Swaziland's Third National Communication to the United Nations Framework Convention on Climate Change

The Kingdom Of Swaziland
Ministry of Tourism and Environmental Affairs
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Acronyms

ACCF	Africa Climate Change Fund
AFOLU	Agriculture Forestry and Other Land Use
CMIP5	Coupled Model Comparison Project Phase 5
COP	Conference of Parties
CTCN	Climate Technology Centre and Network
DBN	Dynamic Bayesian Network
DSSAT	Decision Support System Agro technology Transfer
DWA	Department of Water Affairs
EU	European Union
FAO	Food and Agricultural Organization
GDP	Gross domestic product
GHG	Greenhouse gas
GWP	Global Warming Potential
INDC	Intended Nationally Determined Contribution
IWRM	Integrated Water Resource Management
IPCC	Intergovernmental Panel on Climate Change
KDDP	Komati Downstream Development Project
LEAP	Long-range Energy Alternatives Planning
LUSIP	Lower Usuthu Small-scale Irrigation Project
LULUCF	Land Use, Land-Use Change and Forestry
NAMA	Nationally Appropriate Mitigation Action
NBSAP	National Biodiversity Strategy and Action Plan
NCCP	National Climate Change Policy
NDP	National Development Plan
NDS	National Development Strategy
QA	Quality Assurance
QC	Quality Control
PET	Evapotranspiration
PWA	Protected Worthy Areas
SADC	Southern African Development Community
SCADA	Supervisory Control And Data Acquisition
SEA	Swaziland Environment Authority
SEAP	Swaziland Environment Action Plan
SEC	Swaziland Electricity Company
SNL	Swazi Nation Land
SNTC	Swaziland National trust Commission
TDL	Title Deed Land
TNC	Third National Communication
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WFP	World Food Programme

Abbreviations for Chemical Compounds

CH_4	Methane
N_2O	Nitrous oxide
CO_2	Carbon dioxide
CO	Carbon monoxide
NOx	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

Honourable Minister of Tourism and Environmental Affairs

JABULANI MABUZA

FOREWORD

On behalf of His Majesty King Mswati III's government, it is a great honour and privilege to present the Kingdom of Swaziland's Third National Communication to the United Nations Framework Convention on Climate Change (UNFCCC). This communication builds on the work undertaken for the Initial and Second National Communications, submitted in 2002 and 2012 respectively.

The Kingdom of Swaziland recognizes that climate change is one of the greatest threats to sustainable development. The Government also believes that climate change, if un-mitigated, has the potential to undo or undermine many of the positive advances that the country has made in meeting its own development goals. Escaping poverty is becoming far harder for the poor, who are worst hit by climate impacts. Hunger is increasing as extreme weather and drought punish agriculture and threaten long term food security. Diseases like malaria and many water-borne infections sensitive to changes in the climate are spreading and rolling back advances in health programs. Ecosystems, biodiversity and infrastructure, are all in danger.

The Paris Agreement, finalised in December 2015, represents a critical milestone in the global fight on climate change. The Kingdom of Swaziland is proud to have been among the 161 parties who submitted their Intended Nationally Determined Contributions to the UNFCCC prior to the Paris Agreement and to have been among the first 12 African countries to ratify the Agreement.. Indeed, the Paris Agreement contains weighty obligations that the international community including Swaziland must assume under the principle of common but differentiated responsibilities. Parties would need to ramp up dialogue and cooperation, and ensure robust commitment is in place to push forward the climate financing needed for mitigation and adaptation efforts, and to shape low-carbon, climate-resilient economies.

In that context, this TNC report presents a comprehensive outlook of climate change in the country and outlines Swaziland's efforts to addressing its impacts. The successful completion of this report is yet another milestone in our commitments under the UNFCCC and our efforts in raising climate change awareness and influencing domestic policies and strategies. Subsequently the Cabinet approved the National Climate Change Policy (NCCP) in May 2016, which provides a legal framework for climate change coordination in the country. The NCCP is anchored in the National Development Strategy (NDS) and aims to build a climate resilient nation and its economy and facilitate low carbon development in a manner that promotes national priorities of inclusive growth and sustainable development. It is my expectation that the NCCP will translate into formidable actions and stimulate concerted efforts across sectors of the Swazi society in addressing climate change.

The Kingdom of Swaziland is deeply grateful to the institutions (especially the Global Environment Facility (GEF) and the United Nations Environment Programme (UNEP)), organizations, companies and individuals that supported the preparation of this Third National Communication to the UNFCCC.

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EXECUTIVE SUMMARY

The Kingdom of Swaziland ratified the United Nations Framework Convention on Climate change (UNFCCC) in 1996. As a party to the convention, Swaziland is committed to pursue coordinated actions to reduce greenhouse gas (GHG) emissions and climate change impacts while continuing to advance sustainable economic development. In accordance with the convention, Swaziland has an obligation under article 4, paragraph 1 and Article 12, paragraph 1 to regularly prepare, publish and report its national communication to the Conference of Parties (COP) to the UNFCCC. In 2002 and 2012 the country submitted its first and second national communications respectively to the (COP). This Third National Communication (TNC) builds on the work done under the second national communication by updating and reporting additional information to reflect new developments and any other changes that have taken place since the submission of the second national communication.

NATIONAL CIRCUMSTANCES

FEATURES	DETAILS
Form of state	Monarchy whose current Head of State is His Majesty King Mswati III.
Legal system	Dual in nature – Traditional and Westminster systems
National legislature	Bicameral Parliament consists of the Senate (30 seats); and the House of Assembly (65 seats)
Head of Government	The government is headed by the Prime Minister who is appointed by the King
Population	1 056 000 in 2010 with an annual growth rate of 1.5%
Language	English and Siswati
Currency	Swazi Lilangeni / South African Rand
Location	South Eastern part of Africa, nestle between South Africa and Mozambique
Size	17 364 km²
GDP per Capita	3812.0 US$ in 2010
Main Export Products	Sugar, Beef, refrigerators, citrus and canned fruit, soft drink concentrates
Climate	Temperate climate

Swaziland's vision for economic development is articulated in the National Development Strategy (NDS) which enunciates the country's vision 2022. The NDS is the country's overarching development framework which promotes sustainable development and inclusive prosperity in the medium to long term. The nucleus of the vision is ensuring quality of life in the country whose critical dimensions are poverty eradication, employment creation, gender equity, social integration and environmental protection. The vision fully supports community participation; inclusive participation; rural development and empowerment. The attainment of this vision hinges on four thematic pillars namely; a) good governance, b) a vibrant and diverse climate resilient economy, c) environmental sustainability and d) highest human capital and social development.

While environmental concerns have been mainstreamed in the (NDS) in the past few years, recently climate change has been considered a development priority. Increasing scientific evidence of climate change impacts on basic livelihood and infrastructure has brought about a general recognition that climate change should be incorporated into socio-economic development planning. In order to meet the challenges and uncertainties of climate change, development processes must be rendered more climate resilient and lower in carbon emissions. In this regard, the country has developed a National Climate Change Policy (NCCP) and a National Climate Change Strategy and Action Plan (NCCSP), to promote low carbon and climate resilient development. The NCCP and NCCSP are expected to create and enabling framework and facilitate the implementation on the Swaziland's Nationally Determined Contribution to the Paris Agreement.

NATIONAL GREENHOUSE GAS INVENTORY: 2010

Swaziland's National Greenhouse Gas (GHG) Inventory for 2010 indicates that the country is a net sink of GHG emissions. This means that while Swaziland emitted 4 861 Gg CO_2e, the country's natural flora and farmed areas in the land use, land use change and forestry sectors sequestered emissions by 5 863 Gg CO_2e, resulting in a net sink status of -1 002 Gg CO_2e.

Swaziland's emissions (4 861 Gg CO_2e) are mainly from the country's industrial processes, agricultural, energy and waste sectors as follows:

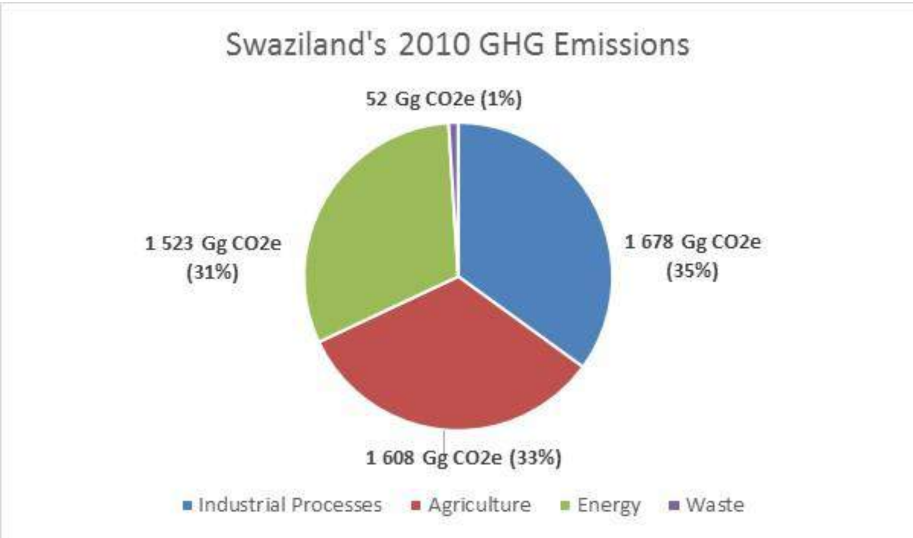


Figure 0-1: Swaziland's 2010 GHG Emissions Profile

Swaziland is considered a net sink on account of the emissions sunk in forestry and other land use sectors. The key category for the 2010 GHG Inventory was therefore identified as Category 3B1a, "Forest Land Remaining Forest Land (Removals) - CO_2".

HFCs and CO_2 are the largest contributing GHGs in Swaziland's 2010 National GHG Inventory. HFCs are derived from the Industrial Processes sector, largely emitted from products used as substitutes for ozone depleting substances in the refrigeration industry. CO_2 emissions are largely derived from fuel combustion (manufacturing industries and construction as well as road transportation) in the Energy sector. CH_4 and N_2O are typically produced in the Agricultural sector, and to a lesser degree, the Waste sector.

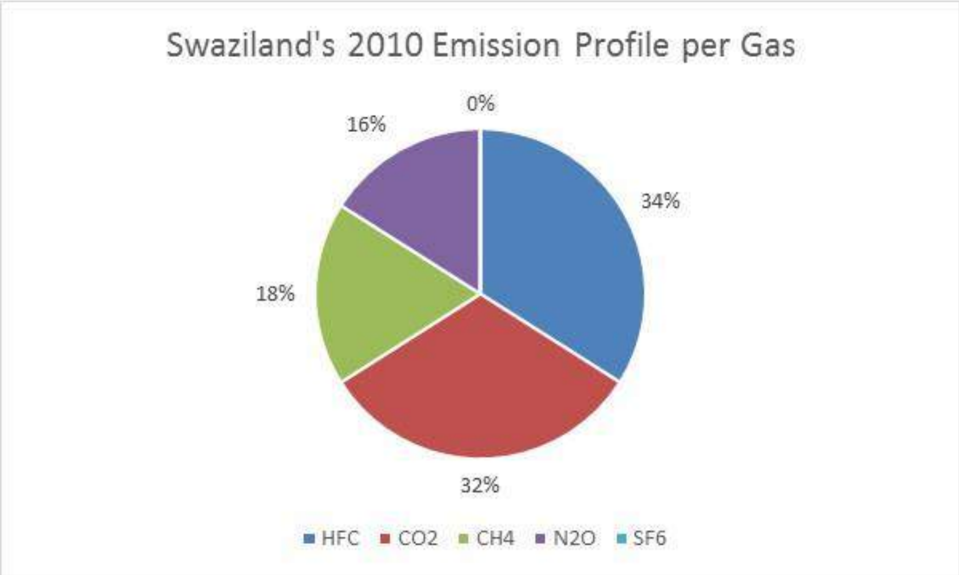


Figure 0-2: Swaziland's 2010 Emission Profile per Gas

A GHG trend analysis has been carried out over the 1990 to 2010 period. Over the entire period, GHG emissions from energy use and waste have been growing at an average rate of about 25% and 8% per annum, respectively. GHG emissions from the industrial sector fluctuated between 1990 and 2005, but witnessed a decline by 82% between 2010 and 2005. This was due to declining activities in the refrigeration and air conditioning subsectors in the country. In the agriculture sector, GHG emissions have also fluctuated but increased by 7% between 2000 and 2010. This is typical for the sector due to varying climatic conditions which affect crop and animal production in some years.

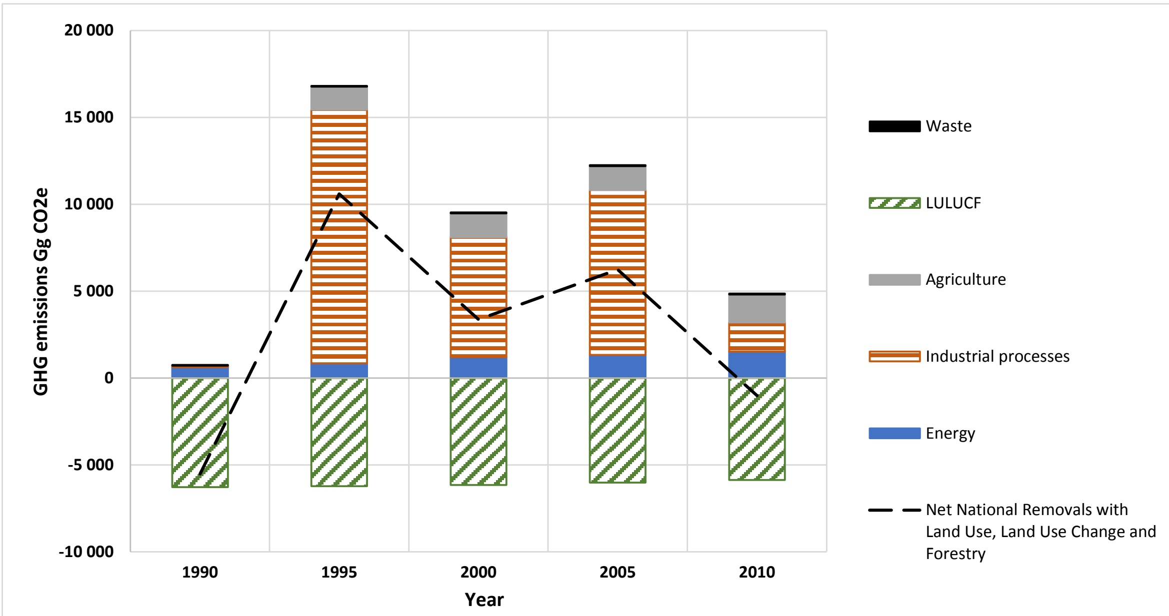


Figure 0-3: National GHG Inventory Trend Analysis from 1990 to 2010

VULNERABILITY ASSESSMENT AND ADAPTATION MEASURES

Swazis depend on the country's natural resources for a wide range of daily functions. This dependence makes the country vulnerable to climate change because it is both sensitive to and exposed to changes in the natural environment.

CLIMATE TRENDS

Daily maximum and minimum temperatures between 1961 and 2010 have been analysed and reveal that temperature extremes show patterns consistent with warming over most of the country in the last decade. Minimum temperatures have been found to have increased more rapidly compared to maximum temperatures. The last two decades (1990s and 2000s) are warmer compared to the 70s and 80s.. In the 1970s, temperatures rarely exceeded 34°C in the Lowveld which is the hottest region in the country. However in the past two decades, the frequency of very hot days, exceeding 34°C, increased. 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 1960 and 2004 during the winter season. This show that the recent decades have experienced upward trends in annual mean, maximum and minimum temperature across the different regions in the country with the most significant warming occurring between 2000 and 2010.

Rainfall trends in the country points towards a decrease in the number of rainy days which has an implication on the intensity of rainfall events and dry spell duration. Apart from changes in total or mean summer rainfall, certain intra-seasonal characteristics of seasonal rainfall such as onset, duration, dry spell frequencies, and rainfall intensity as well as delay of rainfall onset has changed over the country. The analysed available rainfall record for the country (1970 -2010) indicates an increase in inter-annual rainfall variability in the post -1970 periods with an increase on average of dry spell length.

CLIMATE PROJECTIONS

According to projections, Swaziland will continue to get warmer;

(i) Mean temperature is expected to increase

(ii) All projections indicate an increase in the frequency of hot days

(iii) Projections indicate a decrease in cold days and nights

Rainfall will continue to be uncertain and difficult to predict.

(i) Projections indicate an increase in number and frequency of dry spells during the summer season especially between October and February

(ii) All models indicate a decrease in number of frost days in the Highveld region

(iii) Some models predict an increase in number of days with more than 20mm of rainfall while some models indicate a decrease.

Vulnerabilities and adaptations in the agricultural sector

Swaziland's agricultural sector is a vital part of the economy, with more than 70% of the population relying on this sector for income. Over 75% of smallholder farmers in Swaziland rely on rain-fed agriculture for their livelihoods making them more vulnerable to climate change. The exposure to droughts has resulted in the loss of both crop and livestock productivity in Swaziland, highlighting the relationship between climate change and food insecurity. Such trends are likely to persist in the future.

Climate change impacts in the agriculture sector are already being observed in the country. Livestock and crops production under rain-fed conditions have declined by over 30% on average over the last few farming seasons. This has been evident especially in the turn of the century since 2011/2012 till date. This is mainly because of increase in temperatures and below normal rainfall which has seen the country experiencing recurrent droughts and prolonged dry spells over the last five years. This has seen the area under cultivation for various crops especially maize consistently decreasing. The country experienced the worst drought in 2015/16 season and area under cultivation reduced significantly further, by 64%, compared to the previous years. Swaziland's exposure to droughts and extreme temperatures has therefore resulted in the loss of both crop and livestock productivity, highlighting the relationship between climate change and food insecurity

Swaziland has made efforts to understand and respond to climate change impacts in the agricultural sector. Three broad strategies have been adopted to address climate change impacts in this sector: regional and international efforts; policy development and farm level adaptation strategies and programmes.

Vulnerabilities and adaptations in biodiversity and ecosystems

Swazi communities depend directly on the products from local ecosystems for the majority of their basic needs such as food, energy, water, medicinal and livelihood requirements. Research predicts that these ecosystems will be highly vulnerable to biome change in the future.

Many of the important impacts of climate change on biodiversity will be indirect, at community and ecosystem levels, exacerbating existing stressors. For example, for wetlands, the major threats of climate change are not the direct impacts on vulnerable species but rather due to changing fire regimes, overgrazing, farming and overutilization, as well as the consequences of climate change for a number of invasive species.

Various fauna and flora in Swaziland are also at risk of climate change impacts. Selected species, particularly birds (e.g. *Hirundo atrocaerulea* and *Sagittarius serpentarius*) and trees (e.g. *Celtis mildbraedii* and *Euphorbia keithii*) will be driven to local extinction. Species most vulnerable to extinction are those with small populations, slow rates of dispersal, restrictive elevation, climatic requirements and/ or those whose habitat is limited or fragmented.

Swaziland is taking on several measures to ensure adaptation in biodiversity and ecosystems. Swaziland is a party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora and as part of the review of the *National Development Strategy*, the Swaziland

National Trust Commission and the Ministry of Tourism and Environmental Affairs have set a target of protecting 10% of the country's ecosystems. This provides political motivation for ensuring the protection of the country's biodiversity and ecosystems. Swaziland is working internally, and in conjunction with the private sector and international agencies to undertake adaptation actions and projects. The Lower Usuthu Sustainable Land Management Project is a notable example, which is jointly financed by the Global Environment Facility, the International Fund for Agriculture Development and the Government of Swaziland.

Vulnerabilities and adaptations in the health sector

Changes in the agricultural, biodiversity and water sectors have direct bearing on the health of Swazi citizens. Extreme climate events such as heat waves, droughts and floods have environmental effects such as changes in water supply and quality, changes in air quality, food security and pests and infectious organisms. Food security and health both have direct impacts on the Swazi population. Swaziland is exposed to declining maize production due to variable rainfall patterns, which negatively impacts food security. This in turn affects the health of Swazi citizens. Adapting to climate change is therefore crucial to the nation's future sustainability.

Limited health infrastructure and services is increasing the vulnerability of communities to climate change induced impacts. The Ministry of Health in Swaziland is a member of the National Climate Change Committee and the National Disaster Risk Reduction Unit and participated in the development of the National Multi-hazard Contingency Plan.

Vulnerabilities and adaptations in the water sector

Swaziland is a water scarce country. Water is perhaps the most cross-cutting sector in the country where any changes impact the entire nation. For instance impacts of drought extend to food insecurity, water and sanitation, nutrition, health, hydroelectric generation and livelihood vulnerability in rural and urban households in the four regions of the country. The current persistent drought caused by the El Niño phenomenon has resulted in the lowest water levels on record, prompting the declaration of a state of national emergency in February 2016.

Swaziland's water catchments are threatened by increasing population, rising per capita domestic water use, degrading catchments and expanding agriculture. These factors are leading to water demand outstripping available water resources. In addition, limited and reducing rainfall volumes will not sufficiently meet current and future population demands. The Lowveld region of Swaziland will be most severely affected by these shortages.

Under both the wet and dry scenarios, it is projected that there will be less water in all the catchments. The projected increase in water stress under the dry year scenario is likely to be caused by decreased annual precipitation and increasing evaporation / evapotranspiration due to rising temperatures related to climate change, as well as growing water withdrawals. The most important factor for the increase in withdrawals is the likely increase in irrigated areas, due to future expansions of irrigated sugarcane. Domestic water demand is also likely to increase in the future, stimulated by income and population growth.

Furthermore, climate change- induced scarcity and variability of water resources has the potential to create competition among water-using sectors within the country and make trans-boundary water management increasingly challenging. As increasing variability and competing demands intensify under the effects of climate change, effective governance and planning for managing water demand for the sustainable use of water resources will become essential.

The figure below shows that the Komati catchment at GS30 and Usuthu catchment at GS7 will face severe water stress under climate change. Sub-catchments Usuthu at GS2 and Usuthu at GS16 will face high water stress given climate change Sub-catchments Usuthu at GS6 and Usuthu at GS19 will face moderate water stress given climate change (dry year scenario).

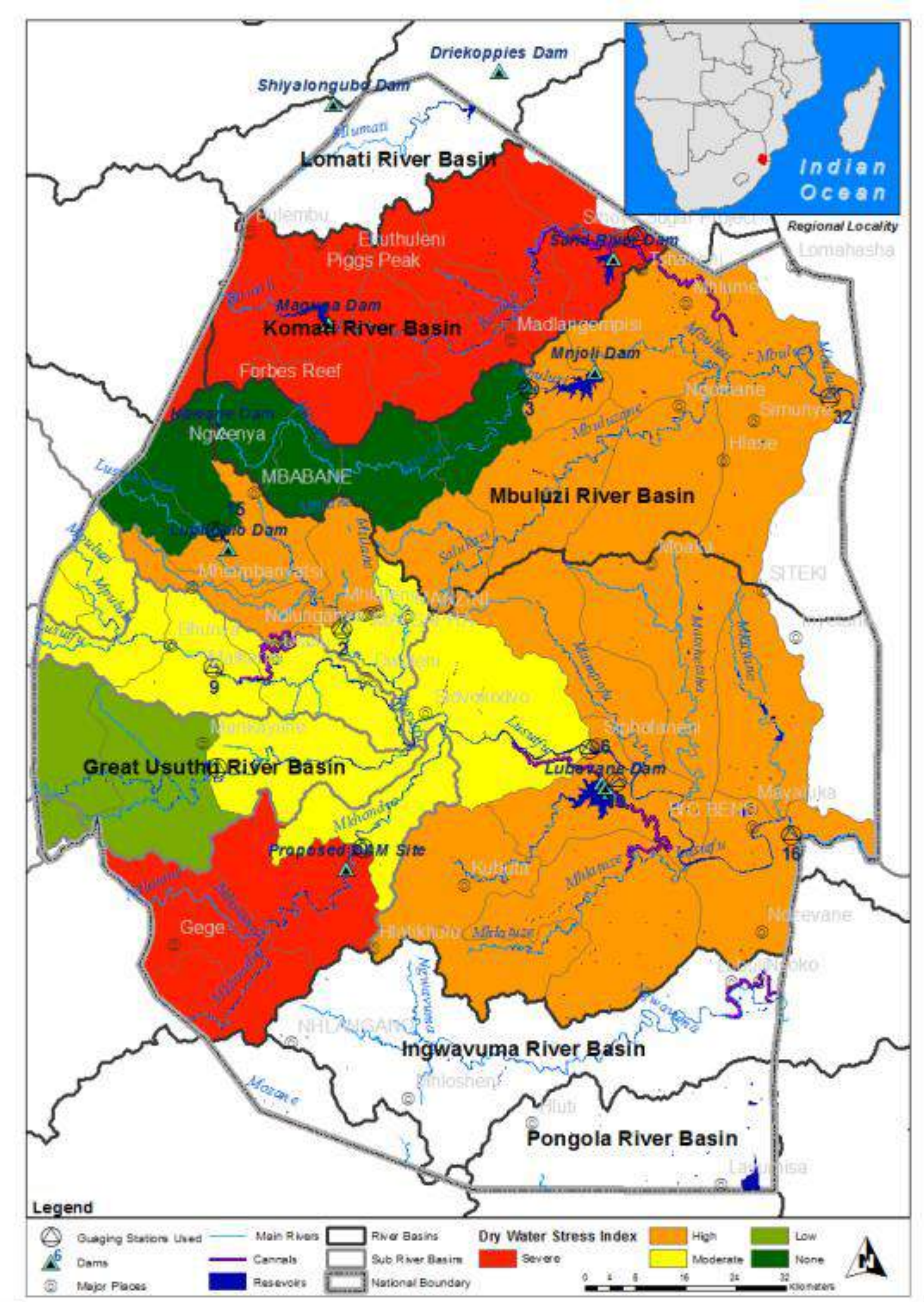


Figure 0-4: Map of future water stress index in respective sub-catchments

The proposed adaptation strategies that address four priority areas:

- Institutional strengthening to support climate change resilient strategies
- Systems for weather and climate early warning and information

- Community-based adaptation to climate related changes in water resources (including catchment flows, rainfall pattern and intensity, and water quality)

- Awareness raising and knowledge management for communities

MITIGATION MEASURES

Considering Swaziland's National GHG Inventory for 2010, the country is a very small global contributor (contributing less than 0.002% of global emissions) and a net sink. Swaziland has however taken action towards mitigation as it recognises the importance of its role within the context of global GHG mitigation efforts.

The country is continuing efforts to quantify its emission outputs in conjunction with potential measures to reduce these emissions where possible. Emissions have been found to arise from a number of sources, including the use of industrial products in the refrigeration industry, enteric fermentation, agricultural activities, burning of fields and manure management. Fuel combustion for energy generation and transport are the main sources of emissions in the energy sector. Emissions also result from the open burning of waste, biological treatment of waste, solid waste disposal and wastewater discharges. Swaziland's emission profile is outlined in the following table.

Table 0.1: Summary of GHG Emissions/Removals for the Kingdom of Swaziland for 2010 (Gg CO_2e)

GHG Sources & Sinks	Totals from the 2010 National GHG Inventory	
	Total ($MtCO_2e$)	Percentage (%)
Total National Emissions without LULUCF	4.86	100%
Net National Removals with LULUCF	-1.00	-
1 Energy	1.52	31%
2. Industrial Processes	1.67	34%
3. Agriculture	1.60	33%
4. Land-Use Change & Forestry	-5.86	-
5. Waste	0.05	1%

Although reduction potentials have been identified for the country, cost assessments of applicable technology measures have not yet been undertaken.

A major mitigation measure identified in the energy sector relates to Swaziland's international commitment to introduce a 10% ethanol blend in petrol. This measure could result in a reduction of 28% and 81% of the business as usual projected emissions from transport, in the years 2020 and 2050 respectively. A major co-benefit of ethanol blend measure is the simultaneous support of the local agricultural sector. In addition, the increased uptake of efficient vehicles could result in the further mitigation of 16% of the projected emissions from business as usual in the transport sector, in the year 2050. Another of Swaziland's international energy commitments relates to increasing renewable energy generation in the country by 50%. This could amount to a 97% reduction of the 2050 expected emissions related to the electricity supply sector.

Mitigation options for industry include fuel switching and energy efficiency activities. Expected emission reductions from fuel switching, such as from coal to biomass, could reduce the use of coal to 2% of the total fuel intake by 2050, depending on the level of technology interventions.

Furthermore Swaziland commits to phasing out the use of HFCs, PFCs and SF_6 gases as well as substitutes with global warming potential, by developing the value chain for alternative zero-GWP and enhancing the skill level for these conversions.

Fuel switching (for example from biomass to LPG) and energy efficiency measures (such as improved cook stoves) could also be undertaken in Swaziland's residential sectors. The use of biogas from feedstocks related to livestock is another mitigation option being considered in Swaziland. A co-benefit of this process would be the production of organic compost that may replace fertilisers, thus reducing both GHG emissions and water pollution associated with the use of fertilisers.

The agricultural sector represents opportunities for mitigation measures, particularly those related to conservation agriculture, manure management and changing practices associated with sugar cane harvesting. Mitigation options to enhance Swaziland's sink potential also exist. These include the restoration and management of grass lands, afforestation, reforestation and forest conservation, among others. The forestry sector is vulnerable to the effects of climate change impacts, specifically drought, increased fire risks, floods and pests. The protection of this sector is critical not only due to its status as a national industry (and source of employment) and its GHG removal potential, but also due to the forestry sector being a source of energy in both rural and industrial contexts.

TECHNOLOGY TRANSFER

Swaziland's Technology Needs Assessment has identified the most appropriate adaptation technologies in the country. These are related to integrated river basin management, wetland restoration, rooftop rainwater harvesting, livestock selective breeding, conservation agriculture, micro and drip irrigation, agroforestry, conservation of genetic resources and alien invasive species management. The preferred mitigation technologies were identified as those related to hydropower expansion, combined heat and power, energy efficient buildings, municipal waste recycling/ reuse/ separation facility, semi aerobic landfills, municipal solid waste composting, grazing land intensity management, agroforestry for mitigation and urban forestry.

RESEARCH AND SYSTEMATIC OBSERVATION

There are various projects and initiatives related to the research and systematic observation of climate change related phenomena in Swaziland. A number of key government departments are tasked with research activities. These include the National Meteorological Service, which runs a country-wide network of meteorological stations that records, transmits and processes meteorological information, according to internal needs and the directives of the World Meteorological Organisation. While national climate and climate change research occurs in an *ad hoc* manner, mainly through the University of Swaziland.

EDUCATION, TRAINING AND PUBLIC AWARENESS

Swaziland's Climate Change Programme aims to inform the public on the effects of climate change; collect views on a possible action plans to address issues on climate change and engage all climate change stakeholders in the country with a view to sharing climate change roles between them. Swaziland also participates in global events such as Environment Day and Earth Hour, in addition to other domestic awareness initiatives.

CAPACITY BUILDING

A National Capacity Needs Self-Assessment revealed that the key national institutions dealing with climate change face a severe shortage of trained staff. A study by the Southern African Regional Universities Association further found that the country faces various challenges in climate change related capacity building and technical assistance. The study recommends that the Ministry of Tourism and Environmental Affairs facilitate the development of a comprehensive, costed capacity building programme aimed at involving a wide range of stakeholders (i.e. government officials, the private sector and civil society organisations). Further recommendations include the development of a resource mobilisation plan for capacitating key national institutions in climate change and data management and dissemination activities which could be led by the Central Statistics Office, as well as the development of the Department of Meteorology's capacity in terms of numerical weather prediction and modelling.

INFORMATION AND NETWORKING

Swaziland participates in information sharing and networking on both regional and international levels. The country participates in the Sustainable Development Goals and is a party to the Tripartite Programme on Climate Change Adaptation and Mitigation, which is implemented jointly by the Common Market for Eastern and Southern Africa, the East African Community and South African Development Community. Other notable initiatives include the Food, Agriculture and Natural Resources Policy Analysis Network, the United Nations Convention to Combat Desertification, the United Nations Convention on Biological Diversity the Paris Declaration on Aid Effectiveness and the Accra Agenda for Action, amongst others. Swaziland is also a participant in the Sustainable Energy for All initiative.

CONSTRAINTS AND GAPS

Inadequate capacity in all Swazi sectors to conduct and prepare GHG inventories leads to gaps in the data required for GHG emissions modelling and limits appropriate sectoral planning. The absence of scientific assessments and research hinders the prioritisation of adaptation strategies and mitigation measures in the decision-making process. In addition to information constraints, there are also gaps in the institutional capacity and human resources required to develop the policies and actions required. Limited sustainable funding and technological support for climate change research programmes and policy development constrain the extent to which these gaps can be addressed.

Capacity building is also required with regards to Swaziland's data analyses, management, information sharing and climate research and modelling. To make the best use of the data collected as a result of improved finance, capacity and technology, close collaboration is required between and among climate change stakeholders in government, private sector, non-governmental organisations, international partners, donors, academia and communities.

1. INTRODUCTION

In March 1995 the Kingdom of Swaziland became a signatory to the United Nations Framework Convention on Climate Change (UNFCCC). This was followed by the adoption of the Kyoto Protocol in 1997, recognising the complex effects of climate change on the evolution of humankind. To this end, Swaziland has committed to promote sustainable development, to contribute to the achievement of the Convention's objectives and to assist Annex I Parties to fulfil their commitments to limit and reduce greenhouse gases (GHGs).

By ratifying the convention, the Kingdom of Swaziland decisively committed itself to pursue coordinated actions to reduce greenhouse gas emissions and climate change impacts while continuing to advance national sustainable development. As a party to the convention, the country has the obligation under Article 4 paragraph 1, and Article 12, paragraph 1 of the convention to regularly prepare, publish and report its national communications to the Conference of Parties (COP) to the UNFCCC. In 2002 and 2012 the country submitted its first and second national communication to the COP and this third national communication is building on the work done under the first and second national communication pursuant to Swaziland's obligations under the convention.

In order to ensure continuity with the previous national communications, the Third National Communication (TNC) builds on the work done under the second national communication by updating and reporting additional information to reflect new developments and any other changes that have taken place since the submission of the second national communication. 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).

The communication has been developed within Swaziland's "Enabling Activities for the Preparation of the Third National Communication under the UNFCCC" Project, executed by the Department of Meteorology within the Ministry of Tourism and Environmental Affairs. The Global Environment Facility through the United Nations Environment Programme provided funding for the preparation of this TNC.

The TNC is considered by Swaziland as a major effort to shape climate change actions and policy development and facilitating its integration to broader national development priorities. The preparation of the TNC has been very participatory and interactive involving a wide range of stakeholders. This facilitated a broader understanding of climate change at national level and strengthened stakeholder coordination and information sharing. The process of completing the Third National Communication have strengthened the country's potential for assessing climate change impacts. This has positioned the country to promote and implement strategies, politics, action plans, programmes and technologies that are focused on mitigating the effects caused by such changes, with a view to adapting to new climate conditions.

Continuity in the fight against climate change and improving people's knowledge on the subject will enable Swaziland to successfully engage in the global efforts needed to mitigate climate change.

2. NATIONAL CIRCUMSTANCES

As a developing country in which a significant portion of the population is reliant on subsistence farming for their daily sustenance and livelihoods, the Kingdom of Swaziland is particularly vulnerable to climate change impacts. The ability to adapt to and cope with climate change depends on economic resources, infrastructure, technology and social safety nets – many of which are typically lacking in Swaziland. Furthermore, climate change is only one of the many environmental problems the nation is confronted with. Swaziland is under pressure due to rapid urbanisation and resource depletion, making it even more vulnerable to the additional challenges resulting from climate change.

Swaziland has therefore recognised the need to develop an effective climate change response whilst ensuring a long-term, just transition to a climate-resilient and low-carbon economy and society. The following figure illustrates the milestones achieved thus far in this regard.

Figure 2-1: Swaziland's Milestones in Response to Climate Change

The country is actively participating in international climate change dialogues, notably the post-Kyoto negotiations. Swaziland's international climate change responses have progressed since the submission of the country's initial National Communication in 2002, with the latest statement being Swaziland's *Intended Nationally Determined Contribution*, submitted in late 2015. This document outlines the country's commitments regarding adaptation and mitigation measures aimed at addressing climate impacts and reducing emissions.

Swaziland has developed a National GHG Inventory and commissioned a number of reports that support the National Communications. Key documents in this regard include a *Vulnerability and Assessment Report*, a *GHG Mitigation Options Analysis Report* as well as a *Technology Needs Assessment Report*. These reports form the basis of this Third National Communication and outline Swaziland's national development priorities, objectives and circumstances that underlie the Kingdom's response to climate change.

2.1 National Climate Change Priorities

The *National Development Strategy*, formulated in 1997 and reviewed in 2014, is the over-arching framework that provides a platform for the achievement of sustainable development in the country. It seeks to balance the needs of the Swazi people with the environment's carrying capacity. The strategy has a medium to long term perspective (25 years). Various national strategies to address climate change (within the context of national development) are outlined, including:

- Mainstream climate change into national development, sectoral planning and budgeting;
- Promote the development and implementation of adaptation and mitigation actions that contribute to sustainable development, poverty eradication and adaptive capacity;
- Pursue capacity building to improve understanding of climate change;
- Develop a legislative framework for climate change;
- Promote and facilitate climate research and establish a national climate research centre;
- Modernisation of meteorological, hydrological and agricultural observation networks;
- Establish a national framework for climate services to strengthen availability, production and application of science-based climate prediction services;
- Mobilise resources for implementation of climate change policy and strategy; and
- Develop strategies for collecting sectoral data for modelling and inventory preparations.

Swaziland's *National Development Plan* was subsequently developed with the aim of accelerating inclusive economic growth and sustainable development in the country, as outlined in the *National Development Strategy*. The Swazi government is responsible for the three-year-rolling development plan, which is operationalised through each annual budget and implemented in various sectors through the respective ministries. The plan proposes various climate related actions to address this national priority. Actions to raise awareness regarding environmental and climate change issues, notably in the education system, are also included, as are actions related to the development of climate smart and cost effective agriculture technologies by 2016.

Swaziland's cabinet recently approved the *National Climate Change Policy* (2016), which supports the priorities outlined in the *National Development Plan*. The aim of the policy is to provide the enabling framework that will guide Swaziland in addressing the challenges posed by climate change, per relevant sectors in the country. The policy options are specifically aligned with the commitments in Swaziland's *Intended Nationally Determined Contribution* and the actions prescribed to meet them.

The development of cleaner and renewable energy options are key climate change priorities in Swaziland. For example, Swaziland's *Intended Nationally Determined Contribution* commits to increasing renewable energy capacity in the country by 50% as well as the introduction of the commercial use of bio-ethanol (a 10% blend) in petrol, for use in all petrol vehicles. The biofuel blending commitment is further supported by the *National Biofuels Development Strategy* and the subsequent *Draft National Biofuels Development Action Plan*, *2009*. The latter specifically outlines the country's approach to facilitating a viable biofuel industry that builds on existing strengths in the sugar industry and in ethanol production.

Capacity building in the climate change sector is another key priority in Swaziland. The *Swaziland Country Report* (2014) by the Southern African Regional Universities Association is a synthesis of background documentation on climate change in the country. The report presents insights into knowledge and research needs as well as individual and institutional capacity gaps. Swaziland's climate relevant institutional structures, roles and responsibilities were documented. The documentation of such structures, with accompanying mandates, will facilitate the monitoring and reporting of progress relating to climate change actions across the country.

The State of Environment Report 2012 is also one of the key documents that outlines Swaziland's climate change priorities. The report fulfils the Swaziland Environment Authority's legal obligation to inform the nation, every two years, on the condition of the country's environment and the factors influencing it. It provides strategic guidance on actions that need to be carried out to improve the overall management of the country's environment.

The report uses a framework which highlights the chain of causal links. Five priority themes, land, water, atmosphere, biodiversity and human development, are assessed under the framework. These themes are interrelated and changes in one may have knock-on effects in others. Water is a particularly important example. It is a key climate change priority on account of the recent drought in the 2015/2016 season that continues to affect agro-pastoral practices, food security, health, biodiversity and commercial activities in the country.

Measures to adapt to climate change in Swaziland are increasingly prioritised, as these have the potential to positively enhance human development considering that the nation relies extensively on the agricultural sector for sustenance and sources of income. Socioeconomic development is therefore a key national priority in Swaziland. Increased economic pressures on Swazi-citizens amplify impulses to engage in risky or illegal activities in order to sustain their basic livelihoods. The high prevalence and mortality rates of the HIV/AIDS epidemic further exacerbate the cycle of poverty in the country.

The number of climate related programmes, measures and activities is steadily increasing in Swaziland. The *Swaziland Sustainable Energy for All Country Action Plan* (2014) is a notable programme in this regard. It identifies priority intervention areas with the aim of achieving sustainable energy, on a global basis, by 2030. The priority areas in Swaziland are those related to increasing the energy efficiency measures and the implementation of renewable energy projects. To date, the Swazi Government has funded various solar photovoltaic installations in public buildings, improved cook stoves and rural electrification initiatives. The plan also highlights the need to develop appropriate policy and regulatory instruments to promote renewable and energy efficiency technologies, as well as the need to gather reliable data. Swaziland and various international development partners are in the process of leveraging funding to develop an Investment Prospectuses for implementation of the Sustainable Energy for All Action Agenda. The related Global Tracking Framework is particularly relevant because it provides a monitoring system for participating nations who can track their progress in this regard.

Swaziland is prioritising the move from *ad hoc* data collection and analysis to monitoring and reporting climate change data. This is specifically outlined in the *Revised Statistics Bill*, which has been recently submitted to Parliament for approval.

These national priorities relating to climate change are critical in understanding the country's vulnerabilities as well as its capacity and options for adapting to the adverse effects of climate change. They also provide the starting point for identifying and pursuing the options for addressing the country's GHG emissions, within the broader context of sustainable development.

2.2 Physical Context

Figure 2-2: Map of Swaziland. ***Source: www.maps.com***

The Kingdom of Swaziland is a landlocked and mountainous country situated in the south eastern part of the African Continent. Swaziland is physically located between the latitudes of 25° 43' and 27° 19'S and longitudes of 30° 47' and 32° 08' E. With the exception of a short border stretch with Mozambique in the east, Swaziland is bounded and surrounded by the Republic of South Africa. The country covers a land area of 17 364 km^2, making it one of the smaller members of the Southern African Development Community. 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 to 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.

2.2.1 Relief

Swaziland has a surprising variety of reliefs. There are four well-defined physiographic regions, extending longitudinally from north to south in roughly parallel belts. From west to east they are the Highveld, the Middleveld, the Lowveld, and the Lubombo escarpment. Each of the physiographic regions has its own climate. In terms of altitude, Swaziland's highest summit point stands at 1 862 m above sea level, and the lowest point is at 152.4 m. The figure below shows the agro-ecological regions of Swaziland, from west to east.

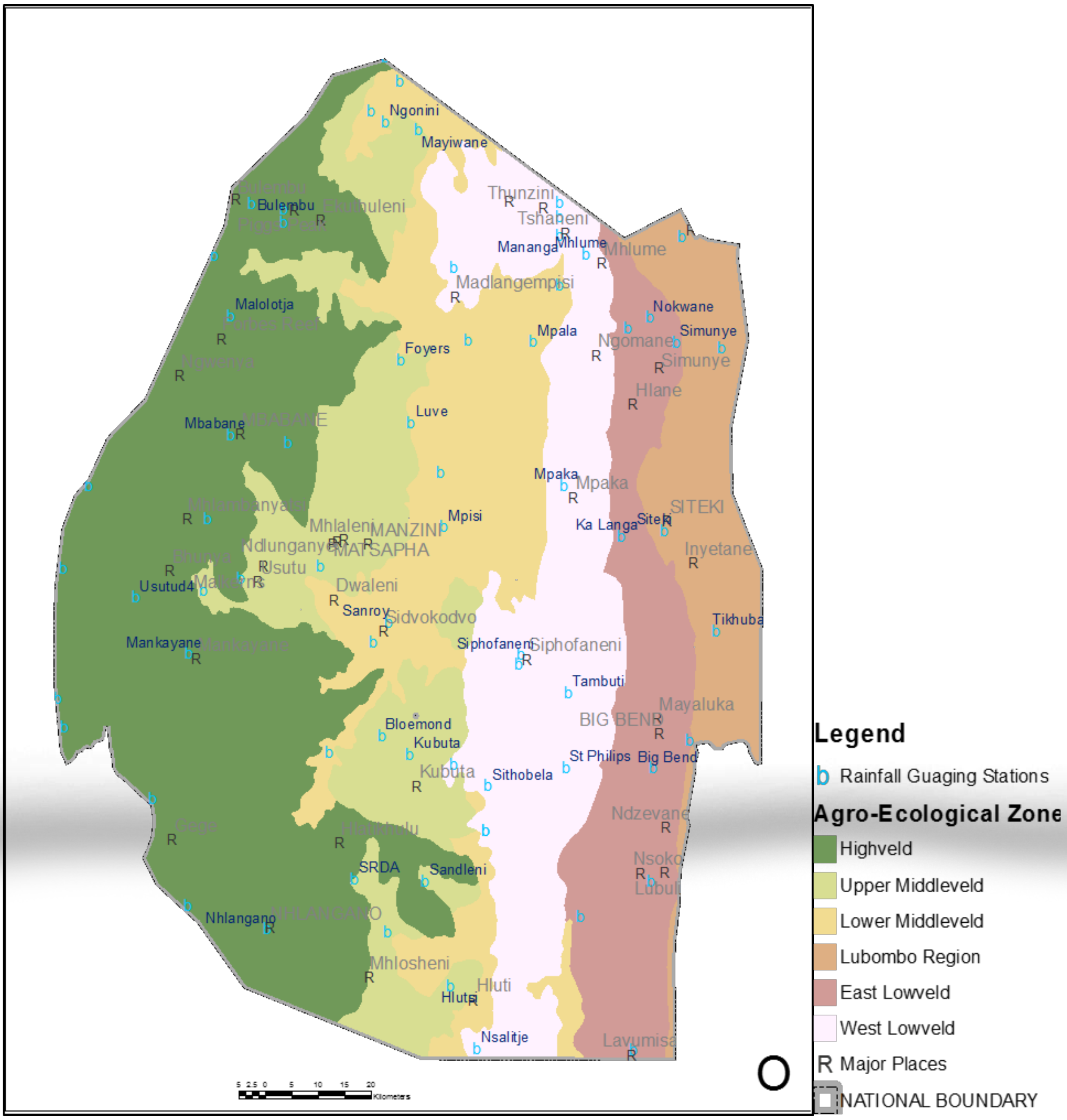


Figure 2-3: Swaziland Agro-ecological Zones

2.2.2 *Climate*

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). The climate of Swaziland is highly variable at intra-seasonal to inter-annual timescales due to a number of influences that include varying topography and multi-scale interaction of weather producing systems. Droughts, floods and extreme temperatures, veldt and forest fires, lightning and hailstorms are distinct and regular features that characterize the climate of the country. The intensity and frequency of extreme weather events such as droughts and heat waves have been observed to increase over the past few years. The country has estimated ground lightning flash densities of more than 12 flashes/km2 /year that mainly occur in the Highveld where there is a high incidence of thunderstorm occurrences every year with an annual average fatality rate of 15.5 people per million, which is rated amongst the highest recorded rate in the world. Most of the lightning occurs during the austral summer which coincides with high convective activity and intense thunderstorms associated with weather systems of both tropical origin which at times include passages of tropical cyclones from the southwest Indian Ocean and extra-tropical origin and their interactions.

The country receives the majority of its rainfall in the summer months, mainly between October and March. However, there is a large difference in the amount of rainfall experienced in the eastern and western parts of country, primarily due to the influence of topography and the direction of prevailing winds. Mean annual rainfall ranges from about 1 500 mm in the northern Highveld to 500 mm in the southern Lowveld. Precipitation varies considerably however from year to year, which leads to increases instances of flash flooding or drought. High recorded rainfall variation makes it difficult to identify trends with a high degree of certainty. The figure below illustrates the typical annual rainfall patterns.

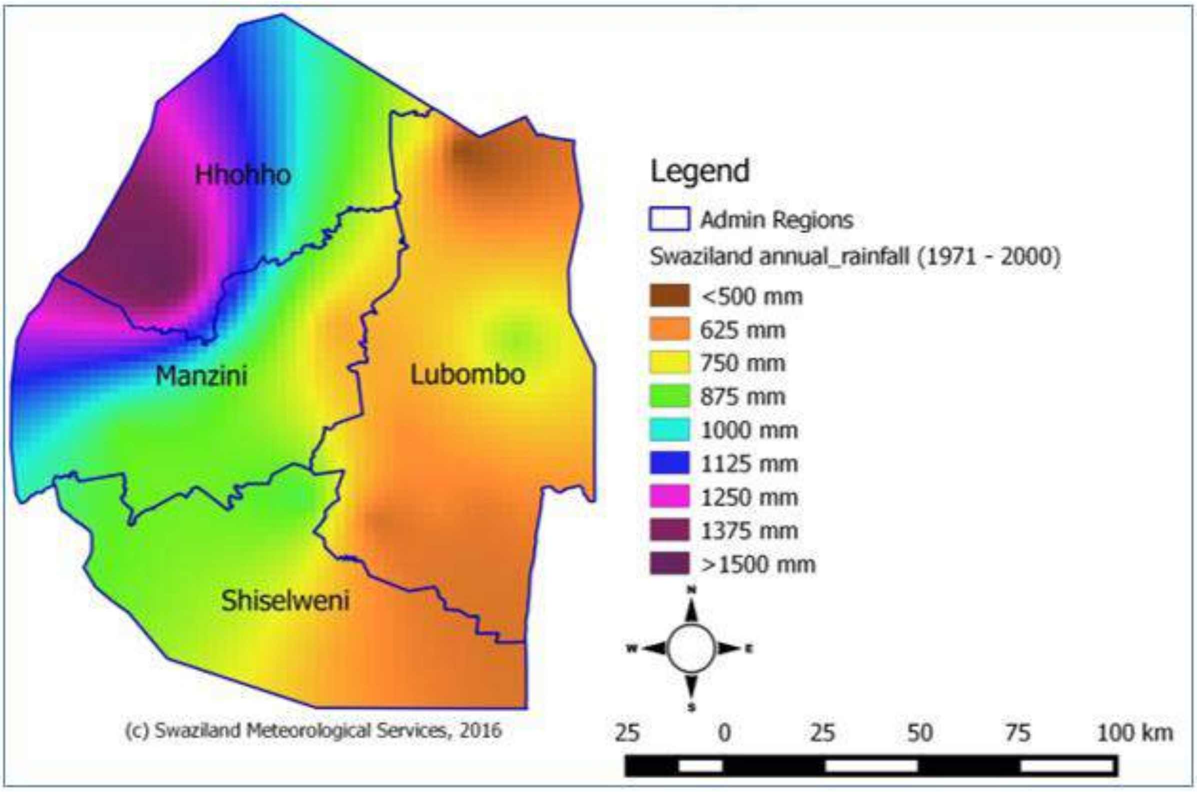


Figure 2-4: Swaziland Annual Rainfall Pattern

Drought is an inherent feature of the current semi-arid climate. Rainfall levels have consistently reduced over the last decade (2000-2010). The El Niño phenomenon has exacerbated the drought over the last two years, where the lowest rainfall levels over the five year period occurred during the 2015/16 season, as illustrated in the following figure.

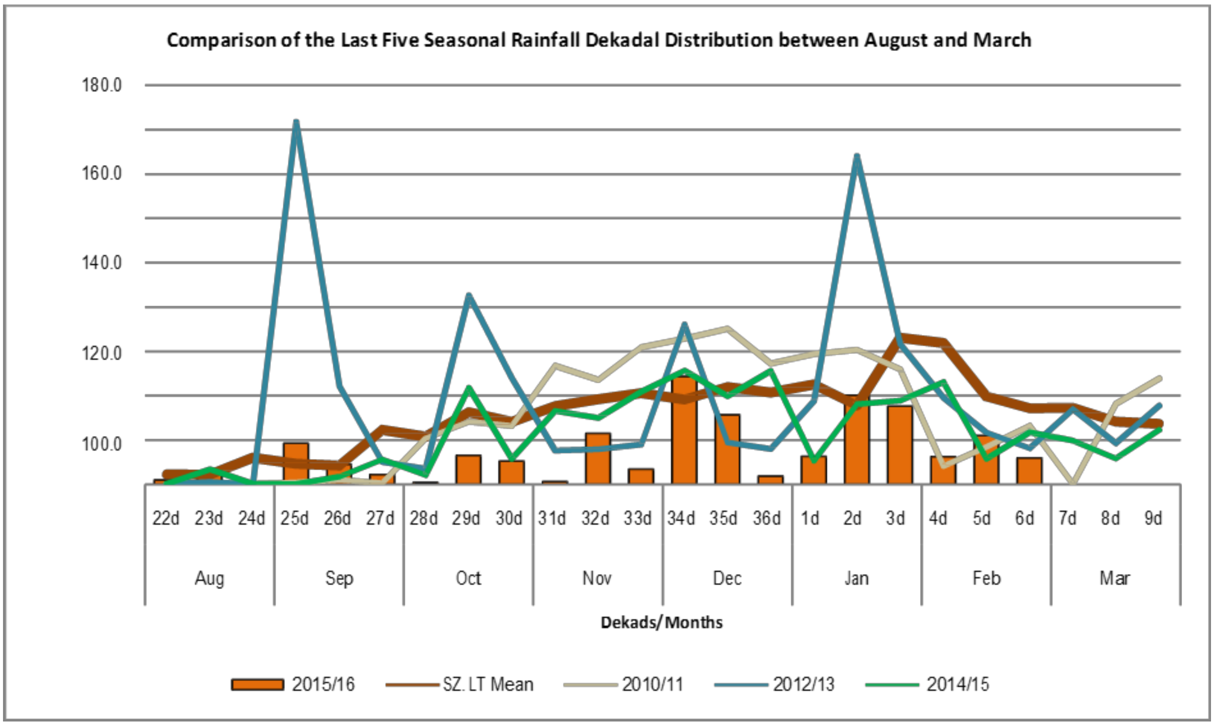


Figure 2-5: Comparison of the Last Five Seasonal Rainfall Dekad Distribution

The highest temperatures are experienced in the Lowveld region which is located in the low lying areas in the eastern part of the country near Mozambique. In this region the diurnal cycle can be large (>20°C), with extremely high daytime maximum temperatures (>35°C). The lowest temperatures are found in the high altitude areas along the Highveld region; in the western parts of the country, where temperature go below 0oC in winter. Generally, the Lowveld region is hot and dry while the Highveld region is cool and wet. The figure below shows the average annual temperature across the country.

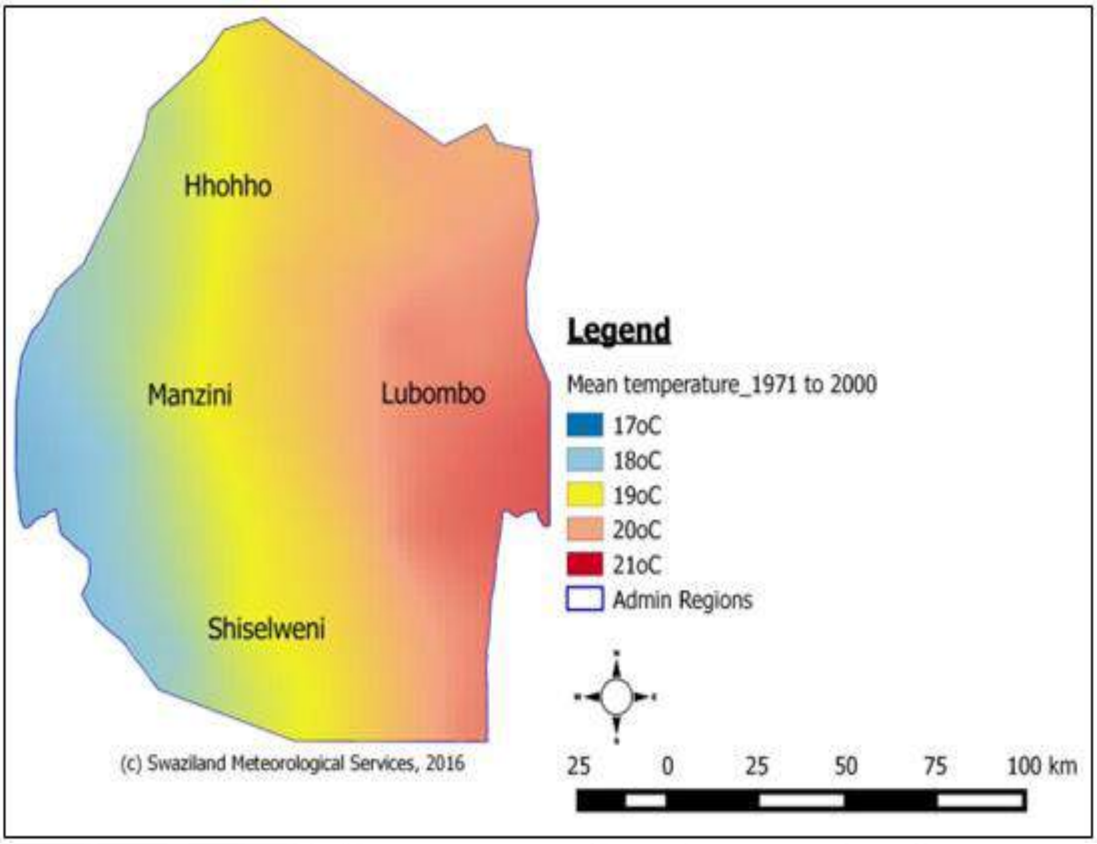


Figure 2-6: Swaziland Mean Temperature

Mean annual temperatures vary from 17°C in the Highveld to 22°C in the Lowveld. These temperatures are zonal averages, with variation across zones. Swaziland's climate change projections indicate an increasing trend in the frequency of very hot days exceeding 36°C in the country. There is general agreement that the country is expected to experience higher temperatures year-round in the future, although uncertainty remains regarding how much warming will occur. Swaziland's drylands are depicted in the figure below.

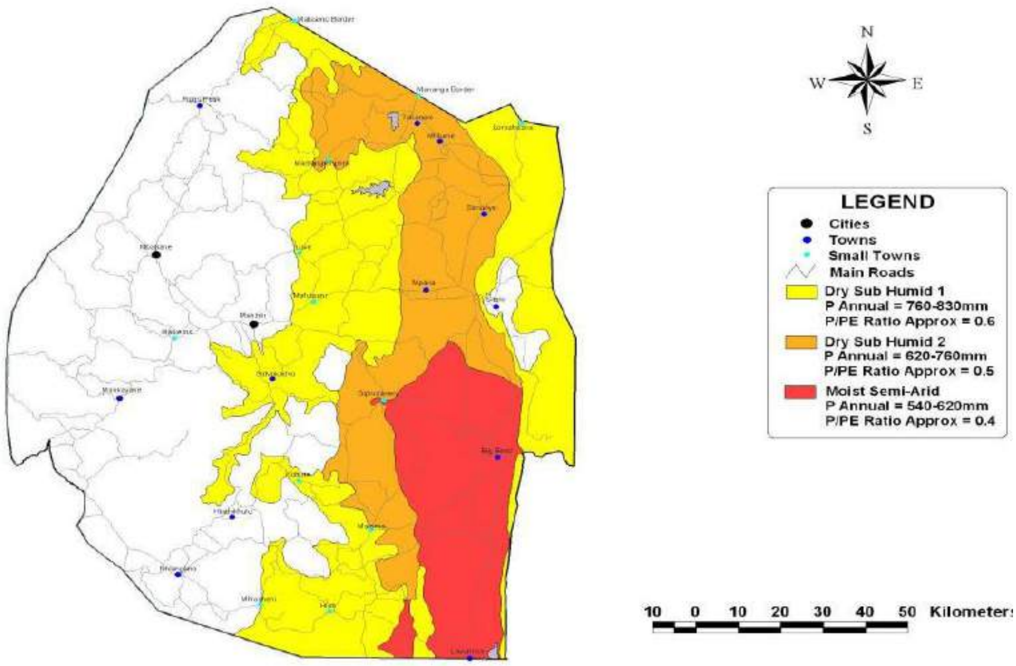


Figure 2-7: Dryland Zones of Swaziland

The recorded and projected climate trends indicate that the Kingdom of Swaziland is particularly vulnerable to the effects of climate change. Measures to improve the functioning and wider disbursement of meteorological stations will assist the country to monitor and record climate related trends.

Climate Projections

According to projections, Swaziland will continue to get warmer;

(iv) Mean temperature is expected to increase

(v) All projections indicate an increase in the frequency of hot days

(vi) Projections indicate a decrease in cold days and nights

Rainfall will continue to be uncertain and difficult to predict.

(iv) Projections indicate an increase in number and frequency of dry spells during the summer season especially between October and February

(v) All models indicate a decrease in number of frost days in the Highveld region

(vi) Some models predict an increase in number of days with more than 20mm of rainfall while some models indicate a decrease.

2.3 Social Context

The Kingdom of Swaziland is a monarchical-democracy. The country has a concurrent parliamentary system, which is headed by the Prime Minister. The 2006 Constitution provides for a separation of powers between the executive, the legislative and the judiciary, and provides for various individual rights.

It is estimated that approximately 70% of the population live in rural areas. Rural communities typically depend on climate sensitive sectors as the basis for their livelihoods. Apart from climate change, communities of this nature are exposed to various other challenges, notably the high prevalence of HIV/AIDS infections in the country. Improvements to the existing, but limited, basic services such as access to healthcare, education and energy infrastructures will assist the country to improve poverty levels and increase human development. The key is to undertake such measures in a sustainable manner and in ways that simultaneously address climate change effects and the long term mitigation of GHGs.

2.3.1 Population, life expectancy and fertility rates

Population growth can have a significant impact on energy consumption, land-use patterns, housing density and transportation. As Swaziland's population grows, the demands on resources and infrastructure (e.g. schools, roads, health-facilities, etc.) increase as well. These demands inevitably lead to stresses on the environment. In 2007, Swaziland's population was reported in the national census to be 1 020 102. The table below outlines the estimated annual population growth from 2007 to 2018.

Table 2.1: The Population of Swaziland in Thousands ('000)

Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Female	538	544	549	555	562	568	574	581	588	594	601	608
% of Pop.	53	53	53	53	53	53	53	53	53	53	53	53
Male	482	488	494	500	506	512	519	525	532	538	545	551
% of Pop.	47	47	47	47	47	47	47	47	47	47	47	47
Total Pop.	**1 020**	**1 032**	**1 044**	**1 056**	**1 068**	**1 080**	**1 093**	**1 106**	**1 119**	**1 133**	**1 146**	**1 159**

In Swaziland, like many other developing countries, the percentage of women is higher than the percentage of men in the country. The following charts compare Swaziland's population for the years 2007 and 2014.

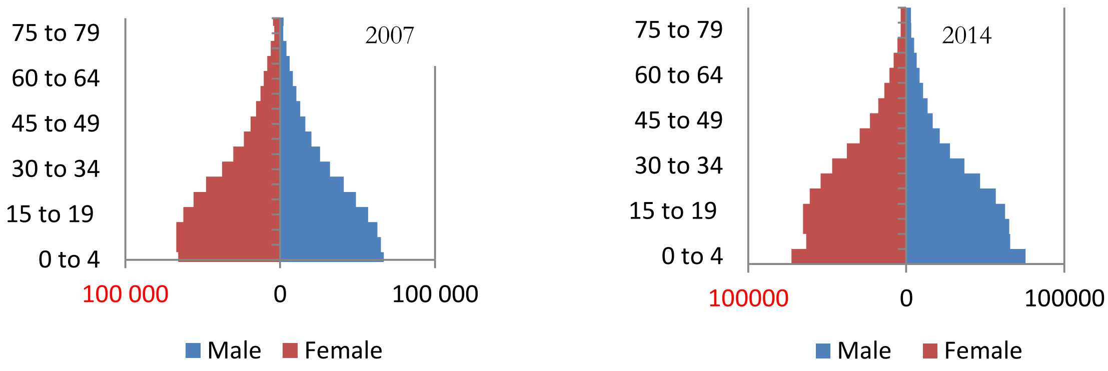


Figure 2-8: Swaziland's Population Pyramid for the Years 2007 and 2014

The length and quality of life of Swaziland's population are related to a number of factors. These include levels of poverty, food security, access to health care facilities and others, many of which are directly affected by climate change. Swaziland's mitigation and adaptation efforts must therefore be considered in the context of human development in the country.

The higher a population's life expectancy, the higher the population's quality of life, and *vice versa*. Swaziland is a developing country with a high number of people infected with the HIV, tuberculosis and other illnesses including diabetes and pulmonary disease which threaten the population. The *Population Census of 1997* found that the typical Swazi had a life expectancy of 55 years. While the following table indicates that the average life expectancy age in 2014 has dropped considerably from this level, it is showing signs of gradual improvement.

Table 2.2: Life Expectancy of Swaziland in Thousands ('000)

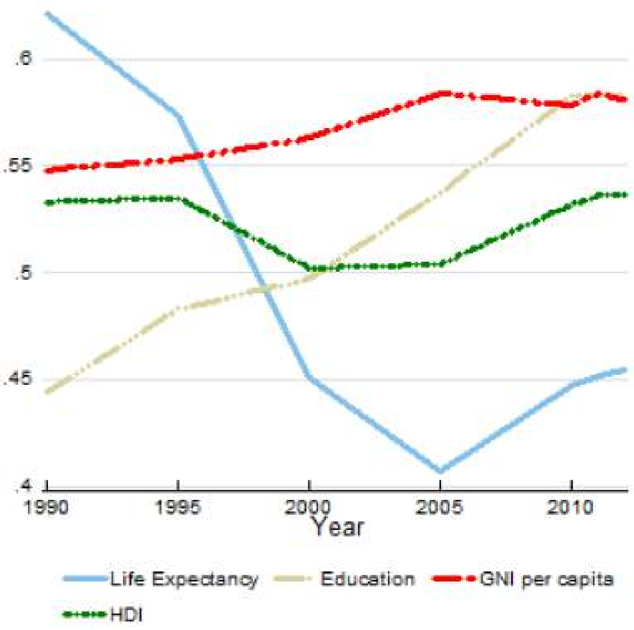
Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Female	42.8	41.7	40.6	47.2	47.2	47.2	47.2	47.3	47.4	47.5	47.6
Male	41.5	40.9	40.3	43.2	43.2	43.2	43.1	43.2	43.3	43.4	43.6
Total	**42.2**	**41.3**	**40.5**	**45.2**	**45.2**	**45.1**	**45.1**	**45.2**	**45.3**	**45.5**	**45.6**

The country's total fertility rate in 2007 was 3.5%, and is projected to drop to 2.9% in mid-2030. The reduction is attributed to factors such as increased family planning and education levels of women, enabling them to actively participate in the economy. Low life expectancy and fertility rates in Swaziland are therefore affected by the levels of human development and poverty. Socio-economic development is consequently a key priority across the country.

2.3.2 Human development and poverty in Swaziland

According to the Human Development Report compiled by the United Nations Development Programme (2013), Swaziland's Human Development Index value for 2012 was 0.536, positioning the country in the medium human development category. Swaziland was ranked 141st out of 187 countries and territories. Swaziland's trends in this regard are illustrated below.

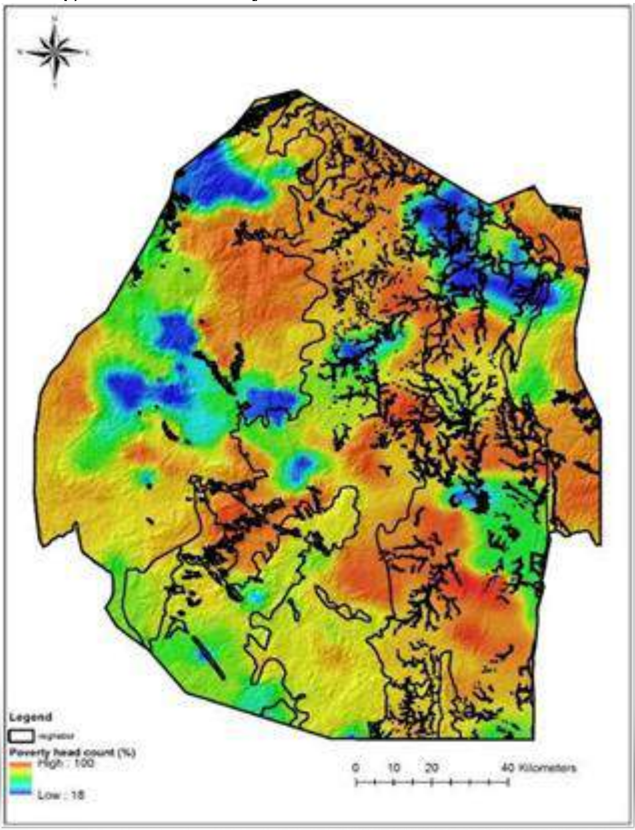
Figure 2-9: Trends in Swaziland Human Development Index



One of the most critical drivers of human development is the economic status of the society. The country is characterised by high income inequality as shown by the GINI coefficient of 0.51 (the internationally acceptable level is 0.3) in 2010. This is an increase from 0.48 in 2007. The proportion of the population defined as poor fell from 69% in 2000/01 to 63% in 2009/10. The decrease withstanding, the percentage of people living below the poverty line is extremely high for a middle-income economy, which also reflects the high levels of inequality in the economy. Furthermore the national decline of 6% in the poverty rating was not evenly distributed across the four administrative regions, meaning that levels of poverty remain extremely high for many Swazis. In addition, there is also a gender disparity to poverty, with 67% of female-headed households living in poverty compared to 59% of male-headed households (African Economic Outlook, 2015).

The adjacent figure below illustrates the geographical distribution of poverty in Swaziland in 2010, which was based on household income and expenditure levels.

Figure 2-10: Poverty Head count in Swaziland



Swaziland's poorest people live in rural areas, where per capita income is one-fourth, and food consumption half, of the urban average. Poor communities in these areas are more vulnerable to, and also have limited means to cope with, the losses and damages caused by extreme weather events. Location, lack of services and infrastructure and poor building structures all increase the vulnerability to flooding, storms and cyclonic wind and rain. Poor farmers also risk losing crops due to the flood season occurring at times when crops ripen for harvest. In the longer term, poor households also risk losing wage opportunities as the sick and injured cannot work or as the disasters destroy the need for labour. Recovery strategies, like selling assets, can leave the poor without income and thus more vulnerable to the next disaster. The temptation to engage in risky or illegal coping strategies, for example the production of marijuana plantations in Swaziland[1], increases in proportion to the population's levels of poverty and vulnerability.

Efforts to reduce poverty and increase human development in Swaziland are inextricably linked to food security.

2.3.3 Food security

The connection between climate change, mitigation and food security has become a priority issue in Swaziland. The country's poorer communities are most at risk of global climate variations and global commodity price fluctuations. The country has consistently failed to produce enough food to cover domestic requirements, contributing to the food insecurity of an estimated 20%-25% of the population (UNDP, 2012).

The *Swaziland Drought Assessment Report: Rapid Assessment 2015/16* projects that the agricultural harvests for Swaziland in 2016 will be at their lowest in over 20 years of recording. The areas planted for maize have reduced by 80% while current production levels are expected to decrease by 64% compared to levels in the 2014/15 season.

[1] Anecdotal evidence discussed at a stakeholder consultation meeting in Swaziland, March 2016.

Maize production, the staple crop, is reliant on stable, favourable rainfall and temperature levels in Swaziland. Irregular rainfall patterns place small scale and subsistence farmers at enormous risk of crop failures, and hence increase their vulnerability to the impacts of climate change. The decline in agricultural production potential, combined with the recent food commodity price hikes are likely to affect the majority of Swazi households. Over 550 744 people (49% of Swaziland's estimated population in 2016) are projected to have livelihood deficits during the 2016/17 consumption year. 275 274 people (24% of Swaziland's estimated population in 2016) are projected to have food deficits in the same period.

Figure 2-12: Smallholder farmer in Swaziland.

Such households tend to employ negative coping strategies, which have both socio and economic impacts on the population and communities at large. These include reducing the number of meals (68% of households indicate that they decrease the number of daily meals); migration to urban areas; distress sales of livelihood assets; increased reliance on social protection and safety nets and increased instances of substance abuse, prostitution and petty crime.

The following graph illustrates that nearly half of the households surveyed lacked food reserves at the beginning of the last 'lean' season.

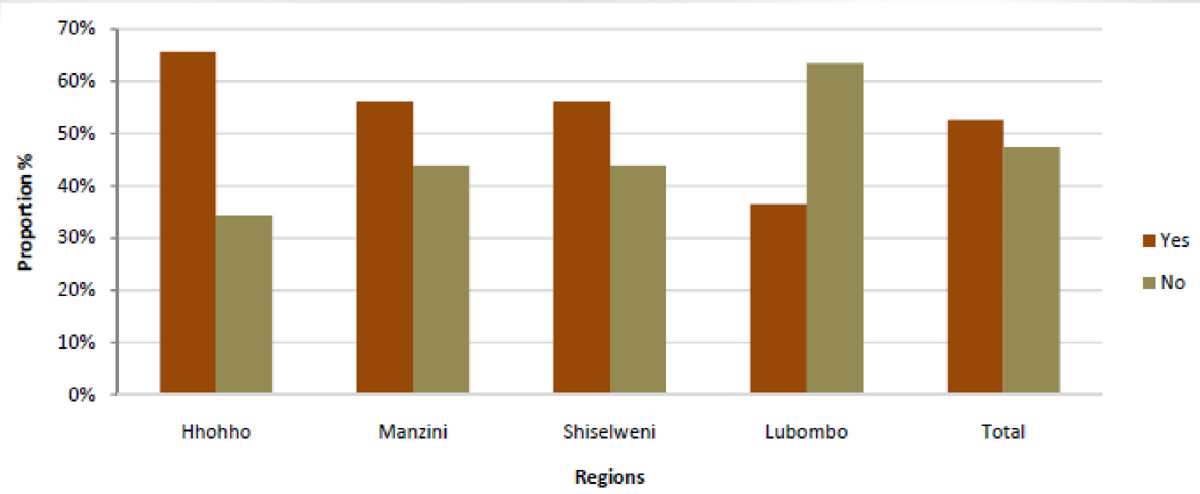


Figure 2-13: Households with Food Reserves in October 2010

The more vulnerable members of affected communities in Swaziland, particularly children, youth and women, are at the greatest risk of food insecurity which is inextricably linked to climate change.

2.3.4 Children's health and nutrition

Children in Swaziland face disproportionate risks associated with climate change because they are not equipped with the resources and capabilities required to deal with risks and natural disasters. The effects of climate change are principally felt in Swaziland's agricultural and food production sectors, which have serious impacts on children's health and nutrition. Access to sufficient and adequate food sources, particularly during childhood, affect health and education levels – some of the principal drivers underlying the fight against poverty in Swaziland.

Nutrition status is a result of complex interaction between food consumption and the overall status of health and care practices. While stunting rates still remain very high in Swaziland, there have been slight improvements in the wasting and underweight categories. Stunting levels are higher in rural areas (33%) than urban areas (23%). Stunting is especially high in the Shiselweni region (38%), among children whose mothers have no education (40% showed signs of stunting) or primary education (where 38% showed signs of stunting) and those from the poorest households (where 42% showed signs of stunting). The *Cost of Hunger* study in Swaziland estimates that child under-nutrition generates health costs equivalent to 0.6% of the total health budget, and that only three of every 10 children are getting proper health attention. Nearly one of 10 reported deaths of children is associated with under-nutrition. Furthermore 18.9% of all grade repetitions are associated with higher incidence of repetition among stunted children. The findings of the study therefore indicate the need for scaling-up current interventions and developing innovative solutions to fight undernutrition in children in Swaziland.

2.3.5 Education and youth vulnerability

While English and SiSwati are the official languages of Swaziland, only English is the medium of instruction. Education levels are acknowledged as challenges to human development, where low school readiness of learners combined with resource and teacher capacity constraints are noted as challenges. The figure below illustrates the high level of primary school enrolment compared to poor levels of secondary enrolment.

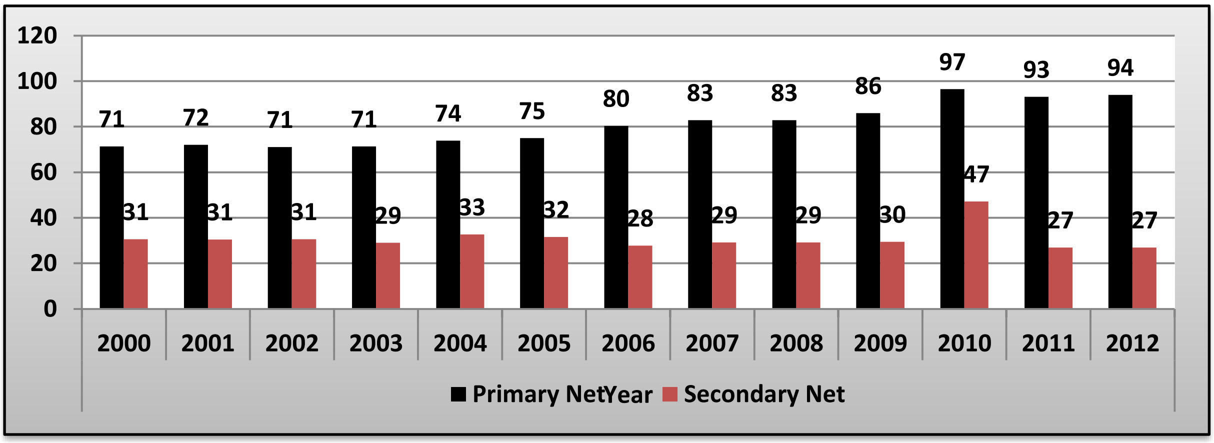


Figure 2-14: Enrolment in Swaziland for Both Primary and Secondary School.

Despite free primary education, the cost of education is still a significant barrier to enrolment and completion. Furthermore there have been recommendations to incorporate indigenous knowledge systems into the school curriculum, in order to revive these effective and sustainable practices (Dube and Musi, 2002). Access to adequate education is a challenge for Swaziland, as the required resources and infrastructure often do meet the needs of the country's citizens. These resource constraints contribute to the vulnerability of youth in Swaziland.

Unemployment is linked to low education levels, which is related to low income levels and limited opportunities. The majority of the active youth in the Swazi labour market are unemployed. The 2007 Census revealed that the majority of the unemployed youth (two in three males, and one in two females) had not progressed beyond primary levels of education. Most youth (about 88%) live in rural areas, with very limited prospects for gainful employment. Limited job opportunities, lack of robust safety nets and weakened financial situation of families hamper access to education and compel more youth to enter the Swazi labour market at lower ages and levels of training.

The following table illustrates the youth unemployment rate, compared against the adult unemployment rates and as a percentage of the total labour force.

Table 2.3: Rural and Urban Labour Markets in 2007, by Young and Adult Worker Categories

	Youth / adult unemploy-ment rate (ratio)	Youth unemploy-ment rate (%*)	Adult unemploy-ment rate (%*)	Youth – total unemploy-ment (%)	Youth unemploy-ment to youth population (%)	Adult unemploy-ment to adult population (%)
Rural	2.3	57.8	25.1	41.2	15.5	14.3
Urban	3.0	45.8	15.4	44.8	19.0	12.0
Total	2.5	53.3	21.0	42.3	16.5	13.5

** % of labour force*

In 2010, only about 10% of youth aged 15-19, were actually active in the labour market, compared to almost half of youth aged 20-24 were active in the labour market. The high unemployment rates and long duration of unemployment suggest that youth unemployment mostly reflects youth who have never had the opportunity to enter the labour market, rather than redundancies. By 2010, 14% of male youth and 17% of female youth, were neither in school nor employed (Central Statistics Office, 2010a).

The government is addressing youth unemployment through empowerment programmes such as implementing a Youth Enterprise Fund and introducing entrepreneurship education in the secondary school curriculum. Slow economic growth in Swaziland as well as the current global fiscal crisis suggest however, that the current generation of youth will face greater exclusion from the labour market than previous generations. Youth may also be at greater risk of prolonged unemployment or poverty traps, where capacity, human capital and morale is eroded, reducing future opportunities as well. High youth unemployment therefore carries present and future risks such as reduced social cohesion and increased incidences of violence. Improvements at childhood levels in nutrition, health, education and skills development will contribute to the reduction of youth vulnerability in the country.

2.3.6 Vulnerability and empowerment of women

In Swaziland, women are less likely than men to be active in the labour market. They are more likely to be unemployed if they are active and have less access to more secure forms of employment, in particular formal sector jobs. Women in the country also earn, almost invariably, less or much less, than their male peers. Female unemployment rates, whether narrow or broad, exceed those of men, for youth as well as adults. These barriers to employment and equitable participation in Swaziland's economy are some of the factors that make women in the country vulnerable, and hence position them, as a group, at a disadvantage when it comes to coping with natural disasters associated with climate change.

The figure below compares employment rates between the years of 2010 and 2007.

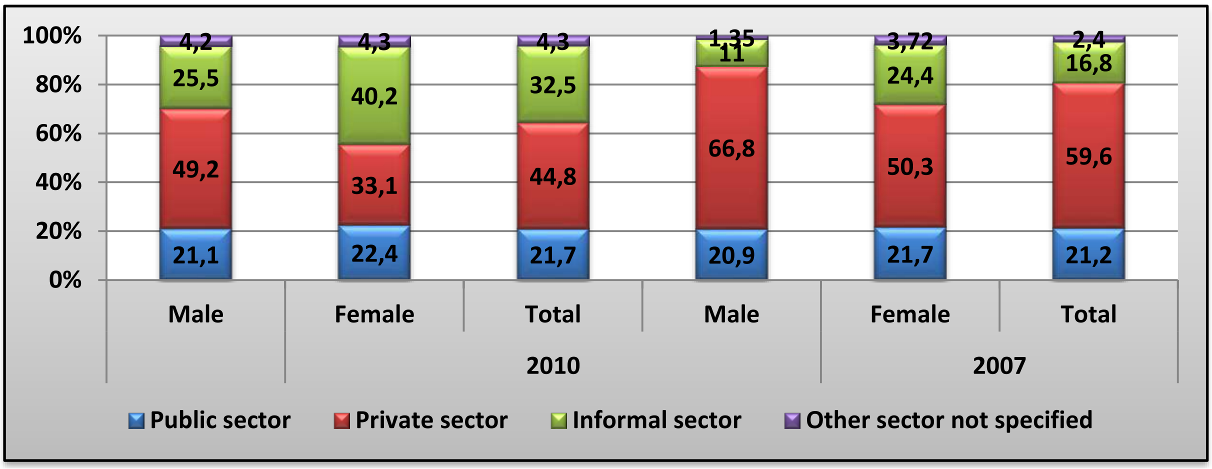


Figure 2-15: Employment Rate Comparisons by Sector of Employment and Sex.

The high prevalence and death rates resulting from the HIV/AIDS epidemic further reduce the resilience of vulnerable groups, such as children, youth and women, to climate change impacts.

2.3.7 HIV/AIDS and tuberculosis

According to World Health Organisation (2016), sub-Saharan Africa is the region most affected with HIV. In 2014, there were around 25.8 million people living with HIV in the region. Sub-Saharan Africa also accounts for almost 70% of the global total of new HIV infections.

HIV prevalence and rates of infection among the populace of Swaziland are correspondingly high. As a result of the virus, households are made vulnerable to food insecurity, especially when breadwinners or adult members in the household die or become indisposed for long periods of time. Such circumstances lead to poorer household nutrition status – a key factor that negatively affects the life expectancy of infected individuals. These households are often forced to sell valuable assets in order to cope, or engage in risky practices in order to secure access to food, such as prostitution, further exacerbating their risks and vulnerabilities to the virus.

HIV prevalence was 31% among those aged 18-49 years. It is estimated that 167 641 adults and 17 220 children were living with HIV and AIDS in 2010. The people living with HIV and AIDS are expected to increase to 212 151 by 2020. The youth are the hardest hit segment of the population. HIV prevalence levels are highest among the age groups 20-24 and 25-29, at 46.3% and 56.3%, respectively. HIV prevalence in urban areas (46.4%) is slightly higher than in rural areas (41.4%).

The incidence of HIV and AIDS in Swaziland is also linked to the prevalence of tuberculosis. Incidences of tuberculosis have been increasing in Swaziland since the early nineties. In 2011 there were 1 317 cases per 100 000 people. Tuberculosis, aggravated by HIV/AIDS, remains the main cause of tuberculosis deaths in Swaziland. Both pandemics are affected by climate change because the impacts which result in reduced food security, which in turn disproportionately impacts the more vulnerable members of society who are often not able to access state resources. Swaziland's scarce resources are likely to be stretched even further, as people migrate to urban centres to seek employment opportunities.

2.3.8 Urbanisation

While urbanisation is driven by a number of factors, natural disasters and related food shortages that are a result of climate change are some of the prominent drivers in Swaziland, where livelihoods in rural areas tend to be insecure and highly informal. Households in the country's urban areas are likely to have both better access to government institutions and infrastructure than households in rural areas.

In 2007, Swaziland's urban population was estimated to be 225 700. It is projected that due to urbanisation, the urban population will increase 53% by 2030, assuming a constant growth of 0.2% of urbanised people. The major urban areas in Swaziland include Manzini, Mbabane, Big Bend and Malkerns. The migration of people to these centres will increase demands for infrastructure and services, such as housing, water and sanitation, electricity, road networks, education, health, and more, as people are driven to exploit employment opportunities in urban areas.

2.4 Swaziland's Economy

Human development in Swaziland is linked to the improvement of socio-economic status of its citizens. Growing the country's economy, on an equitable basis, will assist its citizens and the nation become more resilient to the impacts of climate change.

Swaziland is classified as a lower-middle income country even though it exhibits features similar to those of Africa's low-income countries. 70% of the population derive their livelihoods from agriculture, which also provides raw material for the agro-based manufacturing sector. About 63% of the population live below the poverty line (one in two people who are poor in the country tend to suffer from food poverty as well) and output and trade are not well diversified (African Development Bank, 2011).

The economy is fairly diversified and exports are predominantly sugar, beef, textiles, forestry products and citrus. Growth prospects are predicated for the export sector, considering the ratification of the Economic Partnership Agreement with the European Union signed in August 2014.

Swaziland has very close links with its neighbours, South Africa and Mozambique, in terms of trade, transport, communications and energy. Inflation, interest and exchange rates in Swaziland display a high level of co-movement with those in South Africa, as most of the country's imports originate from its larger neighbour. Manufacturing continues to be the foremost contributor to the stock of foreign direct investment in the country, followed by the agricultural sector and subsequently the services sector.

Attracting foreign direct investment is one of the main policy measures that the government is using to revive economic growth through job creation for the population. The government created the Swaziland Investment Promotion Authority to focus on ensuring that foreign direct investment flows into the country by removing all impediments. USAID is also assisting the government improve foreign direct investment through measures such as reducing bureaucratic barriers involved in setting up businesses and creating investor friendly tax and labour laws.

The Kingdom is a highly open economy, with the ratio of exports plus imports to GDP estimated at about 194% in 2010. The high degree of openness presents opportunities for growth, but it also places the country at a high level of vulnerability to external shocks due to limited output and market diversification. In addition, the country's debt position is well below the recommended range by international organisations. It is therefore crucial that Swaziland improves its economic outlook to ensure the country has the financial resources required to address the many challenges it faces, many of which are exacerbated by the impacts of climate change.

2.4.1 Gross domestic product

Growth in real gross domestic product (GDP) in Swaziland has continued to be far below levels experienced in the 1970s and early 1990s. For the past decade growth has averaged 2%, which is almost half that of other Southern African Customs Union member countries. Furthermore, this is far below the required growth rate of 5% in order for the country to halve poverty and thus achieve the first Sustainable Development Goal.

Real output growth dipped further to 0.2 percent in 2012 after recording 0.7 percent in 2011 and 1.9 percent in 2010. As a small open economy, Swaziland suffered from the general slowdown in global economic activity in 2012. The Eurozone crises affected the country in two ways: first directly through Swaziland's trade links with the EU and secondly indirectly through South Africa's trade links with the EU. The poor performance in the EU and South African markets, which collectively consumes about 70 percent of Swaziland's exports, translated to a slower performance in the domestic economy. From the domestic front, the economy endured the second round effects of the fiscal crisis which was evident not only in the government sector but also in other sectors which are directly and indirectly linked with the government sector. These included inter alia; commerce, construction and financial intermediaries.

The agriculture subsector recorded an overall decline of 1.3 percent in 2012 after expanding by 8.5 percent in the previous year. Significant decreases were noted in maize, citrus and livestock production. On the other hand, the forestry sector portrayed signs of recovery from the prolonged negative effects of the 2008 forest fires. The mining and quarry subsector output doubled buoyed by a significant rebound in coal and quarried stone production which rose by 27 and 49 percent, respectively. This subsector was further boosted by the re-opening of the Ngwenya iron ore mine which started operating in the last quarter of 2011. The mine intensified its operations during the course of 2012.

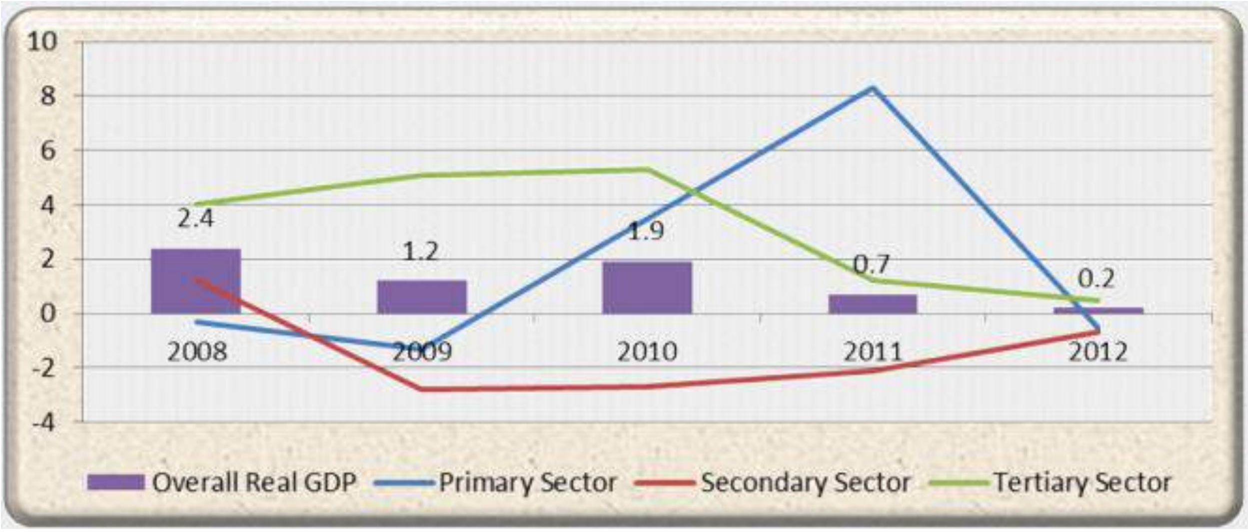


Figure 2-16: Swaziland Real GDP Growth Rates 2008-2012

2.4.2 Agricultural production

Developments in the agriculture and forestry subsector were mixed in the 2014/15 financial year. Subsistence agriculture output rose by 15.7% in 2014, following a significant jump in maize production from the previous season. Commercial agriculture in the (Individual Tenure farms) contracted by 2.4%, mainly due to a significant decline in citrus production.

Of the various components that contribute to Swaziland's GDP, agricultural production is also the most vulnerable to the negative impacts of natural disasters that result from climate change. Agricultural production is crucial because of its direct links to food security and human development.

Sugar Cane

Sugar cane production is Swaziland's key cash crop. In 2015, the sugarcane industry represented 74% of the total agricultural output in the country. It contributed 35% and 18% to total agricultural and manufacturing wages respectively; 13% to Swaziland's GDP (through cultivation and milling activities) and 16% to the country's total export earnings.

The effects of climate change are particularly severe in this industry, where natural disasters such as heavy rains, floods, droughts and fires place communities and their livelihoods at risk.

Recent trends in sugar production quantities and sales are illustrated in the following table.

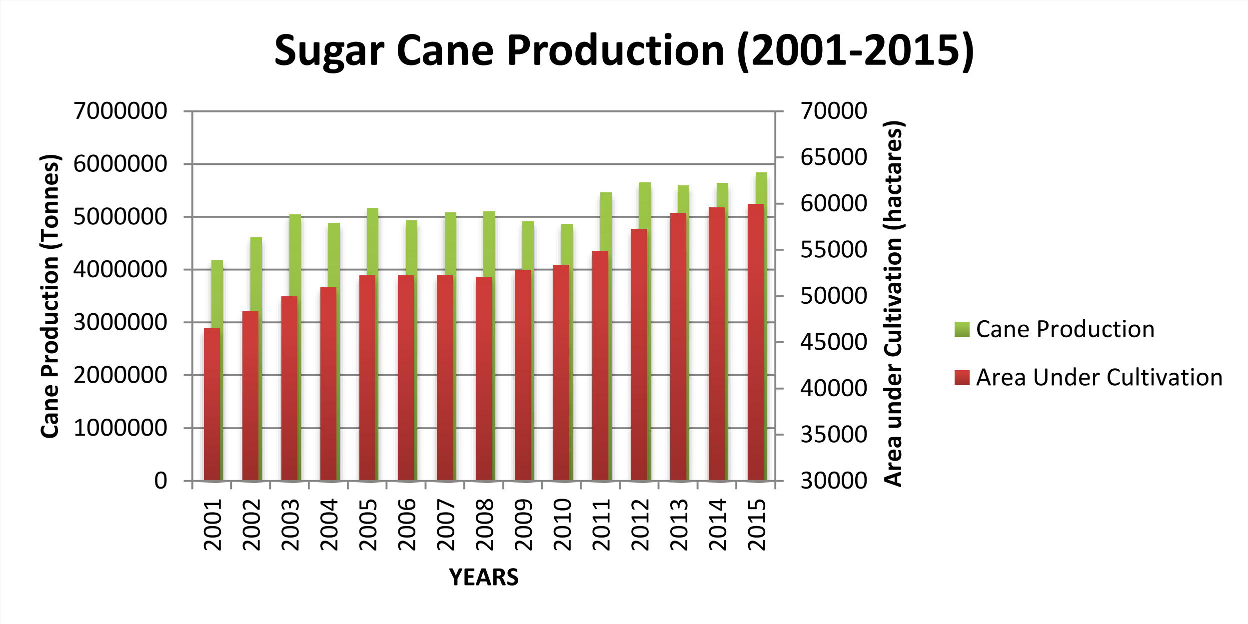


Figure 2-17: Sugar Cane Production (2001-2015)

Prospects for the sugar industry are mixed. On the marketing side, a recent increase in flooding of the European Union market by other giant sugar suppliers has somewhat negatively affected sugar prices in the European Union and this will limit the scope of increasing volumes to this market. On the positive side, a sustained depreciation in the Lilangeni exchange rate against major trading currencies will somewhat cushion returns from non-Southern African Custom Union sales.

Due to the current drought in the 2015/16 season, rationing of irrigated water has affected over 30% of Swaziland's sugarcane production area. As a result, sugarcane and sugar production are forecasted to decrease by 22% and 25% respectively compared to 2015 levels. This will affect sugar sales revenues which are expected to decline by E500 Million from total revenues of E4.3 Emalangeni in 2015.

Citrus and banana crops

Citrus and banana production in Swaziland are also key cash crops in the country. Prospects for the industry are however severely compromised by changing climatic conditions caused by global warming. During the last quarter of 2013, there was a severe hailstorm that destroyed nearly two-thirds of the citrus crop and 20% of bananas in the country.

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Area harvested	9 531	11,465	11,025	11,112	10,997	11,475	11,205	11,212	11,800	12,204	12,207	12,141
% Change	-	20.29%	-3.84 %	0.79 %	-1.03 %	4.35 %	-2.35 %	0.06 %	5.24 %	3.42 %	0.02 %	-0.54%

Table 2.4: Citrus Production in Swaziland (2002-2013)

Forestry

The forestry sector in Swaziland mainly involves the farming of pine, eucalyptus and wattle trees for the production of round wood timber, saw logs, pulp and biofuel, mining timber and different varieties of finished products from timber. This sector is particularly vulnerable to the effects of climate change which include droughts, increased incidence of pests and higher risks of natural disasters such as floods or fires.

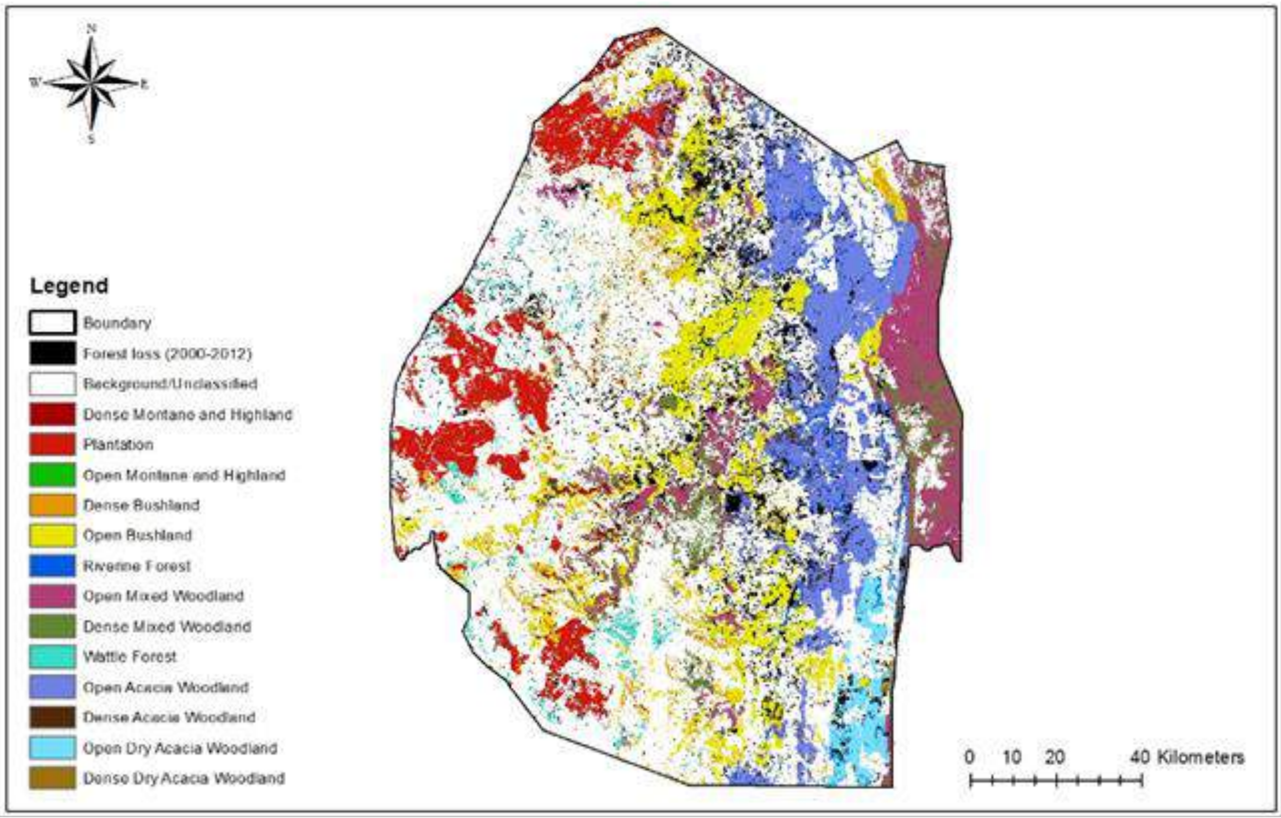


Figure 2-18: Map of Swaziland Showing Forest cover

The effects of climate change are already evident in the sector. Severe forest fires experienced in 2007/08 destroyed a sizable proportion of forest plantations in the country and culminated in the closure of the pulp mill at Bhunya in 2010. Following this period the forestry sector has been on a recovery trajectory in recent years. Forestry output recorded a 17% increase in GDP in 2014 compared to a 13% increase in GDP the previous year.

Prospects for the timber sector are therefore bright. Most of the trees that were replanted after the 2007/08 forest fires have started maturing. This is expected to increase the forestry output in the medium term. There has been continuous investment towards value addition in this sector including production of fine finished products. These include, among others, laminated desk tops, doors, ceilings, skirting, flooring and chip boards. However, the sustainability of this sector requires minimisation of potential threats such as forest fires, hailstorms, droughts and invasive forest insects such as sires wasp and pitch canker fungus.

Maize

Maize is the staple crop in Swaziland. The country's requirement is 118 000 metric tonnes annually, a level which the country has been unable to meet for many years. Swaziland therefore regularly imports maize supplies to meet domestic demand. The graph below shows maize production in Swaziland over the last 36 years.

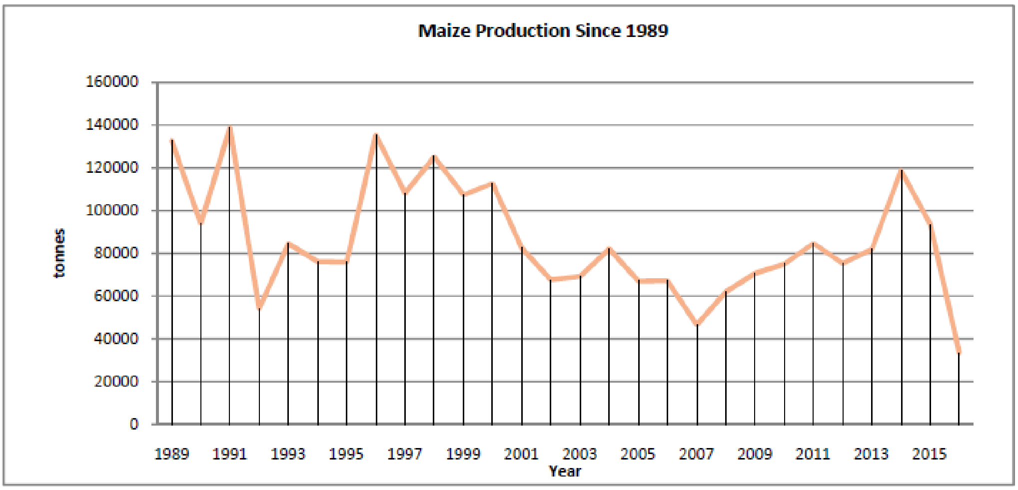


Figure 2-19: Maize Production from 1989-2015

As a result of the persistent dry spells, late rainfall and high temperatures, the Maize production has been dwindling especially in the Lowveld region. The 1992, 2007 and 2015 were the worst years in the country and maize production values in the 2015 season were the worst on record since 1989.

The increasingly erratic weather conditions associated with climate change pose serious challenges for Swaziland's subsistence and commercial farmers. Dry-spells are frequently experienced during January and February when most produce is at its critical growth stage, resulting in lower yields per hectare. In addition, crop failures are exacerbated by other agronomic factors such as poor variety selection, non-fertiliser application, weeds and soil sustainability.

Cotton

Cotton production is another key contributor to Swaziland's economy. Cotton is the second major cash crop after sugarcane in Swaziland and the main source of income for small scale famers, especially those in drought prone areas. The cotton industry is currently under performing yet the cotton industry used to be a source of livelihood for over 40 000 Swazis. Farmers grow cotton to pay school fees, build houses, and buy food and clothes. The decline of cotton prices in world markets over the years has resulted to a price drop locally making cotton farming less lucrative.

In the 2012/13 year, production increased to 2 485 Mt from 1 951 Mt in the 2011/12 year. In addition, the area of plants increased slightly from 2 800 ha in 2011/12 to 3 000 ha in 2012/13.

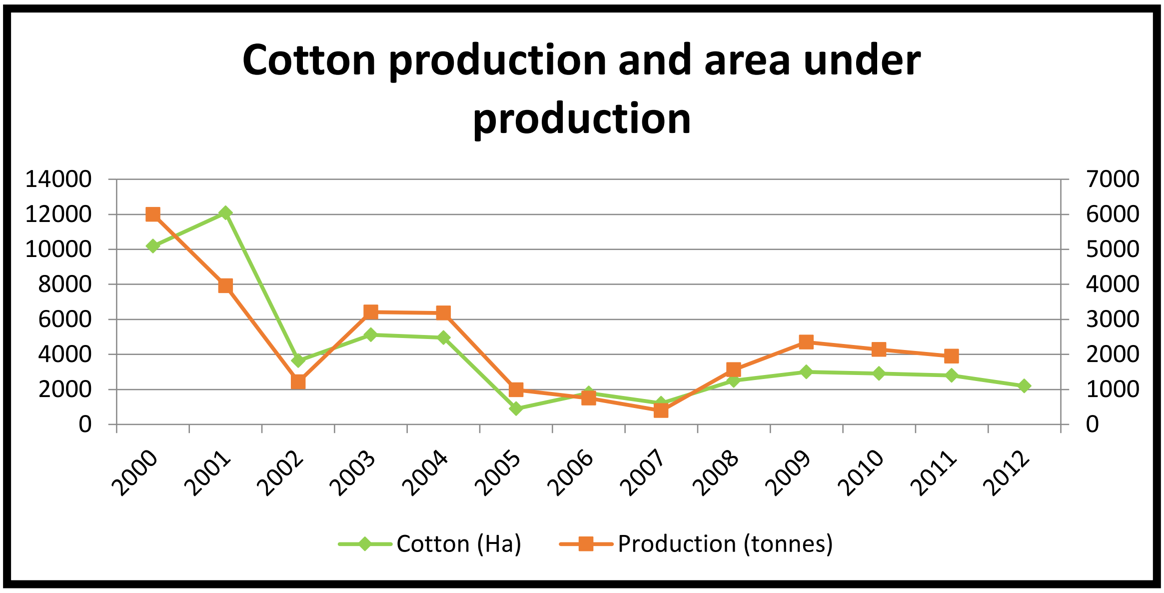


Figure 2-20: Trends in Cotton Production

Swaziland's textile industry has however been set back following the termination of the African Growth and Opportunity Act in the country, with effect from 1 January 2015. The greatest risk to the industry lies however in the effects of the current drought and long term climate variances. The significant reduction in the area planted for cash crops such as cotton in the 2015/16 season will negatively affect households' purchasing power, particularly those households that rely on agriculture as a source of income. This setback will limit their coping strategies going forward.

Livestock

The livestock subsector is particularly exposed to the impacts of climate change. Vulnerabilities in this sector have a direct bearing on the exposure of communities to climate change risks. This is due to the fact that livestock represent sources of food, insurance, cash and wealth for subsistence farmers. Livestock play an important role in the production system and the livelihoods of smallholders in Swaziland. Cattle population is the largest in rural area but a large proportion of rural households also own goats and other back yard stock such as chicken and ducks. The cattle population has been on the decline mainly due the shrink in the country's grazing land as a result of allocation of more land to resettle rural household. Poultry farming is more common among commercial farmers and generally has a fluctuating trend depending on the market and diseases outbreak.

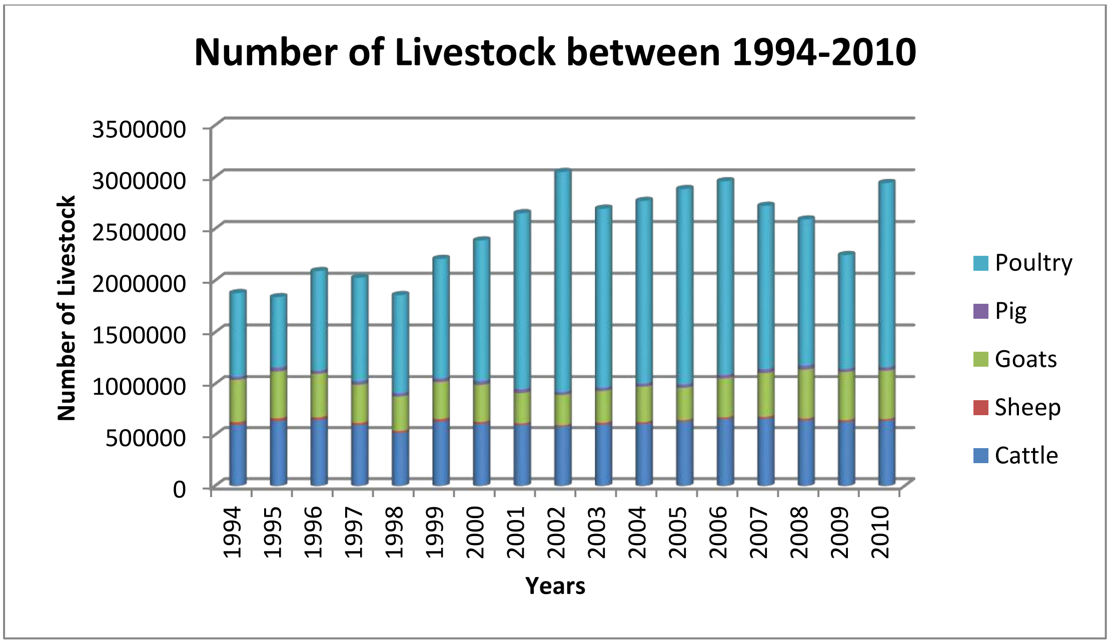


Figure 2-21: Number of Livestock (1994-2010)

Vegetation cover has been decreasing over the past few years due to recurrent drought, which has resulted in reduced cattle pastures which in turn has led to increased cattle deaths. Cattle mortality was found to have increased significantly over the past three years with 2015 having approximately 47 000 cattle deaths between May and December, accounting for 7.3% of the total population.

Prospects for the livestock sector are therefore mixed where persistent drought and the effects of climate change have a direct bearing on the viability of pasture lands. Poor range management, animal husbandry practices, take-off rates (high calf mortalities), and poor quality due to high costs associated with cattle breeding and feed-lotting are some of the other major challenges that persist in the livestock sub-sector. On the positive side, production of processed meat is projected to remain on the upward trend as there is continuous investment on improving productivity and efficiencies mainly by the export abattoir. Subject to continuity of trade agreements with the European Union, markets in the European Union and Norway offer good prospect for the beef industry in the medium term.

Indigenous knowledge

While the potential use of indigenous knowledge in Swaziland's agricultural sector is widely acknowledged, a lack of documentation constrains its application. Indigenous knowledge practices can be more economical than western technologies however a number of plant species in this regard face threats of extinction. Further studies are required to determine the best avenues for pursuit, and there is a need to educate the youth in these sustainable practices.

2.4.3 Construction, mining and quarrying

The construction sector expanded in 2013 mainly driven by growth in real capital expenditure and improvement in the implementation rate of government capital projects in the 2013/14 fiscal year.

Mining output in 2014 remained unstable mainly driven by a general turbulence in the international commodity prices. Following a boom in 2013, global iron ore output was affected by Australian iron ore producers increasing their supply whilst on the other hand, there was a moderation in demand for iron ore, mainly by Chinese steel producing companies. Coal production also recorded a poor performance in 2014. Coal production fell by 31% from 2013 levels. This decrease was mainly due to geological constraints which affected production time and resulted in lower coal yields which decreased from 56% in 2013 to 51% in 2014. On the other hand, quarried stone production grew by 6.1% in 2014 compared to levels in 2013. This increase was mainly buoyed by positive performance in the construction sector.

Table 2.5: Production and Value of Mineral Sales from 2010-2013

	2010	2011	2012	2013	2014
Production Volumes					
Coal (mt)	145 903	121 050	152 284	257 090	177 930
Quarried Stone (m^3)	304 844	206 341	308 440	297 704	310 659
Iron Ore (mt)	-	79 553	1 032 230	1 258 560	603 251
Sales Value (E''Million)					
Coal	126	117	158	246	210
Quarried Stone	19	21	21	29	37
Iron Ore	-	47	394	559	381
Total Sales	145	180	573	833	628

Prospects for the sector remain positive in the medium term. Growth is expected from the public sector, where the 2014/15 fiscal year budget allocation depicted a 44% increase in envisaged capital expenditure. Approximately 81% of the total capital expenditure focuses on completing on-going projects while 19% is a provision for new capital projects.

2.5 The Environment: Natural Resources Use and Management

There is a close relationship between the environment and the socio-economic development of the Kingdom of Swaziland. As a developing nation, the country relies heavily on its agricultural and environmental sectors to provide basic livelihoods for its citizens. Swaziland is therefore very exposed and sensitive to the negative impacts of climate change and the effects that these have on the environment.

The high levels of exposure and sensitivity to climate variability and change directly affect the potential impacts on the Swazi environment and society. Notably, a high proportion (63%) of the population live below the poverty line. Swaziland's adaptive capacity to cope with climate change is therefore severely constrained on account of the socioeconomic challenges in the country, making the nation highly vulnerable. The country needs to manage the use of its natural resources in such a way that the needs of the population and the welfare of the environment are well balanced, for the sustainable development of both in the long term. The following sections outline the current state of the natural resources and the management thereof.

2.5.1 Energy

Energy plays a significant role in improving people's living, thereby contributing to development. Energy is used for water supply and fuels agricultural output, health, education, job creation and environmental sustainability. Despite this, over 1.6 billion people in developing countries are deprived of access to reliable and affordable energy services (such as electricity), and over 80% of the population of sub-Saharan Africa including Swaziland use traditional biomass for cooking and heating. Swaziland, like any other country, needs modern energy resources for development and the sustenance of livelihoods. The main energy resources currently used in the country include coal, traditional and industrial biomass, electricity, and petroleum products. The table below shows the energy consumption for Swaziland in the year 2010/2011.

Energy Source	Local Production (TJ)	Imports (TJ)	Contribution (%)
Industrial Biomass - Bagasse	4,329.56		10.58
Industrial Biomass - Wood	458.01		1.12
Traditional Biomass	16,346.91		39.6
Hydro Electricity	601.03		1.47
Cogeneration electricity	815.60		1.99
Solar	0.25		0.0
Total Local Production	**22,551.2**		**55.11**
Unleaded Petrol		2,597.81	6.35
Leaded Petrol		585.64	1.43
Aviation Gasoline		6.49	0.02
Diesel		4,508.80	11.02
Paraffin		292.87	0.72
LPG		242.93	0.59
HFO		10.31	0.03
Coal		7,223.97	17.65
Imported electricity		2,899.80	7.09
Total Imports		**18,368.62**	**44.89**
Total Consumption		**40,919.98**	

Table 2.6: Energy Consumption for Swaziland in the year 2010/2011

The contribution share of each energy source to the energy consumption for the country is shown in the figure below; with traditional biomass having the biggest share of 39.73%.

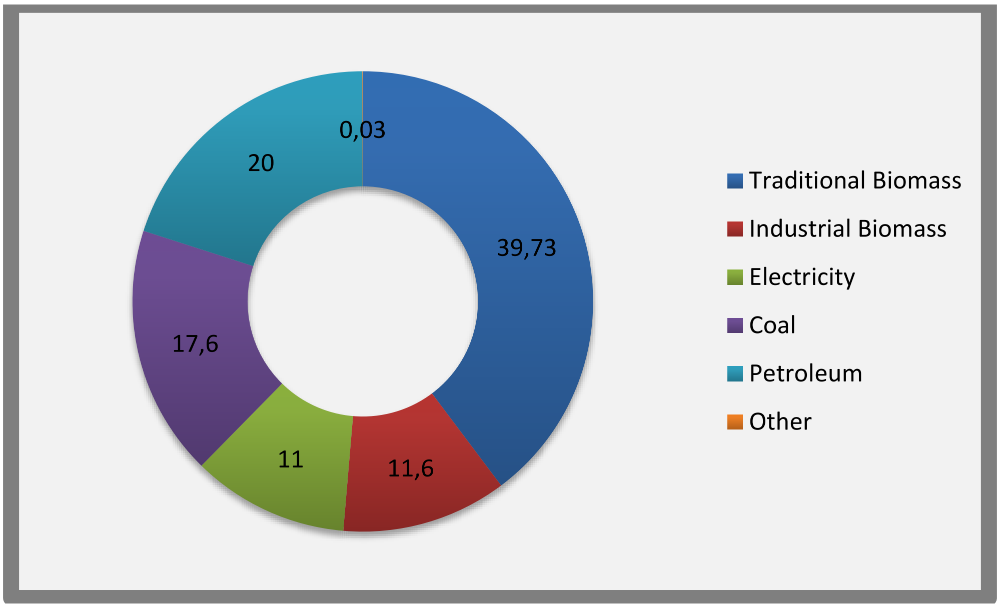


Figure 2-22: Share of Each Energy Source to the Energy Consumption

2.5.2 Electricity production

Swaziland has a national electrification rate of 61%, where urban access is 77% and rural access stands at 50%. Swaziland's electricity is mainly supplied by the Swaziland Electricity Company, the vertically integrated national utility. The utility currently monopolises the import, distribution and supply of electricity via the national power grid. Various self-producers in the sugar and textile industries also contribute to the country's electricity supply.

The Swaziland Electricity Company's total electricity demand in 2014 was 221 MW. The country's total installed generation capacity was 150 MW, consisting of 90 MW thermal power generation (bagasse, waste products, coal, and diesel) and 60 MW hydro generation. Due to the vast difference between the country's capacity and demand, the Swaziland Electricity Company typically imports 80% of its electricity from Eskom, a South African electricity utility company, and 10% from Electricidade de Mozambique of Mozambique. The figure below illustrates recent trends in this regard.

Table 2.7: Trends in in Electricity Generation

	2010/11	2012/13	2013/14	2014/15
Domestic Generation (GWh)	333	278	350	279
Imports (GWh)	806	822	860	978
Climatic trend of the year	Wet	Medium	Medium	Drought

Due to the current drought however in the 2015/16 season, Swaziland has had to suspend all hydropower generation in the country. This has resulted in the Swaziland Electricity Company importing 100% of its electricity demand to satisfy local requirements during 2016.

2.5.3 *Generation Capacity*

Electricity is generated in Swaziland mainly through hydro power plants owned and operated by SEC with a total installed capacity of 69.6 MW, of which 60.1 MW of hydropower and 9.5 MW are diesel. However, the diesel generators have since been suspended and the hydropower plants are used only at peak time for two reasons. The first is to reduce expensive imports during these periods. The second reason is the limited storage capacity of the hydropower schemes and unsteady rainfall throughout the year. In addition, the sugar industry (Ubombo Sugar and Royal Swaziland Sugar Corporation) has an installed capacity of 105.5 MW mostly for its own use.The plants are fuelled by bagasse and coal during the low season. Since 2011, Ubombo has started to supply power to the grid following an agreement with SEC. The table below shows the current generation capacity.

SEC POWER STATIONS	INSTALLED CAPACITY (MW)
Ezulwini hydropower station	20
Edwaleni hydropower station	15
Edwaleni diesel power station	9.5
Maguduza hydropower station	5.6
Maguga hydropower station	19.5
Ubombo Sugar	41
Royal Swaziland Sugar Corporation	64.5
TOTAL	175.1

Table 2.8: Installed Electricity Capacity

Swaziland Electricity Company is continuing to work on projects geared towards improving efficiency, quality and reliability and stability of supply. Efficiency gains are envisaged through a system with distribution management capability known as the SCADA Project. To improve quality and reliability of supply, the utility is continuing its construction of new, and rehabilitation of, existing substations. However, the major challenge for this subsector include the drought, which is affecting supply from the country's hydro facilities, and the continued over reliance on electricity imports which are increasingly uncertain and more expensive due to supply shortages in the region. Hence the pressing need for the country to intensify and implement projects that will increase domestic power generation to self-sufficiency levels, while simultaneously making the country more resilient to the effects of climate change.

2.5.4 *Water resources and management*

The surface water resources of the country are estimated at 4.5km^3/year, with about 42% originating from South Africa (Manyatsi and Brown, 2009). Swaziland has five major rivers; namely, Great Usuthu, Mbuluzi, Ngwavuma, Lomati and Komati. All these rivers are international rivers and the water which Swaziland can use from its rivers is governed by agreements with South Africa and Mozambique. The Komati, Usuthu and Mbuluzi basins are of particular relevance due to their transboundary nature.

RENEWABLE WATER RESOURCES	AMOUNT	UNIT
Average precipitation 788 mm/yr	13.7	10^9 m^3/yr
Internal renewable water resources	2.6	10^9 m^3/yr
Total actual renewable water resources	4.5	10^9 m^3/yr
Dependency ratio	41.5	%
Total actual renewable water resources per inhabitant	4164	m^3/yr
Total dam capacity	785	10^6 m^3

Table 2.9: Water Resources in Swaziland[2]

There are nine major dams with a height of more than 10 metres and with a total storage capacity of about 785 million m3. Seven are used for irrigation purposes, one for hydroelectric purposes and one for water supply.

Name of Dam	Capacity (1000m^3)	Surface area (1000m^2)	Date established	River system	Location	
					Latitude	Longitude
MAGUGA	332, 000	7507	2001	KOMATI	26.10 S	31.23 E
LUBOVANE	155, 000	215690	2007	USUTHU	26.752S	31.66 E
MNJOLI	153, 000	14800	1980	MBULUZI	26.17 S	31.67 E
SAND RIVER	50, 330	698	1965	KOMATI	26.00 S	31.70 E
LUPHOHLO	24, 000	7851	1984	USUTHU	26.37 S	31.08 E
Hendrick Van Eck	9, 865	145	1969	USUTHU	26.75 S	31.92 E
SIVUNGA	5, 920	120	1972	USUTHU	26.67 S	32.00 E
NYETANE	6, 780	137	Raised 1992	USUTHU	26.37 S	31.57 E
HAWANE	2, 750	70	1984	MBULUZI	26.23 S	31.80 E
LAVUMISA	345	27	1996	PONGOLA	27.28 S	31.85 E
TOTAL	**784 990**					

Table 2.10: Main Reservoirs in Swaziland

The figure below shows the major rivers, main tributaries and streams, the dams, weirs and canals. It generally shows the available sources of surface water. Also shown in the figure are the five river basins for Swaziland. According to the Climate Change Vulnerability Assessment the Komati Basin was predicted to suffer water stress come 2050. The basin is already fully committed and can no longer survive further allocations. This is similar to the Usuthu Basin, Lomati and Mbuluzi. The Usuthu will be stressed further even more because most of the towns, industries and sugarcane schemes are located within it. The situation will be dire as the population increases. The DWA is in the process of conducting water use audits for all the basins in Swaziland. This will give the actual indication of the actual situation on the ground versus water availability.

[2] (FAO Aquastats format) http://www.fao.org/nr/water/aquastat/countries_regions/swz/index.stm

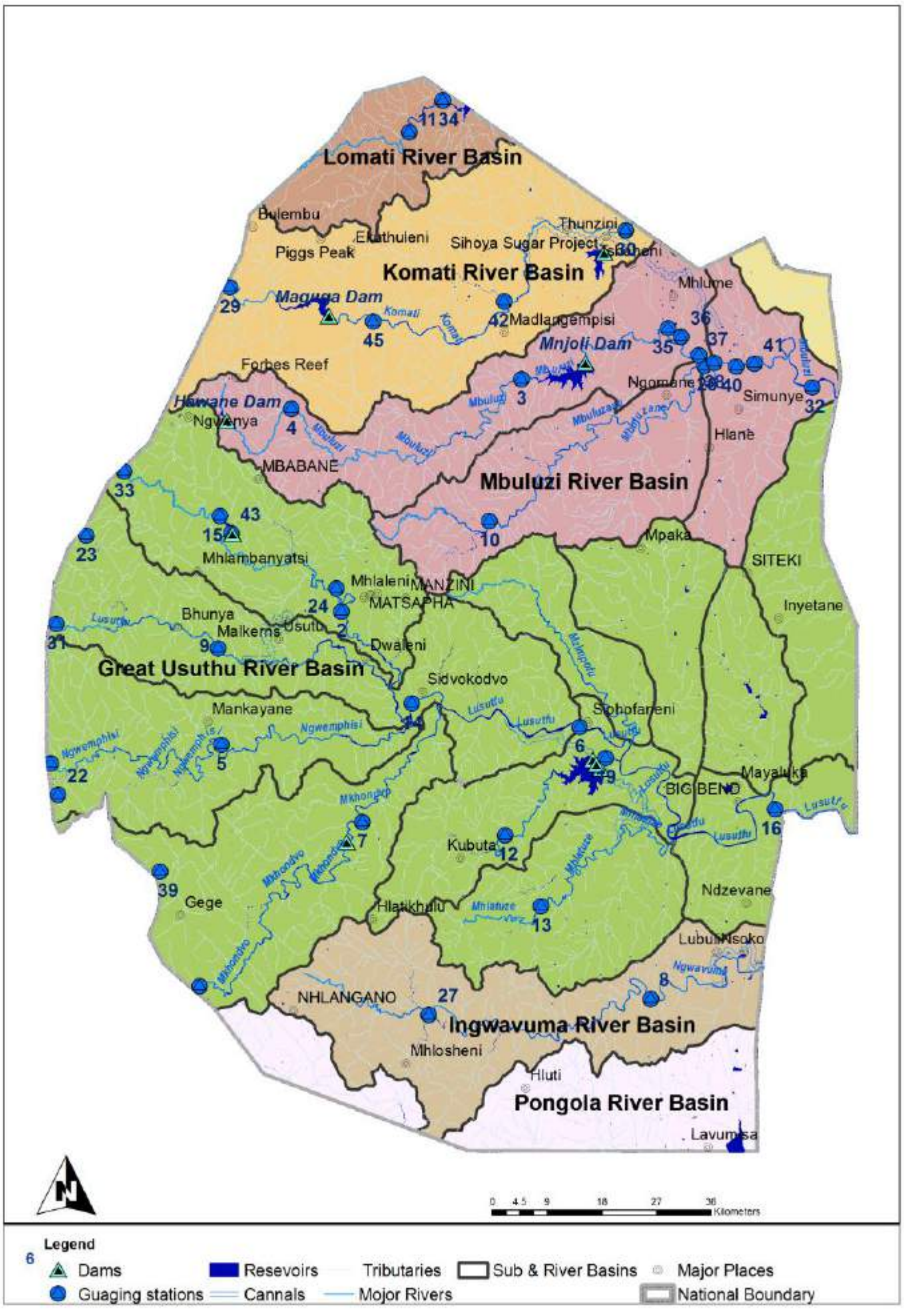


Figure 2-23: Swaziland Hydrology and Drainage Map

Due to the current drought however, all hydropower generation in the country has been suspended, requiring the national utility to import 100% of its electricity needs to meet local demand.

The following graphs show the percentage of water storage in the Maguga and Mnjoli dams since 2012.

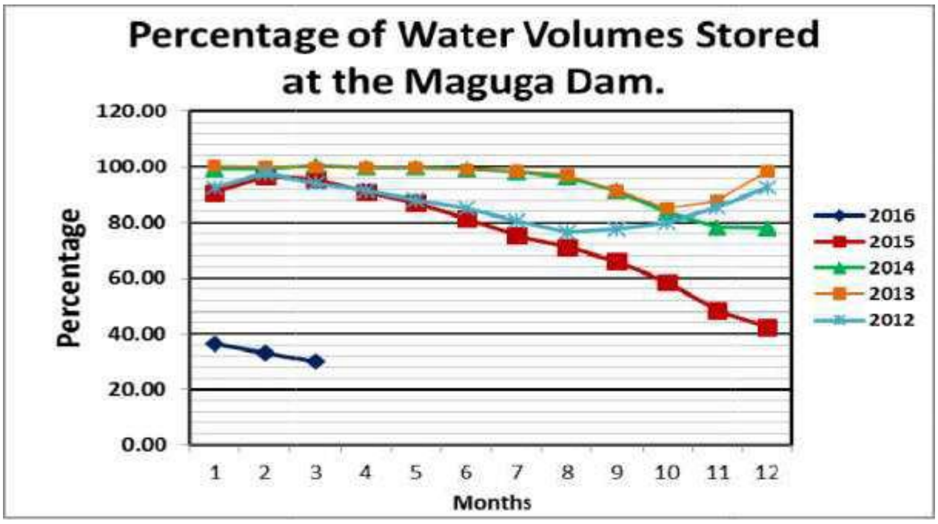


Figure 2-24: Comparison of Water at the Maguga Dam since 2012.

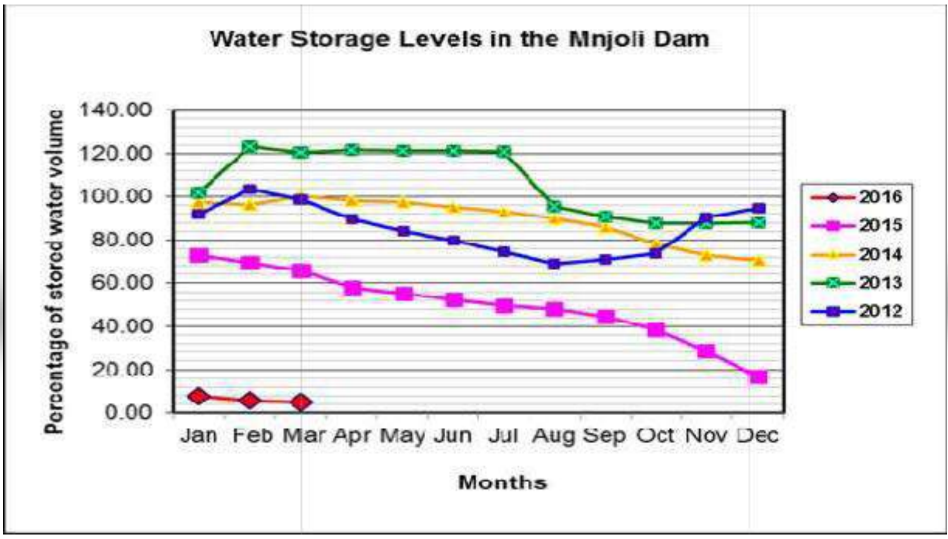


Figure 2-25: Comparison of Water at the Mnjoli Dam since 2012.

The majority of water usage in the country is for irrigation purposes (mainly for sugar cane), which utilises about 96% of water. Overall, groundwater in the country is of good quality compared to World Health Organisation guidelines, except in some areas of the Lowveld. The Lowveld has low quality water with high fluoride content and high salinity levels due to stagnant conditions.

The country relies on its water assets for power generation, commercial irrigation and domestic water use required for daily consumption and sanitation. The eastern regions of Swaziland have been especially water stressed due to the current drought. Swaziland's water resources in these areas have been negatively impacted and the knock-on effects within the country are severe. The flows in all of Swaziland's major rivers are reported as critically low, compared to levels in 2015. Swaziland's earth dams, springs and boreholes are also demonstrating critically levels of dryness, indicating that the majority of groundwater sources are depleted.

This may severely compromise Swaziland's efforts to meet its development goals. About 72% of Swaziland's population had access to improved drinking water sources and only 53% had access to improved sanitation facilities. In this regard, the Ministry of Natural Resources and Energy, through the Department of Water Affairs' Rural Water Supply Branch, initiated a process of mapping all rural water points and sanitation infrastructure in Swaziland in 2013. The main objective was to establish an up-to-date database to record the location and functionality of the water points of established rural water supply schemes. Additional data regarding the homesteads served by infrastructure as well as the type of sanitation systems used were also collected. The information is required for effective monitoring of the country's progress towards the national and international goal of reducing the proportion of people without access to safe drinking water and basic sanitation.

The Ministry of Natural Resources and Energy found that the coverage of rural water schemes in the mapped areas is quite high but a significantly high percentage of the schemes are either non-functional or partially functional. As a result, the access to potable water by communities is compromised. The major constraint was determined to be a lack of financial resources for maintenance of the systems.

In terms of sanitation, Swaziland has experienced steady increases in household access to improved water as well as improved sanitation facilities. These trends are illustrated in the following graph.

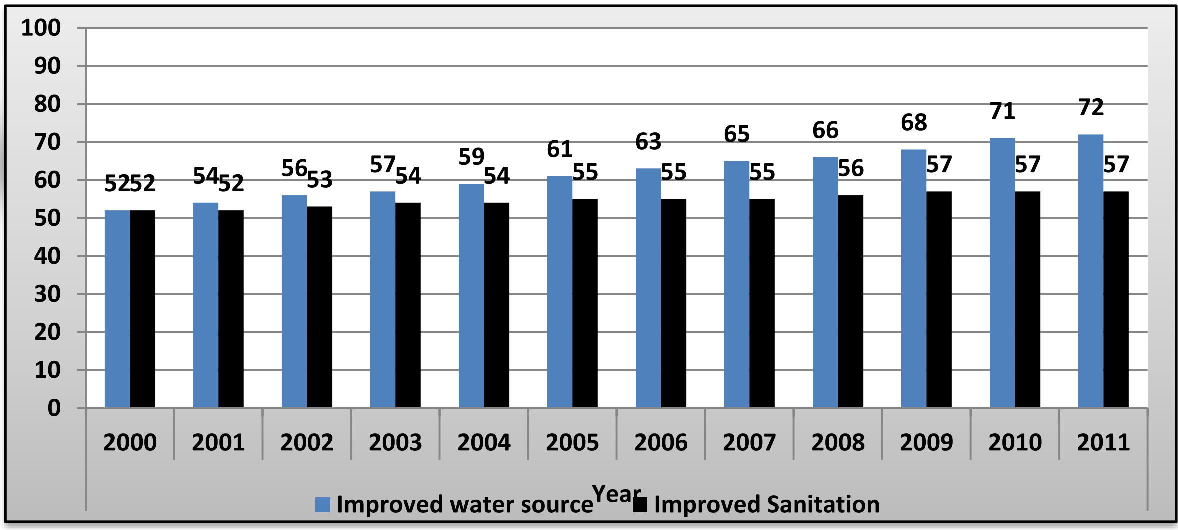


Figure 2-26: Access to Improved Water and Sanitation.

The Swaziland Water Services Corporation is mandated to supply clean treated water in the country. In collaboration with the Government of Swaziland, the Swaziland Water Services Corporation and other partners continue to facilitate major water treatment projects in the country. Projects to improve water supply include pipeline upgrading in Nhlangano, refurbishment of the Ngwane Park sewer treatment plant and upgrading of water supply at Ezulwini, among others. Rural areas are also targeted for improved water supply, and on-going projects include treatment plants at Lomahasha, Somtongo, Matsanjeni and Siphofaneni.

To assist in maintaining water sustainability in the country, Swaziland Water Services Corporation aims at increasing the water storage reservoirs. Despite continuous improvements by the relevant entity, there still remain concerns regarding constraints of sustainable water supply. Some of the challenges in storage capacity also relate to aging infrastructure.

Combined with the effects of the current drought, such constraints and shortages can have major impacts on current and growing urbanised communities, as well as the large portion of the population that practices subsistence farming.

2.5.5 Land use and management

Swaziland has a dual land tenure system of land management and administration covering two main types of land namely, Title Deed Land and Swazi Nation Land. About 69% of the land is under Swazi Nation Land whiles the balance is under Title Deed Land.

The land tenure system in the country is reported as one of the major constraints to raising agricultural productivity in the country (World Bank, 2013). Agriculture on Swazi Nation Land remains relatively unproductive and yet Swazi Nation Land constitutes the bulk of land tenure in the country. Different schemes have been put in place to help counter these challenges (World Bank, 2013).

While the Swazi Nation Land system may be a constraint to increased agricultural productivity, it ensures that even the poor have access to land ownership, which otherwise would not have been the case. Under the Swazi Nation Land system, every Swazi citizen is entitled to have land where he or she can build a home and grow crops. Many of Swaziland's citizens are subsistence farmers, making them particularly vulnerable to the negative impacts of climate change such as highly variable rainfall patterns, drought, floods and reduced biodiversity.

Grazing occupies the biggest proportion of land on Swazi Nation Land. Overgrazing is believed to be the major cause of soil erosion on Swazi Nation Land and also causes the increase of invasive plants and bushes.

Approximately 20% (350 000 ha) of the total land in the country is considered to be good for cultivation. With the increasing population growth, more pressure is applied to Swaziland's natural resources. Instances associated with the conversion of arable land and land used for grazing into residential areas are not confined to peri-urban areas, but are also increasing in rural areas. There is therefore an increasing need for intensified controls on new settlements, to help curb this problem.

2.5.6 Mineral resources

Minerals found in Swaziland include coal, diamond, iron ore, gold, asbestos and quarry stones. Base metals such copper, nickel and chromium also occur, some of which have been mined before. Currently only the Maloma coal mine is operational even though there are other coal deposits at Mpaka. Operations at the iron ore mine were terminated in 2014 and the Bulembu asbestos mine was closed in 1997, following consistent decline in production. The Dvokolwako diamond mine was closed in 1996, however, the government is actively involved in attracting investors who can operate the mine.

2.5.7 *Biodiversity*

Swaziland is rated as "at risk" according to the United Nations Environmental Vulnerability Index (UN, 2005), and the country's rich biodiversity is currently under threat. While there are varying factors driving this phenomenon, climate change is recognised as one of the major underlying factors.

The decline in biodiversity is reported across the entire spectrum. It is most severe with regards to indigenous flora and large mammals. Wetland mammals such as otters, mongooses and hippopotamus may be at particularly susceptible to habit changes. Loss of habitat, over exploitation and invasive alien species (the latter is reported to be exacerbated by overgrazing practices) are reported as the main causes of the decline in biodiversity.

Degradation of natural forests and woodlands is commonly observed in Swaziland. Uncontrolled veld fires are the major contributor to forest fires. The driving forces behind deforestation and woodland areas include population growth which has resulted in increasing demand for land for human settlement, expansion of agricultural land, increased pressure on land for grazing, land conversions and poverty. The country's lack of capacity to manage natural forest has led to indiscriminate extraction of timber and none-timber forest products including medicinal plants, wood for utensils and craft, fuel wood, fruits and edible plants.

Swaziland's government is developing policies to restructure the management of biodiversity in the country. The country is also developing adaptation options and building capacity to improve the understanding of the impacts of climate change on biodiversity, in addition and to increasing awareness of climate change impacts. Measures are also being developed to manage the impacts of alien and invasive organisms on biodiversity in future climates, while factoring the impacts of climate change on biodiversity into natural resource management and land use planning.

2.5.8 *Waste management*

Swaziland's waste sector faces a variety of challenges and constraints. Strategic planning has been hampered by increased industrial activities in the country, consumer patterns, urbanisation and population growth as well as the absence of waste management information plan.

Waste management in Swaziland is governed by the *Waste Regulations, 2000*. There is also the *National Solid Waste Management Strategy*, which mainly aims at developing, implementing and maintaining an integrated waste management system that will reduce the adverse impact of all forms of solid waste. Given the increasing population growth rate together with the tendency to locate investments in economic infrastructure in peri-urban and rural areas, there is an urgent need to improve waste management in these areas. This is relevant for household waste, waste from commercial nodes, as well as health care risk waste from health care facilities.

2.6 Institutional Arrangements

The Ministry of Tourism and Environmental Affairs plays the lead role in climate change reporting in Swaziland. The Ministry is responsible for the coordination and management of all climate change related activities such as mitigation, adaptation and compilation of the national GHG inventory. Within the Ministry, the Department of Meteorology has been responsible for the coordination and compilation of the GHG inventory and the three national communications to the UNFCCC. Swaziland is actively seeking support to develop robust and continuous reporting frameworks in order to advance the national GHG inventory.

The country is putting in place institutional arrangements for the regular preparation on its national communications through the *Draft Climate Change Policy* and strategy. *Ad-hoc* structures are currently in place, mainly constituting of a project steering committee and technical working groups supported by consultants. Reporting is therefore currently done on a project by project basis, without continuity, due to a lack of sustainable institutional arrangements.

In compiling the Third National Communication, the institutional arrangements were structured in three tiers at project advisory, coordination and implementation levels. This structure is illustrated in the following figure.

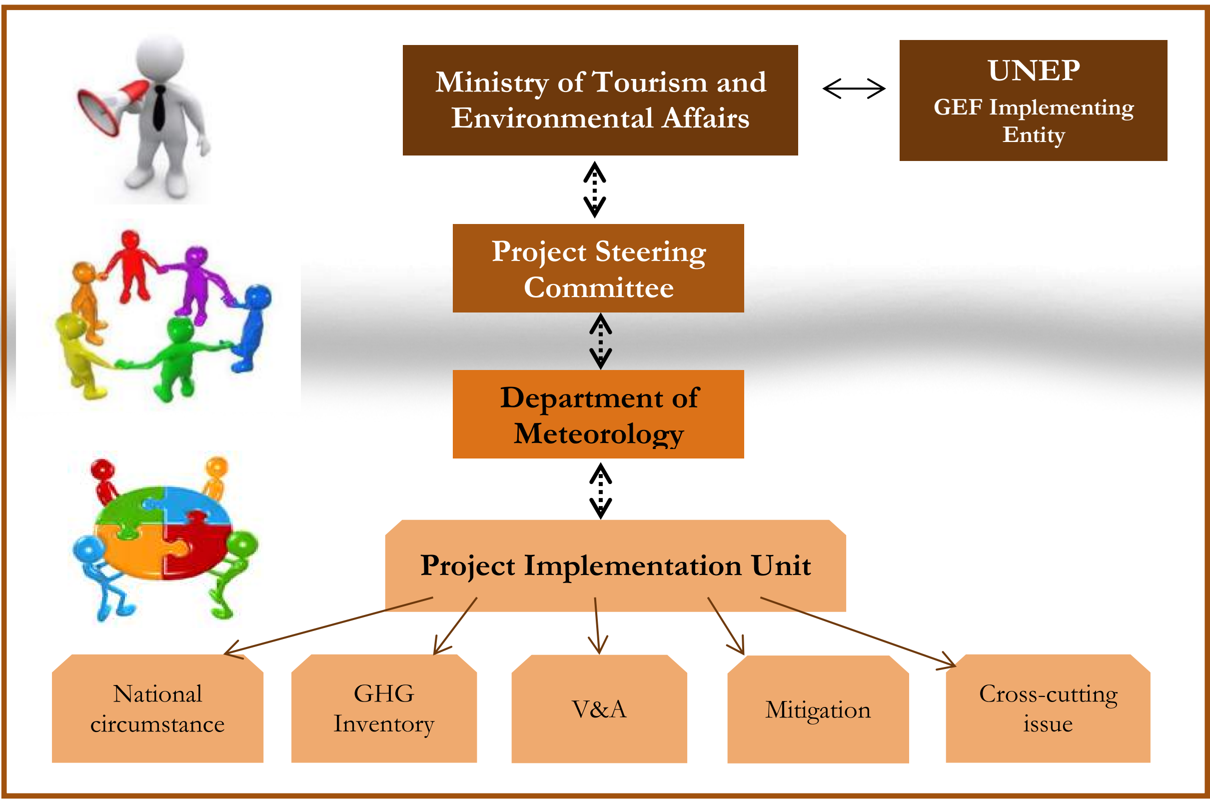


Figure 2-27: Institutional Arrangements for Compiling the Third National Communication

At the project advisory level, the National Climate Change Committee served as the Project Advisory Committee. The Committee met every six months to evaluate progress on the project and where necessary provided overall policy direction and oversight. A Project Steering Committee was constituted mainly as a clearing house for the implementation of the project. The Steering Committee met quarterly to evaluate progress of work, approve quarterly reports and procurement request submitted by the project implementation unit. The Steering Committee was made up of 15 senior representatives drawn from government, academia, private sector and civil society.

The Project Implementation Unit was focused on the implementation aspects of the national communication including the planning, implementation and reporting of activities of the Technical Working Groups. The Unit was housed within the Department of Meteorology and headed by a National Project Coordinator who was supported by a Project Administrator.

Technical Working Groups operated under the Project Implementation Unit. Each group focused on specific aspects of the national communication. The membership of the Technical Working Groups was drawn from relevant private, public institutions and the knowledge community and were constituted on the bases of competence, experience and relevance. In areas where there were no local, competent and experienced individuals, international consultants (mainly from the Southern African region) were engaged to lead the work. This was the case for the *National GHG Inventory*, the *Vulnerability and Adaptation Assessment* and the *GHG Mitigation Option Analysis*. The regional consultants worked with local technical working group members for experience and skills sharing purposes. The work of the consultants was guided by contract agreements which contained specific information on the scope of work, responsibilities, timelines and budget narratives.

3. NATIONAL GREENHOUSE GAS INVENTORY: 2010

The Kingdom of Swaziland's latest National GHG Inventory has been calculated for the year 2010, using the *Intergovernmental Panel on Climate Change (IPCC) Guidelines* (both the revised 1996 and 2006 versions). It was drawn up in line with Articles 4 and 12 of the UNFCCC and the *Guidelines for National Communications of Non-Annex I Parties of the UNFCCC*.

The total GHG emissions in Swaziland for the year 2010 were 4 861 Gg CO_2e. This total includes 1 678 Gg CO_2e from the industrial processes and product use sector, 1 608 Gg CO_2e from agriculture, 1 523 Gg CO_2e from the energy sector and 52 Gg CO_2e from the waste sector. Swaziland has a GHG sink, estimated at -5 863 Gg CO_2e, from the land use, land use change and forestry sector. This makes the country a net sink for the 2010 year, with a net value of - 1 002 Gg CO_2e. The industrial processes sector is responsible for largest source of emission (35%), followed by agriculture (33%), energy (31%) and waste (1%). GHG from industrial processes arise from the existence of air conditioning and refrigeration assembly in the country.

The country's first Inventory was compiled for 1994, following which the Inventory for 2000 was compiled and reported in Swaziland's *Second National Communication* to the UNFCCC. The third Inventory, for the period 1990-2010, is reported on in this *Third National Communication*.

The calculations of the 2010 Inventory estimate emissions by source and sink according to the five IPCC emission categories:

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

The 2010 Inventory focuses on direct emissions of GHGs and indirect emissions of other gases. Global Warming Potential (GWP) values, as recommended by the IPCC's *Second Assessment Report,* have been used to convert the emissions to CO_2 equivalent values. The GWP values are summarised in the table below.

Table 3.1: Global Warming Potential for GHGs from IPCC Second Assessment Report

GHG	Chemical Formula	Second Assessment Report GWP Value
Carbon dioxide	CO_2	1
Methane	CH_4	21
Nitrous oxide	N_2O	310
Sulphur hexafluoride	SF_6	23 900
Hydrofluorocarbons (HFC)		
HFC-23	CHF_3	11 700
HFC-32	$CH2F_3$	650
HFC-43-10mee	C_5H2F_{10}	1 300
HFC-125	C_2HF_5	2 800
HFC-134a	$C_2H_2F_2$ (CH_2FCF_3)	1 300

GHG	Chemical Formula	Second Assessment Report GWP Value
HFC-143a	$C_2H_3F_3$ (CF_3CH_3)	3 800
HFC-152a	$C_2H_4F_2$ (CH_3CHF_2)	140
HFC-227ea	C_3HF_7	2 900
HFC-236fa	$C_3H_2F_6$	6 300
Perfluorocarbons (PFC)		
Perfluoromethane	CF_4	6 500
Perfluoroethane	C_2F_6	9 200
Perfluoropropane	C_3F_8	7 000
Perfluorohexane	C_6F_{14}	7 400

Direct emissions of GHGs include carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); halocarbons (HFC, PFC) and sulphur hexafluoride (SF_6). The indirect emissions reported on in the Inventory include nitrogen oxides (NOx); carbon monoxide (CO); non-methane organic volatile compounds (NMVOCs) and sulphur dioxide (SO_2). These indirect emissions relate to gases that are precursors to GHGs, therefore, these gases may over time form GHGs in the atmosphere.

Various specialists were contracted to compile the inventories, per category, and were overseen by Sector Leads, typically within the related government departments. The University of Swaziland prepared the GHG sector inventories for the energy, industrial processes and product use, agriculture and land use, land use change and forestry sectors. The waste inventory was prepared by a private specialist in the waste management sector.

Swaziland's *Intended Nationally Determined Contribution's* action based commitments were linked to the Inventory, and included specific commitments to develop a robust national GHG Inventory, a credible baseline and emissions trajectory as well as a comprehensive measurement, reporting and verification system.

3.1 National GHG Inventory Methodology

A summary of the methodologies and procedures used in quantifying GHG emissions from each sector is given below.

The Ministry of Tourism and Environmental Affairs contracted a team of consultants to prepare and submit a *National GHG Inventory Report: 2010*, which formed part of the *Third National Communication* report deliverable. The *National GHG Inventory: 2010* report aims to present information in a consistent, transparent, comparable and flexible manner, in order to promote the nation's technical and institutional capacity.

The composition of the team comprised of experts for energy, industrial processes and product use, agriculture, land use change and forestry and waste, mainly from the University of Swaziland and private sector for the waste component. The respective experts delivered *Sector GHG Inventory Reports* which were used to compile the *National GHG Inventory Report: 2010*. The experts were assisted by Team Leaders within various government departments, who participated in a series of Quality Assurance/Quality Control (QA/QC) processes. The *National GHG Inventory Report: 2010* was compiled using the sector reports as its basis, and was also subjected to a QA/QC procedure (discussed further in 3.2 below).

In addition to preparing the GHG sector reports, the experts also completed standard templates for activity data and emission factors, which served as inputs into the national GHG Management System. Further details regarding the institutional arrangements are presented in section 3.3 below.

A summary of the methodologies and procedures used in quantifying GHG emissions from each sector is given below.

Table 3.2: Methodologies, Procedures and Data Sources for the 2010 Inventory Quantification, Per Sector

IPCC Category	Reference Used	Tier Used	Emission sources included	Activity Data Sources
Energy	*2006 IPCC Guidelines for National GHG Inventories*	– Tier 1 – Default emission factors – Local net calorific values for coal were used.	– Fuel consumption emissions from manufacturing, agriculture, transport, commerce and institutional and, residential sectors. – Fugitive emissions from surface coal mining and handling.	– Department of Energy – Petroleum product import sales data reports – Mining Department – Swaziland Revenue Authority – Sugar Industry.
Industrial Processes and Product Use	*2006 IPCC Guidelines for National GHG Inventories.*	– Tier 1 – Default emission factors.	– Mineral Industry (soda ash and clay bricks) – Non-energy products from fuels and solvents use (lubricant and solvent use) – Substitutes for ozone depleting substances – Other product manufacture and use – Pulp and paper – Food and beverage Industry.	– Swaziland Revenue Authority – Swaziland Environmental Authority – Sugar companies – Municipalities – Related industries.
Agriculture	*Revised 1996 IPCC Guidelines for National GHG Inventories.*	– Tier 1 – Default emission factors	– Domesticated animals – Enteric fermentation and solid waste – Animal waste management systems – Agricultural soils – Rice cultivation – Agricultural crop waste burning – Savannah burning.	– Ministry of Agriculture – Swaziland Royal Sugar Association – Swazi Food Canners – Cotton Board – Farm Chemicals.
Land Use, Land-use Change and Forestry	*IPCC 2003 Good Practice Guidance for Land Use, Land-Use Change and Forestry*	– Tier 1 and Tier 2 – Default emission factors	– Forest land – Cropland – Grassland – Wetlands – Settlements	– Datasets prepared for other purposes, such as forestry and agricultural statistics – Primary data collection – Selective visual interpretation of remotely sensed data.

IPCC Category	Reference Used	Tier Used	Emission sources included	Activity Data Sources
Waste	*2006 IPCC Guidelines for National GHG Inventories*	– Tier 1 – Default emission factors	– Waste disposal on land (managed and unmanaged) – Wastewater handling (industrial, domestic, commercial and other wastewater) – Waste incineration – Open burning	– Landfill sites at Mbabane, Manzini, Matsapha and Piggs Peak – Royal Swaziland Sugar association. – Biological treatment of waste and industrial wastewater were used and obtained from surveys and expert judgement. – Default activity data for domestic wastewater were used.

3.2 Quality Assurance and Quality Control

National inventories must be transparent, well documented, consistent, complete, comparable, assessed for uncertainties, subject to verification and quality assurance and quality control. Swaziland used the following quality assurance/quality control institutional arrangement for its 2010 Inventory:

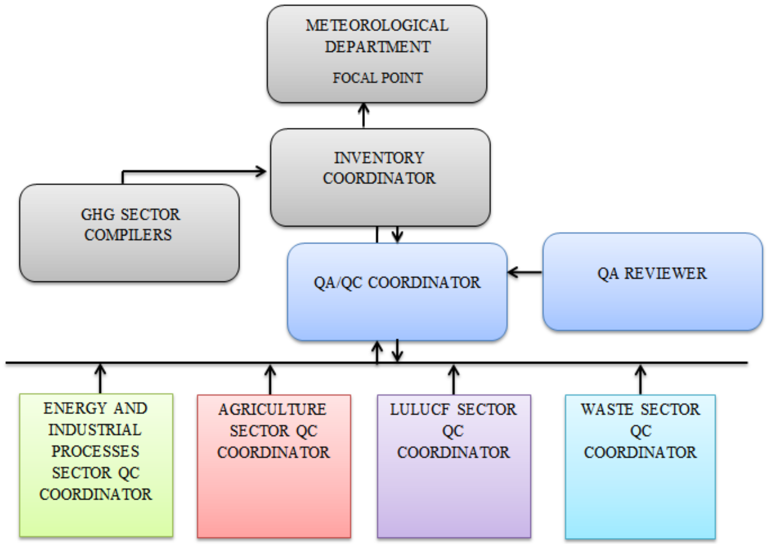


Figure 3-1: GHG QA/QC System for Swaziland's 2010 GHG Inventory

An extensive series of quality assurance and control activities were undertaken during the preparation of the 2010 National GHG Inventory. These included the presentation of the various sector reports to the Steering Committee for comment and discussion; consideration of the reports by sector QC Coordinators in collaboration with Team Leaders, followed by the submission of sector quality control reports to the QA/QC Coordinator. The sector reports were only finalised once all comments had been received and taking into consideration.

The various sector Team Leaders then compiled the sector GHG reports which were synthesised and submitted to the United Nations Environment Programme for review and further quality assurance. The final main and sector GHG reports therefore take into account the comments from the review undertaken by the United Nations Environment Programme. In the future, Swaziland may consider the appointment of an independent quality assurance reviewer. The archiving of all quality assurance/quality control data and documentation by the documentation and archiving officer is the final step that assures quality control in the system.

3.3 Institutional Arrangements

No permanent institutional arrangements were put in place for the compilation of Swaziland's 2010 GHG Inventory. However, provisions exist under the Meteorology Department to ensure the finalisation of this deliverable. The overarching responsibility of the compilation of the National GHG Inventory lies within the Ministry of Tourism and Environmental Affairs. A Project Steering Committee was formed to ensure the project was completed on time, where the Meteorology Department was given the project responsibility. A Project Implementing Unit within this department was set up to run the project. The Project Implementing Unit utilised various GHG inventory consultants to assist in the 2010 Inventory compilation, as depicted in the Figure 3-2 below. Swaziland received funding from the United Nations Environment Programme for the compilation of the 2010 GHG Inventory.

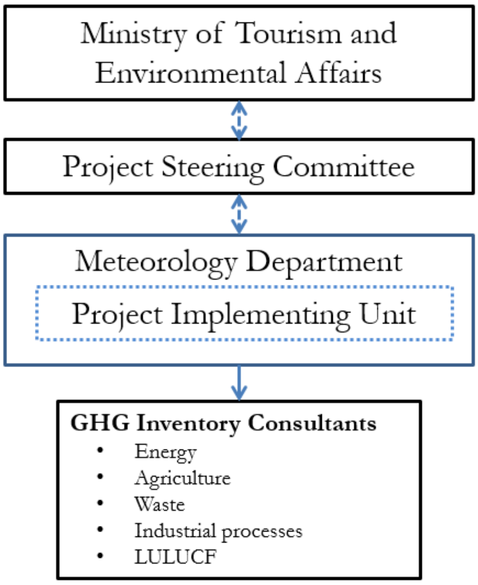


Figure 3-2: Institutional Arrangements for the Compilation of 2010 GHG Inventory

As part of UNFCCC requirements on preparation of National Communications, and in the context of more frequent reporting of Inventory data, a new institutional arrangement has been proposed developed by Swaziland with regards to the compilation of its national inventories.

The Meteorology Department, situated within the Ministry of Tourism and Environment Affairs, is the current Focal Point for Swaziland's National Communications. The Department also serves as a Central Coordination Agency of the Inventory. The Inventory Coordinator is responsible for inventory compilation, documentation and archiving, and the Quality Assurance/Quality Control system. Accordingly, an Inventory Compiler, IT Documentation and Archiving Expert, and a Quality Assurance/Quality Control Coordinator were appointed which report to the Inventory Coordinator.

Swaziland's proposed institutional arrangements for the oversight and management of the national inventories are outlined in the figure below.

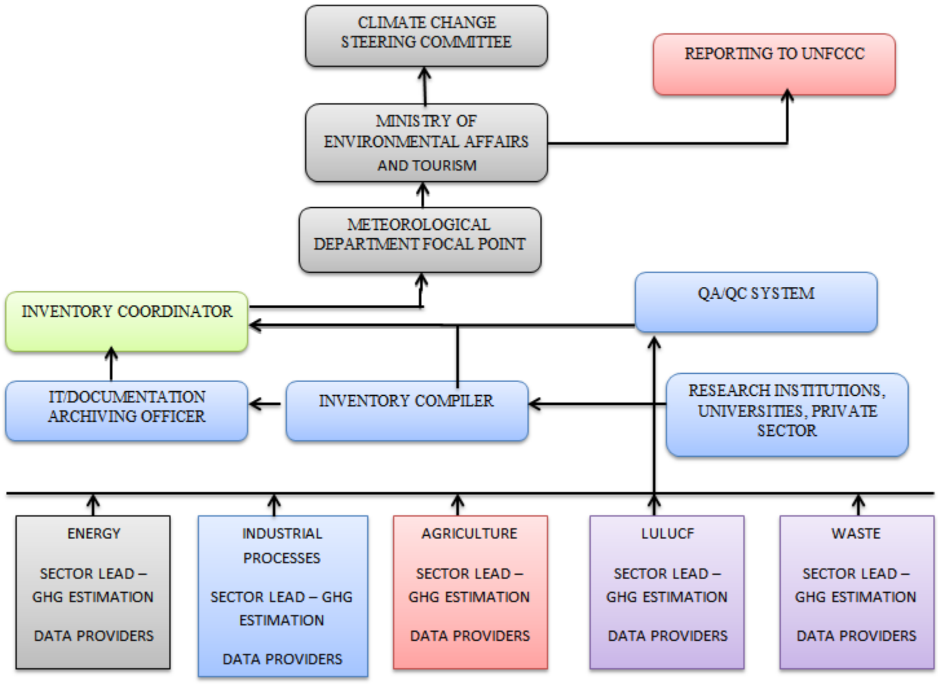


Figure 3-3: GHG Management Systems Institutional Arrangement

The broad objectives of these institutional arrangements include ensuring sustainability of the inventory preparation processes, support of the timely delivery of the required information and more efficient use of available resources.

In the future, the Central Coordination Agency will work more closely with mandated Government Institutions/Departments tasked with GHG estimations. Arrangements will also be made with various data providers, which will be facilitated through the relevant Sector Leads. The Sector Leads will oversee each sector, namely, Energy (Department of Energy), Industrial Processes (Swaziland Environment Authority); Agriculture (Department of Agriculture); Land Use, Land Use Change and Forestry (Department of Forestry) and Waste (Ministry responsible for Local Government and/or the Swaziland Environmental Authority).

Improving the National GHG Inventory requires improvement of activity data and emission factors. This is a time consuming process, and requires research and surveys. Most importantly the government of Swaziland needs to put in place sustainable greenhouse gas inventory system to guarantee sustainable reporting and institutional capacity. The whole process needs to be institutionalized to ensure adequate human resource, financial, and technological capacities are available and dedicated to improving the inventory. Such a system will also ensure that data is managed and archived properly. Data management systems are critical for developing and regularly updating national greenhouse gas (GHG) inventories that, in turn, are foundational to national and international GHG mitigation efforts.

3.4 Key Category Analysis

Swaziland has carried out a key category analysis, which assists the country to prioritize efforts and improve the overall quality of the national inventory. A key category is prioritized because its estimated GHG emissions have a significant influence on a country's overall GHG inventory in terms of absolute emissions, trend of emissions or a combination of both. Swaziland's key category analysis was carried out by comparing the 2010 GHG Inventory to the 2000 GHG Inventory (the base year inventory).

The three tables below show the results of the key category analysis for Swaziland's GHG inventory based on the Tier 1 methodological approach. This analysis includes the emissions from the Land Use, Land Use Change and Forestry sector. A summary of the key categories in 2000, in descending order, is presented in Table 3.3 below, with Category 2F1, "Product Uses as Substitutes for Ozone Depleting Substances - Refrigeration and Air Conditioning - HFCs, PFCs" classified as the key category in 2000.

Table 3.3: Key Category Results for Swaziland's Base Year 2000 GHG Inventory

CATEGORIES		Base Year Emissions (Gg CO_2e)	Level assessment	Cumulative Percentage
2F1 -	Product Uses as Substitutes for Ozone Depleting Substances - Refrigeration and Air Conditioning - HFCs, PFCs	6 852	0.406	41%
3B1a -	Forest Land Remaining Forest Land (Removals) - CO_2	-5 288	0.313	72%
3B3a -	Grassland Remaining Grassland (Removals) - CO_2	-1 471	0.087	81%
1A2 -	Fuel Combustion Activities - Manufacturing Industries and Construction - CO_2	610	0.036	84%
1A3b -	Fuel Combustion Activities - Transport - Road transportation - CO_2	579	0.034	88%
3A1 -	Enteric Fermentation - CH_4	557	0.033	91%
3B2a -	Cropland Remaining Cropland (Emissions) - CO_2	402	0.024	93%
3C4 -	Direct N_2O Emissions from Managed Soils - N_2O	304	0.018	95%

A summary of the key categories for 2010, in descending order, are presented in Table 3.4 below. The key category for the 2010 GHG Inventory is Category 3B1a, "Forest Land Remaining Forest Land (Removals) - CO2".

Table 3.4: Key Category Results for Swaziland's 2010 GHG Inventory

CATEGORIES		Current Year Emissions (Gg CO_2e)	Level assessment	Cumulative Percentage
3B1a -	Forest Land Remaining Forest Land (Removals) - CO_2	-5 069	0.423	42%
2F1 -	Product Uses as Substitutes for Ozone Depleting Substances - Refrigeration and Air Conditioning - HFCs, PFCs	1 666	0.139	56%
3B3a -	Grassland Remaining Grassland (Removals) - CO_2	-1 471	0.123	69%
1A2 -	Fuel Combustion Activities - Manufacturing Industries and Construction - CO_2	865	0.072	76%
1A3b -	Fuel Combustion Activities - Transport - Road transportation - CO_2	631	0.053	81%

CATEGORIES		Current Year Emissions (Gg CO_2e)	Level assessment	Cumulative Percentage
3A1 -	Enteric Fermentation - CH_4	580	0.048	86%
3C4 -	Direct N2O Emissions from Managed Soils - N_2O	453	0.038	90%
3B2a -	Cropland Remaining Cropland (Emissions) - CO_2	342	0.029	92%
3A2 -	Manure Management - N_2O	246	0.021	95%
3 -	Miscellaneous - CH_4	211	0.018	96%

Following an analysis of the key categories for Swaziland's 2010 GHG Inventory, the key sub categories were identified as:

- Land Converted to Forest Land (Removals) (CO_2);
- Land Converted to Forest Land (Emissions) (CO_2);
- Wastewater Treatment and Discharge: Industrial (CH_4);
- Product Uses as Substitutes for Ozone Depleting Substances - Refrigeration and Air Conditioning (HFCs, PFCs);
- Grassland Remaining Grassland (Removals) (CO_2);
- Fuel Combustion Activities - Manufacturing Industries and Construction (CO_2);
- Combustion Activities - Transport - Road transportation (CO_2);
- Enteric Fermentation (CH_4);
- Forest Land Converted to Cropland (Emissions) (CO_2); and
- Direct Emissions from Managed Soils (N_2O).

A summary of the key categories and the trend assessment are presented in Table 3.5 below, in descending order. The key category from the trend assessment of 2000 and 2010 is Category 3B1a, "Forest Land Remaining Forest Land (Removals) – CO_2".

Table 3.5: Key Category Results for Swaziland's GHG Inventory Trend Assessment: 2000 and 2010

CATEGORIES		Base Year Emissions (Gg CO_2e)	Current Year Emissions (Gg CO_2e)	Trend assessment	Cumulative Percentage
3B1a -	Forest Land Remaining Forest Land (Removals) - CO_2	-5 288	-5 069	0.429	40%
2F1 -	Product Uses as Substitutes for Ozone Depleting Substances - Refrigeration and Air Conditioning - HFCs, PFCs	6 852	1 666	0.232	62%
3B3a -	Grassland Remaining Grassland (Removals) - CO_2	-1 471	-1 471	0.116	73%
1A2 -	Fuel Combustion Activities - Manufacturing Industries and Construction - CO_2	610	865	0.063	79%
1A3b -	Fuel Combustion Activities - Transport - Road transportation - CO_2	579	631	0.049	84%
3A1 -	Enteric Fermentation - CH_4	557	580	0.045	88%
3C4 -	Direct N_2O Emissions from Managed Soils - N_2O	304	453	0.033	91%
3B2a -	Cropland Remaining Cropland (Emissions) - CO_2	402	342	0.028	94%
3A2 -	Manure Management - N_2O	232	246	0.019	95%

Following an analysis of the key categories for Swaziland's 2000 and 2010 GHG Inventory trend assessment, the key sub categories were identified as:

- Product Uses as Substitutes for Ozone Depleting Substances - Refrigeration and Air Conditioning (HFCs, PFCs);
- Land Converted to Forest Land (Removals) (CO_2);
- Land Converted to Forest Land (Emissions) (CO_2);
- Wastewater Treatment and Discharge: Industrial (CH_4);
- Fuel Combustion Activities - Manufacturing Industries and Construction (CO_2);
- Product Uses as Substitutes for Ozone Depleting Substances -Aerosols (HFCs, PFCs);
- Grassland Remaining Grassland (Removals) (CO_2); and
- Fuel Combustion Activities - Transport - Road transportation (CO_2).

3.5 National 2010 GHG Inventory Summary

Swaziland's National GHG Inventory for 2010 includes both direct and indirect emissions, from a range of GHGs.

3.5.1 2010 emissions by gas

HFCs and CO_2 are the largest contributing GHGs in Swaziland's 2010 National GHG Inventory (Ministry of Tourism and Environmental Affairs, 2016). HFCs are derived from the Industrial Processes sector, largely emitted from products used as substitutes for ozone depleting substances in the refrigeration industry. The CO2 emissions are largely derived from fuel combustion (manufacturing industries and construction as well as road transportation) in the Energy sector. CH_4 and N_2O are typically produced in the Agricultural sector, and to a lesser degree, the Waste sector.

Swaziland's emission breakdown, per gas, is outlined in the figure below.

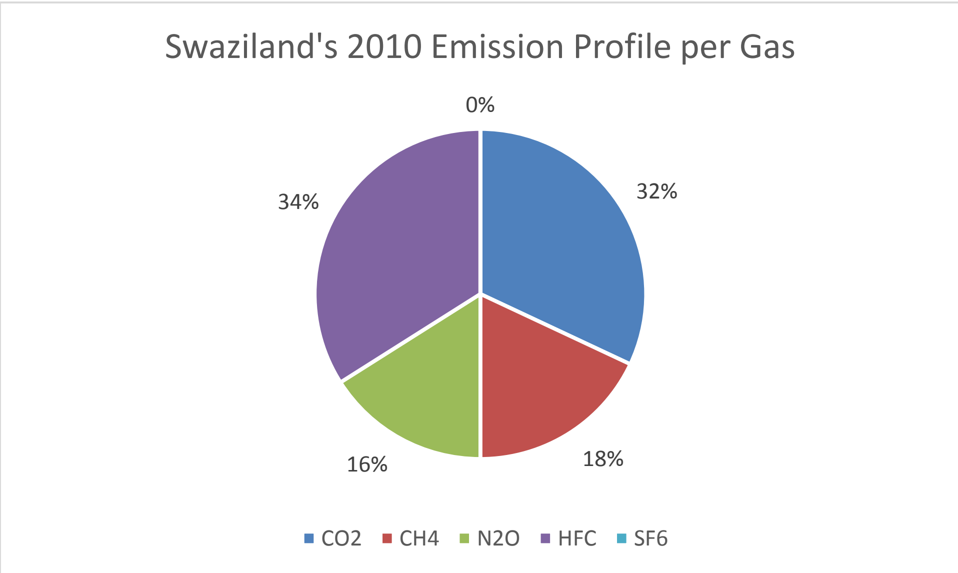


Figure 3-4: 2010 GHG Inventory per Gas. Direct GHG emissions

The total 2010 GHG emissions from the Energy, Industrial Processes and Product Use, Agriculture, Land Use, Land-Use Change and Forestry and Waste categories came to 4 861 $GgCO_2$ equivalent. This figure excludes the emission removals from the Land Use, Land-Use Change and Forestry sector.

The largest sources of GHG emissions were derived from Industrial Processes with 35% (1 678 $GgCO_2e$) of the total emissions, followed by Agriculture at 33% (1 608 $GgCO_2e$), Energy with 31% (1 523 $GgCO_2e$) and Waste with 1% (52 $GgCO_2e$). GHGs from Industrial Processes arise from the existence of air conditioning and refrigeration assembly in the country.

Swaziland's Land Use, Land-Use Change and Forestry sector is a net GHG sink, estimated at – 5 863 $GgCO_2$. The emissions from these sectors are presented in the table below.

Table 3.6: Summary of GHG Emissions/Removals for Swaziland for 2010 GHG Emissions (Gg CO_2e)

GHG Sources & Sinks	CO_2	CH_4	N_2O	HFC	PFC	SF_6	Total
	(Gg CO_2e)						
Total National Emissions without Land Use, Land-Use Change and Forestry	1 536	867	792	1 644		21.75	4 861
Net National Removals with Land Use, Land Use Change and Forestry	-4 428	949	811	1 644		21.75	-1 002
1. Energy	1 508	9.9	5.33				1 523
2. Industrial Processes and Product Use	12.02	NO	0.091	1 644	NO	21.75	1 678
3. Agriculture		826	782				1 608
4. Land Use, Land Use Change and Forestry	-5 964	82	19				-5 863
5. Waste	16	31	5				52

HFC emissions are the largest contributors of GHG emissions by gas in Swaziland, estimated at 1 644 GgCO_2 equivalent, 34% of the total country emissions. These are followed by CO_2, CH_4 and N_2O, at 32%, 18% and 16%, respectively.

The country's national GHG emissions are further summarised per IPCC category and per GHG source and sink, in the table below.

SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS								Year	2010
								Submission	2016
								Country	Swaziland
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)(1)	**-4427.61**	**2771.048**	**810.072**	**1644.1**		**21.75**			**819.36**
1. Energy	**1508.04**	**9.9**	**5.33**						**1523.27**
A. Fuel combustion (sectoral approach)									
1. Energy industries	NO	NO	NO						NO
2. Manufacturing industries and construction	864.78	5.68	3.06						873.52
3. Transport	630.877	4.142	2.23						637.25
4. Other sectors	12.38	0.08	0.04						12.5
5. Other									
B. Fugitive emissions from fuels		0.00009							0.00009
1. Solid fuels									
2. Oil and natural gas and other emissions from energy production									
C. CO_2 transport and storage									
2. Industrial processes and product use	**12.02**								**1677.87**
A. Mineral industry	6.64								6.64
B. Chemical industry	NO								NO
C. Metal industry	NO								NO
D. Non-energy products from fuels and solvent use	5.38								5.38
E. Electronic Industry									NO
F. Product uses as ODS substitutes				1644.1	NO	21.75			1665.85
G. Other product manufacture and use	NO								NO
H. Other									
3. Agriculture		**826.018**	**781.882**						**1607.9**
A. Enteric fermentation		580.183							580.183
B. Manure management		20.325	245.6						265.88
C. Rice cultivation		0.01							0.01
D. Agricultural soils		NO	452.842						452.842
E. Prescribed burning of savannahs		15	2.98						17.98
F. Field burning of agricultural residues		210..5	80.46						290.96
G. Liming									
H. Urea application									
I. Other carbon-containing fertilizers									
J. Other									
4. Land use, land-use change and forestry(1)	-5 964.00	82.00	19.00						**-5964**
A. Forest land	-5 069.00								-5069
B. Cropland	342.00	82.00	19.00						443
C. Grassland	-1 471.00								-1471
D. Wetlands	171.00								171
E. Settlements	63.00								63
F. Other land									
G. Harvested wood products									
H. Other									
5. Waste	16.33	1 853.13	3.86						**1873.32**
A. Solid waste disposal		7.89							7.89
B. Biological treatment of solid waste		7.26	2.60						9.86
C. Incineration and open burning of waste	16.33	5.68	1.25						23.26
D. Waste water treatment and discharge		1 832.30	0.01						1832.31
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	81.08								
Aviation									
Navigation									
Multilateral operations									
CO_2 emissions from biomass	**2.48**								
CO_2 captured									
Long-term storage of C in waste disposal sites									
Indirect N_2O									

Total CO_2 equivalent emissions without land use, land-use change and forestry	**6 682.36**
Total CO_2 equivalent emissions with land use, land-use change and forestry	**819.36**

Table 3.7: National GHG Inventory of Emissions by Sources and Removals by Sinks for 2010 (Gg CO2e)

The Kingdom of Swaziland calculated emissions from international bunkers with aviation emissions for the first time in 2010. The emissions amounted to 81 Gg CO_2 equivalents. This improvement makes the inventory more complete, but no historic comparison can be made.

3.5.2 *Indirect GHG emissions*

Indirect emissions are emissions from gases which have the potential to change the concentration levels of GHGs when these gases break down in the atmosphere. The indirect GHG emissions for 2010 are presented in the table below for the various sectors.

Table 3.8: Indirect GHG Emissions 2010 (Gg)

	NO_x	CO	NMVOC	SO_2
Energy	1	35	7	3
Industrial Processes and Product Use	0.29	1	89	6
Agriculture	10	193	15	8
Land Use, Land-Use Change and Forestry	6	1	NE	17
Waste	NE	NE	NE	NE
Total	18	230	110	34

3.6 2010 GHG Inventory by Sector

The breakdown of GHG emissions per sector facilitates the identification of high carbon industries. This allows prioritisation of efforts to mitigate emissions, so that Swaziland may progress towards its goals of becoming a lower-carbon economy and climate resilient society.

The following graph outlines the emissions per sector according to the 2010 GHG Inventory.

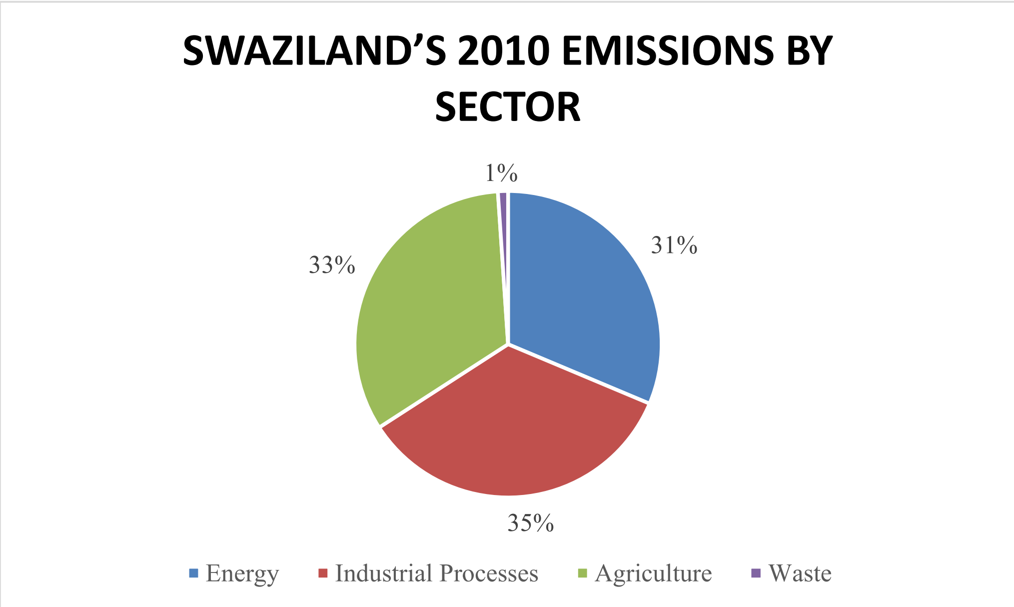


Figure 3-5: GHG per Sector in the 2010 Inventory.

3.6.1 Energy sector

The country's energy supply mix consists of petroleum products, renewables (including biomass) and coal. Electricity is generated mainly from hydropower. Biomass, used for the generation of power and steam, is utilised by auto producers, in conjunction with coal.

The national utility, the Swaziland Electricity Company, owns a majority of the country's power stations consisting of four hydro stations (61 MW) and diesel generation. There are also three cogeneration plants in the sugar industry (Ubombo owned by Illovo Sugar, Simunye and Mhlume owned by the Royal Swaziland Sugar Corporation). The sugar industry uses bagasse and coal as fuel. Coal is used in the off-milling season. The paper and pulp industry uses waste products (such as black liquid) from the manufacturing process for power generation. A substantial amount (almost 25%) of energy used in the Kingdom is supplied by self-generators. The sugar and textile industries remain net buyers of power from Swaziland Electricity Company. Swaziland Electricity Company imports 80% of its electricity from Eskom, a South African electricity utility company, and 10% from Electricidade de Mozambique of Mozambique.

Energy related activities in Swaziland's 2010 GHG Inventory accounted for 1 523 Gg CO_2 equivalents. This is estimated at 31% of the country's GHG emissions, excluding GHG removals from the Land Use, Land-Use Change and Forestry sector. Emissions from this sector came from fuel combustion (99.99%) and fugitive emissions (0.00001%) arising from coal mining activities. The dominant gas emitted across the energy sector was CO_2, accounting for 99.0% of the energy sector's GHG emissions. The emissions profile of the energy sector is illustrated in the figure below.

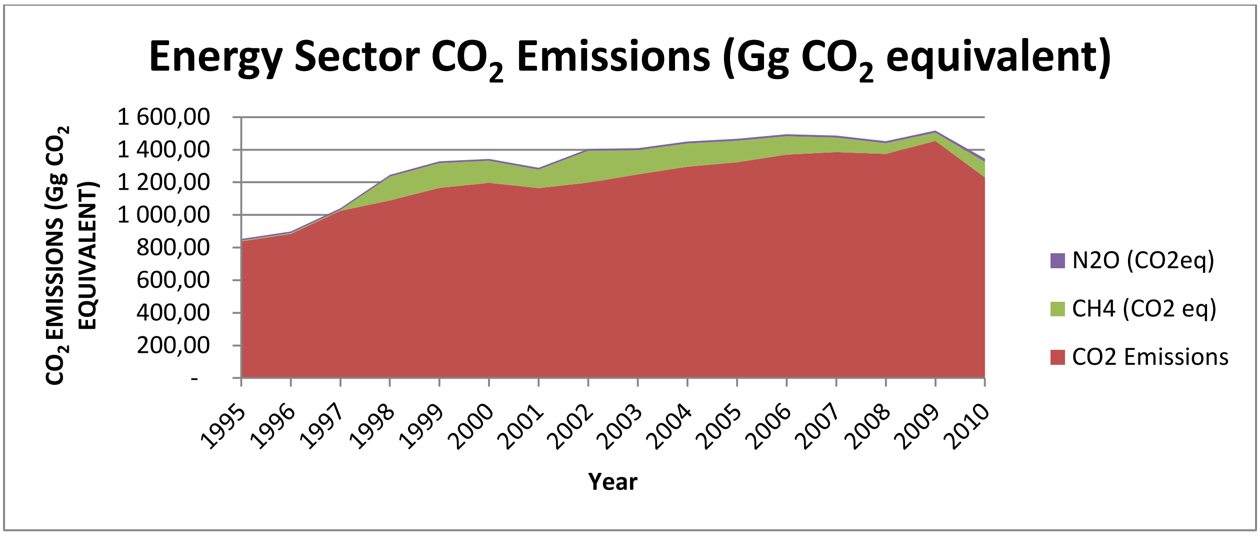
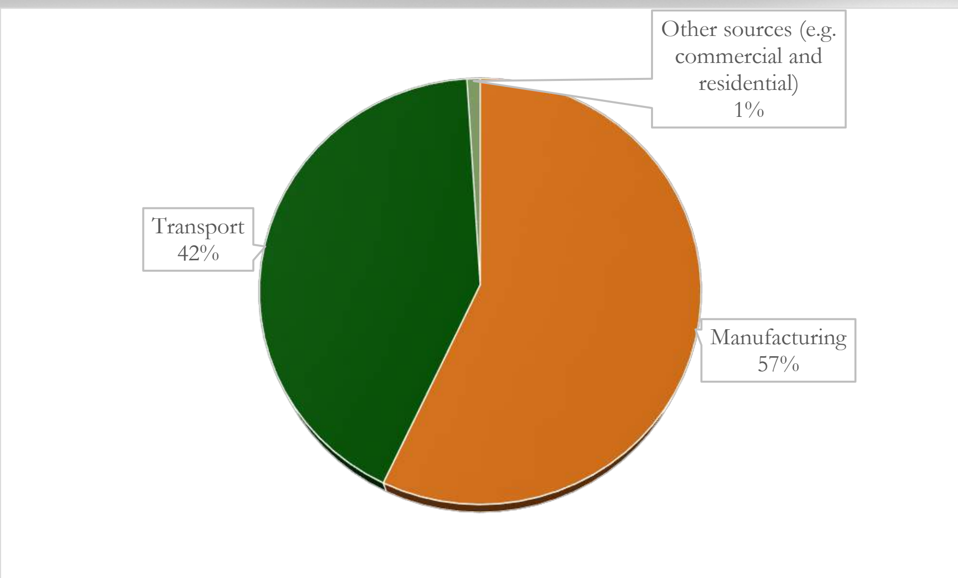


Figure 3-6: Energy Sector CO_2 Emissions (Gg CO_2 equivalent)

Emissions in the energy sector decreased sharply from 2008, due to decrease in coal imports and the shutdown of one of the diesel generators. Coal was used mainly by the sugar cane milling companies in steam production and in 2009 two of the milling companies started to use biomass (sugar cane residues, bagasse and wood chips) for cogeneration and thus imported less coal.

Figure 3-7: Emissions Arising from the Energy Sector.



Two approaches, sectoral and reference have been used to reporting energy emissions data in Swaziland. The reference approach is a top-down method that uses the carbon balance of a country, which requires information about the production, import, export and stored amount of fuels. The sectoral approach is a bottom-up method, which uses detailed information about the fuel consumption in each distinct subsector (power and thermal energy production, processing and construction industry, different ways of transport, trade, institutional and residential sectors, as well as agriculture and other economic branches).

During the Inventory calculation, the 2005 data for petroleum products and coal were considered under both the sectoral and reference approaches. A comparison of the results is given in the table below. A further comparison of the results against the 2010 Inventory was not possible, due to the lack of data for 2010 in this regard.

Table 3.9: Comparison of the Results of Reference and Sectoral Approaches for Fuel Combustion Emissions

GHG Inventory 2005: Fuel Combustion	CO_2 Emissions (Gg CO_2)
Total Carbon Emissions: Reference Approach	808
Total Carbon Emissions: Sectoral Approach	771
Difference	37

The difference between the CO_2 emissions calculated using the sectoral approach and reference approach is 37 Gg, amounting to 4.8%. The *IPCC Guidelines* state that the gap between the two approaches is normally relatively small (5% or less) when compared to the total carbon flows involved. The difference in the reference and sectoral approach for Swaziland is therefore within the required difference range.

Recalculations

The petroleum subsector emissions of the 2000 GHG Inventory were recalculated using the Tier 1 approach on the basis that more reliable data was obtained.

Petroleum data in this regard was sourced from the South African Petroleum Industry Association, through the Ministry of Natural Resources and Energy. These data sets were found to be more reliable because petroleum volumes published by the Ministry are audited, as Government receives a significant share of its revenue from the importation and sale of petroleum products. When comparing the reported CO_2 emissions value with emissions calculated using South African Petroleum Industry Association data, the results show CO_2 emissions which are 2.06% higher than those reported.

Recalculations of years 1995 to 2003 were then undertaken using the aggregated South African Petroleum Industry Association petroleum volumes. The data could only be disaggregated by sub-sector for years 2004, 2005 and 2006. Thereafter data obtained was aggregated. The results of recalculations are provided in Table 3.10 below

Table 3.10: Results of recalculations for years 1995 – 2004 (Gg CO2 eq)

1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Previous Inventory Values									
838.31	883.51	1,024.86	1,089.05	1,166.04	1,196.91	1,164.87	1,198.04	1,249.01	1,295.95
Recalculated Values									
835.00	869.00	1,002.00	1,066.00	1,159.00	1,172.00	1,141.00	1,172.00	1,222.00	1,265.20
Difference									
3.31	14.51	22.86	23.05	7.04	24.91	23.87	26.04	27.01	30.75

Uncertainty

The uncertainty assessment for the 2010 GHG emissions estimate indicate that the transport sector is characterised by the highest level of uncertainty. The primary reason for this is due to the use of IPCC default emission factors, which already have high levels of uncertainly associated with them.

The manufacturing and commercial subsectors have low uncertainties associated with their GHG emissions estimates. Underground mining has the lowest degree of uncertainty in its estimates as there are relatively high levels of confidence in the data capture and storage system by the Mining Department. In addition, localised net calorific values and emission factors are available.

There were activity data gaps in some of the fuel-use subcategories for 2010, including coal, petroleum, fuel wood and bagasse. The GHG emissions from these sources were estimated by linear extrapolation. The baseline data for the period 1995 to 2004 used extrapolation, and it was assumed that the historical trend would be consistent for the period from 2005 to 2010.

Scope for improvements

There is great potential to implement improvements in the assessment of the GHG emissions from the energy sector by developing an energy balance, which corresponds to the IPCC sector categorisation. On-going surveys by various bodies that collect data for energy balances and GHG inventories could be synthesised and improved, to enable the annual collection of detailed energy data.

Further improvements could be made by: (i) increasing the budget for the Department of Energy and Central Statistics Office, (ii) increasing the number of departmental staff with the necessary skills, (iii) encouraging agreement on timeframes and responsibilities of all stakeholders and (iv) development of an appropriate strategy for the flow of data collection processes.

3.6.2 *Industrial Processes and Product Use Sector*

Industrial Processes and Product Use covers GHG emissions that result from industrial processes, the use of GHG in products, and other non-energy uses of fossil fuel carbon. These processes can produce many different GHGs, including CO_2, CH_4, N_2O, HFCs, PFCs and SF_6.

Swaziland's relevant industries and products are divided into five sectors:

- (i) Mineral industries (soda ash and clay bricks);
- (ii) Non-energy products from fuels and the solvents used (asphalt for road surfacing and paraffin wax);
- (iii) Substitutes for ozone depleting substances (in refrigeration, air conditioning, fire protection, aerosols and solvents);
- (iv) Other product manufacture and use (use of electrical appliances and medical appliances); and
- (v) Other processes (pulp and paper production, food and beverage industry).

Swaziland does not have any production industries for cement, chemicals or metals.

Swaziland does not produce HFCs or SF_6. Therefore only GHG emissions related to the consumption of these gases in the repair and assembly of refrigerators, foam blowing, fire extinguishers, aerosols and solvents are reported.

Industry related activities accounted for a large portion of the GHG emissions in Swaziland's 2010 Inventory, estimated at 35% of country's GHG emissions (excluding GHG removals from the Land Use, Land-Use Change and Forestry sector). The industrial sector's GHG emissions experienced an 88.7% decrease over a 15 year period, from 14 597 Gg CO_2 equivalent in 1995 to 1 678 Gg CO_2 equivalent in 2010. This decrease can be attributed to reduced activities in the assembly of air conditioning and refrigeration equipment as well as the phasing out of the gases under the Montreal Protocol.

The HFCs and SF_6 gases, emitted within the category of product uses as substitutes for ozone depleting substances, account for the vast majority of the Industrial Processes and Product Use sector's emissions, i.e. 99.3% of GHG emissions in the sector. The other gases such as CO_2 and N_2O emitted from the mineral industry and non-energy products from fuels and solvent use, accounted for a negligible amount of emissions.

Recalculations

The time series 1990 to 2010 was recalculated because the solvent figures used in the previous inventories were assumed to contain HFCs. According to the *Revised 1996 IPCC Guidelines* however, HFC/PFC solvent emissions occur during the course of precision cleaning, electronics cleaning and deposition applications in the form of particular gases that do not exist in Swaziland. The solvent data were then used to calculate NMVOC emissions in the non-energy product use of fuels and solvents.

Uncertainty

An uncertainty analysis of the emissions estimates for the Industrial Processes and Product Use sector was undertaken based on a Tier 1 approach. The analysis was applied to the emissions estimates from all Swazi industries.

A summary of the uncertainty analysis for both direct and indirect GHG emissions within this sector is given in the table below. The SO_2 emissions estimate has the smallest trend uncertainty at 0.071% and the CO and NOx emission estimates have the largest uncertainty at approximately 89%.

Table 3.11: Uncertainty Analysis (%) for Direct and Indirect GHGs for the IPPU Sector

	Direct GHGs (Gg)					Indirect GHGs (Gg)			
	CO_2	CH_4	N_2O	HFCs	SF_6	NMVOC	SO_2	CO	NOx
1996									
Overall uncertainty	5	n/a	51	77	51	45	14	40	40
Due to emission factor	0.02	n/a	0	0.82	0	26	0.04	0	0
Due to activity data	3	n/a	34	1	14	81	0.1	0	0
Trend uncertainty	3	n/a	34	1	14	85	0.07	89	90

Scope for improvements

Various improvements could be undertaken to increase the quality of Industrial Processes and Product Use GHG emission estimations and reporting, and to allow for migration to the Tier 2 calculation methodology. These improvements include the formalisation of data collection mechanisms, the agreement on standard units of reporting on activity data, especially for substitute ozone depleting substances, and archiving processes. In addition, the implementation of studies or surveys on local emission factors for the food and beverages industries will enhance the overall results. To achieve the above, research partnerships for the development of local emission factors and various improvements could be established.

3.6.3 *Agriculture Sector*

Agriculture related activities account for 33% of the country's GHG emissions in the 2010 Inventory, excluding GHG removals from the Land Use, Land-Use Change and Forestry sector. The Agricultural sector emitted 1 608 Gg CO_2 equivalent in 2010. Emissions in this sector of arise from livestock and crop production. The major livestock produced and contributing to the GHG emissions in Swaziland are ruminants, cattle and goats. The principal contribution of crop production to GHG emissions is through soil cultivation, soil fertility management and the burning of fields and crop residues.

Livestock production contributed the highest agriculture greenhouse gases in 2010 Inventory. Emissions from this subsector were derived from enteric fermentation, amounting to 36% of the emissions. The other subsectors included Agriculture soils at 28%, Field burning of agriculture residues at 18%, and manure management at 17%. The emissions arising from rice cultivation and the prescribed burning of savannas were insignificant in comparison. Emission emanating from the agricultural sector are illustrated in the following figure.

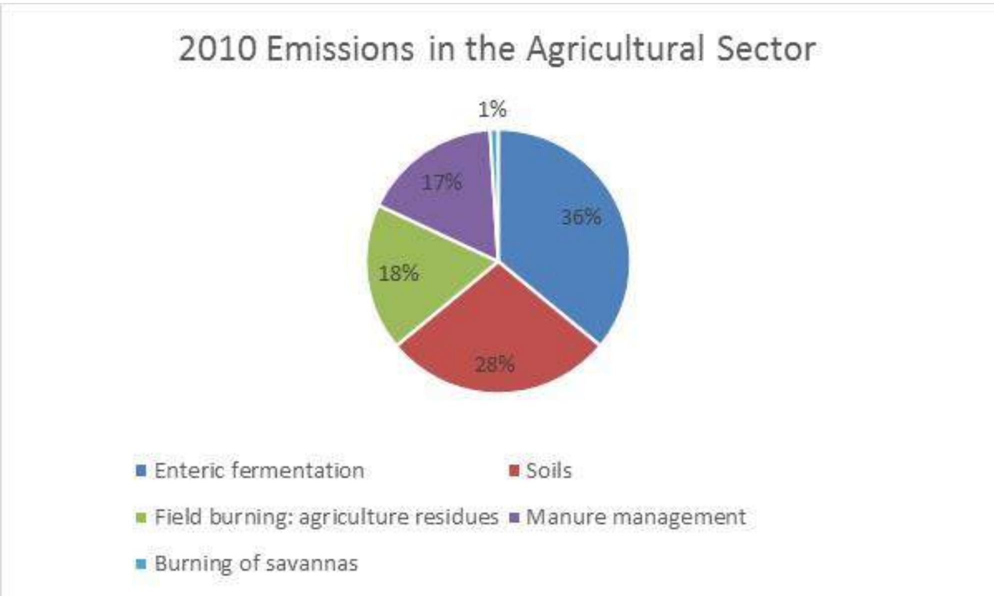


Figure 3-8: 2010 Emissions in the Agricultural Sector

The biggest GHG contributing to the agricultural sectors emissions is CH_4, which contributed 51% of the GHG emissions from the sector. N_2O accounting for 49% of the emissions.

SOURCE CATEGORIES	YEAR												
	1990	1994	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4. Agriculture	1360.4	1425.0	1404.2	1398.6	1040.8	1381.8	1405.9	1373.8	1460.6	1554.7	1480.41	1465.02	1437.34
A. Enteric Fermentation	613.3	595.3	557.3	539.3	524.5	544	554.3	567.5	597.8	612	603.8	589.8	600.8
B. Manure Management	259.3	238.4	232.44	229.46	223.5	229.5	232.4	226.5	250.3	253.3	247.3	250.3	244.4
C. Rice Cultivation	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
D. Agriculture Soils	196.68	303.96	295.03	333.76	286 08	336.74	306.94	247.34	309.92	295.02	306.94	315.9	283.1
E. Prescribed Burning of Savannas	44.96	60.69	50.56	19.48	17.73	13.23	18.48	21.23	6.3	3.55	26.83	13.98	17.98
F. Field Burning of Agriculture Residues	246.06	226.58	268.75	276.48	274.98	258.23	293.69	311.17	296.19	390.76	295.44	294.94	290.96

Figure 3-9: Agriculture GHG Emissions Time series (1990-2010)

Recalculations

The time series 1990 to 2010 was recalculated based on a change of methodology from the *IPCC 1996 Guidelines* to *IPCC Good Practice Guidance (2000)*.

SOURCE CATEGORY	1990				2000				2010			
	CH_4	N_2O	NO_x	CO	CH_4	N_2O	NO_x	CO	CH_4	N_2O	NO_x	CO
Enteric fermentation	24.1				22.29				22.3			
Manure Management	4E-04	0.902			4E-04	1.62			0	1.62		
Agricultural soils		0.336				5.18				3.6		
Burning of Savannah	NE	NE	NE	NE	9.3	0.14	4.95	290	1.78	0.02	0.8	46.8
Field Burning of Agriculture Residues	NE	NE	NE	NE	7.93	0.26	9.26	166.4	7.77	0.25	9.08	163

Figure 3-10: Agriculture Sector Recalculation Results

The results showed a slight difference between methane production by livestock in both the 1990 and 2000 calculations. Recalculated soil cultivation results showed significantly lower emissions because the recalculation did not consider estimations from Histosols, which were found to be absent from the country. The results have also showed significant differences in the estimations of GHG from savannah burning. This was attributed to the higher estimates of burnt area in the initial calculations. In the recalculation the estimated burnt area were readjusted to conform to the report from government statistics.

Uncertainty

The uncertainty analysis of the GHG emissions from the Agriculture sector, by source categories, was undertaken based on expert judgement. This was carried out for livestock enteric fermentation emission data, manure management, N_2O emissions from agricultural soils, burning of savannah and burning of crop residues. As the emission factors for the Tier 1 method used here are not based on country-specific data, they may not accurately represent a country's livestock characteristics, and may be highly uncertain as a result. As stated in the IPCC good guidance manual (2000), emission factors estimated using the Tier 1 method are unlikely to be known more accurately than ± 30% and may be uncertain to ± 50%. This was taken into consideration during the analysis.

Scope for improvements

Various activity data improvements can be achieved within the Agricultural sector. Livestock data could be improved with the capturing of data for the number of lactating dairy animals, country wide milk yields and milk composition. In addition, increased collection of crop yield information across the sector[3] that provides an indication of estimated residues burnt will improve the overall data set and results.

There is also a need for research in these areas, and improvements that reduce uncertainties and allow for the gradual progression to the use of the IPCC Tier 2 emissions calculation approach to calculate the agricultural inventory. Record keeping of fertiliser usage in the country could also be improved.

[3] This data is currently only collected for the sugar subsector.

3.6.4 *Land Use, Land-Use Change and Forestry Sector*

Swaziland's 2010 inventory found that, overall, this sector was a net sink of GHG emissions, of 5 863 Gg CO_2 equivalent. The categories under the Land Use, Land-Use Change and Forestry sector included Forest Land, Cropland, Grassland, Wetland and Settlement, as depicted in the figure below.

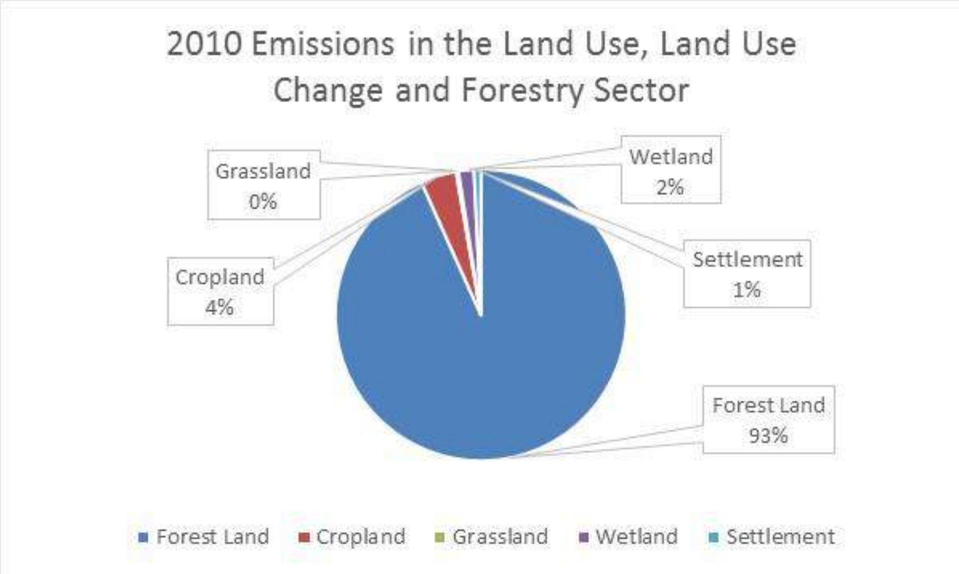


Figure 3-11: 2010 Emissions in the Land Use, Land Use Change and Forestry Sector

The main sources of GHG emissions were derived from the Forest Land category and included the burning of forest by wildfires (55%), fuel gathering (25%) and commercial harvesting (9%). Commercial harvesting was however done on forest plantations that were well managed. The main removals of GHG were due to the increase in biomass production from forest growth, which contributed 82% towards the country's emissions sink.

Recalculations

Swaziland's Second National Communication reported that the Land Use, Land-Use Change and Forestry sector was a net emitter of GHG emissions by 1105.2Gg. A subsequent recalculation of the emissions from the sector, for the year 2000, determined however that the sector was indeed a net sink, resulting in the removal of 6 154 Gg CO_2 equivalent for the country. Furthermore the previous national inventories were conducted based on the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, and not using the Carbon Stock Method.

		CO$_2$ Equivalent (Gg)		
CATAGORY	SOURCES OF GHG	1990	2000	2010
FOREST LAND	Annual carbon dioxide loss due to commercial felling	807	801	901
	Annual Carbon dioxide loss due to fuel gathering	1706	2107	2531.001
	Annual Other losses (burning of forest)	5544	5544	5544
	Non-CO$_2$ emissions from vegetation fires	45	45	45
	Harvest of nonfuel wood products	289	303	289
CROPLAND	Carbon emissions from agricultural lime application	2	1.003	2
	Annual change in carbon stocks in living biomass for land converted to cropland	381	481.004	393
GRASSLAND	Non-CO$_2$ emissions from vegetation fires (CO$_2$ Equivalent)	17.001	17.014	17
	Annual change in carbon stocks in living biomass for land converted to grassland	10.002	10.005	10
WETLAND	CO$_2$ Emission from flooded lands	64	51.002	51
	CO$_2$ equivalent of CH4 emission	32	40.008	48
	Annual change in carbon stock in living biomass	35	72	72
SETTLEMENT	Annual carbon stock change in living biomass	51	51	77
TOTAL		8983	9522	9979
	SINKS OF GHG			
FOREST LAND	Annual increase in biomass due to biomass increment	12477	12830	13149.73
	Land converted to forest	124	151	151.25
	Annual change in carbon stocks in dead organic matter (dead wood and litter (Gg)	1134	1107.014	1077
CROPLAND	Annual change in carbon stocks in living biomass in forest	114	79.163	53
GRASSLAND	Annual change in carbon stocks in living biomass	1370	1498.213	1498
SETTLEMENTS	Annual carbon stock in living biomass (Trees)	7.002	10	14
Total		15227	15675	15942
TOTAL GHG BALANCE FROM LULUCF	(LULUCF sector is net sink)	-6275	-6152	-5964

Figure 3-12: Sources and Sinks of GHG Emissions – LULUCF Sector

Recalculations were then done using the IPCC 2003 Good Practise Guidance for Land Use Land Use Change and Forestry.

Uncertainty

An uncertainty analysis was carried out for all the subsectors of the Land Use, Land-Use Change and Forestry sector. The combined uncertainties ranged from 0.58 to 0.96. The least uncertainty existed for the 'Forest land remaining forest land', and 'Land converted to forest land' categories. Uncertainty was highest for the 'Grassland remaining grassland' and 'Land converted to grassland' categories. The high uncertainties however, were due to lack of country specific values and emission factors. Default factors were used for the computation of the Land Use, Land-Use Change and Forestry sector.

Scope for improvements

The following are planned improvements in the undertaking of the national GHG inventory, which will improve the quality of data collected for this sector:

i. Development of digital land use database using remote sensing and field validation;
ii. Development of digital soil maps, indicating distribution of soil types, such as organic soils, peat soils and mineral soils;
iii. Experiments to determine the carbon content of different land cover and land use categories, and
iv. Fire mapping, using remote sensing tools and field verification.

3.6.5 *Waste Sector*

The main sources of GHG emissions in the Waste sector of Swaziland arise from the following categories: waste disposal on land (managed and unmanaged) and wastewater handling (industrial, domestic and commercial, other wastewater), waste incineration and open burning. Emissions from the waste sector in Swaziland in 2010 amounted to 52 Gg CO_2 equivalent.

The GHGs which contributed to the emissions in the Waste sector included CH_4 which contributed 60%, CO_2 which contributed 32% and N_2O which contributed 9% to the total emissions in this sector .

The largest contributor to emissions in the Waste sector is the open burning of waste, followed by biological treatment of waste, solid waste disposal and domestic waste water treatment and discharge, as illustrated in the following chart.

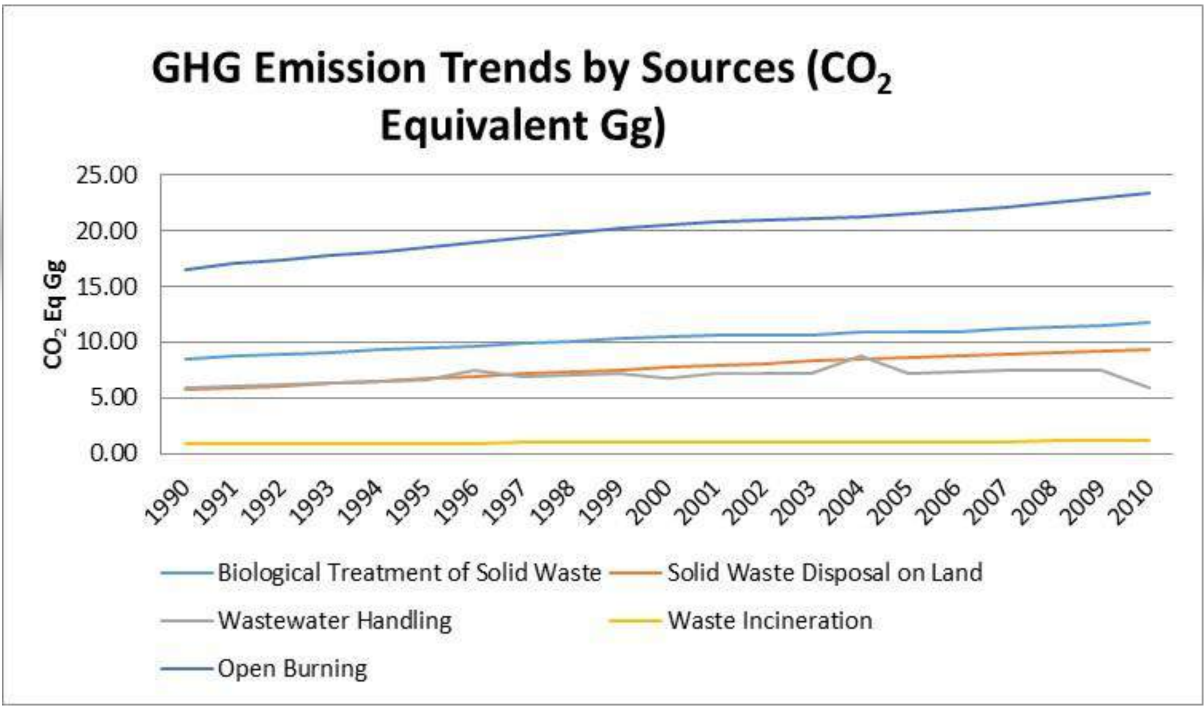


Figure 3-13: GHG Emissions Breakdown from Waste.

In the urban areas, solid waste is managed mainly by land-filling or depositing in municipal dumping sites, recovery through recycling, open burning and on a very limited scale composting and combustion through waste-to-energy facilities.

An assessment of key categories following a Tier 1 approach (IPCC, 2000) found that the Waste sector is not a key category for Swaziland, both at current and trend assessment levels. However, the management of solid waste is seen as an increasing problem in Swaziland which is related to an extent to the increase in urbanization and industrialization as well as growth in population.

Recalculations

Recalculations were undertaken due to change of methodology from revised *IPCC 1996 Guidelines* to the *2006 IPCC Guidelines*.

Uncertainty

The overall uncertainty within the Waste sector was associated with the activity data. The issues which created uncertainty were largely due to the data sources and providers, lack of conclusive and disaggregated data, the collection and analysis process, and the uncertainty due to the default methodologies used.

Scope for improvements

The availability and accuracy of country specific data pertaining to the Waste sector in Swaziland could be improved. The enforcement of periodic reporting to the Swaziland Environmental Authority of waste generated, waste categorisation and weights disposed of by local authorities, Inkundlas (local constituencies), health centres and industries could also vastly increase the scope and quality of data required for the inventory.

To date, only the twelve urban areas as well as the four towns are making systematic efforts to properly manage solid waste. The sector could be improved through increased coordination at various levels, awareness and training, strengthened management structures, improved data collection and record keeping, upgraded infrastructure and technologies for sustainable waste management.

Improvements in the recording of wastewater treated in pit latrines, septic tanks, mini sewer treatment plants as well as industrial waste water could also benefit future inventories. In addition, there are further improvement opportunities in the determination of country specific Chemical Oxygen Demand and Biological Oxygen Demand values for the industrial wastewater sub-sector.

3.7 National GHG Inventory trends 1990-2010

A GHG trend analysis has been carried out over the 1990 to 2010 period. The national GHG inventory over this period is graphically presented in the figure below.

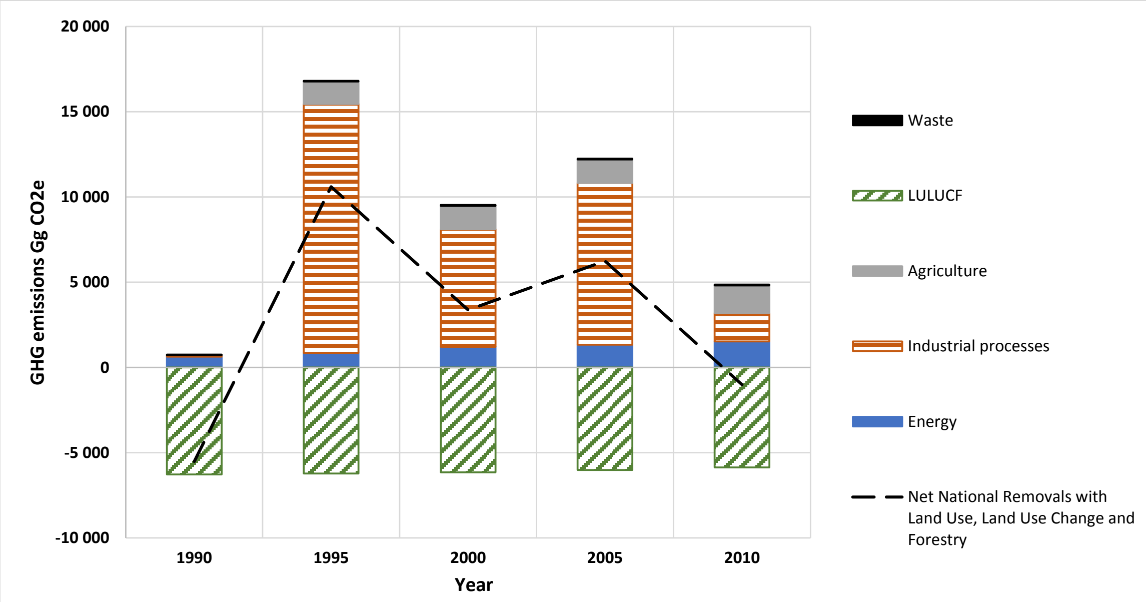


Figure 3-14: National GHG Inventory Trend Analysis from 1990 to 2010[4].

The GHG emission trends are also presented in a tabular format as follows.

Table 3.12: Swaziland's National GHG Trends 1990-2010

Sector	1990	1995	2000	2005	2010
Energy	639	853	1 214	1 341	1 523
Industrial processes	82	14 597	6 890	9 491	1 678
Agriculture	NE	1 322	1 381	1 374	1 608
Land Use, Land-Use Change and Forestry	-6 275	-6 214*	-6 152	-6 008**	-5 863
Waste	38	42	47	49	52
Total National Emissions without Land Use, Land-Use Change and Forestry	759	16 814	9 532	12 255	4 861
Net National Removals with Land Use, Land Use Change and Forestry	-5 516	10 600	3 380	6 248	-1 002

** Value estimated by interpolating the 1990-2000 data for the Land Use, Land-Use Change and Forestry sector*
*** Value estimated by interpolating the 2000 and 2010 data for the Land Use, Land-Use Change and Forestry sector*

Over the entire period, GHG emissions from energy use and waste have been growing on average about 25% and 8% per annum, respectively. GHG emissions from the industrial sector fluctuated between 1990 and 2005, but witnessed a decline by 82% between 2010 and 2005. This was probably due declining activities in the refrigeration and air conditioning subsectors in the country.

[4] The emissions from the LULUCF sector have been interpolated to estimate the values for 1995 and 2005.

In the agriculture sector, GHG emissions have also fluctuated over the period but increased by 7% between 2000 and 2010. This is typical for the agriculture sector due to varying climatic conditions which affect crop and animal production in some years.

4 VULNERABILITY ASSESSMENT AND ADAPTATION MEASURES

In the context of climate change, vulnerability comprises three broad components: exposure, sensitivity and adaptive capacity. A system is vulnerable if it is exposed, and sensitive, to the effects of climate change, and has limited capacity to adapt. Exposure considers how open the system is to significant climatic variations (IPCC, 2001). Sensitivity reflects the degree to which a system is affected, either positively or negatively, by climate variability or change (IPCC, 2007). Adaptive capacity is the ability/potential of a system to adjust successfully to climate change. This would include moderating potential damages, taking advantage of opportunities or coping with consequences (IPCC, 2007). Adaptive capacity requires adjustments in both behaviour, resources and technologies (Adger et al. 2007).

Swaziland has completed a *Vulnerability and Adaptation Assessment,* which was recently updated in 2015. The scope of the assessment covers four key sectors, namely:

- Agriculture;
- Biodiversity and ecosystems;
- Health; and
- Water.

The vulnerabilities to climate change impacts are identified in each of the four sectors, as are the adaptation measures that address these vulnerabilities and increase adaptive capacity.

4.1 Methodological Approach

In Swaziland's *Vulnerability and Adaptation Assessment,* general methods were applied for assessing vulnerability and adaptation to climate change. Both primary and secondary sources of data were used. Primary data sets were collected from field observations and stakeholder consultations. When quantitative information was not available, Swaziland made use of expert opinions of regional stakeholders as alternative sources of information. Secondary data included a review of various national climate change related documents, national climate change scenarios, national sector specific documents, previous national communications and other relevant sources.

Swaziland's method for the analysis of data was informed by the outcome and contextual vulnerability approaches reflected in the figure below. Outcome vulnerability focuses on future vulnerability and contextual vulnerability focuses on current vulnerability. In order for Swaziland to obtain a complete picture of the vulnerability of different sectors, it was necessary to combine the two time horizons (current and future) with biophysical and socio-economic vulnerability determinants. Swaziland found that non-climatic (socio-economic) factors can strongly modify the impacts of climate change, hence implying that future vulnerability critically depends on the present adaptation processes.

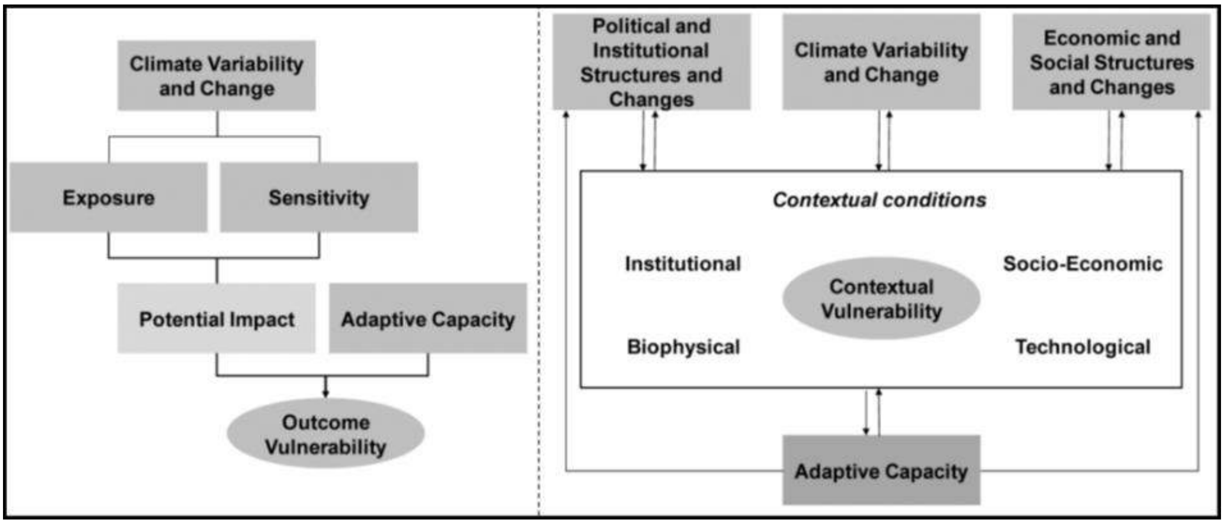


Figure 4-1: Outcome and Contextual Vulnerability Analysis of Data

The documentation and analysis of the country's climate form the basis for establishing Swaziland's current and future vulnerabilities (and related adaptive measures).

Across all the sectors climate risks, current and future climate vulnerability and adaptation options were identified. For projection of future climate impacts different models were used in the agriculture, water and biodiversity sectors. The agriculture sector used the Decision Support System for Agrotechnology Transfer (DSSAT) to ascertain sensitivity of selected crops to current and future climates. For the water sector the WatBal model was used; which is integrated water balance model developed for assessing the impact of climate change on river basin runoff. The model used the mean monthly precipitation for the basin, the mean monthly river discharges in the closing profile of the basin and the mean monthly potential evapotranspiration (PET).

An ecosystem distribution model based on climatic relationships in addition to litho-stratigraphy, slope and proximity to rivers was developed for each ecosystem. This is an approach that was designed to determine the current optimum bioclimatic conditions for a particular ecosystem based on observed variables. This allows a vulnerability assessment to be made by assessing the spatial shift in the optimum conditions for each ecosystem under the selected climate scenario. The ability of the model to predict future distributions of biomes was tested by using it to reproduce the current distribution of ecosystems. In addition Dynamic Bayesian network (DBN) modelling approach was also employed to assess potential shifts in dominant vegetation structural types. In this approach, the response of dominant plant growth forms (e.g. trees and grasses) was modelled using an understanding not only of climate impacts on plant growth, but also changes in disturbance regime, competitive interactions between growth forms, and rising atmospheric CO2.

4.2 Climate Trends

The assessment of climate trends using historical records, together with future projections, provides a quantitative basis for estimating the likelihoods of many aspects of climate change. In performing the analysis of past climate, historical rainfall and temperature records were obtained from 13 stations spread across the country. The data sets for the historical analysis and assessment of future climate for Swaziland were provided by the National Meteorological Service. The historical analysis covered a period of 30 years (1981-2010) and formed the basis of the projections of Swaziland's future climate. Figure 4.2 below shows the location of the different stations that were used in the analysis.

The dataset contains both observed and downscaled time series for each station location. Only stations that include all three primary variables (rainfall, min/max temperatures) are included. The downscaled projections are based on the CMIP5 models for RCP 4.5 and RCP 8.5 scenarios. These climate projections were done by the University of Cape Town's Climate System Analysis Group.

Table 4.1: Locations of Swaziland's Weather Stations used for Climate Downscaling

Station Name	Rainfall observations	Temperature observations
Piggs Peak	Yes	Yes
Mbabane	Yes	Yes
Matsapha	Yes	Yes
Malkerns	Yes	Yes
Mankayane	Yes	None
Lomahasha	Yes	None
Siteki	Yes	None
Nhlangano	Yes	Yes
Mhlume	Yes	Yes
Sithobela	Yes	None
Tikhuba	Yes	None
Mananga	Yes	Yes
Siphofaneni	Yes	None

http://cip.csag.uct.ac.za/webclient2/datasets/swaziland-cmip5/

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4.2.1 Historical climate

Historical climate trends are important as they allow for greater understanding of current and future climate conditions. Temperature and rainfall have been analysed for the past 3 years.

Temperature

Temperatures in southern Africa have risen by more than 0.5°C over the last 100 years, with the most significant warming occurring during the last two decades (IPCC, 2001). In addition, mean surface temperatures over southern Africa are showing an increasing trend that may accelerate from +0.01°C/year to +0.02°C/year (Jury *et al.,* 2013). Daily maximum and minimum temperatures between 1961 and 2010 have been analysed and reveal that temperature extremes show patterns consistent with warming over most of the country in the last decade. Minimum temperatures have been found to have increased more rapidly compared to maximum temperatures. The last two decades (1990s and 2000s) are warmer compared to the 70s and 80s. In the 1970s, temperatures rarely exceeded 34°C in the Lowveld which is the hottest region in the country. However in the past two decades, the frequency of very hot days, exceeding 34°C, increased. 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 1960 and 2004 during the winter season. This show that the recent decades have experienced upward trends in annual mean, maximum and minimum temperature across the different regions in the country with the most significant warming occurring between 2000 and 2010.

Rainfall

Swaziland's winter season (June – August) have been generally dry over the last half century, as is evident from the maps below which illustrate average rainfall during summer (December, January and February) and winter (June, July and August) from 1960 to 2010.

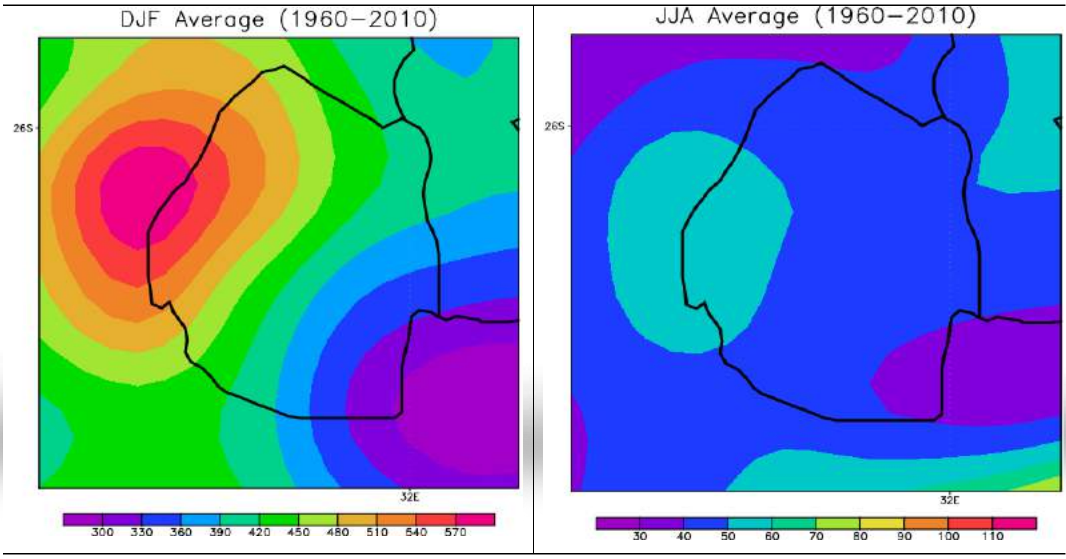


Figure 4-2: Summer and Winter Mean Rainfall Levels.

Rainfall trends in the country points towards a decrease in the number of rainy days which has an implication on the intensity of rainfall events and dry spell duration. Apart from changes in total or mean summer rainfall, certain intra-seasonal characteristics of seasonal rainfall such as onset, duration, dry spell frequencies, and rainfall intensity as well as delay of rainfall onset has changed over the country. The analysed available rainfall record for the country (1970 -2010) indicates an increase in inter-annual rainfall variability in the post -1970 periods with an increase on average of dry spell length. Figure 4.3 below show standardized annual rainfall for the country (1981-2015). It is evident from the figure that the last decade experienced a decrease in rainfall compared to the 1980s and 1990s. This figure also show the worst dry year in history of the country which is 2015. This was due to the ElNino event that affected the whole of Southern Africa during the 2015/2016 season.

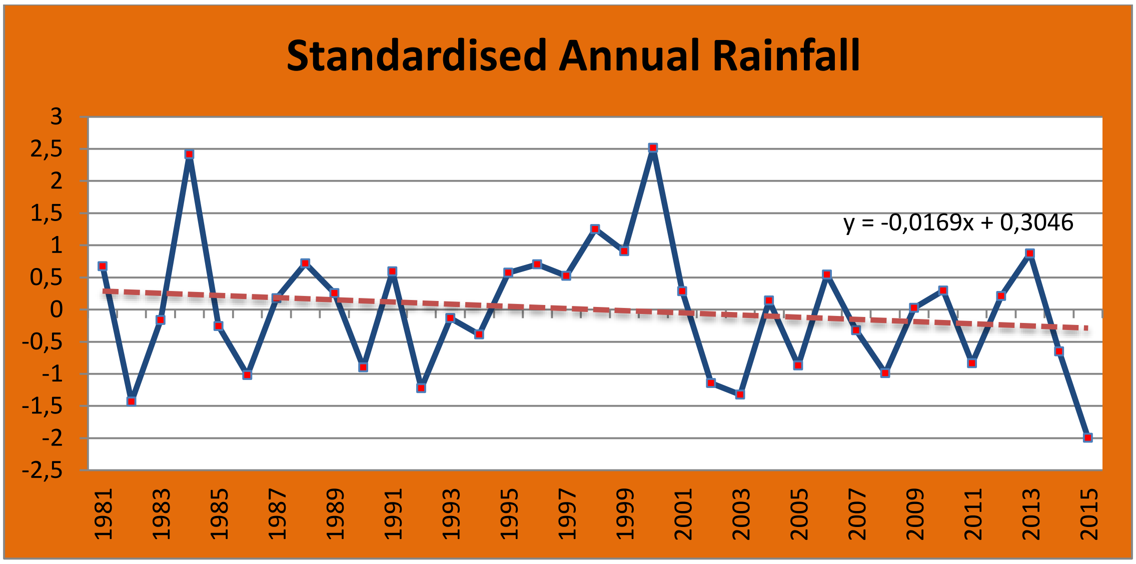


Figure 4-3: Standardised Annual Rainfall (1981-2015)

4.2.2 Future climate projections

The future climate projections were simulated using 10 different statistically downscaled CMIP5 Global Climate models, for each of the 13 weather stations.

Temperature

The models all show that temperatures in Swaziland will rise in the future. Temperature increases will be between 1.5 to 2.5°C for both minimum and maximum temperatures. The highest increases are expected over the Highveld and Lowveld regions.

The models also predict an increase in the number of days with temperatures exceeding 32°C in the Highveld and those exceeding 36ºC in the Lowveld. Temperature increases are expected to be greater during summer months than in winter months. It should be noted that there may be regional variations in projected temperature increases due to Swaziland's undulating topography. The expected increases are consistent with the IPCC *Fifth Assessment Report*, which suggests that the mean land surface temperature for Southern Africa is likely to exceed the global mean land surface temperature increase, for all seasons.

Rainfall

Rainfall projections are more uncertain than temperature projections. There is high uncertainty around projected future rainfall for Swaziland with some models indicating a negative change while others indicate a positive change especially over the northern Highveld. Consistent with the IPCC *Fifth Assessment Report* the downscaled projections indicate drier winters over the country and a decrease in rainfall during spring months (September-November) implying a delay in the onset of seasonal rains over the country.

While uncertainty regarding rainfall levels persists, there is consensus on the concerns relating to increased rainfall variability. This relates to the risks of extended periods without rain, followed by extreme rainfall events that result in floods. More certainty in future rainfall projections may be developed with a better understanding of southern Africa's current climate drivers, such as the El

Niño Southern Oscillation. This is important because enhanced heat waves probabilities are associated with deficient rainfall conditions that tend to occur during ElNino events.

Given the increases in average temperature simulated for the future climates it is expected that the frequency with which daily maximum temperatures will exceed critical thresholds will increase in the future. The increasing temperatures, erratic rainfall patterns and recurrent prolonged dry spells are expected to have a huge impact on all sectors of the economy.

4.3 Agriculture

Swaziland's agricultural sector is a vital part of the economy, with more than 70% of the population relying on this sector for income (Government of Swaziland, 2015b). The sector is divided into two main sectors; commercial and subsistence. Subsistence agriculture is practiced mostly by almost all rural households and is mainly rain-fed agriculture while commercial agriculture is practised at a large scale with irrigation, highly mechanised and resource-rich environments.

Over 75% of smallholder subsistence farmers in Swaziland rely on agriculture for their livelihoods. Activities to support their livelihoods include direct farming on their smallholdings and employment within the rural areas and large citrus and sugar cane estates. Maize is the dominant crop. Under rain-fed conditions, maize represents on average 84% of the cropped area followed by cotton at 7% (Lowveld crop) and groundnuts at 6%. Other crops of significance include grain legumes, root crops (mainly sweet potato) and sorghum (Ministry of Agriculture, 2014).

In addition, sugar cane and cotton are produced as cash crops by many smallholder farmers. As the main producers of food crops, small and subsistence farmers are responsible for the production aspect of food security. The large scale commercial farmers cultivate almost exclusively sugar cane, citrus and forests. To access the impacts of climate change to the agriculture sector an indicator based framework assessment was used to identify the climate risks and associated sensitivities. The Decision Support System for Agricultural Technology (DSSAT v4.5) model was used to generate scenarios of agriculture production for five different crops.

4.3.1 Vulnerabilities

Swaziland's agricultural sector's production has been declining over recent years. Evidence reveals that the country has experienced frequent, unfavourable food security bouts that were largely attributed to droughts and extended dry spells. These conclusions have been supported by a number of studies conducted in the country, that show that Swaziland's agricultural sector is particularly sensitive to climate change (Manyatsi et al. 2010; Sibanda, Kureya & Chipfupa, 2008).

Climate change impacts in the agriculture sector are already being observed in the country. Swaziland has experienced some of its worst droughts and floods in the last two decades whilst significant rainfall deficits/cessation at critical stages of crop growth has frequently led to a serious shortfall in crop production especially maize. According to 2004/2005 crop and food supply assessment of the FAO/ WFP, the production of the country's staple food, maize was on a long term decline, dropping by 70% over a period of five years in most areas. This was due to non-cultivation of the arable lands due to delayed rainfall and the high risk of making loss from agriculture as well as shortage of seeds for alternative crops among others. Swaziland has suffered below average and declining cereal production as a result of erratic rainfall patterns, which are exacerbating the impact of rising unemployment and increased poverty

Livestock and crops production under rain-fed conditions have declined by over 30% on average over the last few farming seasons. This has been evident especially in the turn of the century since 2011/2012 till date. This is mainly because of increase in temperatures and below normal rainfall which has seen the country experiencing recurrent droughts over the last five years. This has seen the area under cultivation for various crops especially maize consistently decreasing. The country experienced the worst drought in 2015/16 season and area under cultivation reduced significantly further, by 64%, compared to the previous years.

Swaziland's exposure to droughts and extreme temperatures has therefore resulted in the loss of both crop and livestock productivity, highlighting the relationship between climate change and food insecurity (Stringer *et al.*, 2009; Oseni and Masarirambi, 2011). Inadequate food supply, poor crop yields and poor performance of pastures have all been attributed to the effects of climate change and climate variability.

4.3.2 Drivers of Sensitivity

Rainfall is the main determinant of crop yield, grass biomass and livestock production in the country; though temperatures also are significant both directly and indirectly through evapotranspiration rates. The table below outlines the sensitivity of the agriculture system to various climate parameters.

Climate Parameter	Sensitivity to the Agriculture Sector in Swaziland
Reduced rainfall with long length of dry spells and increased evaporation	Rain fed crops wither and fail to reach maturity resulting to low yields. Less grass and water for livestock resulting to death. Water shortages, competition over water use between humans and animals. Food insecurity and increase in food imports and food prices. Desertification accelerates
Increased frequency and intensity of flash floods and storms	Destroyed/damaged in field crops, waterlogging of crops, spoilage of harvested crops, increased lightning frequencies leading increased livestock mortality.
Increased temperatures	Heat stress on crops and animals
Thunderstorms – lightning	Increase mortality rate of livestock

Table 4.2: Drivers of Sensitivity in the Agriculture Sector

Changes in rainfall patterns, evapotranspiration regime and directly affect soil-moisture storage. Decreased in rainfall and increased in temperature can each lead to decrease in soil moisture. Soil moisture response has serious implications for crop yields. Changing soil conditions and pressure from human activities has contributed to dominance of invasive bush species in many parts of the country.

Impacts on crop production

Unpredictability of rainfall patterns and late start of onset rainfall make agricultural planning difficult. Consecutive years of drought have continuously undermined crop production, particularly maize. Results of the annual assessment by the Swaziland Vulnerability Assessment Committee indicate that 116,000 people (10 percent of the population) faced a food deficit during the 2012/2013 lean season. This is a 30 percent increase on the 2011/12 figure of 89,000. This has major implications for food security. With regards to access for example, food prices are likely to remain high making it unfordable for those who have limited purchasing power. Factors contributing to low production include poor rainfall and lack of access to farming inputs such as fertilizers and tractor hire.

Maize production in Swaziland has been declining steadily for the past decade. Up until 2000, Swaziland routinely harvested more than 100,000 tons of maize. However, since then, the average harvest has dropped to about 70,000 tons. Poor rainfall and extended dry spells during the critical maize crop development stage (January-March), results in widespread crop losses and reduced yields; this has negatively impacted on the food security situation of a large number of vulnerable people in the country.

The main drivers of food insecurity which exacerbate Swaziland's vulnerability are:

- High dependence on maize production in marginal areas;
- Low income levels of rural small holders;
- Poorly integrated food markets; and
- High import prices of food and agricultural inputs.

Future climate yields of maize in Swaziland's Lowveld are projected to remain modest and unstable for early plantings. Early plantings are at risk of failure to establish on account of high temperature and moisture stresses. Reasonable maize yields ranging between 1 000 and 2 500 kg/ha are predicted for the period between October and February. Future yields for the middleveld location revealed very good yields for the period between November and December period, with productivities ranging between 3 000 and 8 000 kg/ha. Future climate yields for the Highveld are low, averaging about 1 500 kg/ha, save for yields in the December period.

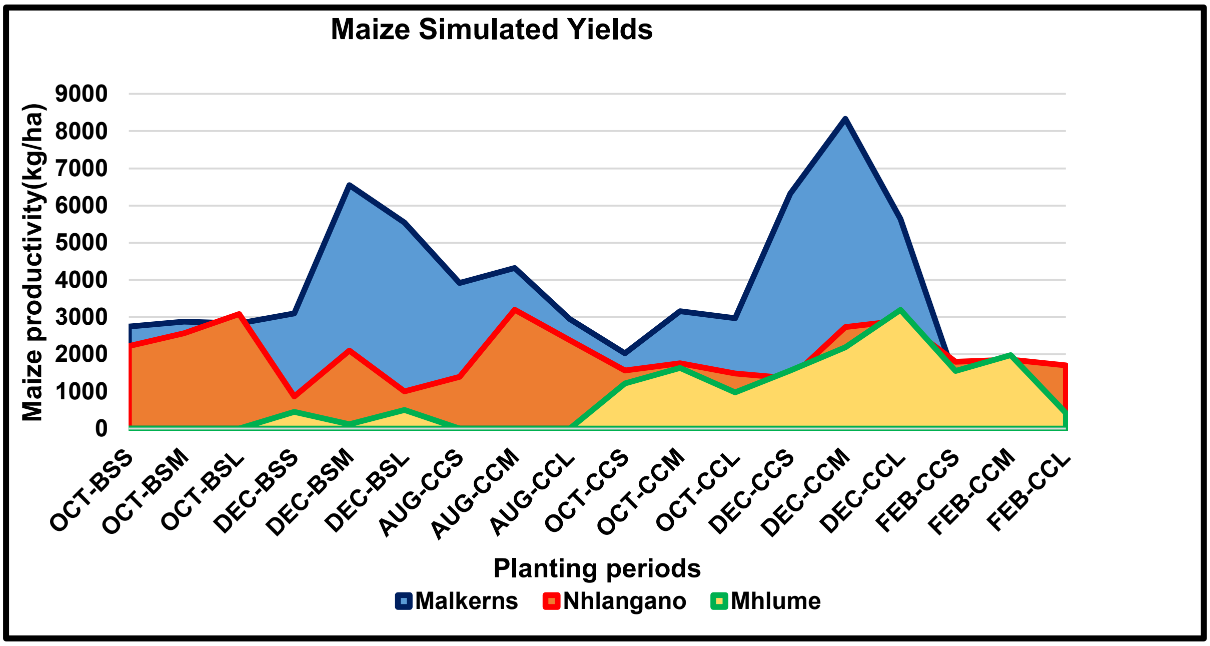


Figure 4-4: Maize Production Simulated Yields in Different Planting Periods

Sorghum is a drought-tolerant crop that performs well under hot conditions. However, favourable moisture and adequate temperature environment are nevertheless necessary for successful yields. For all future climates, all sites under investigation experienced fairly good sorghum yields, with Lowveld conditions providing the most optimum conditions.

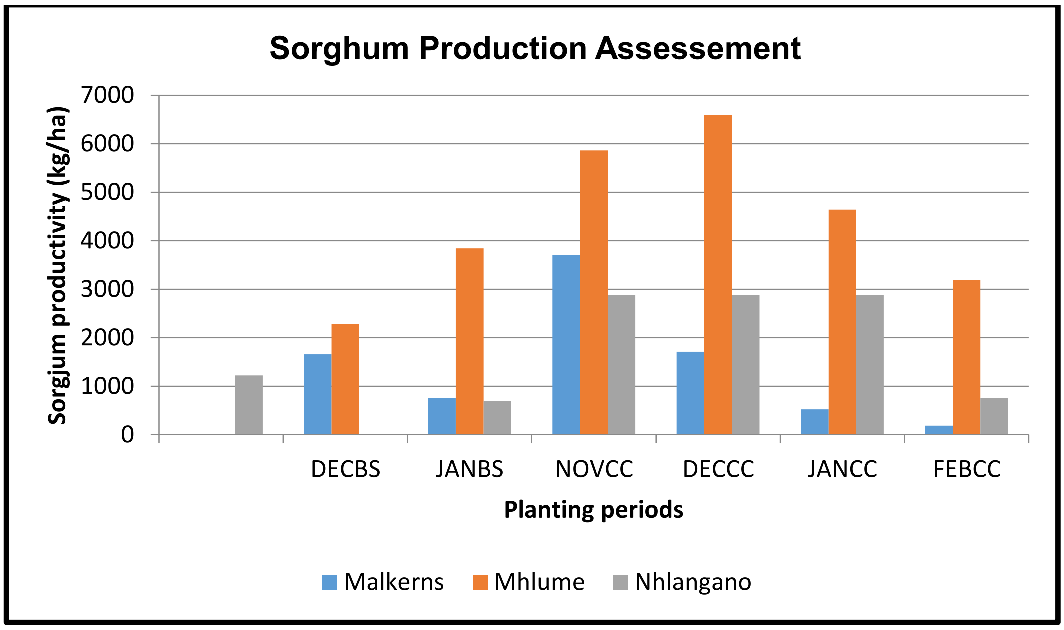


Figure 4-5: Sorghum Yield Production for Different Planting Periods

Future climate production estimates for beans showed modest and fragmented production levels, hardly exceeding 1 000 kg/ha of bean seed at all locations. The data suggest that plantings between September and December may be best considering anticipated climate changes, while plantings outside this window will most likely be risky.

The cultivation of soya beans is being considered as a commercial crop in Swaziland. Projections for the Middleveld and Highveld environments indicate that climate change impacts will severely affect such crops. Yields varied substantially across locations; hence investment in soya beans may therefore not be a profitable proposition.

Cotton is currently grown in Swaziland as a cash crop. Future cotton yields showed that productivity is not compromised by climate change. The most favourable periods to plant are from September to December for Lowveld conditions and September and October for the Middleveld. However, quality is a major factor in cotton production. The quality of the crop depends on the ambient weather conditions before and during harvesting, where rainfall events during this period can reduce crop quality and therefore the commodity price. In order to assist farmers in this regard, Swaziland is currently evaluating the introduction of Bt. Cotton, a genetically modified organism variety, which produces an insecticide to bollworm.

Sugar cane, like all agricultural enterprises depending on the weather and climate, is affected in different ways by climate change. As all commercial sugar production in Swaziland is based on irrigation, the crop is less sensitive to precipitation than temperatures. Precipitation was however found to promote good vegetative growth, and therefore is a key component in determining revenues from the crop. Studies conducted in South Africa (Deressa, Hassan and Poonyth, 2005), revealed that climate change has significant nonlinear impacts on sugarcane productivity and related revenue. The crop was more sensitive to temperatures than precipitation. Temperature requirements for the different stages of the sugar cane growing season result in differences in productivity. Increases in winter temperatures led to higher productivity, due to increased cane and/or sucrose yields. The high level of productivity was achievable as long as temperatures remained below the critical point of 18ºC during the winter above which the environment favoured pest development.

On the other hand, summer temperatures lower than 23^{0}C result in productivity declining, while those between 23ºC and 32ºC increased productivity, temperatures beyond 35ºC were detrimental. The greater productivity for the elevated temperatures of up to 32ºC was the result of the higher requirement by the plant for hotter environments required for maximum production or physiological processes (Blackburn, 1984 cited in Deressa et al., 2005). Finally, this study reported that sugar cane ripening required low temperature levels that allow for sucrose accumulation, temperatures below 10ºC were detrimental.

In those areas (especially in the Eastern Lowveld) where summer temperature will exceed 35ºC thresholds for two or more months, heat stress will be hazardous to cattle. Areas in the eastern Highveld will present high heat stress probabilities in future. There will also be indirect effects which will arise from reduced and declining quality and quantity of herbage; increased pests and disease pressure often exacerbate the situation and in general increased competition for the limited and declining resources especially in where communal grazing is practiced (FAO, 2013).

Non climatic factors contributing declining crop production include high fuel and input costs, the devastating impact of HIV and AIDS, and low implementation of improved agricultural practices. Swaziland also experiences challenges with pests and diseases that are affecting crops and livestock whose impacts depend on climate variability. Water logging and nitrogen starvation cause severe outbreaks of whiteflies. Chilo (Chilo infescatellus) attacks sugar cane during the early part of cane growth, before inter-node formation and stalks in the years of scanty rainfall. Infestation of sugar cane fields by the African Sugar cane stalk borer has negative impacts on productivity; infestations are related to the number of mating hours/year which in itself is a function of hourly night temperature threshold being exceeded.

Impacts on livestock

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 droughts and overgrazing of rangelands. Changes in the quantity and timing of precipitation, was reported to result in water scarcity hence directly affecting livestock feed production systems and pasture yield as well as livestock health and productivity. Increasing temperature and fluctuation water supply have also led to changes in the pattern and range of vector borne diseases and helminth infections.

The severe drought of 2015/2016 has resulted in decreased levels of vegetation cover. This has led to some grazing areas in the country turned semi-arid, with no grass in sight and de-leafing of trees – typical of winter months. This has materially affected the pastures available for cattle, which led to approximately 47 000 cattle deaths during May to December 2015 (as per the graph below). This figure accounts for 7.3% of the total cattle population and over 23 968 households depend on cattle for their livelihood .

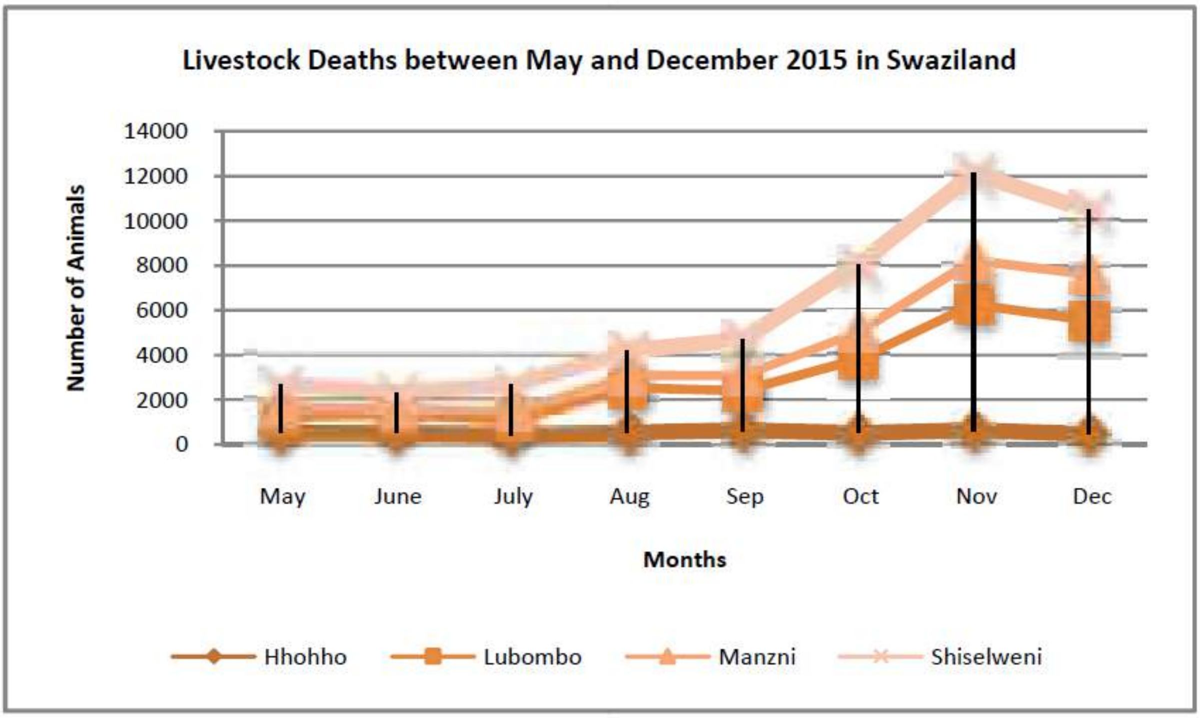


Figure 4-6: Cattle Death by Sub-region, May-December 2015. *Source: Government of Swaziland (2016b)*

In addition to climate related concerns, other factors such as breeding practices, lack of range management, under-utilization of market infrastructure, lack of adaptive research, lack of proper livestock census and lack of capital for improved technologies necessary for animal development were highlighted as important issues to consider when planning and developing adaptation strategies. Future impacts on the agricultural sector

4.3.3 Adaptation measures

Swaziland has adopted three broad strategies to address climate change impacts in the agricultural sector and they include:

- Regional and global participation in foras dealing with climate change.
- Policy development.
- Development of farm level adaptation strategies and programmes;

Adaptation measures are discussed in many GoS policy documents including the (i) National Development Strategy (NDS); (ii) Poverty Reduction Strategy and Action Plan (PRSAP); (iii) Comprehensive Agricultural Sector plan (CASP) (iv); National Food Security Plan, among many. Some of these measures are already undertaken or are being undertaken.

The Government of Swaziland's efforts to adapt to climate change impacts in the agricultural sector have included the introduction of conservation agriculture (CA) practices in agricultural production systems and a focus on changes in land use. Under these initiatives, a number of actions have been taken over the last few years that include:

- ✓ GoS has and continues to harness its many rivers and store such waters in large as well as smallholder dams regardless of their size as adaption measures to address climate change impacts;
- ✓ Irrigation systems have progressively moved from the old surface irrigation to state of the art drip and center pivot irrigation systems;
- ✓ Crop intensification covering diversification and climate smart agriculture practices;
- ✓ Soil fertility management covering, *e.g.*, pilot smallholder liming interventions in the Highveld;
- ✓ Commercialization of the smallholder SNL beef and dairy production as well as establishing suitable feed and fodder production and range management;
- ✓ Research and piloting well-researched extension packages suited to different agro-ecological zones and socio-economic contexts of farmers;
- ✓ Social mobilization/group formation/networking /linkages and capacity building;
- ✓ Rangeland management incorporating community-based natural resources and land; and
- ✓ Integrated land management programme countering land degradation.

The Swaziland Agricultural Development Project was launched with the assistance of the European Union and the Food and Agricultural Organisation in 2009. The objectives of the five year programme were to improve food security and nutrition of the vulnerable, and to help transform agriculture into a vibrant commercial sector. In the early stages of the programme, attention was given to those who were most vulnerable, including the young and the elderly. Over 800 backyard vegetable gardens were established for poor rural households.

In addition, 60 youth groups were formed which encompassed 2 250 young people. The youth groups were given funding to set up small businesses in poultry, pig and vegetable/crop farming. Gradually the project also started educating smallholder famers about good agricultural practice. To date, over 20 000 people were supported in conservation agriculture, agro-forestry and seed multiplication. The image to the left depicts a successful example in this regard.

Way forward – adaptation

- Integrate climate change risk management within a larger national risk management framework.
- Have a comprehensive and dynamic policy approach.
- Put greater focus on the development and utilisation of new technologies. Such technologies include improved seed varieties and improved irrigation systems.
- Strengthen existing partnerships and/or create new ones. In the light of the likely adaptation costs, partnerships between Government and other stakeholders need to be strengthened and leveraged more smartly as important mechanisms and drivers that will help address individual sector institutional fault lines and funding deficits.

- Create a national information management plan to generate new and manage the existing nowledge: This would help in ensuring that knowledge is captured, communicated and shared to facilitate climate change adaptation.

- Adopt and implement a farmer centred innovation system to put farmers at the centre of adaptation actions through the implementation of an appropriate to promote mobilisation and empowerment.

- Draw up and implement an inclusive and comprehensive adaptation communication programme that will feature a strong advocacy element, bringing to the forefront Swaziland specific evidence needed to convince sceptical policy makers, economists and other planners to enable climate change adaptation.

- Mainstream Climate Smart (CSA) agriculture approaches throughout the two main Swazi farming systems (the TDL and the SNL): Mainstreaming will involve an informed, systematic and harmonious inclusion of relevant CSA practices and principles. Furthermore, this would be aimed at promoting the integration of CSA practices in all agricultural programme decision-making processes, policies and laws, institutions, technologies, standards, planning frameworks and actions.

- Introduce market-based measures into the farming system (focus would include value chain approaches within the SNL system) with all stakeholders identifying and agreeing on 'proximate drivers' of climate risks, which are amenable to direct or indirect joint interventions by all stakeholders (*e.g.*, insurers and funders of farming operations).

- Design/Strengthen an appropriate Monitoring and Evaluation Framework: It is important to strengthen monitoring and evaluation systems to make them more results-oriented and suitable for internal and external reporting on progress made in climate change adaptation, including identification of relevant indicators that contain consistent information that all stakeholders can utilise in their efforts to contribute to adaptation efforts.

4.4 Biodiversity and Ecosystems

Swaziland has four main biomes, namely: forests, grasslands, savanna and aquatic. The ecosystems that form part of these biomes provide important services and supporting ecological infrastructure to Swaziland's society.

Swaziland's land cover is predominantly characterised as rural and relies heavily on subsistence agriculture, which depends on ecosystem services. Biodiversity therefore provides a range of goods and services to the people of Swaziland. This means that Swazi communities depend directly on the products from local ecosystems for the majority of their basic needs such as food, energy, water, medicinal and livelihood requirements.

4.4.1 Vulnerabilities

Swaziland's biomes are susceptible to high temperatures, seasonal availability of water, soil conditions and fires. The IPCC's *Fifth Assessment Report* also predicts that Swaziland's ecosystems will be highly vulnerable to biome change in the future.

The spatial distribution of ecosystems in Swaziland is predominantly driven by geology, rainfall and temperature. Slope is particularly important in determining the distribution of the forest biome. The grassland biome is sensitive to annual precipitation and annual mean temperature.
However, the Lebombo bushveld is almost solely characterised by the underlying geology and, to a lesser extent, annual mean temperature. The Lowveld bushveld, which forms part of the savanna biome is highly sensitive to precipitation. In addition, geology is also a major driver of the sour bushveld, followed by precipitation.

Annual rainfall has significant impacts on vegetation growth, as shown in the graph below. The relationship between the Normalised Difference Vegetation Index (NDVI), which represents vegetation vigour, and annual rainfall for the past 15 years is depicted in the graph below. In Swaziland the vegetation growth peaks approximately three months after rainfall. This direct relationship makes subsistence farming vulnerable to extended droughts and delayed rainy seasons.

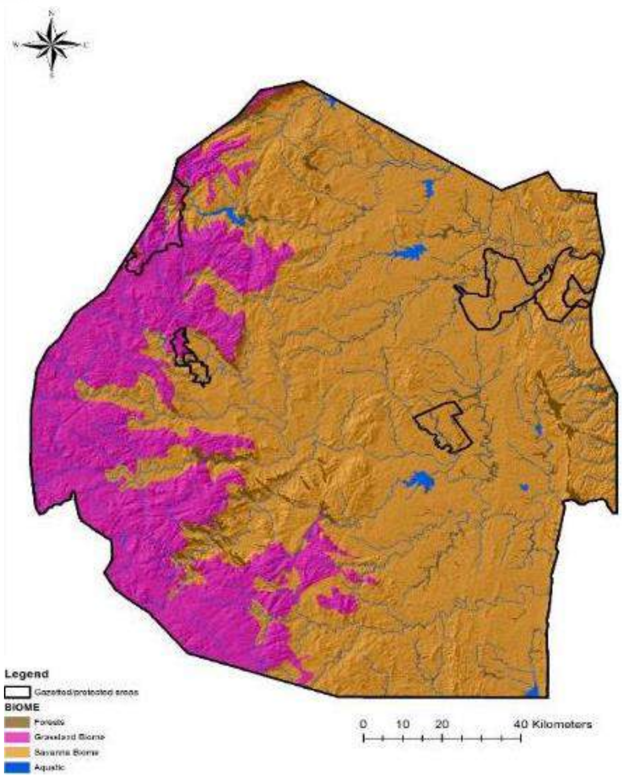


Figure 4-7: Biomes of Swaziland.

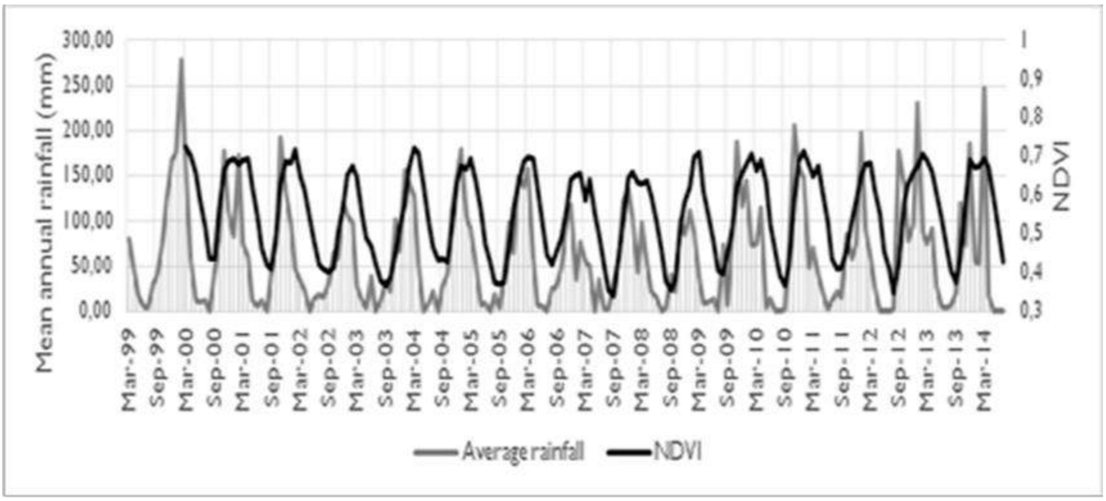


Figure 4-8: Mean Annual Rainfall and Normal Difference Vegetation Index.

In addition to rainfall, geology also has an influence on the spatial distribution of biomes. The spatial distribution of biomes is sensitive to climate, however geology constrains spatial distribution through soils and microclimatic variations caused by landscape structure.

Ecosystems in Swaziland are under pressure due to a combination of factors such as land use changes, climate change, rising atmospheric composition CO2 and the spread of invasive alien species. Impact and vulnerability of ecosystems and biodiversity to climate change therefore takes into account a range of stresses.

The spatial distribution of ecosystems in Swaziland is predominantly driven by litho-stratigraphy (geology) and annual precipitation. Mean annual temperature is also a significant contributor whilst slope is also a major determinant of forest ecosystem distribution. The grassland ecosystem is sensitive to annual precipitation and annual mean temperature whilst the Lebombo bushveld is almost solely determined by the underlying geology and, to a lesser extent, annual mean temperature. The Lowveld bushveld, on the other hand is highly sensitive to annual precipitation and litho-stratigraphy. Lithostratigraphy is also a major driver of the sour bushveld followed by annual precipitation and precipitation of the driest month..

Land use and cover change, is a major driver of current ecosystem and biodiversity change. The most important impacts of climate change on biodiversity are indirect – at the community and ecosystem levels, together with the interactive effects with existing stressors. For example, for wetlands, the major threats of climate change are not the direct impacts on vulnerable species but rather an intersection of effects due to changing fire regimes, overgrazing, farming and overutilization, as well as the consequences of climate change for a number of invasive species. Such indirect effects highlight the difficult but important issues that biodiversity managers face in responding to climate change – severe uncertainties, non-linearities, time lags, thresholds, feedbacks, rapid transformations, synergistic interactions and surprises. The probabilistic trajectories of predicted impacts are non-linear, which is indicative of the inherent uncertainties associated with climate change projections and the complex relationships among natural sub-systems.

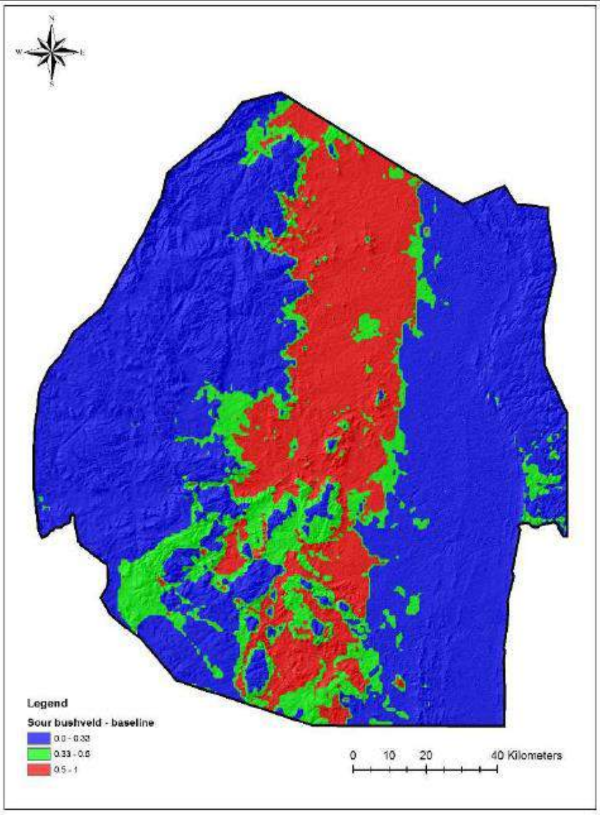
4.4.2 *Future impacts on Ecosystems and biodiversity*

In Swaziland, land use and cover change is both a cause and a consequence of climate change and is the major driver of current ecosystem and biodiversity change and a key cause of changes in freshwater ecosystems. With the projected increased intensity and frequency of extreme weather events related to climate change, the patches of forest in the Lowveld will likely to be depleted in the 2050s as the temperatures increase and precipitation decreases coupled with increasing human pressures. The grassland biome appears to be one of the biomes most at risk of significant climatic and human-induced change. Areas with a climate envelope suitable for grassland are projected to be greatly reduced and to persist only in the patches of highest altitude areas such as the western mountain peaks. The area with a climate envelope presently suitable for sour bushveld increases replacing some of the grassland climate envelope upslope albeit with uncertainty. It is highly likely though that the present ecosystem structure of the sour bushveld will shift towards more Lowveld bushveld structural characteristics as woodiness increases.

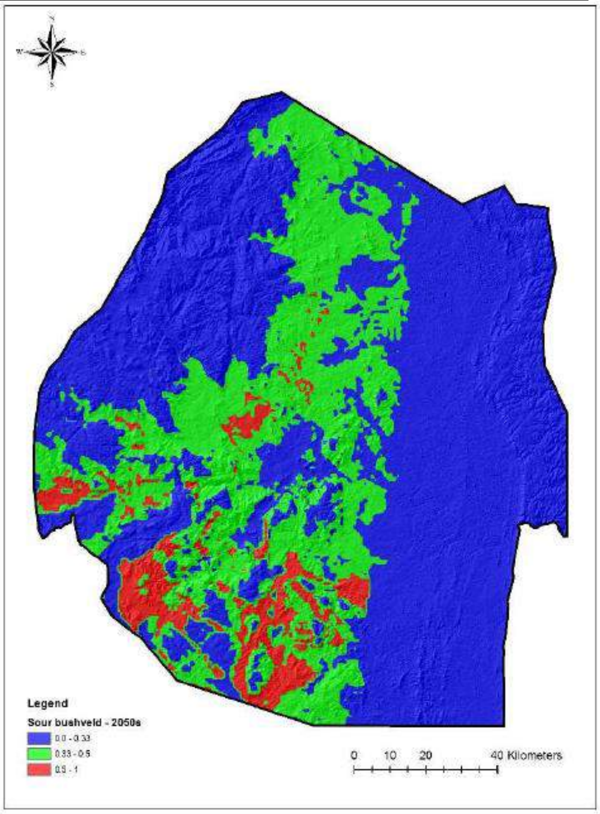
Although the climate envelope suitable for savannah is likely to expand significantly westward in the future, and specific savannah species are likely to benefit, this does not necessarily benefit existing habitats and species assemblages. Current studies show that areas with a climate envelope characteristic of Lubombo bushveld largely persist.

The following maps demonstrate projections of bioclimatic envelopes for Swaziland's ecosystems under statistically downscaled climate scenarios, looking ahead to the 2050s. For each pair of maps, the projection shows the probability of the future climate envelope in an area that is likely to resemble the climate of a particular ecosystem based on the current bioclimatic conditions. However, for areas that indicate changes or shifts, this does not necessarily mean that the vegetation in the area will change to a different ecosystem, but indicates areas where endemic biota of that biome could experience significant climate-related stress resulting in new or novel assemblages. A complex set of factors will influence how ecosystems and species will actually respond over time. The results are summarised as follows for sour bushveld, forestry and grassland ecosystems. However, it is evident that the grassland biome is most at risk of significant change. Areas with a climate envelope suitable for grassland are projected to be greatly reduced and persistent only in areas of high altitude such as the western mountain peaks. The results also indicate that bioclimatic zones suitable for the country's grassland and Lebombo bushveld ecosystems could be reduced by up to 90% and 50% of their current coverage whilst the Lowveld will likely persist and the Sour bushveld ecosystems will shift westwards. These changes are projected to result in increased risks of range reduction or extinction for species with low reproductive capacity or smaller geographic range.

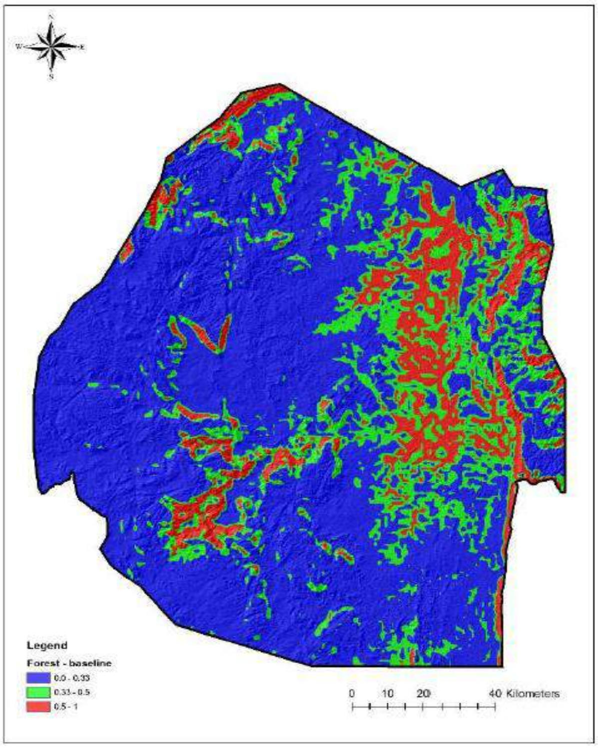
Sour Bushveld: Baseline conditions



Sour Bushveld: Projected Change (1950)



Forestry: Baseline conditions



Forestry: Projected change (1950)

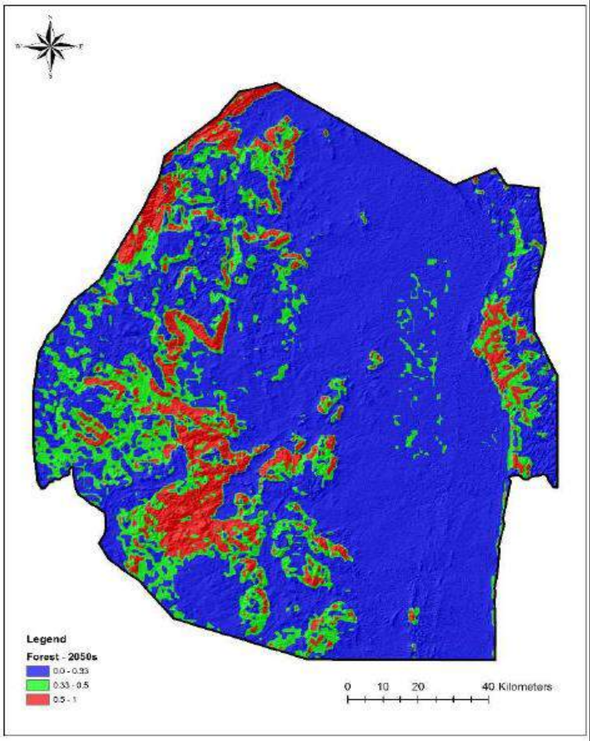
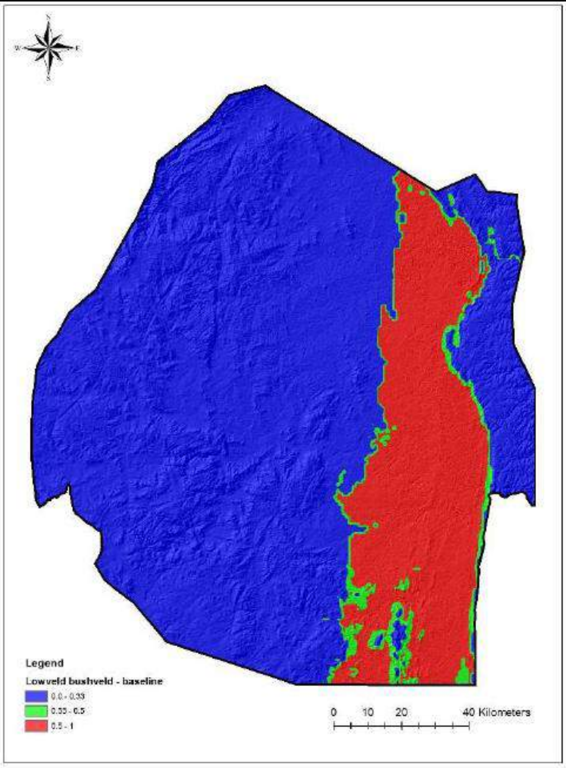
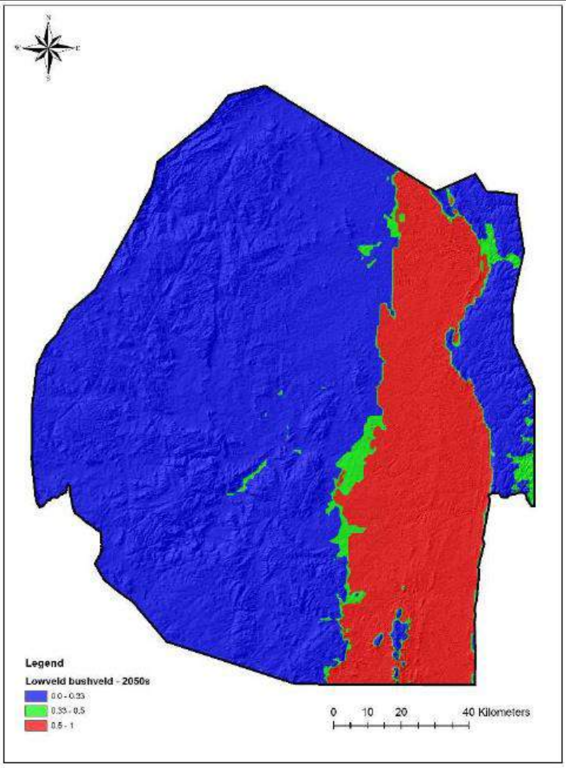


Figure 4-9: Sour Bushveld and Forestry Occurrence Probability under Baseline and in the 1950s

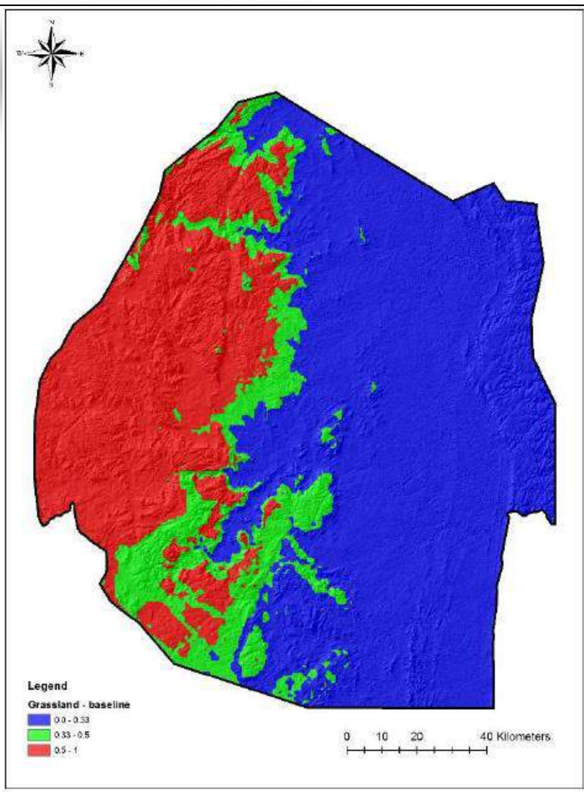
Lowveld bushveld: Baseline conditions



Lowveld Bushveld: Projections (1950)



Grassland: baseline conditions



Grassland: Projections (1950)

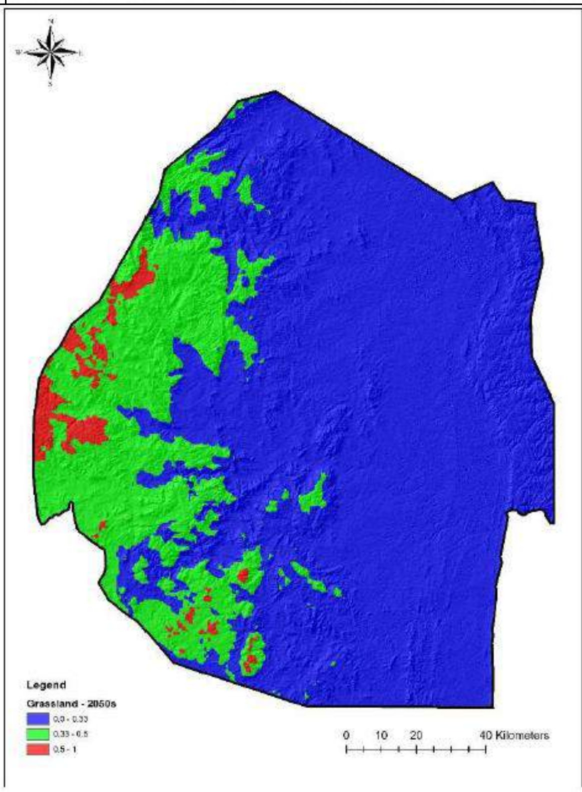


Figure 4-10: Lowveld Bushland and Grassland Baseline Conditions and Projections

Various animal species are also at risk of climate change impacts. The status and trends of bird populations are particularly powerful indicators of the health of our planet. The potential climate impacts on 487 of Swaziland's bird species were therefore modelled in order to gain a preliminary understanding of the potential range shifts of different populations of highly mobile individuals. Generally, the projections for Swaziland indicate a relatively lower risk for significant bird range shifts that result in species losses as a result of climate change (temperature and rainfall) alone. A high potential rate of species richness loss is projected in the central interior and the Lebombo bushveld, especially parts of the Lubombo Transfrontier Conservation Area. The following table illustrates the possible changes in status for current threatened birds in Swaziland.

Table 4.3: Possible changes in status for current threatened birds in Swaziland

Scientific name	Change in bioclimatic envelope/habitat	Current status	Possible new status (only due to climate change)
Hirundo atrocaerulea	Decrease	Critically Endangered	Critically Endangered/Extinct
Ephippiorhynchus senegalensis	Increase	Endangered	Endangered
Sagittarius serpentarius	Decrease	Endangered	Critically Endangered
Torgos tracheliotus	Increase	Endangered	Endangered
Trigonoceps occipitalis	Increase	Endangered	Endangered
Aquila rapax	Increase	Endangered	Endangered
Hieraaetus fasciatus	Increase	Endangered	Endangered
Terathopius ecaudatus	Increase	Endangered	Endangered
Turnix hottentotta	No change	Endangered	Endangered
Sarothrura affinis	Decline	Endangered	Critically Endangered
Neotis denhami	Increase	Endangered	Endangered
Tyto capensis	No change	Endangered	Endangered
Bucorvus leadbeateri	Increase	Endangered	Endangered
Gorsachius leuconotus	No change	Vulnerable	Vulnerable
Ciconia nigra	Increase	Vulnerable	Vulnerable
Leptoptilos crumeniferus	Increase	Vulnerable	Vulnerable
Geronticus calvus	Decrease	Vulnerable	Critically Endangered
Aquila verreauxii	Increase	Vulnerable	Vulnerable
Polemaetus bellicosus	Increase	Vulnerable	Vulnerable
Stephanoaetus coronatus	Increase	Vulnerable	Vulnerable
Circus ranivorus	Decrease	Vulnerable	Vulnerable
Podica senegalensis	No change	Vulnerable	Vulnerable
Eupodotis cafra	Decrease	Vulnerable	Critically Endangered
Glaucidium capense	No change	Vulnerable	Vulnerable
Smithornis capensis	No change	Vulnerable	Vulnerable
Lioptilus nigricapillus	Decrease	Vulnerable	Endangered
Turdus gurneyi	Decrease	Vulnerable	Endangered

Similarly, models were developed for 695 indigenous tree species to represent the country's flora. Plants are primary producers and hence very important ecosystem function and biodiversity determinants in general. The studies found that more than two thirds of the threatened tree species will experience a decrease in their bioclimatic envelope whilst the rest will experience expansions especially to the west as the temperatures rise uphill. The following table illustrates the possible changes in status for current threatened trees in Swaziland.

Table 4.4: Possible changes in status for current threatened trees in Swaziland

Scientific name	Change in bioclimatic envelope /habitat	Status	Possible new status (only due to climate change)
Celtis mildbraedii	Decrease	Critically Endangered	Extinction
Encephalartos heenanii	Slight decrease	Critically Endangered	Critically Endangered
Encephalartos laevifolius	Slight decrease	Critically Endangered	Critically Endangered
Encephalartos umbeluziensis	Increase	Critically Endangered	Critically Endangered
Euphorbia keithii	Decrease	Critically Endangered	Extinction
Excoecaria madagascariensis	Decrease	Critically Endangered	Extinction
Gardenia thunbergia	Decrease	Critically Endangered	Extinction
Ocotea kenyensis	Slight decrease	Critically Endangered	Critically Endangered
Warburgia salutaris	Slight decrease	Critically Endangered	Critically Endangered
Celtis gomphophylla	Decrease	Endangered	Critically Endangered
Encephalartos aplanatus	Slight decrease	Endangered	Endangered
Ficus sansibarica subsp. sansibarica	Increase	Endangered	Endangered
Lannea antiscorbutica	Increase	Endangered	Endangered
Oxyanthus pyriformis subsp. pyriformis	Decrease	Endangered	Critically Endangered
Protea comptonii	Slight increase	Endangered	Endangered
Prunus africana	Decrease	Endangered	Critically Endangered
Encephalartos paucidentatus	No change	Vulnerable	Vulnerable
Encephalartos senticosus	No change	Vulnerable	Vulnerable
Ficus polita subsp. polita	Slight decrease	Vulnerable	Endangered

Climate change is also expected to have severe impact on certain species of plants. In some cases selected species will be driven to local extinction. Species most vulnerable to extinction are those with small populations, slow rates of dispersal, restrictive elevation, climatic requirements and/ or those hose habitat is limited or fragmented. The tree species *Celtis mildbraedii*, *Euphorbia keithii, Excoecaria madagascariensi*s and *Gardenia thunbergi*a are projected to go extinct during the 2050s as a result of climate change as their bioclimatic envelope is completely changed in the country.

Figure 4-11: ***Celtis mildbraedii*, *Euphorbia keithii*, *Excoecaria madagascariensis* and *Gardenia thunbergia*.**

With regards to the invasive plant species, climate change potentially provides a better bioclimatic envelope as 10 of the species (two thirds) will either shift westwards or their bioclimatic envelop will increase in some other way (see table below). Only those species adapted to cold climates and the grassland ecosystem such as *Rubus spp*., *Acacia mearnsii, Pinus spp*. and *Eucalyptus spp*. will be experience shrinkages in their bioclimatic envelope. Chromolaena odorata is poised to spread throughout most of the country by the 2050s save for a few patches of frosty mountain peaks in the west (Figure 22). The bioclimatic envelope of *Lantana camara*, on the other hand, will generally shrink although there is a likelihood for further incursion westwards mainly along river courses. This highlights the need to control these two problematic species as early as possible before the costs of control increase to unmanageable levels.

Scientific name	Common name	Change in bioclimatic envelope/habitat
Acacia mearnsii	Black wattle	Decrease
Ceasalpinia decapetala	Mauritius thorn	Increase
Cereus jamacaru	Queen of the night	Decrease
Chromolaena odorata	Triffid weed	Increase
***Eucalyptus* spp.**	Eucalyptus	Increase
Jacaranda mimosifolia	Jacaranda	Decrease
Lantana camara	Lantana	Increase
Melia azedarach	Syringa	Increase
***Opuntia* spp.**	Sweet prickle pear	Increase
***Pinus* spp.**	Pine	Decrease
Populus alba	Poplar	Decrease
Psidium guajava	Guava	Increase
***Rubus* spp.**	Bramble	Slight decrease
Senna didymobotrya	Peanut cassia	Increase
Sesbania punicea	Brazilian glory pea	Increase
Solanum mauritianum	Bugweed	Increase

Table 4.5: Changes in Bioclimatic Envelope for Selected Invasive Plant Species

4.4.3 Adaptation measures

Swaziland has an overall commitment to implement environmentally-sound policies and practices for sustainable development as defined in its environment action plan (Swaziland Environmental Action Plan (SEAP), 1997) and its long-term development strategy (National Development

Strategy (NDS), 1999). To this end, the country is taking action on several fronts to ensure adaptation in Biodiversity and ecosystems. For instance, as part of the review of the NDS, the Swaziland National Trust Commission (SNTC) and the Ministry of Tourism and Environmental Affairs have set a target of protecting 10% of the country's ecosystems thereby providing the political impetus for ensuring the protection of the country's biodiversity.

There is much uncertainty about how individual species and ecosystems will respond to the combined impacts of continued climate changes and other pressures on biodiversity. However there is a range of adaptation actions that can help reduce projected impacts. The National Biodiversity Strategy and Action Plan (NBSAP) identify the need to minimize the potential impacts of human induced climate change on biodiversity. In addition to this the Protection Worthy Areas (PWA) survey and the Biodiversity Conservation and Participatory Development (BCPD) project specified the certain targets for biodiversity conservation including protected area management.

The appropriate and specific types of local action required would need to be further defined in ecosystem specific adaptation plans. The figure below highlights the priority areas for adaptation taking into account both species (birds and trees) and ecosystem vulnerability. High value areas indicate areas for immediate adaptation actions. In addition to the currently protected areas, priority should therefore be given to the high value areas for additional protection through protected areas and alien plant management in addition to sustainable land management practices.

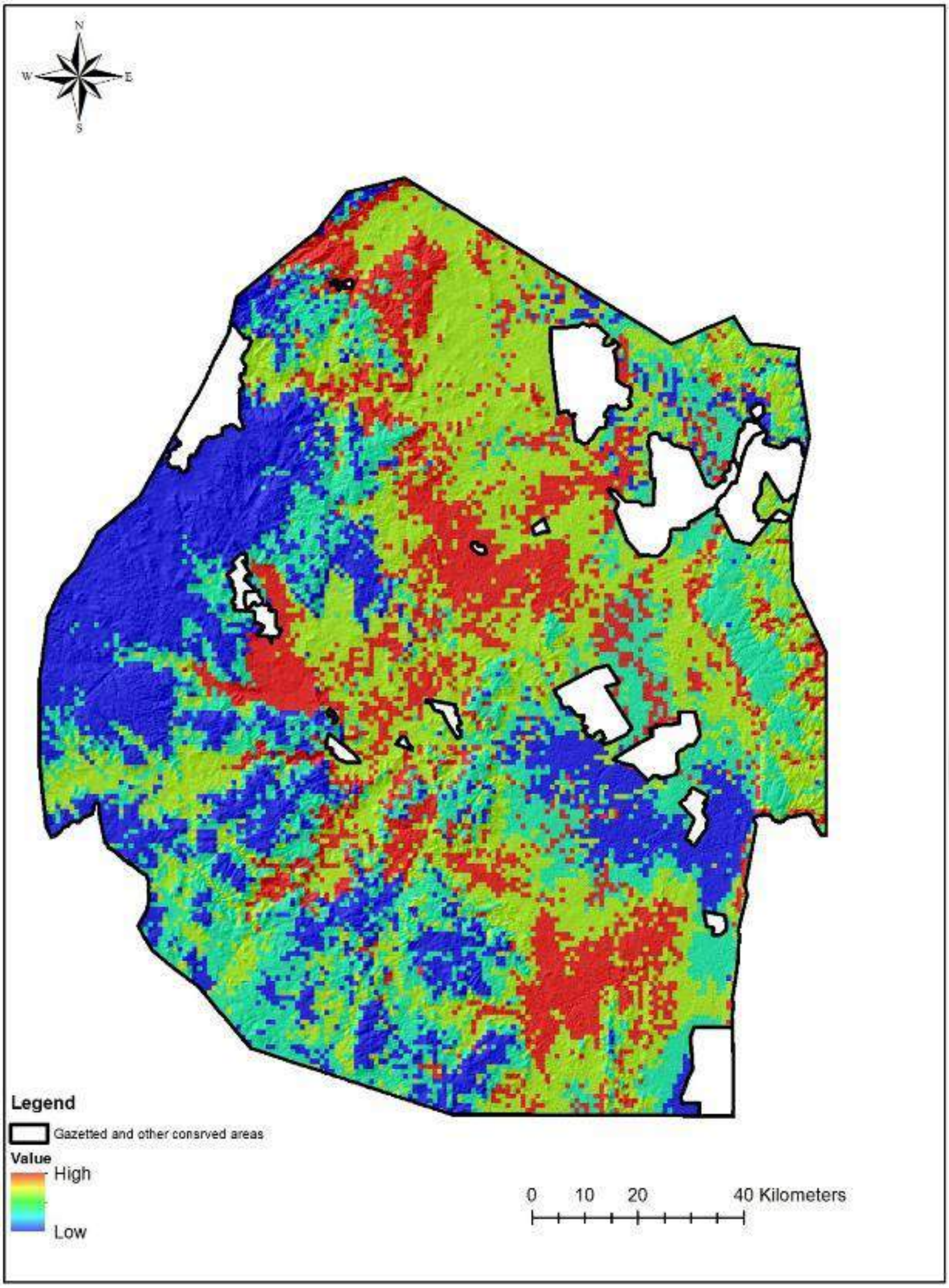


Figure 4-12: Adaptation Priority Areas

The following strategic adaptation actions are proposed for the biodiversity and ecosystem sector;

- Expand protected area and conserve areas for connectivity. Biodiversity conservation should be focused on connecting habitats to facilitate migration of species and support intact ecosystems over time despite changes in climate.
- Put more focus and action on ecosystem restoration and management.
- Act on watershed connectivity restoration and protection of riparian buffers. Restoring connectivity that has been affected by dams and culverts will increase resilience of aquatic organisms and their habitats.
- Design and implement ex situ conservation measures. These ex situ conservation approaches can provide backup for populations and species most at risk from climate change and other pressures.
- Implement programmes to manage invasive species. Such species are best controlled by coordinated national and regional action that identifies the most important threats and areas at greatest risk, provides best management practices and engages in advocacy on the issue.
- Implement comprehensive land use planning. Working together, government agencies, planning agencies and other stakeholders on planning for multiple aspects of climate adaptation. The other solution is to promote the incorporation of ecosystem services into human mitigation and adaptation efforts.
- Increase and establish a diverse funding base. Funding can provide incentives for changing the ways humans interact with the environment.
- Invest in more research and monitoring. Research should be undertaken in order to understand the regional nature, impacts and nature of vulnerability to climate change and options for adaptation. It must also be used to create new knowledge that will allow for adaptive management of species and habitats and enable the country to change how and where it takes action.
- Address capacity deficits and promote advocacy campaign issues. Providing data and recommendations for action to diverse groups will be critical for success.

It is imperative that also the country as it develop its national adaptation plan, it looks in the opportunities of integrating ecosystem based adaptation. Healthy, well-functioning ecosystems enhance natural resilience to the adverse impacts of climate change and reduce the vulnerability of people. Ecosystem-based management offers a valuable yet under-utilized approach for climate change adaptation, complementing traditional actions

4.5 Health

Like its sister countries within the Southern African Development Community (SADC), Swaziland is faced with a burden of disease resulting from emerging infectious diseases (e.g. HIV/AIDS), old infectious diseases (e.g. tuberculosis), chronic diseases (e.g. asthma, chronic obstructive pulmonary disease (COPD), hypertension, ischemic heart disease and diabetes) intentional and unintentional injury (SEAD, 2010).

Communicable diseases continue to be a major challenge for the country. According to Health Statistics Reports, respiratory conditions account for about a quarter of all outpatient visits, from 26.6% in 2002 to 23.1% in 2010. Tuberculosis has also become a very serious public health concern for the country, particularly given the high rates of HIV/TB co-infection. Malaria is endemic in selected parts of the country and is generally well managed. An analysis of the overall disease trend indicates that there has been a significant reduction in the burden of disease in the last 5 - 6 malaria transmission seasons. Between 2002 and 2007, Malaria incidence declined from 49.5 to 18 cases per 1000 of the population at risk. With this progress, Swaziland has already exceeded the MDG on malaria and Roll Back Malaria's Abuja targets

3.1 Vulnerabilities

Human health which is already compromised by a range of factors is further negatively impacted by climate change and climate variability. The health sector is a cross-cutting sector that is dependent on the climate resilience of the agriculture, water, and biodiversity and ecosystems sectors. For example, as highlighted in the 2011 – 2015 United Nations Development Assistance Framework, hunger and malnutrition, which are prevalent in Swaziland, are a direct consequence of food insecurity. It is estimated that a quarter of the population is food insecure and dependent on assistance, and 39 percent of children under five are stunted, which is above the WHO thresholds. With changes in climate impacting on agricultural production, food insecurity is heightened. This is forcing most vulnerable households to depend on cash purchases to access food. Given the high poverty prevalence rates, many poor people cannot access adequate food and nutrition by means of cash purchase, hence undermining nutrition.

Poor access to safe water has also been said to undermine human health. As changes in climate impact fresh water availability, human health continues to be compromised. Observed health consequences in Swaziland due to water scarcity include diarrhoeal diseases such as cholera, typhoid fever, salmonellosis, other gastrointestinal viruses, and dysentery. The link between climate change and health has been most noticeable in cases where extreme weather events such as heat waves, floods, droughts and storms, have been crucial factors. Extreme events such as floods and storms also affect people's access to health care services. In the past most often storms destroy most rural clinics in the country causing a shutdown of the clinics, and in many cases river flodding makes access to clinics and hospitals impossible. Summarized in tables below are reported observed climate related health impacts.

CAUSES OF MORTALITY IN THE COUNTRY	ASSOCIATION TO CLIMATIC FACTORS
Outbreaks of diarrhoeal diseases e.g. cholera and rotavirus	Drought, poor water quality, floods
HIV/AIDS and related illnesses	Indirect association Food insecurity as a result of recurring droughts. Patients on anti-retroviral drugs discontinue taking drugs in the absence of food.
TB	Indirect association Compromised immune system due to malnutrition - linked to food insecurity resulting from droughts
Death and injuries	Lightning, Floods (people drowning in rivers) and storms
Malaria	Increase in temperatures and encroachment of affected areas into new areas

Table 4.6 Key infectious diseases and their association with climatic events

KEY INFECTIOUS DISEASES	ASSOCIATION TO CLIMATIC FACTORS
Malaria	Encroachment of high temperature regions which result in increase in vector-borne diseases
TB, HIV/AIDS	Increase in temperature results in suppression of the immune system resulting in infections caused by opportunistic infections. Vulnerability of HIV infected individuals due decrease in crop production resulting in loss of resources and food insecurity
Diarrheal diseases waterborne diseases e. g Typhoid Cholera E. coli	Water scarcity resulting in poor sanitation has can result in the increase in waterborne diseases The human health impact of poor water quality is reflected in the incidences of diarrhoea. Out- patient records show the prevalence of four common ailments affecting Swaziland diarrhoea accounted for 84.4% of all out-patients cases. Many of the major diseases transmitted by water and by insect vectors are highly sensitive to climatic conditions and weather extremes. Climate change threatens to slow, halt or reverse current progress against many of these infections.2 Incoming floods from neighboring countries

Table 5.3: Observed climatic events and health related impacts

CLIMATIC EVENT OBSERVED	OBSERVED HEALTH RELATED IMPACTS
Heat waves	Skin diseases e.g. skin rashes, acne, Heat strokes , Dehydration,
Change in air quality due to climate change	Respiratory diseases e.g. Pneumonia , Bronchitis, TB Respiratory symptoms can include: (1) coughing, (2) throat irritation, (3) pain, burning, or discomfort in the chest when taking a deep breath, and (4) chest tightness, wheezing, or shortness of breath.
Increase temperature and humidity	Associated with vector borne diseases like malaria
Direct and indirect effects on health	Adverse climate induced changes increase the vulnerability of Swaziland and contribute to the national burden of diseases and health care management.
Floods	These occur mostly every year and this year extreme floods resulted in river bursting and destroying bridges many people drowned in rivers. The numbers are not well documented.
Lightning	Many people and cattle die others injured every year in the country due to lightning. On Average 15.5 people die every year due to lightning mainly occurring in the Highveld where there is a high incidence of thunderstorm occurrences every year.
Drought	Drought conditions may increase the environmental exposure to a broad set of health hazards including wildfires, dust storms, and extreme heat events, flash flooding, degraded water quality, and reduced water quantity.
Cyclone (Domonia)	Many people dies, after there was cholera and diarrhea outbreak
Storms	Property destroyed, people trapped and injured and others died (the numbers are not well documented) Crops and livestock destroyed

4.5.1 Future impacts on health

As the effects of climate change begin to worsen, so temperatures continue to rise with a higher chance of heat waves. Recurring extreme weather events such as floods and droughts will continue to impact negatively, drastically reducing crop yields and food availability. This will continue to threaten the population's nutritional health status, increasing incidence of malnutrition and exposure to hostile physical environments (e.g. destruction of shelter) that could lead to disease. Access to health facilities in Swaziland will continue to be heavily impacted as climate change transforms access to these facilities and services. The stability of supply of medicines like ARVs may be affected, as supply is closely linked to the conditions of the national infrastructure, considering Swaziland's rugged terrain. This includes roads, railways, cargo transfer and the need in some cases to transport supplies over long distances. Roads and storage facilities suffer under increasing weather events. This situation is likely to continue going into the future (Government of Swaziland, 2015b).

Another future threat is the possible increase of vector borne diseases in some areas of the country as a result of recurring extreme weather events. These diseases include Malaria and various types of viral Encephalitis, Schistosomiasis, Leishmaniasis, Lyme disease and Onchocerciasis. Even though the IPCC report speaks about uncertainty in terms of the 'the decrease or increase of the range and transmission potential of Malaria in Africa' (IPCC WGII 2007:9), McMichael et al. (2006: 865) reviewed a number of studies 'that have modelled seasonal changes in transmission [and] researchers estimate a substantial extension - such as a 16-28% increase in person-months of exposure to Malaria in Africa by 2100. The effect of climate change on the HIV & AIDS virus is not sufficiently researched and assumptions are very vague. Brown and Funk (2008: 581) see the virus to be likely to 'become more severe and widespread with warming temperatures', but there is no evidence in the literature about this view.

Anticipated high temperatures and the resultant heat waves will negatively impact on poor communities in Swaziland. The elderly and the young in both urban and rural are going to be affected negatively. This is because socio-economic factors may affect exposure to heat as determined by building types and places of residence but also have an important effect on individual sensitivity. The poor will be negatively affected, in particular women who have to spend hours on outdoor chores such as fetching water, gathering wood and working in the fields. Rural populations will also be hard hit more than the more affluent urban populations who may afford air-conditioning. Those with no access to cooling or better-insulated housing or those who work outdoors will not have any reduced vulnerability.

People living with medical conditions (high HIV & AIDS related conditions in Swaziland) will be negatively affected by climate change impacts. For instance, a robust cardiovascular system is essential for maintaining a normal body temperature during heat stress (Rowell, 1983). While cardiovascular failure is a prevalent cause of death during heat waves, any chronic medical condition must be considered a potential risk factor for heat wave-related illness and death, as demonstrated recurrently in epidemiological studies in Europe and North America (Kilbourne, 1999; Semenza et al., 1999; Hemon and Jougla, 2004; Michelozzi et al., 2005).

People with pre-existing respiratory diseases, which are a significant health burden in Swaziland will also be at higher risks but the extent of the effect remains unclear (Ayres et al., 2009). Heat may produce an exacerbation of symptoms among people with asthma, rhinosinusitis, chronic obstructive pulmonary disease (COPD) and respiratory tract infections. Acute respiratory episodes are associated with airway and systemic inflammation as well as cardiovascular co-morbidity and may be triggered by exposure to heat (Michelozzi et al., 2009).

4.5.2 *Adaptation Measures*

Adaptation in the health sector is taking place at different levels in society: national, regional and local. Swaziland is building institutions that provide the impetus for adaptation. Essential public health services exist and these provide an anchor to adaptation actions being implemented. The Ministry of Health continues to strengthen its preventive services. Although at times conceptualised and designed outside the climate change adaptation contexts, key actions within the health sector that are contributing to national climate change adaptation include the following:

- Surveillance (Improved risk-indicator and disease surveillance specific to known climate change related risks and diseases such as Malaria and HIV & AIDS).
- Disaster preparedness (INGC 2009).
- Disaster preparedness and inter-sectoral capacity to deal with the aftermath climate change related extreme weather events.
- Early-alert systems for impending extreme weather events.
- Enhanced infectious disease control programmes (vaccines, vector control, case detection and treatment). Community-based neighbourhood support/watch schemes (e.g. for elderly, children). For instance, each Health centre even in rural areas has a community health committee as part of the working arrangements for the specific institution. These are important mechanisms for mobilising community partnerships and actions to identify and solve health problems.
- Awareness raising: Inform, educate and empower the public, policymakers and other stakeholders about health risks of climate change

Way forward – adaptation

- Build capacity and other institutional and systemic shortcomings that include the health system's severe human resources constraints.
- Strengthen research and (local, regional and international) knowledge generation on climate change and health impacts relative to Swaziland.
- Promote institutional development and inter-sectoral collaboration and cooperation.
- Adopt an inter-sectoral and integrated approach, and improve information collection, management and sharing.
- Increase the focus on women and children. Because of their socio-economic weaknesses women and children's health status will be relatively more vulnerable to climate change. This is especially because children, (pregnant) women and the elderly are more vulnerable to infectious diseases, malnutrition, heat-related illnesses, water insecurity, extreme events, effects of air pollution and injury (Balbus 2009; Kistin 2010; Luber 2008; Ramin 2009; Shea 2007).
- Mainstream climate change adaptation into the national health planning processes. Health adaptation processes and planning should be embedded within existing national health processes, rather than as an independent process.

Develop and design a Heat-Health Warning System (HHWS). Strengthen and institutionalize the country's Heat Health Warning Systems (HHWSs). HHWSs are an important adaptation strategy and help in providing information that helps households deal with the negative impacts of extreme heat.

The link between food security and health has a direct impact on the Swazi population. Food impacts on human health and the physical conditions of humans. Swaziland is exposed to declining maize production due to variable rainfall patterns, which negatively impacts food security. In addition declining maize production also affects unemployment and poverty, which relate to food security. Adapting to climate change is therefore crucial to the nation's future sustainability.

4.1 Water

Swaziland is a water scarce country. Surface water (rivers and reservoirs), ground water and atmospheric moisture make up the country's main sources of water. Natural water sources are therefore totally reliant on rainfall to feed ephemeral rivers and recharge aquifers. Swaziland has five main river systems, namely: Lomati, Nkomati, Mbuluzi, Usuthu, and Ngwavuma. It is important to note that all rivers in Swaziland are international and therefore, the development of surface water resources must be undertaken in collaboration with the other riparian states (South Africa and Mozambique).

The average annual runoff for all rivers in Swaziland is estimated to be 2.6 billion m3/year representing 18% of total annual rainfall. The seasonal nature of rainfall within the country renders surface water discharge extremely variable. The total renewable water resources of the country are 4.51 km3/year, with 1.87 km3/year or 42 percent originating from South Africa. With regards to groundwater, while no quantitative assessments have been carried out, the potential of groundwater is thought to be limited. The bulk of the groundwater resources is said to occur in the Highveld and Middleveld regions. In the Lowveld region groundwater quality is poor due to high salinity.Water scarcity is further exacerbated by insufficient storage facilities, inefficient water usage and degradation of the water resources, which in turn affect water quality. Intra-national competition for the limited water resources by different users from Mozambique and South Africa also adds constrain on the water resources.

WATER USE		CURRENT AND FUTURE TRENDS
Irrigation		Presently uses 95% of all the water consumption in the country. Sugar cane is by far the dominant irrigated crop in the country, and then comes citrus and vegetables. This is expected to increase due to agriculture expansion initiatives.
Livestock		The water demand of this sector is expected to stay relatively constant, as the number of livestock is limited by the carrying capacity
Domestic	Rural	This sector is relatively small (0.9%) and is not expected to increase substantially, as the increasing numbers will be absorbed by urban growth. Rivers and unprotected wells are the main sources of household water in the rural areas making them more vulnerable to climate change
	Urban	Presently uses about 1.4%, but the demand will almost double by 2030, due to the high rate of urbanization, and rising income levels.
Industry		This sector uses about 1.2% and is expected to grow dues to forecasted industrial development.

Table 4.7: Main water consumers in Swaziland

4.1.1 Water Demand

Water demand is projected to increase significantly over the next 35 years, adding up to deficits that are projected to get increasingly larger in the future. Demand increases are projected of up to 28 percent by 2050 overall leading to increasing deficits, which will be worsened by climate change. It is also worth noting that the estimated deficits are average annual totals, but given seasonal variations, deficits may become more pronounced at certain times of the year. Table below show the water demand, supply and deficit figures for three major basins in the country with and without climate change.

Usuthu

	Demand (Mm3)	Supply (Mm3)	Deficit (Mm3)	Percent change	Supply with climate change (Mm3)	Deficit including climate change (Mm3)	Percent change relative to no climate change
2010	505	484	21	-4.2%			
2025	724	680	44	-6.1%	522	202	-28%
2050	729	684	45	-6.2%	528	201	-28%

Komati

	Demand (Mm3)	Supply (Mm3)	Deficit (Mm3)	Percent change	Supply with climate change (Mm3)	Deficit including climate change (Mm3)	Percent change relative to no climate change
2010	287	278	9	-3.1%			
2025	337	315	22	-6.5%	305	32	-9%
2050	384	334	50	-13%	319	65	-17%

Mbuluzi

	Demand (Mm3)	Supply (Mm3)	Deficit (Mm3)	Percent change	Supply with climate change (Mm3)	Deficit including climate change (Mm3)	Percent change relative to no climate change
2010	258	257	1	-0.4%			
2025	306	286	20	-6.5%	274	32	-10%
2050	349	307	42	-12%	288	61	-17%

Figure 4-13: Water Demand and Supply for Three Major Basins

Observed impacts and vulnerabilities generally Swaziland is a water scarce country with a highly variable climate. The water scarcity problem is further compounded by the high temperatures especially during summer months. Recently experienced drought years include 1991/1992, 1994/1995, 2001/2002 and 2007, all which have impacted the water sector. The observed climate variability in Swaziland, as part of the southern Africa region, over the recent past includes up to a 50% decline in rainfall during the months of September and October; and an increased inter-annual variability of rainfall in the post-1970 period, with higher rainfall anomalies and more intense and widespread droughts.

Based on past and current exposure to extreme climatic events, negative impacts on Swaziland's water resources have been observed with high levels of both water stress and scarcity. Results based on previous vulnerability assessments for Swaziland's major river basins (Komati, Mbuluzi and Usuthu) revealed wide-ranging impacts of climate change on water resources (availability, accessibility and demand). The river basins are known to be home to the majority of Swaziland's population therefore exposure of the country's population to increased water stress can be expected. These river basins are also fundamental to the socio-economic development of the country as they support agricultural and hydro-electric sectors. Managing these rivers appropriately in the face of climate change risks is therefore very critical.

Consecutive years of drought have continued to put stress on Swaziland's water sector resulting in a series of impacts and vulnerabilities. In 2007 and 2015/2016 Swaziland experienced one of its experienced one of its worst and longest drought leading the Government to declare a national disaster. Assessments conducted in the country revealed that the nation struggled to cope with one of the longest dry period in the country's history. About 410,000 people required varying levels of humanitarian assistance including food, agricultural inputs, water and sanitation, health and nutrition services, as well as early livelihood recovery. The country's rivers and dams were at record low levels resulting in water rationing country wide.

Some key challenges that continue to be experienced within the water sector and their association to climatic factors were identified. These are highlighted in table 6.1 below. Highlighted in table 6.1 are observed climatic events in Swaziland and their impact on water resources. Hydroelectric power generation in the country is also vulnerable to the effects of climate change. The *Swaziland Drought Assessment Report* (Government of Swaziland, 2016b) reports all hydropower generation in the country has been suspended due to the current drought, requiring the national utility to import 100% of its electricity needs to meet local demand. The country will only be able to resume hydropower generation once the levels of water in the respective dams improve sufficiently in the next wet season (October 2016 – March 2017).

MAJOR CHALLENGES WITHIN THE WATER SECTOR	ASSOCIATION TO CLIMATIC FACTORS
Decrease in ground water flows	Reduction in rainfall
Drying of small streams	Reduction in rainfall and extended drought
Decrease in ground water reserves therefore resulting in more dry boreholes	Intensity of rainfall in short space of time Lack of rainfall for the rest of the year
Decrease in water storage	Due to high intensity of rainfall in short space of time Inadequate management of springs , marshes , and wetlands as sources of water compromising their ability to filter and store water
Increase in water demand	Shortage of rainfall which has resulted in lower levels of water in dams and siltation Irrigation is the major user of water in the country and accounts for 96.6% of available supply. Irrigation is extensively used for growing sugarcane, citrus fruits, and vegetables. Due to climatic variables, most of the irrigation activities are located in the Lowveld region which also receives the lowest rainfall
Ground water recharge and quality	Decrease in rainfall and drought Groundwater recharge in the most critical areas of Swaziland is estimated at 2% in the Lowveld and 5% of annual rainfall in the Lubombo, however elsewhere going up to 20%. There is an increase in demand and use of the groundwater resources by communities in the rural and peri-urban areas.
Change in river morphology(fluvial geomorphology)	Flooding , Siltation ,drought Aquatic ecosystems are regulated by features and processes occurring at a range of spatial scales. At the largest scale, climate, geomorphology, and land use control channel morphology and stream hydrology, thermal regime and water chemistry, and biotic community structure. Climatic changes influence anthropogenic activities causing environmental disturbances which result in : changes in the stream flow regime through dams or diversions non-point source runoff from agriculture, urban or mining areas alteration of channel characteristics via sedimentation or siltation removal of riparian zone vegetation introduction of exotic or alien species
Decrease water quality	Flooding and Siltation
Decreases in runoff and stream flow	Drought
Interference of water run-off and use of high volumes of water	Expansion of alien invasive species and bush encroachment

Table 4.8: Key Challenges within the Water Sector and the Association to Climatic Factors

Climatic event observed	Water resource Affected	Impact on water resource
Drought	Boreholes	Ground water depletion.
	Rivers	Decrease in water levels in big perennial rivers Many seasonal rivers and small perennial have dried up Reduced stream flow affecting water supply and quality
	Water reservoirs	Decreases in runoff and stream flow
Floods	Mnjoli Dam	The dam bust - Increasing risk of flooding due to changes in river bank protection
	Rivers	Flooded rivers the erosion of soil and other pollutants that accumulate on the surface of the catchment. Affects sanitation through blockage of sewage Damage to bulk water infrastructure (dams), irrigation systems
High temperatures	Surface waters	Increased evaporation

Table 4.9: Observed Climatic Events and Impact on the Water Resources

4.1.2 Future impacts on water

Overall, a warmer and drier climate, with drier winters and wetter summers, coupled with the risk of more frequent and intense floods and droughts, is predicted for Swaziland. Projections based on the GCM simulations predict an increase in temperature and a decrease in precipitation. An increase in temperature is expected to be between 2.0° and 2.5°C with a reduction in precipitation of about 200 millimetres. This will negatively affect stream flows and recharge rates, with large seasonal variations and therefore have significant impacts on the quality and quantity of water in the country. As a result, hydro-electric power generation, agricultural production and sanitation will likely be directly affected with adverse consequences for food security, livelihoods, health and the country's overall economy.

Overall though, there is likely to be a decrease in the annual run-off volumes across all the sub-catchments for the dry and wet year scenarios. Together with demand projections, results indicate that the Komati, Usuthu and Mbuluzi catchments will face significant water stress under climate change.

The most prevalent and future threats and priorities identified for adaptive water management across Swaziland's river basins include drought, floods, rising surface temperatures and changing rainfall patterns. Droughts and floods are sources of shock on water resources including infrastructure, whereas periodic shifts in seasons and mid-season dry spells are sources of stress. In this context it should be noted that the risk of mid-season dry spells and periodic shifts in seasons could not be assessed due to the lack of daily data for Swaziland. Table 4.11 summarizes the risk of severe drought (SPI < 2.0) and severe floods (SPI > 2.0) occurring in each of the four river basins. The risks are quantified by counting the number of events with SPI below (drought) or above (floods) the stated thresholds over the period 1901 to 2010.

River Basin	Average annual rainfall	Severe drought risk	Severe flood risk	Future projections (2050)
Komati	1290	20%	12%	Frequency likely to increase
Mbuluzi	1300-700	13%	14%	Frequency likely to increase
Usuthu	1500-500	16%	12%	Frequency likely to increase
Ngwavuma	800-500	17%	18%	Frequency likely to increase

Table 4.10: Risk of Severe Drought and Floods in the Different River Basins

Table 4.12 shows the observed trends in rainfall and temperature across the four river basins over the period 1901 to 2009, and the projected changes in the same parameters by the 2050s. Observed climatic data clearly shows evidence of warming across all the four river basins. The warming ranges from about 1°C in the Mbuluzi and Ngwavuma River Basins to 1.5°C in the Komati and Usuthu River Basins. Observed rainfall does not show any definite trend but exhibits high inter-annual variability which has important implications for water resources management.

River Basin	Observed temperature (1901-2009)	Observed rainfall trend (1901-2009)	Future projected temperature change (2050)	Future projected rainfall change (2050)
Komati	+1.5ºC	-higher inter-annual variability - No definitive trend in annual rainfall	+1.5 to +3.5ºC	High uncertainty – with 10 -15% decrease by some models and 5-10 increase by other models
Mbuluzi	+1ºC	-higher inter-annual variability - No definitive trend	+1.5 to +3.5ºC	High uncertainty – with 10 -15% decrease by some models and 5-10 increase by other models
Usuthu	+1.5ºC	-higher inter-annual variability - No definitive trend		High uncertainty – with 10 -15% decrease by some models and 5-10 increase by other models
Ngwavuma	+1ºC	-higher inter-annual variability - No definitive trend	+1.0 to 3.0ºC	High uncertainty – with 10 -15% decrease by some models and 5-10 increase by other models

Table 4.11: Observed Trends in Rainfall and Temperature in the Different River Basins

A general feature of future climate change projections is the consensus for Swaziland across all models showing significant warming of mean annual temperatures in all the river basins ranging from about 1 to 3.5°C by the 2050s. Models run on the Ngwavuma basin suggest that Ngwavuma River Basin will warm at a slightly reduced rate compared to the other river basins, possibly because of the modulating effects of the Indian Ocean. Envelopes of downscaled rainfall typically show a large spread across the models as rainfall is very sensitive to the regional synoptic systems that the models simulate. However, the general message is that total annual rainfall amounts are likely to change little.

Together with demand projections, results indicate that the Komati, Usuthu and Mbuluzi catchments will face significant water stress under climate change. The impacts of the predicted seasonal changes in flow magnitudes (i.e. reduced flows in winter and increased flows in summer) are likely to make the joint management of water resources in the trans-boundary context (with Mozambique and South Africa) increasingly complex. The impacts of climate change are likely to be starker in the Lowveld of Swaziland. Over the years, the region has been getting warmer and drier. With climate change, there will be a risk of increased frequency and intensity of droughts, and many small rivers and streams such as the Lugulo will continue to dry up, negatively impacting the quality of life of the communities that rely on them.

All catchments are projected to increase in water stress which is likely to be caused by projected decrease in annual precipitation and increasing evaporation due to rising temperatures related to climate change, as well as growing water demand. The water stress index was estimated for the current and future projection to identify which sub catchments will suffer water stress in the future. The water stress index is defined as the ratio between the water demand and the runoff. The table below summarizes the current and future water stress index in the different sub-catchment areas.

SUB-CATCHMENT	CURRENT WATER STRESS INDEX (%)	PROJECTED FUTURE WATER STRESS INDEX (%)	VULNERABILITY
Komati at GS30	50.5	199.6	- Currently facing high water stress and this is expected to be severe in future. - Worsening water stress is likely to affect sugar industry at Mhlume and Simunye. - This will have impacts on sugar cane yields and consequently affect the country's economy.
Mbuluzi at GS3	3.1	7.2	Relatively no water stress projected
Mbuluzi at GS32	25.6	60.9	- Water stress to shift from moderate to high - Rural communities likely to be affected
Usuthu at GS2	26.1	64.0	Water stress to shift from moderate to high. - Lusushwana river and Matsapa urban and industrial area mostly affected. - Effluent discharge from industries may increase water pollution - Downstream water users such as livestock and communities on SNL will be affected and tis could lead to increase in incidences of diseases.
Usuthu at GS5	2.9	11.5	Water stress highly unlikely
Usuthu at GS9	11.6	37.2	Water stress to shift from low to moderate Water stress likely to affect forestry industry. Malkerns irrigation are and small scale sugar cane farms
Usuthu GS15	1.4	4.4	Water stress highly unlikely
Usuthu GS6	12.6	36	Water stress to shift from low to moderate

			Small scale sugar cane farmers will be mostly affected
Usuthu GS19	5.8	42.2	Most likely to have high water stress in the future Main affected river is the Mhlatuze river
Usuthu GS16	45.4	72.8	Water stress to remain high Will affect sugar cane production at ILLOVO.

Table 4.12: Current and Projected water Stress in the Different Sub Catchment

The projected water stress will affect mostly sugarcane production. Under this situation of severe and high water stress, the economy of the country is likely to decline due to reduced foreign exchange earnings from the sale of sugarcane. The areas of increasing water stress where increasing water use is more important include Komati at GS30, Usuthu at GS2 and GS16 and Mbuluzi catchment at GS32. These areas are within the sugarbelt and the continued conversions of land to sugarcane farming will exert more pressure on the decreasing water availability in the catchments and give rise to conflicts.

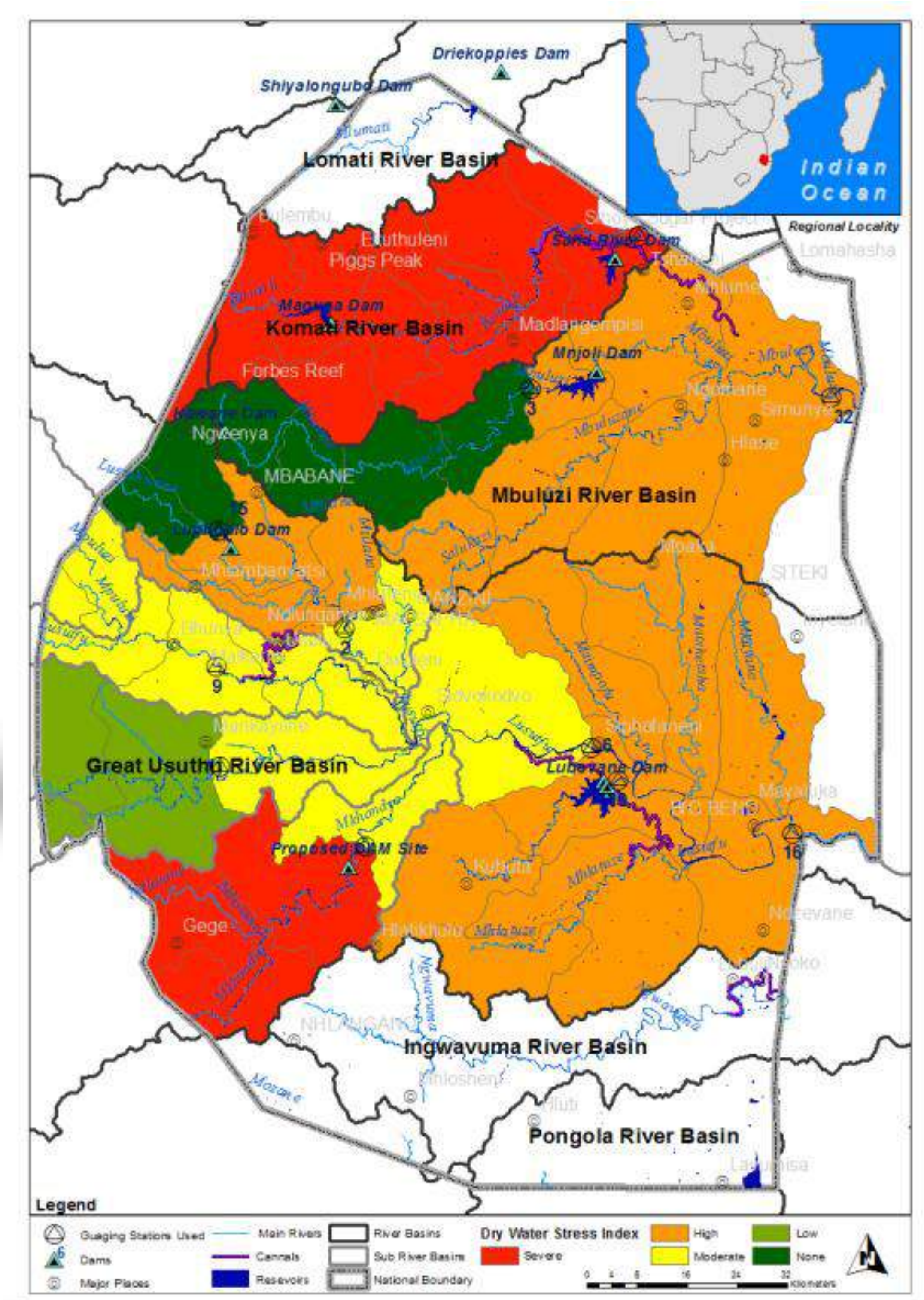


Figure 4-14: Map of future water stress index in respective sub-catchments

4.2 Adaptation Measures

Swaziland's National Development Strategy (NDS) advocates the development of a new water legislation, policy and regulatory mechanism to facilitate delivery and management of water resources in the country. It also encourages the expansion of smallholder irrigation within a national irrigation development plan by further planning and construction of small- to medium-sized dams to promote irrigation-based agriculture and a shift from subsistence farming to commercial agricultural production on SNL . To date, Swaziland is actively addressing policy deficits, improving the legislative framework and introducing new/modified institutional arrangements for the water Sector.

The Water Act (Act No. 7 of 2003) declares all water found naturally in the country as a national resource and seeks to streamline the water allocation process and to improve catchment management through enhanced stakeholder participation and decentralisation of the management.

Based on the concept of Integrated Water Resources Management (IWRM), Swaziland's Water Policy provides clear demarcation of the responsibilities of the various stakeholders and institutions involved in the integrated development and management of water resources in the country . A major step in Swaziland's adaptation efforts has been the creation of requisite institutions especially those focused on water development and management.

Swaziland has also been implementing pivotal on ground adaptation efforts targeting the water sector. A major initiative has been the Transboundary water and adaptation project funded by the Global Environment Facility (GEF). The project focused on one of the national priorities presented in Swaziland's First National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), namely 'adapting national and trans-boundary water resource management to manage the expected impacts of climate change'. A vital element of the project is that it links with ongoing country interventions including the Komati Downstream Development Project (KDDP) and the Lower Usuthu Smallholder Irrigation Project-GEF (LUSIP-GEF). The three river basins included in the project area, for example, cover a wide variety of natural habitats such as grasslands, bushveld with mixed tree types (broad-leafed and thorny species), evergreen forests (including riverine forest), and aquatic habitats for a wide variety of species, including those classified as threatened. The Incomati, for example, provides refuge to at least 40 threatened bird species, 11 threatened terrestrial mammal species, 12 threatened fish species, and eight threatened reptile and amphibian species, which are all wholly or partly dependent on water and/or riverine vegetation. In the Lower Usuthu river basin, 200 water-bird species were recorded. In addition, there are conservation areas of particular importance within the basins such the Kruger National Park.

The Transboundary water and adaptation project has been promoting rainwater harvesting technologies and techniques aimed at improving rainwater infiltration rates through demonstration sites. These on-the-ground activities are likely to provide benefits such as: i) improving access to water for sanitation and drinking purposes; ii) preventing the decline of the water table, iii) reducing pumping costs; and iv) improving agricultural productivity by increasing the availability of water for irrigation purposes (with positive consequences for food security and income streams).

Way Forward – Adaptation

In the light of the above-mentioned climate change-induced challenges, the proposed solutions (normative situation) for managing the likely consequences of climate change on water resources have been identified and these are detailed below.

- Increase the water-sector knowledge base through investments in research and knowledge building in the sector.
- Build a centralised Water Resources Management Information System to alleviate the problem of poor quality of hydrological and climate-related data.
- Strengthen institutional capacity for Integrated Water Resource Management (IWRM) in the context of climate change.
- Integrate climate change related risks into local, national, regional policies, plans and legislation that affect Integrated Water Resources Management (IWRM).
- Early warning systems and information sharing
- Public awareness and knowledge management

Design and implement more programmes and projects in line with Swaziland's long-term trans-boundary water management strategy and coherently mainstream climate change into trans-boundary water resources planning and agreements..

4.3 Summary of Progress

In the time since its second national communication to the UNFCCC, the Kingdom of Swaziland has made consistent progress in its efforts to identify climate related vulnerability and to put adaptive policies and supporting measures in place.

Adaptation is a high priority in Swaziland. It is increasingly being viewed, locally and internationally, in the context of development because the effects of climate change are well recognised as key determinants of socio-economic growth or constraints. The country has developed a number of new policy documents and instruments, such as the revised *National Development Plan* (2014), the National Emergency Response Mitigation and Adaptation Plan (2015) and the newly approved *National Climate Change Policy* (2016). Swaziland actively participated in and endorsed the Paris Agreement (2016). Swaziland has also made a number of key adaptation related commitments in its *Intended Nationally Determined Contribution* (2015), which the country means to realise through increased national efforts and with the assistance of the international community.

Numerous adaptation measures are ongoing in the country, and are beginning to bear fruit. These include the various agricultural and community irrigation projects as well as biodiversity and conservation efforts. The focus is currently on cross-cutting measures that address priority areas related to water and agriculture, motivated by the devastating El Niño phenomenon which has led to severe food insecurity and loss of livelihoods in the country since its arrival towards the end of 2014. Swaziland is therefore concentrating research efforts to investigate the nation's vulnerabilities with regards to the current water sector, as well as the impacts of future development and changing climates. The purpose of these studies is to establish the best integrated methods to manage the country's water resources for the benefit of all its citizens.

The country has also increased efforts to monitor and report on the various indicators of climate change in Swaziland. A nation-wide monitoring, reporting and verification system is being developed in this regard, which will track and report on the progress of climate related activities in the country.

5 MITIGATION MEASURES

Swaziland's GHG emissions, in global and per capita terms, are modest representing less than 0.002% of global emissions. Although there is a high degree of uncertainty with regards to the actual GHG quantification, the country can either be considered as a very small global contributor or a net sink. This uncertainty withstanding, the country has taken action towards mitigation as it recognises the importance of its role within the context of global GHG mitigation efforts.

The national efforts towards mitigation have been outlined across different documents, plans and strategies. Swaziland also actively participates in other initiatives that may have indirect emissions reduction consequences, such as the United Nations' Sustainable Energy for All programme. Swaziland's *Intended Nationally Determined Contribution* is a key national document which outlines the country's mitigation commitments. An overview of these mitigation commitments is presented in the figure below.

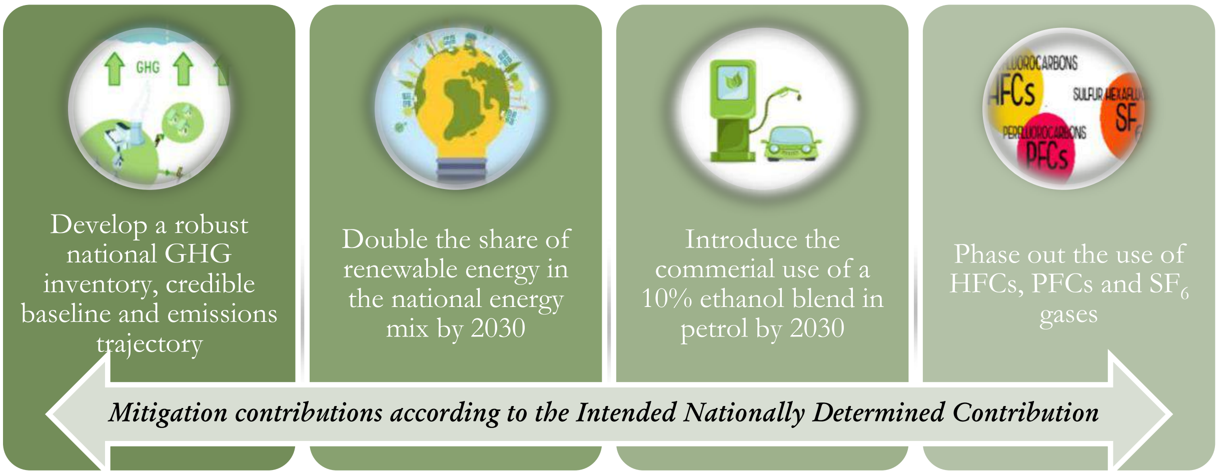


Figure 5-1: Swaziland's Mitigation Contributions as stated in the *Intended Nationally Determined Contribution* (2015)

5.1 Baseline

The 2010 National GHG Inventory is used as the Baseline. Swaziland's current national GHG emissions inventory for 2010 identifies industrial processes, agriculture and energy as the main sources of emissions. Table 5.1 presents the estimated totals per sector, further details are provided in Chapter 3 of this communication: "National Greenhouse Gas Inventory: 2010".

Emissions from industrial product used are related to the emissions of global warming gases from the refrigeration industry. Enteric fermentation is the largest contributor to the agriculture emissions, followed by agriculture activities, burning of fields and manure management. Fuel combustion for energy generation and transport are the main sources of emissions in the energy sector; while the open burning of waste, biological treatment of waste, solid waste disposal and wastewater discharges are activities responsible for emissions in the waste sector.

The mitigation options are reported separately for the energy sector; synthetic GHG emission sources, as well as mitigation measures related to the agriculture, forestry and other land use and waste sectors. Although reduction potentials were identified, cost assessments of applicable technology measures have not yet been undertaken.

Table 5.1: Summary of GHG Emissions/Removals for the Kingdom of Swaziland for 2010 (Gg CO_2e)

GHG Sources & Sinks	Totals from the 2010 National GHG Inventory	
	Total (GgCO_2e)	Percentage (%)
Total National Emissions without LULUCF	4.86	100%
Net National Removals with LULUCF	-1.00	-
1 Energy	1.52	31%
2. Industrial Processes	1.67	34%
3. Agriculture	1.60	33%
4. Land-Use Change & Forestry	-5.86	-
5. Waste	0.05	1%

5.1.1 *Baseline emissions*

Emissions stemming from the BAU scenarios for the base year 2010 and the projections for 2020, and 2050 are given in table below. The baseline emissions however do not include the Industrial processes sector. Relative to the base year 2010, it is projected that the country will lose its sink capacity and becomes a net emitter of GHG. While significat component of the toatal emissions is due to energy suspply largely from emissions from a proposed coal fired electricity power plant, transport, waste and AFOLU emissions are also expected to increase.

Table 5.2: Aggregated business as usual (BAU) baseline from all sectors [GgCO2eq]

SECTORS	SUB-SECTORS	2010	2020	2050
AFOLU	Land Use	3.26	4.23	5.71
	Agriculture	1.60	2.30	2.92
	Total AFOLU	**4.86**	**6.53**	**8.63**
Energy Demand	Commercial	0.15	0.20	0.62
	Industry	0.07	0.09	0.14
	Residential	0.12	0.15	0.49
	Transport	0.80	1.08	1.41
Energy Supply	Electricity	0.18	1.34	2.56
	others	0.10	0.14	0.54
Total Energy	**All Sectors**	**1.52**	**3.00**	**5.76**
Waste	Waste	0.39	2.16	7.03
TOTAL emissions	**TOTAL**	**5.14**	**11.69**	**21.42**

Different mitigation options have been evaluated for the Energy, AFOLU and Waste sectors as detailed further down. For summing up to obtain the national mitigation values at the different time horizons, the best scenarios were chosen.

5.2 Mitigation Measures in the Energy Sector

Emissions from the energy sector arise from the generation and supply of electricity, generation of energy for industrial processes, energy used for household needs, and the transport sector. Biomass (firewood, charcoal and agricultural waste) account for 66% of the country's energy supply and is mainly used for household cooking and heating, as well as cogeneration in the sugar industry. Oil related products account for 23% of the energy supply. Petrol is mostly used in transport services and kerosene and gas are used for cooking and heating. Coal and hydropower account for the remaining supplies of energy.

Swaziland is investigating options to increase the country's installed capacity, with the aim of reducing reliance on neighbouring countries. The options include grid connected supply from renewables and grid connected supply from fossil fuels, both of which have an impact on the future country GHG emissions. The following planned opportunities for mitigation have been extensively investigated within the energy sector, as it has a number of practicable opportunities for interventions and savings. Swaziland's most ambitious mitigation commitments pertain to the inclusion of the commercial use of a 10% ethanol blend in petrol and the doubling of renewables in the energy mix compared to 2010 levels[5].

In 2010 60% of emissions from the energy sector are mainly from the transport sector. However emissions from electricity generation are expected to increase largely around 2024, owing to the bringing into operation of the coal fired Lubombo power station, these account for steady growth in emissions under business as usual scenario. The main mitigation option therefore lies in not building the Lubombo coal power station. Other mitigation scenarios investigated under the energy sector include; Energy efficient scenario, renewable energy scenario, and a no coal power plant scenario. While for the transport sector, two scenarios were investigated: more efficient vehicles and ethanol blending. The Figure below shows the total emissions from four energy scenarios that were considered in the mitigation potential analysis.

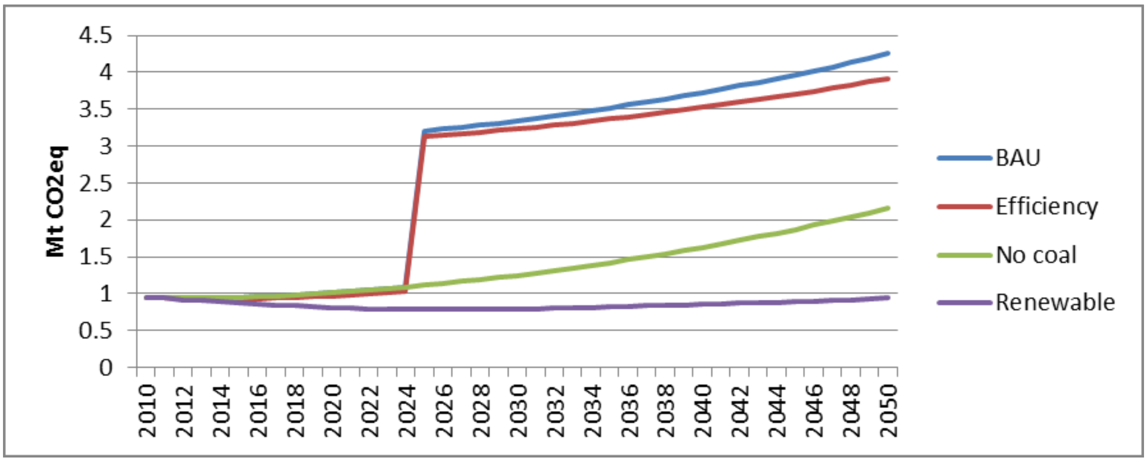


Figure 5-2: Emissions in Baseline and Energy Mitigation Scenarios

[5] The share of renewable energy in the national energy mix in 2010 was 16% energy and sustainable/renewable biomass (Government of Swaziland, 2015).

Ethanol for transportation reduces the emissions by 60% relative to baseline scenario in 2050. The energy efficiency scenario has a small impact on reducing emissions. This scenario only reduces emissions by 8% relative to baseline scenario in 2050.

The greatest impact in the renewables scenario comes from the increased use of ethanol in transport sector. The figure below shows the impact of including energy efficiency in the Renewable and No coal scenarios and it shows that efficiency has the highest impact in No coal scenario while it has minimal impact in Renewable scenario.

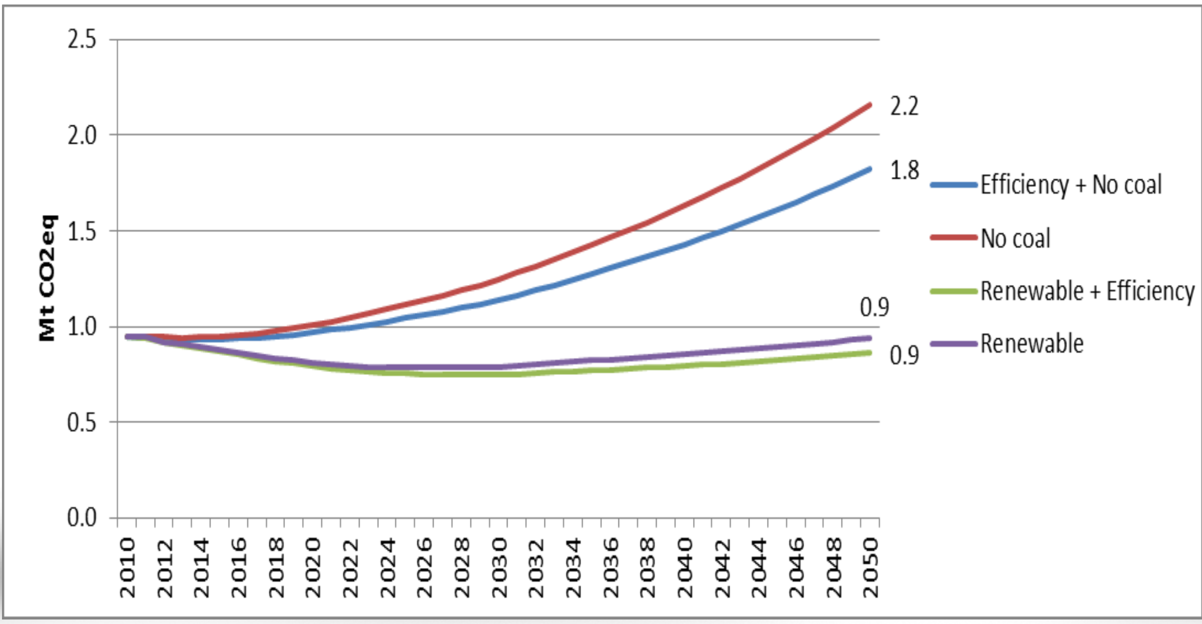


Figure 5-3: Emissions in the different Energy Mitigation Scenarios

While there is significant potential for renewables for electricity generation, if this substitutes for electricity imports from South Africa the impact on emissions attributable to Swaziland is negligible even though the actual impact on emissions is considerable as South African electricity is likely to continue to have a large emissions factor linked to the large proportion of coal used for electricity generation in South Africa. It is unlikely to substitute for electricity from the planned Lubombo power station as it is most likely that Swaziland will choose to run this station at full capacity as its main stated purpose is to decrease reliance on electricity imports.

5.2.1 Energy Mitigation Scenarios

Two mitigation options within the transport sector were assessed as part of the mitigation scenarios in the energy sector: the ethanol blend in petrol and the increase in the uptake of more efficient vehicles.

Commercialisation of a 10% ethanol blend in petrol

Swaziland intends to introduce the commercial use of a 10% ethanol blend by 2030. It is estimated that this measure would result in a reduction of 28% and 81% of the business as usual projected emissions from transport, in the years 2020 and 2050 respectively.

The main milestones achieved so far in this process include: vehicle testing facilities completed with diagnostic instruments installed, the Swaziland Revenue Authority approved a zero rated VAT for fuel intended ethanol, discussions and consultation with the various distilleries, petroleum bill consultations enforcing mandatory blending, as well as the development of a national standard on blending anhydrous ethanol in unleaded petrol.

Increase uptake of efficient vehicles

Vehicle ownership rate is low in Swaziland compared to international levels, with only 89 vehicles per 1 000 people in 2011 (The World Bank, 2013). The majority of the population use public transport. There are limited government statistics regarding vehicle fleet composition and age. A report in 2001 estimated that there were 92 564 private owned vehicles in 2001, and 4 579 government vehicles for the same period (African Development Bank, 2003).

Imports of old vehicles from South Africa represent a frequent source of vehicles for Swaziland. The vintage vehicle fleet is fuel inefficient and some of the older vehicles require leaded petrol for operation. Improvements in vehicle emissions may be achieved by annually removing the oldest 1% of the fleet from the road. Should this occur, it is estimated that there is a mitigation potential of 16% of the projected emissions from business as usual in the transport sector, in the year 2050.

5.2.2 Electricity production and supply

Figure 5-4: Swaziland's Maguga Dam.

Swaziland depends heavily on energy imports from Mozambique and South Africa. The country generates about 25% of its own electricity requirements, mainly from state-owned hydro-power stations. Considering the low national electrification rate of approximately 27% (40% urban, 4% rural), there is a great need to increase generation capacity within the country, along with increasing electrification.

Electricity is the backbone of socio-economic development of a country and provides numerous services to the population, which directly enhance their quality of life. As a consequence of poor access to electricity and unaffordability, the bulk of the population turns to biomass, both sustainable and unsustainable, to supply their cooking and heating requirements. The country is planning to install a 300MW coal fired power plant in the Lubombo.

Grid connected supply from renewable energies

One of Swaziland's commitments documented in the *Intended Nationally Determined Contribution* is to double the share of renewables within the national energy mix, by 2030. The country is well endowed with solar resources and sugar cane residues, and these sources have great potential for electricity production. This is in addition to smaller opportunities in the hydropower sector.

Important stepping stones for the development of renewable projects include a resource assessment, identification of the energy access profile and creation of entities and policies to support and regulate the initiatives. Swaziland has already started wind and solar resource measurement programmes, a mini and micro hydro power study and pilot programme, and has created the Renewable Energy Association of Swaziland. The USAID Southern Africa Trade Hub is assisting in the development of an independent power producer policy for renewable energy technologies as well as an energy access survey. The aim of this survey is to establish an accurate profile of the energy mix utilised for different household purposes as well as to establish the energy access rate in Swaziland. While The *National Renewable Energy Generation Plan* has already committed the construction of almost 194 MW, prior to 2021, additional capacity of more than 87 MW is in the process of approval. These are listed in the tables below.

Table 5.3: Future Generation Plan used in the Renewable Mitigation scenarios

Year	Description	Capacity (MW)	Technology
2015	Feasibility study on Hydro Power generation at Lubovane Dam	0.85	Hydro
2016	Feasibility study for Lower Maguga Hydro Electric Scheme	2	Hydro
2016	Daroway	5	Hydro
2018	Lower Maguduza Hydro	12	Hydro
2021	Ngwempisi Hydro	120	Hydro
2016	Clean Energy Africa - Ngodwane	10	Biomass (wood fuel)
2018	Nsoko-Msele	30	Bagasse (renewable)
2019	Montigny (Usuntu)	35	Biomass (renewable)
Tbc	Symbion Biomass plant at Havelock	10	Biomass (wood fuel)
Tbc	RSSC Biomass Generation	93	Biomass
2016	Kalanga Solar PV project	0.95	Solar PV
2016	Solar PV at Various Locations	46	Solar PV
2016	AFRICA Energy	10	Solar
2017	Lavumisa Solar PV	5	Solar
2018	PV Utility - SGL	100	Solar PV
Total capacity		**479.8**	

The major renewable energy targets of the Government are:

- The installation of solar water heaters in 20% of all public buildings by 2014;
- The development of solar water heater standards by 2012;
- The establishment of fiscal incentives to promote renewable energy by 2013; and
- The establishment of a demonstration centre for renewable energy technologies by 2015.

Other mechanisms identified for long term roll out of the renewables include a renewable energy policy, an independent power producer framework, a feed in tariff framework, a grid code and generation plan.

It is estimated that emission reductions, from the uptake of renewable energies, will amount to a 97% reduction of the 2050 expected emissions of the electricity supply sector.

No-Coal Scenario

Swaziland is evaluating plans to install two 300MW coal-fired thermal plants at Lubhuku. Swaziland has coal reserves; however, it is high grade metallurgical coal, which has better coking properties and a higher value in the commodities market. The no coal scenario is looking at Swaziland maintaining its status quo by not building any new coal fired power plants (i.e. continue to import electricity from the Southern African Power Pool platform). Under this scenario there is a reduction potential of 97% of the estimated GHG emissions from the energy sector, in the year 2050.

5.2.3 Energy for industrial processes

Energy used for industrial activities, which is not derived from the grid, is self-generated by companies within Swaziland. Steam is generated in boilers onsite, using either coal, biomass, bagasse or diesel as fuel sources. Given the low electricity levels, most of the GHG emissions reported within the energy sector correspond to emissions incurred from industrial operations (57%). Mitigation options include fuel switching and energy efficiency activities.

Fuel switch

Swaziland's industry consists mostly of sugar, forestry and citrus operations, with sugar being the largest subsector. These industries all use steam at some stage of their processes. Steam is typically derived from either coal, diesel, biomass or bagasse. Fuel switching from a fossil fuel to renewable energy source has potential to reduce emissions, although it would require technology interventions. In many cases coal is used as the primary fuel source in boilers for steam generation, however there is potential to reduce the volumes over time. The use of coal could be reduced to 2% of the total fuel intake by 2050.

Expected emission reductions from fuel switching, such as from coal to biomass, in the sugar industry are estimated at 41% and 82% in 2020 and 2050 respectively. The Royal Swaziland Sugar Corporation states that an extensive fuel switch has already occurred in the sugar industry, with a current estimated fuel share composed of 90% bagasse, 5-10% woodchips and 5% coal for the generation of heat and electricity.

Energy efficiency activities

Measures to provide the same service while reducing the amount of energy used in the industrial sector typically include: installation of energy efficient boilers, improvement of boiler efficiencies (through measures such as the insulation of pipes, valves and flanges, modifications of the burner setup adequate to the input material, and temperature controls), improvements of processes and operations, and training and skills development. These are valuable methods to improve the energy efficient operation of facilities. In addition the Swazi government has undertaken various measures to promote energy efficiency in the industrial sector. These include a time-of-use tariff which was introduced for industrial customers, in addition to industrial stakeholder engagement on power factor correction.

The replacement of inefficient boilers was investigated by the and a potential emission reduction of 75% in the industrial energy, in the year 2050, is expected. However, the current lack of incentives may limit the implementation of these measures, as they depend solely on the resources and willingness of private companies.

5.2.4 Energy for residential usage

Household energy requirements for cooking and heating are predominantly supplied from electricity and LPG in the urban areas, with wood used in the rural areas. The use of unsustainable wood as a fuel source has added a significant burden to the indigenous forest and woodlands. In addition, increasing demand for arable and grazing areas factors which have contributed to increased deforestation, soil erosion and desertification. There is also a need to improve the efficient use of biomass in rural areas where firewood is used for cooking on open fires.

Mitigation options for the residential sector include fuel switching, technology improvements, rural electrification, anaerobic digestion and energy efficiency programmes.

Fuel switch

Approximately 90% of the total rural energy in the country is provided from fuelwood. The Sustainable Energy for All initiative works towards the universal access to modern energy services. As part of the country's assessment, it was identify that while LPG and paraffin are becoming accessible to the more affluent citizen in Swaziland, they are also becoming unaffordable to the country's poor. Interventions in the supply chain are required to assure a transparent product pricing and a more inclusive distribution infrastructure. The use of LPG for cooking also raises safety concerns. The Sustainable Energy for All Action Plan has therefore proposed prioritised solutions that address regulations in the LPG market and its usage.

Technology improvement

The use of efficient cook stoves is promoted by the Swazi government and various shareholders. Currently, Swazis are being trained in the construction of effective cook stoves and various programmes that have been put in place to ensure that the cook stove projects do not have negative environmental impacts such as indoor pollution and forest destruction.

The planned rollout of more efficient cook stoves include:

(i) Implementing domestic policy for improved cook stove use and advanced legislation for development and promotion thereof,

(ii) Implementing incentives to enhance and promote the efficient cook stove subsector,
(iii) Testing and certification facilities for improved cook stoves,
(iv) Consumer surveys and regional energy needs assessments, and
(v) Inclusion of the financial sector in the design and implementation programmes.

The use of LPG is deemed a cleaner technology and therefore promoted, although not yet incentivised.

Fuel from anaerobic digestion
Another mitigation option is the use of biogas in rural households to replace LPG and wood. Replacing the traditional wood supply with biogas avoids methane emission from the livestock, general household and human waste. The captured gas can be used for electricity generation or as a replacement fuel for cooking and heating. A co-benefit would be the production of organic compost that may replace fertilisers, thus reducing both GHG emissions and water pollution associated with the use of fertilisers.

The operating model for anaerobic digesters, including its co-benefits, is presented below. Given that the dominant rural population engages in extensive subsistence agricultural practices, this mitigation option is promising as it provides a solution not only for GHG mitigation. This mitigation opportunity also has the added benefit of being a response to the needs for cleaner energy, rural electrification, forest conservation, reduced energy dependence and social upliftment. These are priority issues that Swaziland is responding to by participating in the Sustainable Development Goals network and the Sustainable Energy for All programme, as well as through its commitments in the country's *Intended Nationally Determined Contribution*.

Energy efficiency
Planned interventions for energy efficiency in the household sector include the distribution of efficient lamps, which will be made available at either no cost or at subsidized cost, to selected communities. The distribution of 500 000 CFLs per year is planned over a 3 year period, starting in 2015, together with the development of suitable disposal sites. Other mitigation options envisaged include the promotion of efficient lighting in all new social housing projects and facilitating financing schemes to cover the upfront payment of energy saving appliances and efficient lighting products. The processes to develop regulations to prohibit the use and importation of energy inefficient, incandescent lamps is scheduled for completion by December 2016.

5.2.5 National promotion of energy efficiency
The Swaziland Electricity Company has developed a campaign to increase public awareness of energy efficiency through various forms of media – newspapers, television, radio, and in schools – in collaboration with various stakeholders. The campaign aims to encourage the public to save electricity and includes the provision of tips and best practices.

Government is leading the process by installing solar photovoltaic solutions at the national blood bank (30 kW), the campus of the University of Swaziland (60 kW) and the Mhulemeni border gate (30 kW). LED lights have also been retrofitted at these institutions.

The promotion of energy efficiency could be improved by various measures, including:

- Development, adoption and implementation of policy and regulatory framework for energy efficiency;
- Increased public awareness and education on the benefits of energy efficiency;
- Improved institutional capacity building and effective coordination for monitoring and enforcement of relevant regulations;
- Financial incentives to encourage the use of energy efficient appliances and technologies by households, the commercial and industrial sectors;
- Innovative financing schemes for energy efficiency and conservation programmes; and
- Addressing gaps in statistical data for periodically evaluating the rates of energy efficiency and conservation nationwide, covering domestic, industrial, commercial and agricultural users and public services (e.g. health and education).

5.3 Mitigation Measures Relating to Synthetic GHGs

GHG emissions from the industrial sector are mainly attributed to HFCs, PFCs and SF_6 gases. These gases are emitted from products used as substitutes for ozone depleting substances in the refrigeration industry, fire extinguishers, solvents, aerosols and electrical equipment. These are typically known as synthetic GHGs. In the last 15 years there has been a significant decrease of these emissions which can be attributed to the reduced activities in the assembly of air conditioning and refrigeration equipment as well as the closing down of the gas production facility.

As a signatory of the Montreal Protocol, Swaziland closed down the production facility and phased out the production of HCFCs, replacing it with HFCs; however the gases are still being used in the value chain. *Swaziland's Intended Nationally Determined Contribution* commits to phasing out the use of HFCs, PFCs and SF_6 gases as well as substitutes with global warming potential, by developing the value chain for alternative zero-GWP and enhancing the skill level for these conversions.

5.4 Mitigation Measures in the Waste Sector

Although the waste sector appears to be a small contributor to the country's national GHG inventory, there is potential not only for improving the waste management practices, but also for energy production from waste. Apart from the potential for anaerobic digestion to deal with household and agricultural waste, the Swaziland Water Services Corporation has plans to use methane from the wastewater treatment plants for the purpose of water heating.

The table below shows baseline emissions for landfill solid waste, sewerage sludge and incineration. The three mitigation options are increased recycling (IR), increased landfill gas capture (ILGC) and decreased incineration DI.

Table 5.4: Baseline Scenario for waste emissions (Mt CO2eq)

Sectors	Sub-sectors	2010	2020	2050
Landfill solid waste	Waste	0.13	1.82	6.43
Sewerage sludge	Waste	0.14	0.18	0.26
Incineration	Waste	0.12	0.16	0.34
Total		0.22	1.14	3.78

Table 5.5: Levels for Mitigation Options

Increased Recycling Efforts	Levels	2010	2020	2030	2040	2050
IR	A	13%	14%	14%	15%	15%
IR	B	13%	15%	17%	18%	20%
IR	C	13%	16%	19%	22%	25%
Decreased Incineration	Levels	2010	2020	2030	2040	2050
DI	A	27%	27%	27%	27%	27%
DI	B	27%	25%	24%	22%	20%
DI	C	27%	23%	19%	14%	10%
Landfilled waste treatment						
Increased Landfill gas capture	Levels	2010	2020	2030	2040	2050
ILGC	A	0%	0%	3%	4%	5%
ILGC	B	0%	0%	25%	38%	50%
ILGC	C	0%	0%	45%	68%	90%

The figure below shows a baseline which is a combination of level A for each for the options in the table above, Effort level 1, which is a combination of level B for each for the options in table 5.5, and Effort level 2, which is a combination of level C for each for the options in table 5.5.

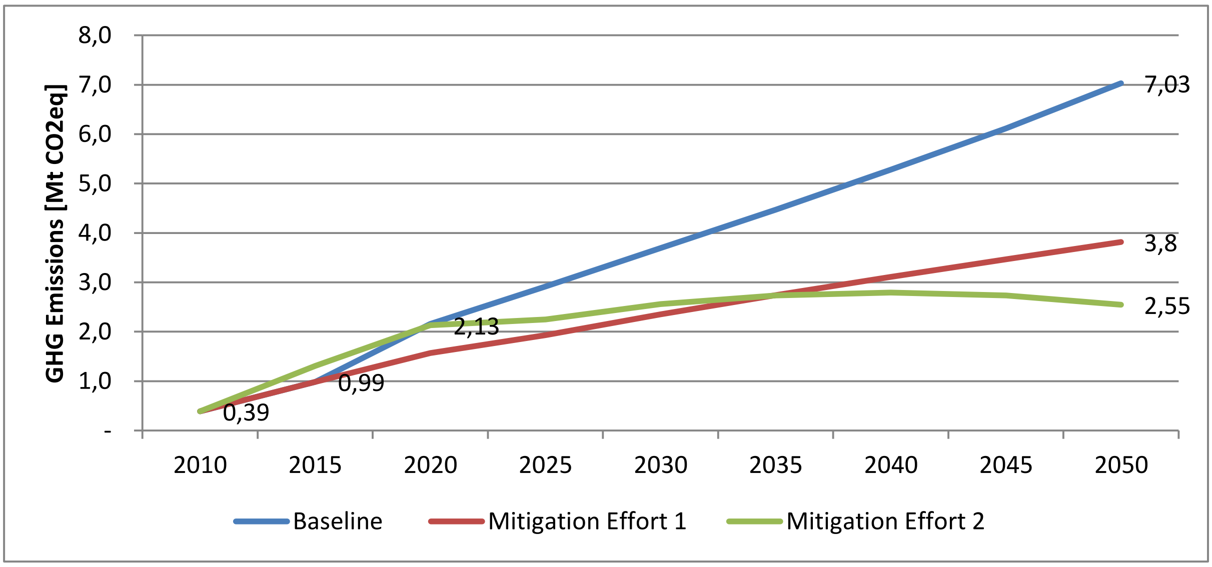


Figure 5-5: Aggregate emissions in the waste sector: baseline and mitigation scenario

5.5 Mitigation Measures in the Agriculture Sector

The agriculture sector is responsible for almost a third of the emissions estimated in Swaziland's 2010 GHG Inventory. Emissions from this sector largely emanate from livestock and crop production. Typical emitting activities within the crop production sector include soil cultivation, soil fertility management and the burning of sugar fields prior to harvesting.

5.5.1 Conservation agriculture

Farming and subsistence agriculture contribute to GHG emissions by the disturbance of the soil (tillage), which releases soil carbon storage, thus reducing soil moisture. Some foreign funded projects have focused on the training of Swazi farmers in conservation agriculture and the provision of soil-improving crops (USAID, 2009). Some studies have found that conservation agriculture has a positive impact, specifically on maize production in Swaziland. Maize farmers utilising conservation agriculture practices obtained increases in yields. These increases translated into higher profits, compared to those farmers practicing conventional agriculture (Oladeebo & Mkhonta, 2013).

To mitigate effects of climate change and improve viability of the agriculture sector, the government of Swaziland and non-state partners have initiated a number of interventions. These include the construction of irrigation infrastructure and downstream development for crop and livestock production, the introduction of conservation agriculture and minimal tillage farming methods.

Conservation agriculture has been practiced in the country for over 10 years, through the use of champion farmers. Champion farmers are trained farmers in the implementation of conservation agriculture. They develop model gardens with the aim that these demonstration initiatives are scaled-up and rolled-out across the country. The practice has however been limited to manual operations and there is now a need to consider mechanisation.

The 'Up-scaling of Climate Smart Agriculture in Swaziland' project seeks to identify the baseline for climate smart agriculture programming which will be followed by a pilot for up-scaling conservation agriculture.

5.5.2 Manure management

Subsistence animal farming takes place within Swaziland's homesteads and virtually every home in the rural areas has some animals. The major livestock produced and contributing to the GHG emissions in Swaziland are ruminants, cattle and goats.

The direct application of manure on the farms fields as a fertiliser is also a common practice across the country (Mijinyawa & Dlamini, 2006). This practice is responsible for uncontrolled released of methane into the atmosphere. In 2010, manure management accounted for 16% of the emissions from the agriculture sector.

The use of biodigesters presents mitigation opportunities for manure management and the production of renewable energy.

5.5.3 Changing practices associated with sugar cane harvesting

The burning of sugar cane in the fields to facilitate cane harvesting and transport to the mill is common practice in Swaziland. However, given the large sugar industry present in the country, the uncontrolled burning of this biomass contributes significantly to the national GHG emissions. Sugar cane burning is not the only method for harvesting. The local industry is aware of the option to cut the green cane (i.e. instead of allowing it to go dry and brown for burning), using manual or mechanised processes. The additional benefit of this practice is that the remaining biomass (leaves and stalks) can be utilised as a biofuel. Producers are aware of the environmental weight of the burning practice, and there is growing support to gradually shift to green-cane cutting practices in the sector.

5.6 Mitigation Measures in the Land Use, Land-use Change and Forestry Sector

Swaziland's land use, land-use change, and forestry sector was estimated to be a net sink of GHG emissions. There are however various sources of emissions from this sector, mainly those that arise from veld fires, fuel gathering and commercial harvesting. The main sinks, or removals, of GHG accruing to this sector emanate from forest cultivation and growth.

Mitigation options in the sector are related to fuel gathering processes. These options are addressed above in the section titled Energy for Residential Usage. Additionally, options for commercial harvesting such as the treatment of forest residues are also considered. From the point of view of the sector as a sink, other mitigation options consist of activities to enhance the sink potential. These include afforestation, reforestation and forest conservation, among others. The forestry sector is vulnerable to the effects of climate change impacts, specifically drought, increased fire risks, floods and pests. The protection of this sector is critical not only due to its status as a national industry (and source of employment) and its GHG removal potential, but also due to the Forestry sector being a source of energy in both rural and industrial contexts.

5.6.1 Forestry

Although the country is still considered a sink, more than 75 000 ha of tree cover were lost during the period 2001-2014. Protection and conservation activities are therefore of priority for Swaziland. Such actions are driven by the *National Forest Policy* of 2001, which provides principles for the conservation of forest biodiversity and protection of indigenous forests.

The demand however for forest products and fuel wood in Swaziland is steadily increasing. Afforestation and reforestation remain the main tool for addressing problems associated with deforestation, loss of biodiversity, shortage of fuel wood, land degradation and drought. Their potential to mitigate climate change is also considerable. The N*ational Tree Campaign* is a countrywide measure that aims to promote and facilitate the planting of trees, particularly in rural areas. It is supported by various communities and the Agriculture and Forestry Extension service.

Swaziland's extensive commercial forestry plantations also contribute to the country's sink-potential. While largely limited to large private companies, such corporates are increasingly looking at expanding their timber supplies through the dedicated support of smaller growers. Distinct from reforestation projects, these tree plantations are developed with the aim of harvesting the timber in 8 to 20 year cycles. Additional reduction potential has also been identified in the planting of trees with minimum soil disturbance, in highly degraded areas with low terrestrial carbon content, on land that has a high probability of degradation in the future.

In addition, forest residues from the timber harvesting process have potential for the production of biomass pellets, which can be used for energy generation. There is an ongoing pilot project on the 55 000 ha of the Usutu Forest to evaluate the technical and economic feasibility of generating a marketable bioenergy product and the development of the forest residue value chain.

5.6.2 Land use

Another area for mitigation intervention is the restoration and management of grass lands. Grasslands in Swaziland are under constant pressure by factors relating to urbanisation, road developments, agriculture and fires. Land degradation has expanded, although there is limited information on the magnitude and severity of the process. Avoiding grassland degradation and associated grassland restoration may be one of the largest Land Use, Land-use Change and Forestry mitigation measures in the region, due to the relatively significant carbon stocks located below the ground in grassland ecosystems.

Mitigation potential from grassland conservation is difficult to estimate, given the lack of knowledge about the spatial extent and nature of grasslands. Suggestions have been raised regarding updating the Swazi land cover and land use map. A project for understanding land use, livelihoods and social-ecological change in rural Swaziland is currently ongoing, supported by the University of Swaziland and the University of Leeds. Conclusions regarding factors that facilitate and inhibit sustainable land management practice (over the past 12 years) in Swaziland and a new land use land management dataset are expected to be released in late 2016.

The *Lower Usuthu Smallholder Irrigation Project,* supported by the Global Environment Facility (IFAD, 2014), is an important project that is investigating options to reduce land-use degradation in Swaziland. It will be implemented at a national level and in the south-eastern Lowveld of Swaziland – a land degradation hotspot with high levels of poverty and food insecurity.

The figure below shows aggregate emissions from the baseline scenario and combined mitigation efforts in the AFOLU sector.

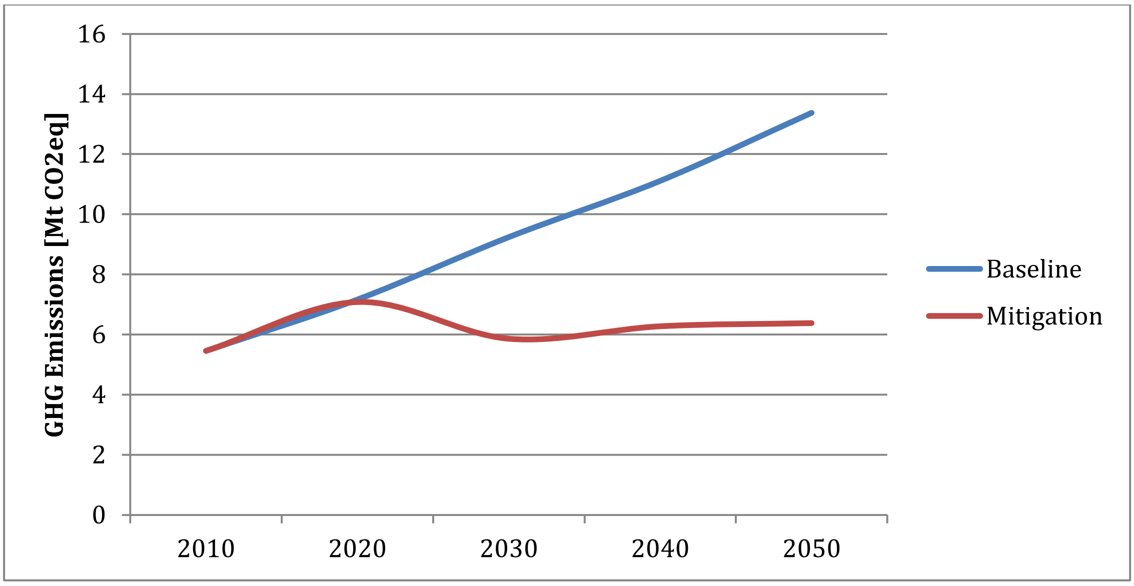


Figure 5-6: Aggregate Emissions-baseline vs combined mitigation efforts

5.7 Summary of Progress

The country has progressed materially with regards to mitigation activities since Swaziland's Second National Communication in 2012. A subsequent Mitigation Options Analysis was undertaken to determine the projections of emissions in key sectors and the approval by cabinet of the *National Climate Change Policy* (2016) marked a significant milestone. Furthermore, Swaziland's *Intended Nationally Determined Contribution* (2015) commits the country to ambitious mitigation commitments including increasing renewable energy by 50% and introducing a 10% bioethanol fuel blend. Swaziland is also participating in international programmes such as the Sustainable Energy for All and the Sustainable Development Goals, which have various mitigation components that will collectively assist the country in meeting its mitigation goals.

6 TECHNOLOGY, RESEARCH, EDUCATION, CAPACITY, INFORMATION AND NETWORKING

In addition to the ongoing development of the National GHG Inventory, various mitigation options and assessments relating to the country's vulnerability and adaptation measures, the Kingdom of Swaziland is facilitating a number of other, related activities with the aim of improving the nation's resilience to the impacts of climate change. These initiatives range from activities that facilitate the transfer of mitigation and adaptation technologies, research and systematic observation, education, training and public awareness, capacity building and information and networking.

6.1 Transfer of Technologies

Swaziland faces many capacity and technology constraints in addressing climate change challenges. There are low levels of awareness of the threats and opportunities of climate change; limited human resources; low technological capacity and inadequate availability of the financial resources to address climate adaptation. Most methods of adaptation involve some form of technology, which in the broadest sense includes not just material and equipment but also diverse forms of knowledge. The transfer of technologies that are suited to Swaziland's specific context is an important component that will assist the country adapt to climate change. As a first step, Swaziland has therefore commissioned a Technology Needs Assessment, to identify and prioritise climate technologies for key sectors in the country.

The Department of Meteorology, within the Ministry of Tourism and Environmental Affairs, spearheaded the Technology Needs Assessment project with the support from the partnership between the United National Environment Programme and Denmark Technical University. The current project is an update on an initial assessment undertaken in 2010, as part of the country's Second National Communication to the UNFCCC.

Stakeholder consultation was identified as a critical component of technology transfer in Swaziland. Stakeholders were therefore identified during the course of the country assessments according to their field of expertise. Stakeholder engagement followed, to elicit information on existing projects as well as their views on the relevant sectors and best practice.

A Multi Criteria Analysis methodology was used to prioritise the technologies identified in Swaziland's latest Technology Needs Assessment. This methodology establishes preferences between technology options, by reference to an explicit set of objectives and measurable criteria that the decision making body has identified. This facilitates an assessment of the extent to which the objectives have been achieved.

The analysis was initiated by the identification of technology options per sector. Various sector criteria were subsequently identified. Technologies which had high capital costs were not preferred, while technologies that created jobs, were environmentally sustainable and socially acceptable were preferred. Mature technologies, proven in Swaziland, were also preferred due to ease of implementation. Weighting of criteria was carried out, in order to reflect their relative importance to the decision. The weights and scores for each of the technology options were subsequently combined to derive an overall value. The results were examined and then presented to the plenary for further discussion.

Swaziland's top three adaptation and mitigation technologies, as prioritised by stakeholders in the Technical Needs Assessment, are presented in the tables below, per sector.

6.1.1 Adaptation technologies

The adaptation technologies outlined below are highlighted as especially suitable for use in initiatives that practically manage risks from climate impacts in Swaziland, with the aim of protecting communities and building resilience in the environment and in the economy.

The adaptation technologies have been categorised according to three sectors: Water, Agriculture, Forests and Biodiversity.

Table 6.1: Results of Multi Criteria Analysis of Adaptation Technologies

Sector	Technology	Description and Benefits of the Technology
Water	#1: Integrated River Basin Management	Entails coordinating conservation, management and development of water, land and related resources across sectors within a given river basin. This is in order to maximise the economic and social benefits derived from water resources in an equitable manner, while preserving and, where necessary, restoring freshwater ecosystems.
	#2: Wetland Restoration	Involves planting of wetland plants and fencing wetlands to protect them. Restoration activities help maintain the ecological functions of flood control and biodiversity maintenance in wetlands.
	#3: Rooftop rainwater harvesting	Collecting rainwater from rooftops is an easy and fairly inexpensive way to increase amount of water availability in a household. The harvested water can be used for a myriad of uses from domestic to irrigation uses, depending on how it is filtered and treated. Rooftop rainwater harvesting helps households adapt to climate change through diversifying household water supply and by increasing resilience to water quality degradation. Harvesting rainwater also helps reduce the pressure on surface and groundwater resources by decreasing household demand. With climate change affecting rainfall patterns, storage of rainwater can provide short-term security against periods of low rainfall and the failure or degradation of other water supplies. Water scarcity impacts of hindering economic development and affecting human health and well-being, can be reduced using rooftop rainwater harvesting.
Agriculture	#1: Livestock Selective Breeding	Improves the value of animal genetic diversity. This technology can be applied to all types of livestock and helps in increasing their productivity, health and welfare. Livestock and poultry produced through selective breeding will be sturdier and able to withstand shocks such as prolonged dry spells, extreme temperatures, pests and diseases, which will occur due to climate change.
	#2: Conservation Agriculture	Involves minimum soil disturbance, maintaining a permanent soil cover through retention of crop residues and growing cover crops, crop rotations and application of integrated pest management strategies. It helps promote soil fertility and improves crop yields, below ground carbon storage and water retention.
	#3: Micro and drip irrigation	This technology contributes to improving food security by enhancing food production. Both micro and drip irrigation systems use water efficiently and therefore save water by reducing water losses. Water is also distributed more evenly across crops helping to avoid wastage. Both systems increase crop yield and allow for various types of crops including row, field and tree crops that are grown closely together. Soluble fertilizers may be used in sprinkler systems. Since less water is used at a time, there is less risk of soil erosion as soil disturbance is low. There are secondary benefits from improved crop

Sector	Technology	Description and Benefits of the Technology
		productivity such as income generation, employment opportunities and food security.
Forests and Biodiversity	#1: Agroforestry	Agroforestry is a technology that improves fertility of soil and thereby productivity of land. It provides multiple benefits including provision of firewood, organic materials that can be used as natural fertilisers, as well as improvements in soil fertility and water flows as soil structure is upgraded. Crops planted with trees such as *Acacia albida* provide higher yields. Agroforestry assists in the provision of year-round income as farmers can derive construction materials (wooden poles) and fuelwood, in addition to reduced needs for items such as fertilisers.
	#2: Conservation of Genetic Resources	*In situ* conservation refers to the conservation of important genetic resources in wild populations and land races, and it is often associated with traditional subsistence agriculture. *Ex situ* conservation refers to the conservation of genetic resources off-site in gene banks, such as seeds.
	#3: Alien Invasive Species Management	The impacts of invasive species can be immense, insidious and are usually irreversible. They damage native species and ecosystems through loss and degradation of habitats. The cost of reversing their impact is large, however they can be mapped and uprooted manually, and controls on imports can be put in place.

6.1.2 *Mitigation technologies*

The mitigation technologies referred to below are highlighted as the most practical means by which to reduce GHG emissions in Swaziland, which therefore reduce the drivers of climate change.

The mitigation technologies have been categorised according to three sectors: Energy, Waste and Land Use, Land Use Change and Forestry.

Table 6.2: Results of Multi Criteria Analysis of Mitigation Technologies

Sectors	Technologies	Description and Benefits of the Technology
Energy	#1: Hydropower Expansion	Hydropower systems exploit the energy of moving water by passing water through a turbine and converting it to electricity through the use of generators. Modern hydro turbines can convert up to 90% of the water energy into electricity. This is a clean source of power.
	#2: Combined Heat and Power	Utilisation of different biomass forms to produce power and heat. Often used for rural electrification, industrial scale applications as well as large scale electricity generation.
	#3: Energy Efficient Buildings	Efficiently managing the energy needs of buildings can have considerable mitigation benefits. Various technology measures can be used to monitor and control the building's energy needs. Energy efficient technologies can be applied to heating, ventilation and air conditioning, lighting or security.
Waste	#1: Municipal Waste Recycling/ Reuse/ Separation Facility	Many of the items in municipal waste are recyclable or contain materials that could be reused. Recycling or reuse could maximize the recovery of resources which could provide additional revenues. Furthermore, recycling/reuse of such items could conserve scarce landfill space.
	#2: Semi Aerobic Landfills	Water is used as barrier to line the landfill sides and bottom, to avoid leachate seepage into the ground. Soil and clay layers are subsequently added. If managed correctly, co-benefits include reduction instances of odours, spread of vermin/pests and scattering of light waste by wind.
	#3: Municipal Solid Waste Composting	Organic waste such as paper cardboard, garden waste, tree and shrub trimmings found in municipal waste could be converted into a compost fertiliser. Compost contains nutrients essential to plants and has water retention properties.
Land Use, Land Use Change and Forestry	#1: Grazing Land Intensity Management	The intensity and timing of grazing can influence the removal, growth, carbon allocation and flora of grasslands, thereby affecting the amount of carbon sequestered in soils. Carbon sequestration on optimally grazed lands is often greater than on un-grazed or overgrazed lands. Managing grazing land intensity is important for Swaziland as livestock production is a key agricultural activity.
	#2: Agroforestry for Mitigation	Involves combining a mixture of trees, agricultural crops and pastures to exploit the ecological and economic interaction of an agro-ecosystem. Agro-ecosystems play a central role in the global carbon cycle and contain approximately 12% of world terrestrial carbon. Increased carbon sequestration by agroforests is an important element of a comprehensive strategy to reduce GHG emissions.
	#3: Urban Forestry	Involves the care and management of tree populations in urban settings for the purpose of improving the urban environment. In addition to the physiological, sociological, economic and aesthetic benefits, urban forestry can be a tool for mitigating carbon dioxide emissions.

Swaziland is in the processes of formally analysing the barriers to the deployment of the various technologies described above. Once the barriers have been identified and analysed, Technology Action Plans will be developed to guide the implementation and transfer of such technologies. The action plans will also facilitate the advancement of systematic research and observation, which underscores the development of technical capacity in country.

6.2 Research and Systematic Observation

The Kingdom of Swaziland is active, through a number of different government departments, with regards to research and systematic observation to assist the nation understand, mitigate and adapt to climate change. In this regard, Swaziland is in the process of establishing a bio-technology park with the objective of undertaking research on climate related matters. Various other specific research and systematic observation initiatives are described below.

6.2.1 Climate change research

The research needs on climate change for the country are significant and urgent. However, nationally there is no clear research agenda and there is inadequate research capacity related to climate change. A research agenda is pertinent in as far as outlining the issues that need to be investigated in order to produce an informed assessment of what strategies and policies the country should pursue with respect to climate change. The main challenge Swaziland is faced with climate change research is inadequate funding from the central government. Hence any current research is done on an ad-hoc basis and it is mainly through projects. Most research institutions and academics that are involved in climate change research rely on external funding sources. These external funding although useful in filling the research funding deficit in most cases the research areas they commit funding to, do not necessarily fit into national priorities. However most of the research carried out under different projects is useful in understanding localized climate change impacts.

6.2.2 Systematic Observations

Systematic observations of the climate in Swaziland are done through the national synoptic network of meteorological stations under the National Meteorological Service. The country-wide network of meteorological stations gives coverage of approximately 75% of the country's territory for the measurement and monitoring of atmospheric phenomena. The National Meteorological Service provides climate services to the general public, civil aviation, and other key economic sectors and manages the whole observation network. .

The information obtained from monitoring is used for various purposes. These include the development of meteorological and agro-meteorological forecasts, warnings on natural meteorological phenomena, for use in global and regional meteorological data exchange networks and climate change assessments. The main parameters being monitored are temperature, humidity, daily sunshine hours, atmospheric pressure, average daily wind speed and direction, rainfall, lightning data and evaporation rates.

6.3 Education, Training and Public Awareness

The Kingdom of Swaziland recognises the critical role public awareness plays in educating and informing stakeholders on climate change. The need for targeted awareness and education campaigns to convey information on climate change was also reiterated in the Southern African Regional Universities Association's *Climate Change Counts Mapping Study*. Unfamiliarity with climate change constrains the adaptive capacity of vulnerable communities in Swaziland to the impacts of climate change.

Swaziland has therefore initiated a Climate Change Programme that includes specific objectives related to public awareness. The objectives include:

- Informing the public on the effects of climate change;
- Collecting the public's views on a possible action plan to address issues on climate change;
- Engaging all climate change stakeholders in the country and sharing climate change roles between them; and
- Formulating a national climate change public awareness strategy with public involvement.

These objectives informed the development of a number of educational and public awareness projects. One of these campaigns focussed on achieving grassroots-level education and awareness. This campaign covered 12 constituencies across the region. The campaign involved a climate change team and a drama group visiting each of the constituencies, where the drama team performed an informative dramatisation on climate change. This was followed by an interactive question and answer session. In addition, the campaign launched a competition in each constituency, where the public was invited to suggest a SiSwati word for climate change. This allowed for an open dialogue on climate change and its impacts, also encouraging the public to get involved with localised initiatives and determining adequate responses.

Climate Change Dialogues were also held in Swaziland, and took place in two phases. The first stage included a number of regional dialogues across the four geographical areas of Swaziland. The second stage was a national dialogue where all stakeholders, including youth representatives, civil society and non-governmental organisations came together to share views on ways and means to address climate change and its impacts.

Swaziland also participates in commemoration of global events such as Environment Day, World Meteorological day, Forest Day, World Water day, Earth Hour, etc. These commemoration events are also used as a platform to convey the message of climate change to different stakeholders.

Effective awareness campaigns, as well as stakeholder engagement through international reporting processes, have contributed to a cross-pollination of information and awareness on climate change across various departments and sectors in Swaziland. The preparation of this National Communication has also facilitated wide range of stakeholder awareness events through the different enabling activities of the TNC.

This has been illustrated in the climate change related events organised by the Swaziland Electricity Company, the dominant supplier and distribution of energy in the Kingdom of Swaziland. The most recent events included the following:

- Earth Hour 2015: Earth hour 2015 saw hundreds of people using the *#UsingTheirPower* to help fight against climate change by switching off non-essential lights for an hour, in the process reducing the nation's electricity consumption. This initiative reduced the country's electricity consumption by 14MW. This exceeded the set target of 10MW and showed a substantial increase from the 3MW reduction during the 2014 campaign.

Figure 6-1: Picture Submitted for Climate Change Competition

- Competition for the young: To inspire the young to partake in the *#UseTheirPower* initiative and to raise awareness on climate change, a competition was held for children under the age of 18 years. The competition included poems, stories and drawings describing how climate change has affected earth/ their country and how they are using their power to contribute to addressing climate change. Suggestions have been made to include climate change in the primary school curriculum.
- Climate Week: The Ministry of Tourism and Environmental Affairs in trying to raise awareness and build support for the Swaziland INDC organized a climate week, with different activities each day of the week, involving different stakeholders. The theme of the week was 'say YES to climate action' #climateactionnow. This activity attracted a large number of stakeholders and culminated to the launch of the national climate change policy and strategy on the last day.

In addition, the Ministry of Education and the Department of Water Affairs have collaborated on a climate change adaptation project. This project was made possible by the Global Environment Fund and involved the installation of 43 rain water harvesting tanks with storage capacity of 350 000 litres in 10 rural schools benefiting 3 247 students and 136 teaching staff. Water scarcities in rural schools have been highlighted as a key adaptation focus in Swaziland's *National Climate Change Strategy and Action Plan*. This project not only ensured improved access to clean water in rural schools, but enabled the practical integration of water conservation and climate change into the educational context. As a result the Ministry of Education National Curriculum Centre has agreed to review the primary and secondary school national curriculum to integrate climate change.

In an effort to maintain the momentum Swaziland has achieved significant strides in public awareness and education of climate change. Lessons learnt from these campaigns will be used to inform future actions and strategies. Valuable lessons for future planning of public awareness included:

- It is important to be cognisant of the scientific language and concepts used in terms of climate change. There is still some difficulty in translating this type of information into local language. There is a need to provide the public with easily understandable information;
- Due to the nature of the Swazi economy, there is a greater need for public awareness campaigns to focus on adaptation; and
- The response on these campaigns was very positive and the public was keen to get involved in projects to address climate change hence the need to keep them constantly involved.

The department of meteorology for the first time in 2015 through the TNC project did a public survey to find out what the public know and what their perception with regards to climate change is. The results of the survey can be summarized as follows;

- 37% of the respondents have a good knowledge of what climate change is
- 57 % stated that human activities are the cause of climate change
- About 50% are concerned about climate change
- 83% think that climate change is already happening and they think it will affect them personally
- 33% think climate change is an important issue but there are more important and pressing problems to deal with in Swaziland.
- 60% stated that the government is not doing enough regarding climate change
- Drought and intense rainfall were top two ranked impacts that most respondents think they have experienced as a results of climate change.
- 22% expressed that they would like receive more information about climate change through radio

Overall, this study supported the need for an increase in public education and awareness activities as respondents from the various samples made suggestions about amplifying activities carefully designed to make the public more aware of the issues surrounding climate change. Future communication-based interventions will have to move beyond merely sharing information and spreading awareness, and now focus as well on promoting specific behavioural practices that are feasible for most of the population to implement.

6.4 Capacity Building

The Second National Communication provided the opportunity to raise awareness about the impacts of climate change, strengthen national institutions and human resources by building the capacity in the areas of GHG inventory, vulnerability and adaptation assessment, mitigation analysis, models, public awareness, research and education. Capacity building in these areas has been developed further during the course of the compilation of this Third National Communication. Efforts were concentrated in building capacity in the GHG inventory, vulnerability and adaptation assessment and mitigation analysis.

As such, a number of technical working committees were established to source information about climate change impacts across varied sectors. These working groups established cross-sectoral relations to improve and share information. This process also facilitated capacity building by exposing various sectors to the different impacts and/or possible responses to climate change from an integrated perspective. The consultants that were engaged in the different components of the TNC also had opportunities to attend different workshops especially on GHG inventory, and vulnerability and adaptation.

Localised issues such as climate sensitive land use planning and urban and rural water management have become increasingly important in discussions around climate change capacity building in Swaziland. Key national institutions dealing with climate change are facing a severe shortage of trained staff. This stems from the fact that there is a need for well-structured capacity building programmes to deal with the diverse nature of required climate change technical capabilities.

In an effort to support capacities building in a bottom-up approach; public awareness campaigns have facilitated the integration of climate change across educational spheres. Tertiary education played an important role therein. In this regard the Southern African Regional Universities Association undertook a study to assess, among other things, knowledge and research needs and capacity gaps.

The study mapped existing university roles and contributions to climate compatible development. The study found that the following are key challenges in capacity building and technical assistance:

- There is a need for data and information management systems that allow sharing, integrated analysis and synthesis for local, regional and continental application;
- Technology transfer must be facilitated and maximised to explore the potential of national resources;
- There is a need for modelling capacity in terms of, *inter alia,* long term forecasts and/or climate outlooks and early warning systems; and
- Local climate change experts required up-skilling to ensure cross-cutting climate change issues are holistically addressed.

Based on the above, the Southern African Regional Universities Association made the following recommendations in terms of capacity building:

- The Ministry of Tourism and Environmental Affairs should facilitate the development of a comprehensive costed capacity building programme aimed at involving a wide range of stakeholders (i.e. government officials, the private sector and civil society organisations);
- A resource mobilisation plan is required for capacitating key national institutions in climate change;
- Capacitating key national institutions in data management and dissemination activities can be led by the Central Statistics Office; and
- The Department of Meteorology's capacity could be developed in terms of numerical weather prediction and modelling.

These initiatives withstanding, improving Swaziland's capacity, required in all sectors, with regards to data collection, the reporting of and implementation of climate change related measures, will significantly assist the country respond to the impacts of climate change.

6.5 Information and Networking

Swaziland participates in information sharing and networking on both regional and international levels. Enhanced information sharing and networking will assist the Kingdom adapt to and mitigate the negative impacts of climate change.

Swaziland is a party to the Tripartite Programme on Climate Change Adaptation and Mitigation, which is implemented jointly by the Common Market for Eastern and Southern Africa, the East African Community and South African Development Community.

This regional collaboration aims to ensure that the shared impacts of climate change regions are addressed through successful adaptation and mitigation actions, which will also build economic and social resilience for present and future generations. The country's participation in the Sustainable Development Goals is another example of regional collaboration in this regard.

The Kingdom's participation in the *Southern African Regional Universities Association Climate Change Counts* mapping study also attests to ongoing efforts to share information and network in the region. In addition to identifying and connecting Swaziland's existing university roles and contributions to climate compatible development, the study also focused on future collaborative knowledge co-production and use in the country.

In addition, Swaziland is part of the Food, Agriculture and Natural Resources Policy Analysis Network, which is a regional multi-stakeholder network that seeks to inform policy harmonisation at regional level in East and Southern Africa. The network combined a Youth and Climate Smart Agriculture National Stakeholder Dialogue in Swaziland in 2013, which was focussed on youth involvement in agriculture and policy development.

Swaziland is also a participant in the Sustainable Energy for All initiative. The country has developed strong partnerships with the private sector and development partners such as the United Nations, European Union Commission, USAID Trade Hub, Republic of China and Taiwan and the Energy and Environment Partnership, amongst others, to leverage funding to develop an Investment Prospectuses for implementation of the programme's Action Agenda in Swaziland.

The effort to raise awareness, to create educated and skilled experts to handle climate change issues should continue through various means such as:

i. Enhancing climate change information sharing platforms;

ii. Preparing and disseminating information and teaching materials as well as fact sheets on climate change; and

iii. Producing articles and interviews, through the mass media, including translations into the numerous local languages and dialects.

6.6 Summary of Progress

Material progress has been made with regards to Swaziland's efforts to transfer mitigation and adaptation technologies in the country. The finalisation of a Technology Needs Assessment in 2016 marks the first step to identifying the technologies that are best suited to meet Swaziland's specific needs, considering the country's natural environment and national priorities. Mitigation applications in the Energy, Waste and Land Use, Land Use Change and Forestry sectors have been prioritised, as have adaptation applications in the Water, Agriculture, Forests and Biodiversity sectors.

In addition, Swaziland has also increased education, training and public awareness initiatives, and has made significant strides in capacity building and information and networking around climate change since the Second National Communication was submitted in 2012.

7 CONSTRAINTS, GAPS AND RELATED FINANCIAL, TECHNICAL AND CAPACITY NEEDS

The process for the preparation of the TNC has contributed a lot in building capacity in the country, and it has also helped to highlight important climate change issues that need immediate attention for decision makers across sectors. However, there are still many challenges that the country is facing with regards to sustaining the capacity that has already been built and ensuring sustainable reporting/preparation of the national communications.

7.1 Reporting

Preparation of the national communications in the country is done on an ad-hoc basis, and most of the work is outsourced to consultants. However the enhancement of the reporting requirements demands for higher standards and permanent institutional framework to enable sustainable reporting while guaranteeing quality. Therefore there is a need for the country to establish this permanent institutional framework that will be responsible for the production of the national communications. This will also facilitate capacity building of government personnel and ensure continuity and continuous improvement of the reports. The key challenges of the current set up include;

- Insufficient capacity of the coordinating institution
- Lack of institutional and technical capacity for the different thematic areas of the national communication.
- Scarcity/unavailability of national experts especially for mitigation assessment, vulnerability and adaptation assessment and GHG inventory
- Lack of technical capacity and unavailability of personnel from collaborating institutions due to their already overloaded schedules
- Lack of incentives and adequate funds to maintain a permanent team that with continuously work and improve reporting under the national communication.

The TNC used quiet a number of national experts from various departments as members for the different technical working groups. However, it was clear that a number of these experts need capacity building for them to understand the different thematic areas of the national communication.

The national climate change policy, highlights the need for sustainable institutional framework for the national reporting under the UNFCCC and proposed that a department of climate change takes these responsibilities and ensure that adequate and skilled personnel is recruited to ensure sustainability. However, the Ministry of Tourism and Environmental Affairs does not have adequate resources to implement these immediately. Already government budget is strained due to numerous national priorities.

7.2 Greenhouse gas inventory

Although much progress has been made since the submission of the First National Communication to UNFCCC in 2002, Swaziland faces a number of challenges in undertaking detailed GHG inventories. These processes are crucial components that inform the development of effective policies, strategies, and mitigation measures. The following challenges were encountered during the preparation of the national GHG inventory.

- There was no continuity in the estimation of the inventory as there was no data or any information available from the last inventory calculation. This is mainly because there is no archiving system that was put in place or any inventory manual that was produced in the last inventory.
- Some of the activity data was not available for the past years in some sectors especially industrial processes and waste hence a lot of interpolation and extrapolation was done.
- Solid waste characterization data; amount generated and waste water generated are not measured in many towns and had to be derived
- National experts lack technical capacity to estimate the inventory hence training of national experts on the IPCC 2006 guidelines and inventory software should be a priority before the next inventory is prepared.
- The inventory is also done in an ad-hoc manner through consultants; there are no institutional arrangements with regards to data collection and provision. Hence there is a need to put in place sustainable GHG inventory system to help improve inventory estimation and quality.

7.3 Mitigation and Adaptation

Implementation and monitoring of mitigation and adaptation actions since the first national communication is a major challenge for the country, mainly because of other national urgent priorities and the absence of a national climate change policy to guide the implementation of this action. There is a need to create the enabling environment in the country, mainstream mitigation and adaptation to national development objectives and enhance the capacity of the Ministry of Tourism and Environmental Affairs as a coordinating institution for climate change.

The effectiveness of mitigation measures and adaptation options is dependent on strong institutions with technical, financial, and managerial capabilities. Any institutional weakness in these areas undermines the attempt to implement adaptation and mitigation measures effectively. Swaziland's actions are further constrained by the fact that climate change concerns are yet to be fully mainstreamed into national development programmes and integrated into national planning and budgeting. Therefore they are not yet reflected significantly in the sectoral development plans or the overall development agenda for the country at present.

In the preparation of national communication the country faced the following challenges;

- Lack of national experts for mitigation assessment and estimation of abetment cost for mitigation action.
- Lack of capacity in doing GHG inventory projections and use of the LEAP model
- Lack of national experts to do climate change scenarios and projections

- Lack of capacity to do socio-economic scenarios for the vulnerability and adaptation component
- Inadequate climate research experts for vulnerability and adaptation assessments.

The table below summarizes the specific technical capacity, needs and gaps the country has with regards to the preparation of national communication.

ACTIVITY	CAPACITY NEEDED
Sustainable GHG inventory management system	Institutional arrangements and GHG data management
	Development of national GHG manual
	Establishment of a national GHG management system
GHG Estimation	Training on the use of IPCC 2006 guidelines and software
	AFOLU land classification
	Use of satellite remote sensing data, and of Geographic Information Systems
Mitigation	Training on developing mitigation baseline
	Training on use of LEAP
	Training on marginal abatement cost curves
Adaptation	
- **Climate scenarios**	Training in downscaling of meteorological data and climate modelling
- **Climate impacts assessments**	Training on use of statistical and dynamic crop and hydrological modelling
	Scenario development in different sectors
- **Adaptation tools and methods**	Training on the use of different adaptation tools and methods applicable to different sectors including economic models, biophysical models and cost benefit analysis
	Scenario development in different sectors
General	Programme and project development in climate change
	Policy Analysis

Table 7.1: Capacity Needed

7.3.1 Research Needs

Long-term investment in research and development is required to enhance capacity in research, development and innovation to address the challenges of climate change across all key vulnerable sectors. A financing strategy for research and development should be created in partnership with all stakeholders. Continuous research on vulnerability and adaptation in agriculture, water resources, forestry, human health, and biodiversity including wildlife is needed in order to establish the level of the country's vulnerability to climate change and identify the best adaptation options and polices.

7.3.2 Public Awareness

Education, training and public awareness will facilitate capacity building to participate and implement effectively the commitments to the Convention. This activity is also seen as a vehicle that can be used to drive support for actions regarding Climate Change issues nationally and encourage support for government policies and measures as well as influence change in habits. Despite moderate progress in this area, there is a need to improve public education and awareness and prepare communication strategies so as to make climate science accessible to the populace to enhance their understanding of climate change and enable them to reduce their vulnerability to the adverse effects of Climate Change. Besides awareness building at community and local levels, it is also important to involve high-level policy makers to ensure integration of Climate Change considerations into national development policies.

7.3.3 National Coordination of Climate Change

The Ministry of Tourism and Environmental Affairs as a coordinating Ministry for climate change in Swaziland has in adequate capacity to perform its role efficiently and effectively. There is need to strengthen the national focal institutions for climate change in terms of human resource, training, finance and facilities for better coordination of climate change issues in the country. Financial support and capacity-building to enhance the availability of relevant climate change materials for various audiences will be essential. Swaziland's participation in climate change negotiation processes remains inadequate because of financial constraints. Since climate change is a complex and multidisciplinary issue it is essential to have wider representation in the negotiation team. Further, support is required for training in negotiation skills in the various aspects of the Convention. Now that the National Climate Change Policy has been approved there is need for the Ministry to move swiftly in implementing the policy more specifically in developing the legal instrument to institutional climate change in the country.

3.2 Financial, Technological and Capacity Building Needs

7.3.4 Accessing sources of finance

Increased flow of climate finance into the country may be enhanced by relationships with development partners and the private sector. Potential funding sources include the Africa Climate Change Fund (ACCF), Green Climate Fund (GCF), the Global Environment Fund (GEF) and the Adaptation Fund. Sustainable funding for climate change programmes and projects from national budgets is also needed. Strengthening the existing National Environment Fund, through improvement of its financial management systems and development of new systems tailored to harnessing and managing climate finance would be another useful endeavour. The national Climate Change Policy proposes the establishment of a new climate finance institution that will be responsible for sources climate finance and coordinate with local institutions in the implementation of projects. However, government ministries and departments also require capacity building to take advantage of available funding windows under the UNFCCC and other funding mechanisms.

7.3.5 Technology transfer

While there is a need for improved technology transfer, its implementation requires an enabling policy framework and the strengthening of the institutional capacity for private sector and market led dissemination. Specifically this can be enhanced through the finalisation of climate change policy and enactment of supportive legislation as well as the establishment of dialogues and increased dissemination of research findings, innovations and technologies within the country.

In this regard, Swaziland could put in place mechanisms that would allow its national institutions involved in research and development to engage with the UNFCCC's Climate Technology Centre and Networks (CTCN) for the benefit of the country. Through the nationally designated authority, Swaziland would then be able to call on the services of the Centre and its wider network for technical support, advice and capacity building. To build upon this support, Swaziland could establish a climate change technology research and innovation centre as a hub of technology development, transfer and diffusion.

7.3.6 Capacity building

Swaziland needs to put in place a comprehensive costed capacity building programme, aimed at involving a wide range of stakeholders. Such stakeholders could include government officials, the private sector and civil society organisations. Developing and implementing a resource mobilisation plan for capacitating key national institutions in climate change; data management and dissemination would also be extremely valuable. This would include strengthening the capacity of the coordinating institution, which is the Ministry of Tourism and Environmental Affairs and the Department of Meteorology.

Capacity building is also required with regards to Swaziland's data management systems. To make the best use of the data collected as a result of improved finance, capacity and technology, close collaboration is required between and among climate change stakeholders in government, private sector, non-governmental organisations, international partners, donors, academia and communities. However, capacity building is still required in the specific areas of data analyses, management, information sharing and climate research and modelling. There is a need to improve the understanding of climate knowledge by downscaling global and regional models to the national and local circumstances. It would also be desirable to encourage the Department of Meteorology and the Disaster Management Agency to work closely together, with regards to building and strengthening an integrated national early warning system for natural hazards. Beyond these, efforts should be made to share the collected data and projections with those in need of it, in agreed formats.

7.4 Adaptation and Mitigation Needs

An integral part of meeting Swaziland's adaptation gaps involves developing a National Adaptation Programmes of Action. Swaziland will then be able to identify priority activities that must be implemented in the immediate future, in order to address urgent national climate change adaptation needs. It is also necessary to formulate concrete adaptation projects to submit to the Adaptation Fund. These can contribute to incorporating or integrating climate change adaptation concerns and issues into the planning processes over the long term. Specifically, Swaziland requires early warning systems for crop failure and the introduction of new adaptive agricultural practices. These may, for example, require exploiting existing indigenous knowledge on adapting to climate change in agriculture. The upscaling of awareness and outreach activities, which share information about possible and current climate changes and these appropriate adaptive responses, would also be valuable.

There are also opportunities to meet Swaziland's mitigation gaps through catalysing the adoption of clean energy technology. The finalisation of the energy policy, as well as legislation developed to include renewable energy independent power producers, will be necessary to exploit this opportunity. Furthermore Swaziland could explore the use of markets as provided in the article 6 of the Paris agreement. There are potential monetary gains to be made from carbon markets through the sale of Certified Emissions Reduction credits to developed countries. There is also a need for an increased role of the private sector in addressing climate change concerns through direct investments and partnerships to support mitigation actions. This could be facilitated through the development and implementation of a low carbon investment plan as proposed in the national climate change policy.

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