processes, agriculture, Land Use, Land Use Change and Forestry and waste which are a basis for future projections. It should be noted that in a country like Swaziland energy, Land Use, Land Use Change and Forestry sectors are interlinked through household energy, mainly firewood. The interdependence is therefore influenced by the fact that increasing demand for household energy is associated with increasing deforestation and hence the need to undertake mitigation analysis and further implement mitigation measures in these two sectors.

5.1.2. Methodology

In order to assess current and future GHG emissions for energy, industrial processes, agriculture, Land Use, Land Use Change and Forestry and waste, various methods were used. The energy demand and GHG emissions were determined with the help of the Long Range Energy Alternative Planning (LEAP). LEAP is a bottom up model developed by the Stockholm Environment Institute based in Boston (SEI-B). The LEAP focuses energy consumption and GHG emissions by sector and national energy demand by summing up the sectoral energy consumption and GHG emissions.

GHG baseline or business-as-usual emissions and mitigation potential from energy, industrial processes and agriculture were calculated using a spreadsheet developed for this purpose, based on a projected average annual rate of 2.0% from the vision 2030 document. For Land Use, Land Use Change and Forestry, COMAP was used for baseline and mitigation analysis.

Under both baseline and mitigation scenarios COMAP provided the following outputs:

- Land patterns under baseline and mitigation analysis
- Estimate of biomass (carbon) stock during the target period 2010 to 2045 under the baseline and mitigation scenario
- Product and supply demand during the target period
- Cost and benefits of mitigation options

Under mitigation in the forestry and land use sector, three combined options were considered to include enhanced regeneration, reforestation and bioelectricity. These mitigation options were aimed at increasing forest woody biomass for expanded carbon sequestration. Under enhanced regeneration, an estimated 500 hectares per annum was estimated and another 500 hectares was to be created per annum under reforestation. Emissions projections under Land Use, Land Use Change and Forestry were determined based on a growth rate of 2.0% per annum from the baseline.

5.2. Mitigation Potential from Energy, Land Use, Land Use Change and Forestry, and Waste

5.2.1. Energy

GHG emissions from energy sector are projected to increase from 1.63 million tonnes of CO_2 Equivalent for the year 2010 to 2.42 million tonnes by the year 2030, under baseline conditions. Mitigation options available in the energy sector include: fuel switch from coal to sugarcane trash in sugar industry and ethanol blending in transportation energy. The sugar industry currently use coal to power boilers used in the manufacturing of sugar. The fuel switch will involve partial replacement of the use of coal with sugarcane trash to power the boilers.

Ethanol blending involves mixing ethanol from Swaziland's sugar industry with gasoline. Since the country have a relatively big sugar cane industry, it is believed that ethanol is readily available. An analysis was made to investigate the potential changes that can be induced by implementation of the available mitigation options. It was found that iplementation of these options will yield a mitigation potential of 250,000 and 320,000 tonnes of CO_2 equivalent for the years 2020 and 2030, respectively (Figure 5.1).

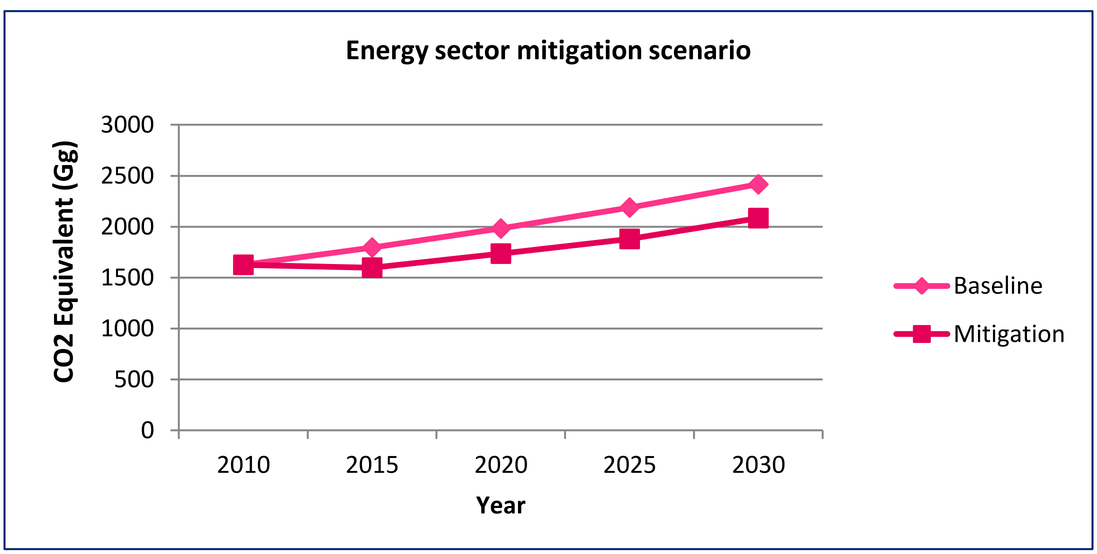


Figure 5.1: *Energy sector baseline and GHG mitigation scenario*

An easily available mitigation option is the efficient use of energy which includes the replacement of lighting bulbs with Compact Fluorescent Lamps (CFLs), replacement of geysers with solar water heating in schools, hospitals and other organisations and hydropower generation. The Energy Department in the Ministry of Natural Resources and Energy has initiated a programme to promote the efficient use of energy which will have an effect of reducing emission from energy from the current baseline condition.

The greatest limitation in the implementation of mitigation measures in the energy sector in Swaziland is the fact that Swaziland exports 80% of its energy from South Africa. This exported energy is predominantly thermal and hydropower generation requires a Southern African Power Pool (SAPP) baseline which is also predominantly thermal based.

5.2.2. Land Use, Land Use Change and Forestry

The forestry sector in Swaziland is a net source of carbon-dioxide due to the poor state of the indigenous forests. When considering only commercial forests, they contribute effectively as a sink of carbon dioxide since they are well managed and their carbon uptake is higher than their carbon release when harvesting. In overall the area under forest cover has been decreasing in the period from 1990 to 2005 but a reduction was noted from 2005. Forest consumption in the country is mainly through fuelwood (major use), fencing, timber for furniture, curving and collection of fruits. Policies and legislation to utilise and manage the forest resources exists in the country and a notable one is the National Forest Policy of 2002. This policy aims at safeguarding the forest resource in the country. Mitigation in the forest sector should aim at terrestrial carbon storage which would reduce atmospheric accumulation. Without the implementation of mitigation options, the area under forest cover is predicted to reduce by 10% in 2050 when compares to the baseline conditions.

Available mitigation options under forestry were identified and they include: forest protection, reforestation through forest regeneration, reforestation through rotation and provision of alternative energy sources like bioenergy and encouragement of active participation of communities in forest conservation and in the implementation of reforestation programmes. The forest protection option is more viable than all the other options as as it has the highest mitigation potential (242 tC/ha) and a conducive initial cost of investment. The intention of mitigation under this sector is to increase the area under forest cover and reduce deforestation and forest degradation through enhanced generation, reforestation and bioelectricity generation.

Other expected changes in land use patterns include conversion of forested land to crop or faming land which is expected to decrease the area under dense forest by 28% over a period of 50 years (from 2000 to 2050). The area under woodlands is also expected to decrease by 11% over the 50 year period and the area of bushes is also expected to decrease by 52% in the same period. It is estimated that 1% of bush lands will be converted to wastelands annually due to overgrazing and land degradation. Urbanisation and unplanned settlements is currently taking land from annual crop or farm land and rangelands and it is expected that by 2050 the rate at which urbanisation claims land would have increase.

To mitigate the expected changes in land use, certain measure and options are available and these include maintaining protected areas like wildlife sanctuaries, controlling and proper planning of urbanisation and reclaiming of wasteland which can increase area of land available for grazing of livestock. Implementation of these measures is expected to create a favourable sink situation for Swaziland in the year 2020 and 2030, amounting to zero and negative sink (Figure 5.2), respectively.

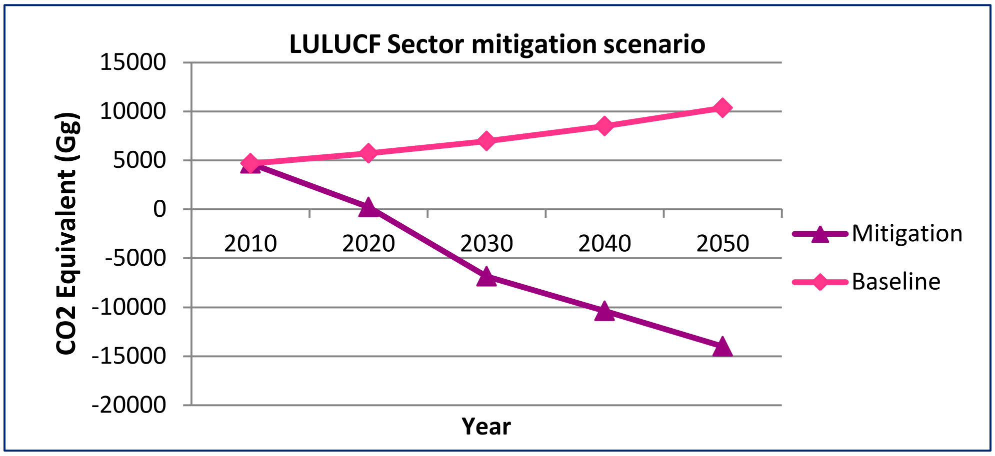


Figure 5.2: *Land Use, Land Use Change and Forestry Mitigation Scenarios*

5.2.3. Waste

Under baseline conditions, GHG emissions under waste are expected to increase from 8.1 to 12.1 million tonnes CO_2 equivalent for the years 2020 and 2030, respectively. These emissions will be from various activities which include: solid waste disposal on land, waste water handling, waste incineration and indirect emissions. The highest contribution is coming from waste incineration, particularly in rural areas. There is need therefore to intensify introduction of mitigation options in this sub-sector aimed at reducing the high GHG emissions arising from this activity.

Mitigation options which can be considered under this sector include development of landfills using organic material of Municipal Solid Waste and biomethanation using sewerage wastewater and sludge, both for electricity generation. Another mitigation option of relevance is introducing measures for reduction of waste incineration in rural areas. Analysis of expected reduction of GHG emissions after implementing mitigation options was not done, however such a task will be carried out and results will be reported in 3rd National Communication.

5.2.4. Aggregate Potential

GHG emissions from all sectors (energy, industrial processes, agriculture, land use change and forestry and waste) are expected to increase to 25.4 million tonnes of CO_2 equivalent in 2010 and 33.4 million tonnes of CO_2 equivalent by the 2030 (Figure 5.4). Implementation of identified mitigation options under energy and land use change, land use change and forestry is gradually contributing to moving Swaziland from a carbon source to a carbon sink after 2030. The trend to attain a carbon sink status could also be enhanced through conservation farming.

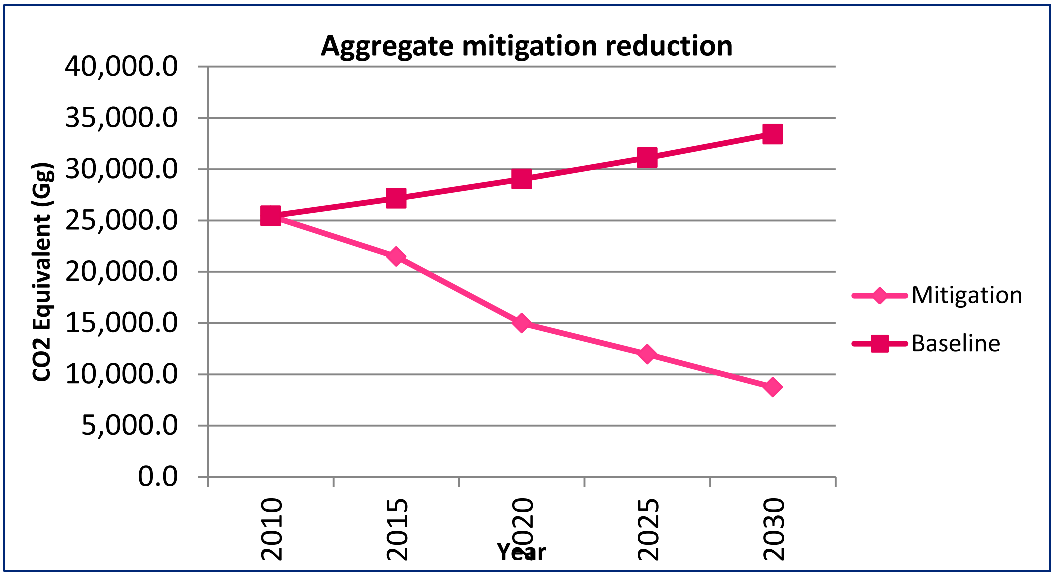


Figure 5.4: *Aggregate GHG emissions from all sectors*

2.3. Policies in Place to Help Implementation of Mitigation Options

As noted above, Swaziland has reasonable potential to contribute towards a low carbon economy through implementation of mitigation options under energy, land use change and forestry, agriculture and waste.

Under energy, the government is in the process of implementing the Swaziland National Energy Policy of 2003 with overall objectives of support programmes promoting the utilisation of renewable energy resources for electricity production. This will involve promoting efficient and environmentally sound technologies for the utilisation of indigenous resources for electricity production, facilitation of appropriate financing mechanisms to strengthen capacities of development agencies which promote and implement sustainable programmes on renewable energy and to encourage a wider use of solar water heaters for residential and commercial buildings through promotional means and support for private sector initiatives.

Swaziland has ratified a number of relevant international conventions that include the African Convention on Conservation of Nature and Natural Recourses (ratified on the 7th of April 1969), the International Convention in Biodiversity (ratified on the 9th of November 1994), the United Nations Convention to Combat Desertification (ratified on the 7th of October 1996) and the Convention on International Trade in Endangered Species of Wild Flora and Fauna (ratified on 24th January, 1997).

The national policies and strategies that are relevant to the forest sector include the National Development Strategy of 1999, the Swaziland Environment Action Plan of 1997 and the Forest Policy of 2002. The Forest Policy seeks to conserve the biodiversity and environmental functions of the Swaziland's forested areas through attainment of sustainable forest management. It is also calls for a nation forest action programme that will operationalize national policies on forestry. The action programme has however not been formulated. The country has several acts and legislation that aim to protect and promote sustainable use of forest resources. They include the Natural Resources Act of 1951, the Swaziland National Trust Commission Act of 1972, the Swaziland Environment Authority Act of 1992, the Flora Protection Act of 1997, the Control of Tree Planting Act of 1972, the Grass Fires Act of 1955, the Private Forest Act of 1951, the Plant Control Act of 1981, the Environmental Management Act 0f 2002, and the Water Act of 2003. Some of the acts are however outdated and they need to be revised. They are also not being enforced.

RECOMMENDATION 4

Costing of the recommended mitigation options and in-depth assessment and discussion of related technological needs for implementing them is recommended in all the above discussed sectors in order to access how viable such options are in the country based on their affordability and technological resource availability. Comparison of cost of implementing such options now and implementing them later can help highlight the urgency of acting on such opportunities. An analysis of economic and social implications of implementing these mitigation options are also recommended as this will provide the necessary advice which will lead to taking informed decisions and making future plans.

CHAPTER 6

Policies and Measures to Ensure the Fulfillment of the UNFCCC Objectives

6.1. The Institutional Framework

Efforts are being made to establish an institutional framework to conduct National Communications (NCs). Thematic groups were established and capacitated to carry out activities of the NC in their respective areas. There was also training for conducting GHG inventories to one of the permanent member of the climate change office and two more officers have been trained on climate change including climate projections. As a result of the training and capacity building in the existing institutional arrangement, it is now easier to do greenhouse gas inventories. The only challenge under GHG inventory is activity data in the sectors and the performance of QA/QC which we expect to pay more attention to in the Third National communication. With regard to mitigation measures, the Energy Sector is more structured than other sectors like Waste and Land Use and Forestry. The health and Economy sector still need more Attention as they are lagging behind, mainly because of lack of understanding and use of appropriate models.

6.1.1. Institutional Responsibilities

The institutionalisation of climate change issues and processes is mandated to the Swaziland Meteorological Services under the Ministry of Tourism and Environmental Affairs. This Department houses the National UNFCCC Focal Point. The department work closely with the Swaziland Environmental Authority in screening and approving possible projects. The Department of Meteorology established a project office to prepare the First National Communication and this office remained though not staffed full time for the purposes of administration of climate change matters.

To assist the Department of Meteorology, a range of key informants covering a range of climate change related expertise was assembled to investigate and prepare advisory information to Government. These Technical Working Groups (TWG) were responsible for the technical studies required to inform both the first and second national communications. Three technical Working Groups have been established – one with the responsibility for the GHG Inventory, another for assessing vulnerability and adaptation, and one for mitigation assessment. Membership of the TWG is voluntary with technical and logistical support provided by the Department of Meteorology and financial support from the Government and the United Nations Development Programme, Unite Nations Environment Programme or any other Executing Agency.

6.1.2. National climate Change Committee

In September 2010, the Ministry of Tourism and Environmental Affairs established an Ad hoc multi-sectoral National Climate Change Committee (NCCC) comprising of various Governments' ministries. The NCCC is responsible for developing and coordinating programmes and projects aimed at addressing climate change in line with the country's development priorities. The only permanent position in the NCCC is that of a Climatologist. The climatologist who provides institutional guidance to the NCCC reports to the National climate Change Focal Point (NCCFP).

In addition, the committee will carry out education and public awareness campaigns on climate change and will also guide the establishment of a technical board comprising of representatives from NGOs and the private sector. The Ministry intends to establish a National Climate Change Unit which will be guided and will report to the National Climate Change Focal Point with four key sections:

- Climate Change Science and Impacts Research section
- Climate Change Mitigation and adaptation section
- Climate Change information section
- Climate Change Projects section

6.1.3. Designated National Authority

The Department of Meteorology is the Designated National Authority (DNA) for the Clean Development Mechanism (CDM). The responsibilities of the DNA among other include issuing written approval of projects. CDM projects are under the Kyoto Protocol which Swaziland Ratified on 16th April 2006. The main task of the DNA is to assess potential CDM projects to determine whether they will assist the country in achieving its sustainable development goals. The DNA also acts as a Focal point for the CDM project approval process and it functions as a one-stop-shop for CDM project developers interested in developing CDM projects in the country.

6.2. Climate Change Mainstreaming

Since the publication of its First national Communication, Swaziland has undertaken a number of activities that can broadly be presented as the first steps towards addressing the needs of climatic change and these include:

- The establishment of a National Climate Change Committee which will strengthen climate change mainstreaming in the country.
- Formulation of a National Bio-fuel Strategy and Action Plan which is aimed at identifying entry points for bio-ethanol usage.
- Conducting research on drought tolerant food crops in collaboration with the University of Swaziland Partnerships with regional seed companies and research institutions have helped fast-track research efforts.
- Media address and press conferences by the Focal Office on different occasions to address the nation and further attend to their questions and concerns.

- Collection of baseline data on solar and wind energy production potentials to facilitate an assessment of their viability nationally.

Integration of environmental and climatic concerns into the main policies and sectors has been catered for since the formulation of the National Development Strategy and the Swaziland Environment Action Plan in the mid-1990s. Both of these have shown a positive influence on the mainstreaming of these concerns. However, the process of mainstreaming climate change has not yet reached major Government programmes such as the PRSAP which only recognises drought as a climate factor.

Swaziland has not yet developed a climate change policy and strategy. However structures have been created which could facilitate such a process. Issues of climate change have been taken into account in the Comprehensive Agricultural Sector Policy (CASP: GOS MOAC, 2005), the National Food Security Policy for Swaziland (GOS-MOAC, 2006), National Biodiversity Conservation and Management Policy (draft, GOS-SEA, 2007), the National Biofuels Development Strategy and Action Plan (GOS-MNRE, 2008) and the draft National Energy Policy Implementation Strategy (GOS-MNRE, 2009).

CHAPTER 7

Other Information Relevant to the Convention

7.1. Transfer of Technologies

A Technology Needs Assessment was carried out (GOS-NMS/SNC, 2010) and this identified various sectoral needs and opportunities notably in the energy, waste, forestry and agriculture sectors. In the energy sector the following needs and opportunities were identified: hydropower expansion, cogeneration (bagasse and wood waste), biofuels: e.g. ethanol blends and biodiesel fuels, power factor correction, energy audits, energy management, solar PV lighting, solar water heating, solar PV water pumping, wind water pumping, solar cookers, CFL lighting, efficient wood stoves, coal replacement with sugar cane trash, efficient boilers, efficient electrical equipment and vehicle efficiency testing.

In the waste sector, the following needs and opportunities were identified: biogas from food waste, methane from landfill and sewage treatment plants. In the forestry sector, increase in aforestation technologies and sustainable forest management was identified. In the agriculture sector, technology needs were identified for identification of suitable crops, solar crop dryers, sustainable pest management, effective land use management, alternative irrigation methods, rainwater water harvesting and tropical disease control. Securing assistance to overcome the identified technological needs will require the development of project proposals and political will.

There is a lack of awareness of the threats and opportunities of climate change due to anthropogenic contribution to global warming. As a result the country still has to develop appropriate policies and institutional framework to address technology transfer to tackle climate change issues.
The country also has low technological capacity. This means that most of the technologies needed are likely to come from outside the country, and may be at higher cost. There may also not be enough skilled personnel to implement the needed technologies. It is proposed that National Climate Change Office spearheaded by the National Climate Change Committee should assume responsibility for technology transfers. This Office has still to be fully established to facilitate technology transfers.

Twenty six individual options were identified for mitigation. They include:

- power generation for selling to the national grid using hydro, and cogeneration with bagasse and wood waste,

- reducing the use of petroleum products using liquid biofuels such as blending gasoline and diesel with ethanol,
- energy efficiency through power factor correction, conducting energy audits and implementing energy management options,
- alternative renewable energy technologies such as solar photovoltaic for domestic, street and traffic lights, and water pumping, solar water heating, wind water pumping and solar cooking,
- energy from waste including biogas from food waste, and sewage treatment plant and landfill methane harvesting,
- compact fluorescent lamps and efficient wood stoves for domestic use,
- coal replacement with sugar cane trash in the sugar industry and the use of efficient boilers and electrical equipment in industry,
- vehicle inspection for efficient fuel consumption,
- low energy buildings,
- natural forest protection and increase in aforestation and
- Sustainable waste management.

Nine options were identified for adaptation. They include agriculture and forestry sector with suitable crops, solar crop dryers, sustainable forest management, sustainable pest management, and effective land-use management, and water resources with alternative irrigation methods, rainwater harvesting, and storm water harvesting, and health with tropical disease control.

7.2. Research and Systematic Observation

Research relating to programmes containing measures to mitigate climate change as well as research pertaining to programmes containing measures to facilitate adequate adaptation to climate change is yet to be consolidated and reinforced in Swaziland. Such an undertaking will enhance the development of emissions factors and activity data through generation, analysis and availability for use and reporting. Pertinent information on climate research as well as systematic observation will be gathered, assessed and reported on during the 3rd National Communication.

7.3. Education, Training, and Public Awareness

Education, training and public awareness has been undertaken without a proper framework to coordinate and collaborate with the various activities undertaken within other sectors. Efforts have been made to strengthen capacity of the Ministry of Education and Training in terms of integration of climate change and investigating ways in which climate change issues can be integrated in school curricula.

Figure 5.1: *A local drama group performing a climate change educational drama in one of the National climate change awareness campaigns initiated by the Department of Meteorology. Picture by: Swazi Photo Pro.*

More efforts are needed to broaden the understanding of climate change to all sectors of society. Details of what it is and how it can be handled are missing at all levels of society. To address this, the Department of Meteorology has embarked upon a national campaign to raise awareness. Various media such as drama have been used in the campaign. The Swaziland Electricity Country (SEC) has initiated a public awareness programme aimed at promoting energy efficient alternatives such as use of Compact Fluorescent (CFLs). Once again, more effort will be given to this topic in the 3rd National Communication.

7.4. Capacity Building

Capacity building priorities have been identified as improving the technical competence of key officials involved in assembling and interpreting climate data and information. Skills and equipment to manage information are still being developed. The National Communication has identified areas wherein data and information have to be improved (e.g. waste, health sector, water resources, agriculture, energy, and more importantly industry).

To support the preparation of the National Communication, several technical working groups were established to source and interpret information and data about the impact of climate. It emerged that the capacity and skills available locally still needs to be developed. Moreover, it was equally noted that the baseline information to model, analyse or interpret climate impacts was well initiated through the Thematic Working Groups. Hence, national research institutions need to upgrade their capacities and skills to ensure that future National Communication Reports are done based on readily available, useful, relevant data and information.

The Department of Meteorology, as the National Climate Change Focal Point has been engaged in a capacity building exercise with the help of the Government through the World Meteorological Organization. This capacity building exercise involved the training of individuals on the key aspects required for implementing projects and for doing research which can help in attaining the objective of the convention. It is therefore believed that such capacity will be of great importance in the preparation of the Third National Communication.

7.5. Information and Networking

Active information sharing mechanisms are yet to be explored and reinforced in order to access and use already available information technologies regionally or beyond. This aspect will be reported on more extensively in the 3rd National Communication.

CHAPTER 8

Constraints, Gaps and Related Financial, Technical and Capacity Needs

Despite positive strides in implementing the objectives of the Convention, Swaziland is facing challenges similar to her counterpart developing countries under Non-Annex 1 Parties. Among these include the following:

- Constraints in research and systematic observation systems;
- Lack of financial support for institutionalization of National Communication Committee;
- Lack of understanding of models and use of estimate values for national conditions (e.g. LULUCF sector);
- Insufficient well trained and skilled people on climate change;
- Lack of climate change data and information collection framework and data base management system.

8.1. Financial, Technical and Capacity Needs

Swaziland faces pressing social and economic challenges which weaken her ability to set aside resources for implementing climate change projects. One of the options for the country is taking advantage of available global funding sources. It is therefore critical that technical capacity and skill to develop sound project proposals is developed and strengthened. This includes capacity in data collection and packaging (according to the UNFCCC standards), research in climate change including downscaling of models. It was noted that the GHG estimates were on the high side due to the extensive use of estimated data.

This National Communication has identified areas wherein data and information have to be improved (e.g. waste, health sector, water resources, agriculture, energy, and more importantly industry). To support the formulation of the National Communication, several technical working groups were established to source and interpret information and data about the impact of climate. It emerged that the capacity and skills available locally still needs to be developed. Moreover, it was equally noted that the baseline information to model, analyse or interpret climate impacts still need to be further developed. Hence, national research institutions need to further develop their capacities to ensure that future National Communication Reports are done based on readily available, useful, relevant data and information.

Capacity issues that need to be addressed include the development of:

- A climate change policy and legislation to coordinate and consolidate climate change activities in the country so that climate change issues are mainstreamed in national development priorities,

- Improvement on the institutional framework which includes government departments, the Climate Change Office, the national Climate Change Committee, climate change in education and private sector involvement, and
- Information systems which covers data collection, record keeping and information management and dissemination systems.

8.2. Proposed Projects for Financing

Projects addressing climate change directly or indirectly have been presented in relevant chapters for adaptation and mitigation. A portfolio of possible actions that policy makers could consider, in accordance with applicable international agreements, to implement low-cost and/or cost-effective measures to reduce emissions of greenhouse gases and adapt to climate change include:

- Implementing energy efficiency measures, including the removal of institutional barriers to energy efficiency improvements;
- Phasing out existing distortionary policies and practices that increase greenhouse gas emissions, such as some subsidies and regulations, non internalization of environmental costs and distortions in transport pricing;
- Implementing cost effective fuel switching measures from more to less carbon intensive fuels and to carbon free fuels such as renewable energy sources;
- Implementing measures to enhance sinks or reservoirs of greenhouse gases, such as improving forest management and land use practices;
- Implementing measures and developing new techniques for reducing methane, nitrous oxide and other greenhouse gas emissions;
- Encouraging forms of international cooperation to limit greenhouse gas emissions, such as implementing coordinated carbon/energy taxes, activities implemented jointly and tradable quotas;
- Promoting the development and implementation of national and international energy efficiency standards;
- Promoting voluntary actions to reduce greenhouse gas emissions;
- Promoting education and training, implementing information and advisory measures for sustainable development and consumption patterns that will facilitate climate change mitigation and adaptation;
- Planning and implanting measures to adapt to the consequences of climate change.

8.3. Implementing Adaptation Measures

Adaptation to climate change remains at its early stage of development due to a number of reasons such as financial resource, skilled people on climate change issues, development of a national adaptation plan etc. Stakeholders consulted during the preparation of this Communication suggested that the low levels of awareness on climate change issues and availability of the financial resources to address climate adaptation are the main reasons. Although the country is implementing a wide range of projects to overcome socio-economic challenges, all were not designed with climate adaptation in mind though most do address this in an indirect way. Interventions in the health sector through improving rural clinics and supporting rural health motivators who are community volunteers will contribute towards broadening access to improved health care and diagnosis of illnesses. Interventions by bilateral donors in rural water supplies will similarly contribute towards easing access to safe drinking water that does fall under the umbrella of adaptation. The large irrigation developments associated with the LUSIP project in the Siphofaneni area comes with improved social services like clinics and schools whilst at the same time providing alternative livelihood opportunities in irrigated agriculture that are intended to reduce vulnerability to climate shocks whilst providing a constant source of income.

REFERENCES

CBS, 2009. Annual Report April 2008 - March 2009. Central Bank of Swaziland. Mbabane.

CBS, 2010. Annual Report 2009 - April 2009 - March 2010. Central Bank of Swaziland, Mbabane.

CIDA/DGSM, 1992. Ground Water Resources of Swaziland.

CSIR, 2000. National Land Cover 2000 Project. Pretoria.

CSIR/ARC, 1997. National Land Cover Database Project. Compiled by M. Thompson. CSIR Environmentek. Pretoria.

Dlamini, W.M., 2010. Management of Forest Fire Disasters: Perspectives from Swaziland, in Jha, M.K. (ed.), Natural and Anthropogenic Disasters: Vulnerability, Preparedness and Mitigation, pp. 366-385, Springerlink/Capital Publishing Co., New Delhi.

Dlamini, W.M., 2010a. Analysis of the frequency, distribution and impact of wildfires using remote sensing and GIS techniques. In Tevera, D.S. and Matondo, J.I. (eds.), Environmental Management in Swaziland, pp. 152-173, Department of Geography, Environmental Science and Planning, University of Swaziland, Kwaluseni.

Dobson L. and De Castro T., 2006. Vegetation Monitoring Programme for the Komati Downstream Development Project. Swaziland Water and Agriculture Development Programme, Mbabane.

Dobson, L. & Lotter, M., 2004. Vegetation Map of Swaziland. In: Mucina, L. & Rutherford, M.C. (eds.) 2004. Vegetation Map of South Africa, Lesotho and Swaziland. National Botanical Institute, Pretoria

Dowdeswell, E., 1998. Where peaceful waters flow. Water International Vol. 23, No. 1 pp.13-16.

EC, 2006. Swaziland Country Environment Profile. European Commission Delegation, Mbabane.

FAO, 2008. Fishery and Aquaculture Country profiles. Swaziland. Fishery and Aquaculture Country Profiles. In: FAO Fisheries and Aquaculture Department [online]. Food and Agriculture Organization, Rome. http://www.fao.org/fishery/countrysector/FI-CP_SZ/en [Accessed 1 December 2010].

FAO/WFP, 2008. Crop and Food Supply Assessment Mission to Swaziland. Food and Agriculture Organization / World Food Programme, Rome.

GOS, 1982. 1:250,000 Geological Map of Swaziland. Mbabane.

GOS/CSO. 2007. Swaziland Demographic and Health Survey: Preliminary Report, Mbabane

GOS/FAO, 1994a. Present Land Use Map of Swaziland. Prepared by A. Remmelzwaal & W. Dlamini. Mbabane.

GOS/FAO, 1997. Towards Sustainable Production and Land Rehabilitation in Swaziland. Edited by A. Remmelzwaal & M. McDermott. Field Document 1. FAO/UNDP/GOS Project SWA 95/002. Mbabane.

GOS/IFAD/GEF, 2009. LUSIP-GEF Project Appraisal Document. United Nations Development Programme, Mbabane.

GOS/SEA/UNDP/GEF. 2005. National Capacity Needs, Constraints and Priorities for the Implementation of the Climate Change, Desertification and Biodiversity Conventions. Mbabane.

GOS/NERCHA. 2006. The second national Multi-sectoral HIV AND AIDS Strategic plan 2006 – 2008, Mbabane.

GOS/UNDP, 2003. National Drylands Development Programme. Prepared by ECS Consulting Services. United Nations Development Programme, Mbabane.

GOS-CSO, 2010. Population and Housing Census 2007. Volumes 1-6. Ministry of Economic Planning and Development, Central Statistical Office, Mbabane.

GOS-MEPD, 2010. Swaziland Millennium Development Goals Progress Report. Ministry of Economic Planning and Development, Mbabane.

GOS-MNRE, 2007. Swaziland Electricity Act 2007. Ministry of Natural Resources and Energy, Mbabane.

GOS-MNRE, 2008. National Biofuels Development Strategy and Action Plan (draft). Ministry of Natural Resources and Energy, Department of Energy, Mbabane.

GOS-MNRE, 2009. Swaziland National Electricity Access and Action (draft). Ministry of Natural Resources and Energy, Department of Energy, Mbabane.

GOS-MNRE/ED, 2010. Woodfuel Pricing Data Report – Swaziland. Energy Department. Ministry of Natural Resources and Energy, Department of Energy, Mbabane. German Technical Cooperation-Programme for Basic Energy and Conservation (GTZ-ProBEC).

GOS-MOA/SWADE, 2008. Towards a Strategy for Agricultural Diversification in Swaziland (draft). Prepared by SWADE & Ryeford. Ministry of Agriculture and Cooperatives, Swaziland Water and Agricultural Development Enterprise, Mbabane.

GOS-MOAC, 2002. National Forest Policy. Ministry of Agriculture and Cooperatives, Forestry Section, Mbabane.

GOS-MOAC, 2005. Comprehensive Agricultural Sector Policy (draft). Ministry of Agriculture and Cooperatives, Mbabane.

GOS-MOAC, 2006. National Food Security Policy for Swaziland. Ministry of Agriculture and Cooperatives, Mbabane.

GOS-MOAC, 2007. National Food Security Programme (draft). Ministry of Agriculture and Cooperatives, Mbabane.

GOS-MOAC, 2000. Livestock Census 2000. Ministry of Agriculture and Cooperatives, Mbabane.

GOS-MOAC/JICA, 1999. A Study to Define a Sustainable Land Management Programme Countering Land Degradation in Swaziland. Ministry of Agriculture and Cooperatives, Mbabane.

GOS-MOAC/UNDP, 2003. National Drylands Development Programme for Swaziland. Ministry of Agriculture and Cooperatives, Mbabane.

GOS-MOH, 2008. National Malaria Control Programme Annual Report 2007-2008. Ministry of Health, Manzini.

GOS-MPWT, 2002. Swaziland First National Communication to the UNFCCC. Ministry of Public Works and Transport, Department of Meteorology, Mbabane.

GOS-NMS/SNC, 2010. Climate Data Analysis. Swaziland Second National Communication. Prepared by F.D. Yamba. Ministry of Tourism and Environmental Affairs, Department of Meteorology, National Climate Office, Mbabane.

GOS-NMS/SNC, 2010. Swaziland's Climate Change Technology Needs Assessment Synthesis Report. Prepared by M. Mathunjwa. Ministry of Tourism and Environmental Affairs, Department of Meteorology, National Climate Office, Mbabane.

GOS-NMS/SNC, 2010a. Vulnerability and Adaptation to Climate Change: Agriculture and Food Sector. SNC Vulnerability and Adaptation Technical Working Group. Prepared by A.M. Dlamini. Ministry of Tourism and Environmental Affairs, Department of Meteorology, National Climate Office, Mbabane.

GOS-NMS/SNC, 2010b. A Vulnerability and Adaptation Assessment of Swaziland's Biodiversity. SNC Vulnerability and Adaptation Technical Working Group. Prepared by W.M. Dlamini. Ministry of Tourism and Environmental Affairs, Department of Meteorology, National Climate Office, Mbabane.

GOS-NMS/SNC, 2010c. Climate Data Analysis. Swaziland Second National Communication. Prepared by F.D. Yamba. Ministry of Tourism and Environmental Affairs, Department of Meteorology, National Climate Office, Mbabane.

GOS-NMS/SNC, 2010d. Vulnerability and Adaptation to Climate Change on the Sector of Water Resources in Swaziland. SNC Vulnerability and Adaptation Technical Working Group. Prepared by J. Matondo. Ministry of Tourism and Environmental Affairs, Department of Meteorology, National Climate Office, Mbabane.

GOS-NMS/SNC, 2010e. Mitigation Assessment: Energy Sector. SNC Mitigation Analysis Technical Working Group. Prepared by M. Mathunjwa. Ministry of Tourism and Environmental Affairs, Department of Meteorology, National Climate Office, Mbabane.

GOS-NMS/SNC, 2010f. Mitigation Analysis and Strategies under Swaziland's Enabling Activity in the Forestry and Land Use Sector. SNC Mitigation Analysis Technical Working Group. Prepared by A.M. Manyatsi. Ministry of Tourism and Environmental Affairs, Department of Meteorology, National Climate Office, Mbabane.

GOS-NMS/SNC, 2010g. Socio-Economic Impacts of Climate Change on Swaziland. SNC Vulnerability and Adaptation Technical Working Group. Prepared by W. S. Madonsela-Kamalandua. Ministry of Tourism and Environmental Affairs, Department of Meteorology, National Climate Office, Mbabane.

GOS-NMS/SNC, 2010h. Vulnerability and Adaptation to Climate Change: Human Health in Swaziland. SNC Vulnerability and Adaptation Technical Working Group. Prepared by N. A. Sukati. Ministry of Tourism and Environmental Affairs, Department of Meteorology, National Climate Office, Mbabane.

GOS-NMS/SNC, 2010i. Second National Communication of the Kingdom of Swaziland under the United Nations Framework Convention on Climate Change. Draft August 2010. Prepared by F.D. Yamba. Ministry of Tourism and Environmental Affairs, Department of Meteorology, National Climate Office, Mbabane.

GOS-NMS/SNC, 2010j. Swaziland's Climate Change Technology Needs Assessment - Synthesis Report. Draft November 2010. Prepared by M. Mathunjwa. Ministry of Tourism and Environmental Affairs, Department of Meteorology, National Climate Office, Mbabane.

GOS-SEA, 1997. Swaziland Environment Action Plan. Volume 1 & II. SEA, Swaziland Environment Authority, Ministry of Tourism and Environmental Affairs, Mbabane.

GOS-SEA, 2001. State of Environment Report for Swaziland. Swaziland Environment Authority, Ministry of Tourism and Environmental Affairs, Mbabane

GOS-SEA, 2003. National Solid Waste Management Strategy for Swaziland. Swaziland Environment Authority, Ministry of Tourism and Environmental Affairs, Mbabane

GOS-SEA, 2007. Biodiversity Conservation and Management Policy (draft). Swaziland Environment Authority, Ministry of Tourism and Environmental Affairs, Mbabane

GOS-VAC, 2010. Report of Vulnerability Assessment Committee. Ministry of Agriculture and Cooperatives, Mbabane.

Hewitson, B. C. and R. G. Crane (2006). Consensus between GCM climate change projections with empirical downscaling: precipitation downscaling over South Africa. *International Journal of Climatology* 26(10): 1315-1337.

IMF, 2010. World Economic Outlook 2010. International Monetary Fund. Washington D.C.

IPCC, 2000. Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change, Geneva, Switzerland. http://www.ipcc-nggip.iges.or.jp/public/gp/english/

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

Ministry of Natural Resources and Energy, 2009. Draft National Energy Policy Implementation Strategy. Mbabane, Swaziland.

SSA, 2009. Swaziland Sugar Association Annual Report 2009/10. Mbabane. Also older versions consulted.

UNDP, 2008. Human Development Report 2007/2008. United Nations Development Programme, New York.

UNDP, 2010. Draft Country Programme Document for Swaziland (2011-2015). Executive Board of the United Nations Development Programme and of the United Nations Population Fund. Geneva.

UNDP, 2010a. Human Development Report 2009/2010. United Nations Development Programme, New York.

WTO, 2003. Climate Change and Tourism. World Tourism Organization. Proceedings of the 1st International Conference on Climate Change and Tourism, Djerba, Tunisia, 9-11 April 2003.

UNFCCC National Focal Point
National Meteorological Service
Ministry of Tourism and Environmental Affairs
PO Box 2652 MBABANE Swaziland
Southern Africa

Tel: (+268) 24046274 / 24045728 / 24048859
Fax: (+268) 24041530
Email: climatechange@swazimet.gov.sz