REPUBLIC OF NAMIBIA

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

November 2015

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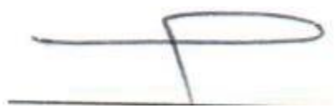
Foreword

On behalf of the Government of the Republic of Namibia, it is an honour and privilege to present Namibia's Third National Communication in fulfilment of its obligations as a Non-Annex I party to the United Nations Framework Convention on Climate Change as mandated by Article 4 & 12 of the Convention.

Namibia ratified to the United Nations Framework Convention on Climate Change (UNFCCC) in 1995 and thus became obligated to prepare and submit national communications. Thus far Namibia has prepared and submitted the Initial National Communication (INC) in 2002, and the Second National Communication (SNC) in 2011. The Third National Communication (TNC) is a follow up and build on the work done and reported under the two previous national communications.

In accordance with the enhanced reporting requirements adopted at the 16th and 17th Conference of the Parties (COP), Namibia became the first Non-Annex I party to prepare and submit its first Biennial Update Report at COP 20. The BUR provided an update on national Greenhouse Gas (GHG) inventory, information on mitigation actions and their effects and needs and support received, and institutional arrangements. Namibia is currently busy preparing its Second Biennial Update Report which will be submitted in 2016. Namibia prepared and submitted to the secretariat its Intended National Determined Contribution (INDC).

Since the submission of the BUR and the two NCs, Namibia prepared its National Climate Change Strategy and Action Plan (NCCSAP), which was approved by the Cabinet of the Republic of Namibia in 2014. The NCCSAP will facilitate the implementation of the National Climate Change Policy (NCCP) which passed in 2011. The strategy is cross-sectoral document, which will be implemented up to the year 2020 and it covers themes of mitigation, adaptation and cross cutting issues. Namibia has also developed its first Nationally Appropriate Mitigation Action (NAMA) which focuses on off-grid rural electrification. All of the above further emphasizes the commitment of the Namibian government in contributing to the attainment of the objectives of the convention.



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Hon. Pohamba Shifeta

Minister of Environment and Tourism

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- Namibia Airports Company
- Petroleum products dealers
- Namport
- AGRA
- Electricity Control Board
- Meatco Namibia

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Abbreviations and Acronyms

Acronym	Definition
°C	degree Celsius
AD	Activity Data
AFOLU	Agriculture, Forest and Other Land Use
AIDS	Acquired Immune Deficiency Syndrome
ALU	Agriculture and Land Use National Greenhouse Gas Inventory Software
AR	Assessment Report
ARV	Antiretroviral
BAU	Business as usual
BCEF	Biomass Conversion and Expansion Factors
BGB	Below Ground Biomass
Bm	biomass
BRACE	Building Resilience Against Climate Effects
BUR	Biennial Update Report
C	carbon
CBNRM	Community Based Natural Resource Management
CBRLM	Community Based Rangeland and Livestock Management
CBS	Central Bureau of Statistics
CCCM	Canadian Climate Change
CCSAP	Climate Change Strategy and Action Plan
CCU	Climate Change Unit
CCVI	Climate Change Vulnerability Index
CCVI-NTS	Climate Change Vulnerability Index of the Namibian Tourism Sector
CDC	Centre for Disease Control
CH_4	methane
CIAT	Centre International de l'Agriculture Tropicale
CNG	Compressed Natural Gas
CO	carbon monoxide
CO_2	carbon dioxide
CO_2-eq	carbon dioxide equivalent
COP	Conference of Parties
CSIR	Council for Scientific and Industrial Research
CSU	Colorado State University
dbh	Diameter at breast height
DEA	Department of Environmental Affairs
dm	dry matter
DoF	Directorate of Forestry
DRFN	Desert Research Foundation Namibia
ECB	Electricity Control Board

EDM	Electricidade de Moçambique
EEA	European Environment Agency
EF	Emission Factor
EMEP	European Monitoring and Evaluation Program
ENP	Etosha National Park
ESKOM	Electricity Supply Commission
FANRPAN	Food, Agriculture and Natural Resources Policy Analysis Network
FAO	Food and Agricultural Organisation
FOLU	Forestry and Other Land Use
GCM	Global Circulation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
Gg	Gigagram
GHG	GreenHouse Gas
GNDI	Gross National Disposable Income
GNI	Gross National Income
GPG	Good Practice Guidance
GRN	Government of the Republic of Namibia
GVM	Gross Vehicle Mass
GWH	Gigawatt Hour
GWP	Global Warming Potential
ha	Hectare
HDI	Human Development Index
HFCs	hydrofluorocarbons
HIV	Human Immunodeficiency Virus
IMR	Infant Mortality Rate
INC	Initial National Communication
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPPC	International Plant Protection Convention
IPPU	Industrial Processes and Product Use
ITCZ	Inter-Tropical Convergence Zone
Iv	Annual growth rate
IWRM	Integrated Water Resources Management
KCA	Key Category Analysis
km	kilometre
LPG	Liquefied Petroleum Gas.
LSU	Livestock Standard Unit
m	metre
m/s	metre per second
mamsl	metre above mean sea level
MCA	Millennium Challenge Account
MCC	Millennium Challenge Corporation

MDG	Millennium Development Goals
MET	Ministry of Environment and Tourism
mm	milimetre
Mm^3/a	million metric cube per annum
MMS	Manure Management System
MODIS	Moderate Resolution Imaging Spectroradiometer
MRV	Measuring, Reporting and Verification
MSW	Municipal Solid Waste
MW	MegaWatt
N$	Namibian dollar
N_2O	Nitrous oxide
NAB	Namibian Agronomic Board
NAFIN	National Alliance for Improved Nutrition
NAMA	Nationally Appropriate Mitigation Action
NAP	National Agricultural Policy
NAP	National Agricultural Policy
NCCC	National Climate Change Committee
NCCP	National Climate Change Policy
NDHS	National Demographic and Household Survey
NDP	National Development Plan
NFI	National Forest Inventory
NHIES	Namibia Household Income & Expenditure Survey
NIIP	National Inventory Improvement Plan
NIR	National Inventory Report
NIRP	National Integrated Resource Plan
NMVOC	Non-Methane Volatile Organic Compound
NNFU	Namibian National Farmers Union
NO_x	nitrogen oxides
NPHC	Namibia Population and Housing Census
NRMPS	National Rangeland Management Policy and Strategy
NSA	Namibia Statistics Agency
NTS	Namibian Tourism Sector
NVDCP	National Vector-Born Disease Control Program
PFCs	Perfluorocarbons
QA	Quality Assurance
QC	Quality Control
SACU	Southern African Customs Union
SADC	Southern Africa Development Community
SAPP	South African Power Pool
SF_6	sulphur hexafluoride
SNC	Second National Communication
SO_2	Sulphur dioxide
t	Tonne

TCI	Tourism Climate Index
TJ	Terajoule
TNC	Third national Communication
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations International Children's Emergency Fund
VFR	Visiting Friends and Relatives
WDM	Water Demand Management
WHO	World Health Organization
WMO	World Meteorological Organization
WTO	World Trade Organization
ZESA	Zimbabwe Electricity Supply Authority
ZESCO	Zambia Electricity Supply Corporation

Executive Summary

Introduction

Namibia's development is guided by its long-term National Policy Framework, Vision 2030, which transcribes into National Development Plans for 5 year periods. The country is currently in its fourth NDP that privileges sustainability within the economic development agenda and aims at a low carbon economy.

National Circumstances

Institutional Arrangements

The Cabinet of Namibia is the Government entity entrusted with the overall responsibility for the development of Policies, including those on Climate Change. The National Climate Change Committee (NCCC) oversees the implementation of the climate change policy, including the preparation of the reports for submission to the Convention and also plays an advisory role to Government on climate change issues. It comprises representatives of the various ministries and other stakeholders such as the private sector and NGOs amongst others. The NCCC is chaired by the Ministry of Environment and Tourism (MET) and the deputy chair is the National Meteorological Service of the Ministry of Works and Transport. The NCCC reports to the Permanent Secretary of the MET via the head of the Department of Environmental Affairs. The NCCC established working groups and subcommittees which have been active and very useful for overseeing and providing guidance on the different thematic areas during the preparation of this national communications.

These existing arrangements worked well for the preparation of the two submitted NCs. With the enhancement of the reporting requirements since the last few years, these past institutional arrangements have become outdated. Thus the MET embarked on a full exercise of reviewing the existing set-up towards developing and implementing new and more robust institutional arrangements for meeting the enhanced and more frequent reporting obligations. Within the planned institutional arrangements, there will be a sharing of responsibilities with the coordinating body taking on most of the planning, preparation, quality control, archiving, evaluation and validation and the other stakeholders concentrating on the preparation of the more technical components, including data collection and validation, performing technical tasks like compilation of the GHG inventory, producing draft reports and documenting these.

Geographical Characteristics

Namibia is situated in the Southwestern region of the African continent and lies between latitude 17° and 29°S and longitude 11° and 26°E. The country covers a land area of 825,418 km^2 and has a 1500 km long coastline on the South Atlantic Ocean. It is sandwiched between Angola to the North and South Africa to the South and also borders with Zambia to the far North, and Botswana to the East. The land surface ascends from the Namib Desert to the mountains of the continental border range with peaks at 2606 metres above mean sea level (mamsl). To the East and North the country then descends into the Kalahari basin with a mean altitude of 1000 mamsl.

Climate

Namibia is one of the biggest and driest countries in sub-Saharan Africa. It is characterized by high climatic variability in the form of persistent droughts, unpredictable and variable rainfall patterns, variability in temperatures and scarcity of water. The mean annual rainfall ranges from just above 600 mm in the Northeast to less than 25 mm in the Southwest and West of the country. The lowest temperatures occur during the dry season months of June to August. Annual average temperature ranges from about 16°C to 22°C across the country along an east-west gradient from the coast. Mean monthly minimum temperatures do not, on average, fall below O°C. High solar radiation, low humidity and high temperature lead to very high evaporation rates, which vary between 3800 mm per annum in the south to 2600 mm per annum in the north. Over most of the country, potential evaporation is at least five times greater than average rainfall. Wind speeds are generally low in Namibia, only at the coast do mean wind speeds exceed 3 m/s, and it is only at isolated climate stations inland, e.g. Keetmanshoop, that the mean wind speeds exceed 2 m/s. Away from the coast, relative humidity averages between 25% and 70%.

Biodiversity

In spite of its very dry climate, Namibia holds a remarkable variety of species, habitats and ecosystems ranging from deserts to subtropical wetlands and savannas. Namibia is one of the very few countries in Africa with internationally-recognized “biodiversity hotspot”. The most significant “biodiversity hotspot” is the Sperrgebiet, which is the Succulent Karoo floral kingdom, shared with South Africa.

Water Resources

Namibia is the driest country in Southern Africa. Water is a scarce resource and one of the major primary limiting factors to development in Namibia. The effects of climate change, rapid population growth, and rural exodus pose additional challenges and threaten people’s livelihoods as well as the balance of the ecosystems. Of the water that Namibia receives as precipitation, it is estimated that only 2% ends up as surface run-off and a mere 1% becomes available to recharge groundwater. The balance of 97% is lost through direct evaporation (83%) and evapotranspiration (14%). Rainfall often evaporates before it reaches the ground. The primary sources of water supply are perennial rivers, surface and groundwater (alluvial) storage on ephemeral rivers, and groundwater aquifers in various parent rocks. Additionally, unconventional water sources have been adopted to augment the limited traditional sources. About 45% of Namibia’s water comes from groundwater sources, 33% from the Border Rivers, mainly in the north, and about 22% from impoundments on ephemeral rivers (Christelis and Struckmeier, 2001).

Agriculture and Forestry

Agriculture in Namibia, like in most developing countries, plays a pivotal role in the economy base of the country. It is an essential source of livelihood for most families in term of food generation. In addition, it is an important sector as it is a predominant occupation for job creation, a major source of income and contributes highly to national foreign exchange earnings for the country. Agriculture and forestry is presently the second highest primary industry contributor to GDP with 5.9%, surpassing fishing and fish processing on board (3.6%), while the mining and quarrying industry still remains the highest, contributing 12.4% in 2007.

Approximately 48% of Namibia’s rural households depend on subsistence agriculture (NDP4). The majority of rural communities, particularly in the higher rainfall areas of the North, depend directly on forest resources for use as fuel wood, building materials, fodder, food and medicine. It is necessary to ensure the systematic management and sustainability of forest resources.

Fisheries

Namibia has one of the most productive fishing grounds in the world, primarily due to the presence of the Benguela current. The up-welling caused by the current brings nutrient-rich waters up from the depths that stimulate the growth of microscopic marine organisms. These in turn support rich populations of fish, which form the basis of the marine fisheries sector. Since independence in 1990, the fishing industry has grown to become one of the pillars of the Namibian economy. The commercial fishing and fish processing sectors significantly contribute to the economy in terms of employment, export earnings, and contribution to GDP. The fishery sector contributed 4.6% in 2009, compared to 3.7% in 2010, representing a 20% reduction.

Tourism

Namibia's unique landscapes and biodiversity support a rapidly developing tourism sector. Travel and tourism's contributes significantly to the Namibian economy directly and indirectly. Community conservation in Namibia covers over 159 755 km^2 which is about 52.2% of all communal land with about 172 000 residents. Of this area, communal-area conservancies manage 158 247 km^2 which is about 19.2% of Namibia. At the end of 2012 there were 32 registered community forests in Namibia. The use of all indigenous plant resources is regulated by the Directorate of Forestry (DoF) within the Ministry of Agriculture, Water and Forestry.

Mining

Namibia is the fourth largest non-mineral exporter in the world and is known world-wide for producing gem quality rough diamonds, uranium oxide, special high-grade zinc and acid-grade fluorspar, as well as a producer of gold bullion, blister copper, lead concentrate, salt and dimension stone. Namibia is among the top 10 world's producers of diamond and capable of providing at least 10% of global uranium. These two minerals play a significant role in the economy of the country as they exported and bring in a large share of the foreign exchange. Mining is one of the major contributor of Namibia's national economy with 13% in 2014 from 11.5% of the country's Gross Domestic Product (GDP) in 2012 and 8.2% in 2011.

Manufacturing

Namibia's manufacturing sector is inhibited by a small domestic market, dependence on imported goods, limited supply of local capital, widely dispersed population, small skilled labour force and high relative wage rates, and subsidized competition from South Africa. The manufacturing sector, a priority sector under the NDP4, is estimated to have recorded a constant growth of 1.2% in both years 2011 and 2012.

Energy

On the supply side, Namibia currently has three electricity power stations, these include: the Ruacana hydroelectric power station with a generation capacity of 240 Mega Watts (MW), which depends on the in-flow of rainfall from the catchment areas in Angola; the Van Eck coal power station with a production capacity of 120 MW, with coal imports from South Africa; and the Paratus diesel plant with a capacity of 20 MW. This translates to 380 MW in total. The local supply does not meet the demand. Currently, Namibia imports most of this difference from South Africa and other Southern Africa Development Community (SADC) member states.

Transport

Namibia's road network is regarded as one of the best on the continent with road construction and maintenance being at international standards. Namibia has a total road network of more than 64 189 km, including 5477 km of tarred roads which link the country to the neighbours Angola, Botswana, South Africa, Zambia and Zimbabwe. The country has two ports handling imported and exported merchandise, and servicing the fishing industry. The only deep-sea harbour is Walvis Bay in the Erongo Region. The other harbour is Luderitz in the Karas Region. The Port of Walvis Bay receives approximately 3000 vessels each year and handles about 5 million tonnes of cargo. Passenger transport is mainly carried out by minibuses and sedans and is increasing in intensity. For business people and tourists, air travel has become a more important means of transport to bridge the long distances. The railway network comprises 2382 km of narrow gauge track with the main line running from the border with South Africa via Keetmanshoop to Windhoek, Okahandja, Swakopmund and Walvis Bay. Omaruru, Otjiwarongo, Otavi, Tsumeb and Grootfontein are connected to the northern branch of the railway network.

Waste

Namibia, as a medium income country with a growing wealthy urban middle class and significant urban drift, is feeling the pressure of amounts of waste generated on its facilities throughout the country and more especially in the urban areas. Solid municipal waste are dumped in landfills or open dumps while almost all urban settlements are connected to reticulated waste water treatment systems. Management of the landfills and dumps are not at the highest standards and very often, the waste is burnt in the open dumps to reduce the volume or reduce health risks. Additionally, in most areas there is no segregation of waste and no separate landfills or dumps implying that industrial waste is dumped along with municipal waste.

Economic Growth

According to the National Accounts estimates, compiled by NSA in 2013, the domestic economy is estimated to have expanded by 5.0% during 2012, compared to 5.7% in 2011. This decline was attributed to the secondary industry that recorded a slower growth of 3.9% in value added compared to 4.7% registered in 2011. The primary and tertiary industries on the other hand recorded increases of 12.8% and 6.4% in value added, respectively. The slow growth in the secondary industry was due to the construction industry recording growth of 12.5% in 2012 from the 19.3% growth registered in 2011.

Population

According to the 2011 Namibia National Population and Housing census, the total population of Namibia was estimated at 2 113 077 people. Woman outnumbered man with 1 091 165, compared to 1 021 912. The age composition of the Namibia population indicates that, 14% of the population is under 5 years, 23% between the ages of 5 and 14, 57% between the ages of 15 – 59 years, and only 7% is 60 years and above. A total of 43% of Namibia's population lived in urban areas, while 57% of the population lived in rural areas. While between 2001 and 2011, the overall population growth was 15.4%, the urban component increased by 48.7% and the rural one decreased by 1.4%. In Namibia 56% of households are headed by males and 44% by females. Male-headed households predominate in most regions, except for the North-central regions of Ohangwena, Omusati and Oshana, and North-east (Kavango) where more than half of the households are headed by women (NSA, 2011).

Health

Namibia's provision of health services is shared between the public and the private sector, the latter focusing on urban areas. Infant and child mortality is comparatively low, but the maternal mortality ratio has increased, despite the fact that over 70% of births are delivered in hospitals. General life expectancy has not improved, partly because of the HIV/AIDS epidemic. Malnutrition levels in children under the age of five years are as high as 38% in some regions. The five leading causes of inpatient deaths (all age groups) are HIV/AIDS, diarrhoea, tuberculosis, pneumonia and malaria.

General Description of Steps Taken or Envisaged to Implement the Climate Change Convention

Introduction

Namibia as a young country, which gained independence some two decades ago, has witnessed major challenges since then in its development, including climate change which has impacted quite heavily on it in addition to the economic downturns that recently hit the world economy. Natural resource based economic development engines, such as the agriculture, forestry, fishing and the tourism sectors, have a direct bearing on the implementation of the Convention as they are highly vulnerable to climate change and variability. Recurrent climate changes experienced at the local level include more prolonged and severe droughts and a more variable climate with new rainfall patterns coupled with higher temperatures which affected agriculture, energy sources and ecotourism. Climate change impacts at the regional and international levels are being felt locally, namely in terms of its food security as about 70% of Namibia's population practice subsistence farming.

Steps Taken or Envisaged to Implement the Convention

Namibia has stood up to its promise since it ratified the Convention and other working instruments through various steps that have been taken to implement the Convention.

The first tangible action taken for implementing the Convention was the creation up of a cross-sectoral NCCC in 1999 to oversee all climate change related activities. A National Climate Change Policy (NCCP) was developed and approved by Cabinet in 2011 for mainstreaming of climate change in the development process. The NCCP observed that many of Namibia's sector-specific policies were developed without due consideration of climate change, because at their time of development, climate change was not regarded as a serious threat. The policy states that it is imperative that all sectors evaluate the impacts of climate change and identify adaptation and mitigation strategies – and that government make sectoral budgetary provisions based on needs assessments of such strategies to ensure adequate resources at all times.

Based on the regulatory and implementation framework provided by the NCCP, the MET has developed, using an extensive stakeholder consultative process, a Climate Change Strategy and Action Plan (CCSAP) for the period 2013 to 2020 to implement the NCCP. The CCSAP proposes basic strategic aims under the three areas Adaptation, Mitigation and Cross-cutting issues for both adaptation and mitigation. The strategy will address each aspect using a thematic approach and provides a framework listing activities, time frames, lead and partner agencies responsible.

Programmes and Measures to Facilitate Adaptation under the CCSAP

Adaptation is addressed through the priority theme food security and sustainable resource base, sustainable water resources, human health and well-being, and infrastructure. These key areas include the sectors agriculture, water, coastal zones, health, infrastructure, biodiversity and ecosystems, forestry, energy, urban management and tourism.

Programmes and Measures to Mitigate under the CCSAP

Namibia is a net sink of GHGs but this situation is expected to change by the mid 2020s when Namibia will potentially be a net emitter on the BAU scenario. On the other hand, the recent Fifth Assessment Report of the IPCC presents a bleak picture of the level of GHGs in the atmosphere that is dangerously indicating a temperature rise heading beyond 2^{o}C unless drastic measures are adopted very quickly by the international community. Namibia has submitted its Intended Nationally Intended Contribution (INDC) to the secretariat, aiming at an overall reduction of 89% of its emissions projected under a BAU scenario in

2030 Inclusive of the Land Use Change and Forestry sector. Sustainable energy, transport and AFOLU will be the major areas to achieve this INDC mitigation objective.

Cross-Cutting Issues for Adaptation and Mitigation under the CCSAP

- Cross-cutting issues will be addressed under the themes;
- Capacity building, training and institutional strengthening;
- Research and information needs;
- Public awareness, participation and access to information;
- Disaster reduction and risk management;
- Financial, resource mobilisation and management;
- International cooperation and networking;
- Technology development and transfer; and
- Legislative development.

Reporting Under the Convention

In order to meet its reporting obligations, Namibia has submitted two national communications (NCs); the initial national communication in 2002 and the second national communication in 2011 with support from the GEF through UNDP. It was a landmark for Namibia to be being the first Non-Annex I Party to submit its BUR in Lima during COP 20. Namibia met the deadlines and submitted its INDC in September 2015.

National Greenhouse Gas Inventory

Introduction

Namibia has submitted three inventories so far as components of its first and second national communications, and its first Biennial Update Report. These inventories have been compiled and submitted in line with Article 4.1 (a) of the Convention whereby each party has to develop, periodically update, publish and make available to the Conference of the Parties (COPs), in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol. These inventories have been produced to the extent of the countries capabilities and using recommended methodologies of the IPCC agreed upon by the Conference of the Parties.

Coverage (period and scope)

Namibia compiled and published GHG inventories for the years 1994, 2000 and 2010, each one being on a stand-alone basis for the requirement of individual reports. A full time series covering the period 2000 to 2010 is presented in the TNC. The inventories covered the full territory of the country and have been compiled at the national level. It addressed the IPCC sectors Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry, and Other Land Use (AFOLU) and Waste subject to AD availability.

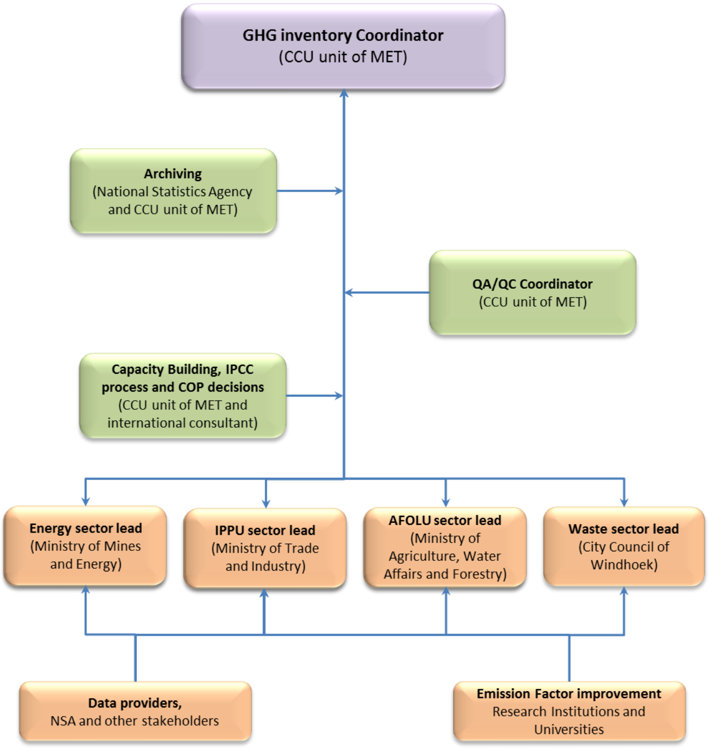
Institutional arrangements and GHG inventory system

Namibia outsourced its two previous inventories and participated actively in the production of its inventories published in the BUR1. This exercise continued with the inventory of the third national communication (TNC) to further improve, implement and consolidate the GHG inventory system being put in place. The process of preparation of GHG inventories by the newly formed team remained a very laborious exercise as resources and human capacities continued to be limiting factors. Implementation of the different steps of the inventory cycle was staged over about two years. The responsibilities allocated within the institutional arrangements are depicted below.

Methodology

Guidelines and software

The present national GHG inventory has been prepared in accordance with the IPCC 2006 Guidelines for National Greenhouse Gas Inventories and using the IPCC 2006 software for the compilations. As the IPCC 2006 Guidelines do not cover all the GHGs, it has been supplemented with the European Monitoring and Evaluation Program/European Environment Agency (EMEP/EEA) air pollutant emission inventory guidebook for compiling estimates for nitrogen oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2). Since the IPCC 2006 Guidelines do not compile estimates at the Tier 2 level also, the Agriculture and Land Use Software of the Colorado State University (CSU) was adopted for estimating emissions at the tier 2 level partially for the AFOLU sector as this is a key category.



Gases

The gases covered in this inventory are the direct gases carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) and the indirect gases nitrogen oxides (NO_x), carbon monoxide (CO), non-methane organic volatile compounds (NMVOCs) and sulphur dioxide (SO_2). AD and important information required to allow on the choice of the EFs on the carbon fluorocarbons (CFCs), hydro-fluorocarbons (HFCs) and perfluorocarbons (PFCs) were missing and thus estimates of emissions have not been made for these gases. As well, Sulphur hexafluoride (SF_6) has not been estimated since AD were not available.

GWPs

Global Warming Potentials (GWP) as recommended by the IPCC have been used to convert GHGs other than CO_2 to the latter equivalent. Based on decision 17/CP.8, the values adopted were those from the IPCC Second Assessment Report for the three direct GHGs, namely;

Gas	GWP
Carbon Dioxide	1
Methane	21
Nitrous Oxide	310

Activity Data

Country-specific AD pertaining to most of the socio-economic sectors are collected, quality controlled and processed to produce official national statistics reports by the National Statistics Agency (NSA) for government and other public uses. These data are then entered in a database and archived within the existing statistical system. Thus, data collected at national level from numerous public and private institutions, organizations and companies, and archived by the NSA provided the basis and starting point for the compilation of the inventory. Additional and/or missing data, required to meet the level of disaggregation for higher than the Tier I level, were sourced from both public and private institutions through direct contacts. Data gaps were filled through personal contacts and/or results of surveys, scientific studies and statistical modelling. Expert knowledge was resorted to as the last option. For the LAND sector, remote sensing technology was used whereby maps were produced from LandSat satellite imagery for the years 2000 and 2010. These maps were then used to generate land use changes from the land covers obtained for these two time steps and annualized for yearly values.

Emission Factors

Country emission factors (EFs) were derived for the Tier 2 estimation of GHGs for some animal classes for both enteric fermentation and manure management. A similar exercise was performed for the LAND sector where stock factors have been derived to suit national circumstances. This is Good Practice towards enhancing the quality of the inventory and especially as these activity areas were major emitters from previous inventory results. Additionally, default IPCC EFs for the remaining source categories were screened for their appropriateness before adoption on the basis of the situations under which they have been developed and the extent to which these were representative of national ones.

Recalculations

The inventory for the years 2000 and 2010 were recalculated to provide for a consistent time series. The scope of the 2000 inventory has been widened to include the IPPU sector and the 2006 IPCC Guidelines has been used instead of the Revised 1996 IPCC Guidelines to be consistent with the compilation for the period 2001 to 2010.

Inventory Estimates

Aggregated emissions

Namibia remained a net GHG sink over the whole period 2000 to 2010 as a result of the AFOLU sector turning out to be a sink. However, this sink capacity steadily declined by 64% over this period. The net removal of CO_2 thus decreased from 18 278 Gg to 1339 Gg, result of the AFOLU removals falling from 44 459 Gg CO_2-eq in 2000 to 28 534 Gg in 2010.

Total national emissions ranged from 26 180 Gg CO_2-eq in the year 2000 to 27 195 Gg CO_2-eq in 2010, representing an increase of 3.7% over these 11 years. The AFOLU sector remained the leading emitter throughout this period followed by Energy, Waste and IPPU for most of the years under review. AFOLU, with an aggregated emission of around 24 000 Gg CO_2-eq over that period, accounted for nearly 92% of the country's emissions in 2000 and this fell by 4% by the year 2010. Energy emissions increased from 1995 Gg CO_2-eq (7.6%) of national emissions in 2000 to 2904 Gg CO_2-eq (10.7%) in 2010. The IPPU sector emissions is on the rise as a result of industrial development in the country and increased substantially from 25 to 302 Gg CO_2-eq. Waste varied slightly over this period with the tendency for a slight increase over time.

National GHG emissions (Gg, CO_2-eq) by sector for the period 2000 to 2010.

SOURCE CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Energy	1995	2157	2269	2455	2562	2695	2795	2897	2981	2986	2904
Industrial Processes	25	25	26	110	235	260	255	294	291	303	302
AFOLU	24064	24290	24038	24141	24089	23790	24030	23969	24573	24550	23843
Waste	96.18	98	99	110	113	120	123	121	131	139	146
Total emissions	**26180**	**26569**	**26433**	**26817**	**26999**	**26866**	**27204**	**27281**	**27976**	**27978**	**27195**

Emissions by gas

The major gas emitted for all years remained CO_2 followed by CH_4 and N_2O. The amount of CO_2 increased slightly from 20 197 to 21 366 Gg for an average annual increase of 0.6%. CH_4 and N_2O varied around an average of 4584 Gg CO_2-eq and 1492 Gg CO_2-eq respectively during this period.

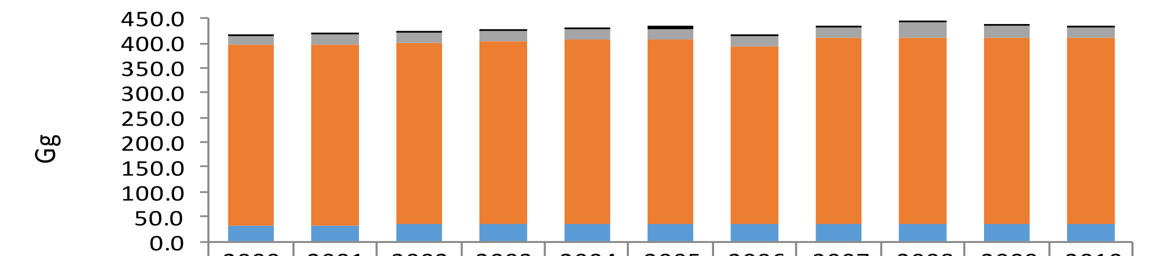
National emissions and removals (Gg, CO_2-eq) by gas for the period 2000 to 2010

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average annual change (%)
CO_2	20197	20359	20470	20736	20965	21121	21215	21353	21433	21449	21366	0.6
CH4 (CO_2-eq)	4651	4694	4505	4599	4545	4319	4504	4446	4928	4899	4336	-0.5
N2O (CO2-eq)	1331	1516	1457	1482	1489	1425	1486	1483	1616	1630	1493	1.3
Total GHG emissions (CO2-eq)	**26180**	**26569**	**26433**	**26817**	**26999**	**26866**	**27204**	**27281**	**27976**	**27978**	**27195**	0.4
Removals (CO_2)	-44459	-42739	-41501	-39532	-37707	-36402	-34781	-33264	-31641	-30075	-28534	-4.3
Net removals (CO2-eq)	**-18278**	**-16171**	**-15069**	**-12716**	**-10708**	**-9536**	**-7577**	**-5983**	**-3664**	**-2096**	**-1339**	-22.0

CO_2 increased from 77.1% in the year 2000 total aggregated national emissions to 78.6% in 2010. The other two gases, CH_4 and N_2O, varied at around 17% and 5.5% over this period of 11 years.

Among the GHG precursors, CO largely exceeded the others in emissions with an increase from 365 to 375 Gg from 2000 to 2010. NMVOCs varied between 19.5 and 32.9 Gg while SO_2 dwindled from 2.2 to 4.0 Gg. NO_x increased from 31.5 Gg to 35.2 over this same period with inter-annual variations and a peak of 36.5 in 2005. The emissions by gas and share at national level are presented in the Table below.

Emissions (Gg) of GHG precursors and SO_2 during the period 2000 to 2010



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SO2	2.2	2.4	2.8	3.1	3.6	3.8	4.2	4.0	4.2	3.7	2.8
NMVOC	19.5	20.6	20.5	20.8	21.2	21.1	20.5	21.9	32.9	23.0	22.0
CO	364.9	365.6	366.9	368.7	371.6	373.1	360.2	375.5	375.6	375.9	375.3
NOx	31.5	32.6	34.7	35.8	36.0	36.5	33.5	34.6	34.6	35.5	35.2

Summary result for the year 2010

Based on the 2010 compilations, most CO_2 were emitted in the AFOLU sector with some 18 000 Gg. Concurrently, this sector acted as a sink of about 28 400 Gg to be a net sink of -10266 Gg for the year 2010. The Energy sector came next with emissions of 2793 Gg for the year 2010.

CH_4 emanated mainly from the AFOLU sector also, followed by the Waste sector. Emissions were 198 Gg (96%) and 5 Gg for the year 2010 for these two sectors respectively. The Energy sector was responsible for 3 Gg of CH4 emissions in 2010.

N_2O emissions, amounting to 4.57 Gg, were linked to the AFOLU sector primarily and represented more than 98% of national emissions.

Among the indirect GHGs, the AFOLU sector was the highest emitter of CO at 75% of national emissions with 283 Gg, followed by Energy, 85 Gg and Waste with 7 Gg. Energy emitted 60% of national NO_x emissions with 21 Gg and AFOLU was responsible for 14 Gg. The Energy and AFOLU sectors contributed 51% and 47% of national emissions of NMVOCs which stood at 22 Gg.

With regard to SO_2 emissions, 2.75 Gg emanated from the Energy sector out of a total of 2.76 Gg, the remainder coming from the Waste sector.

Quality Assurance and Quality Control (QA/QC)

QC and QA procedures, as defined in the IPCC 2006 Guidelines (IPCC, 2007) were implemented. Whenever there were inconsistencies or possible transcription errors, the responsible institution was queried and the problem discussed and solved. QC was implemented through, routine and consistent checks to ensure data integrity, reliability and completeness; routine and consistent checks to identify errors and omissions; accuracy checks on data acquisition and calculations; the use of approved standardized procedures for emissions calculations; and technical and scientific reviews of data used, methods adopted and results obtained.

QA was undertaken by independent reviewers who were not involved with the preparation of the inventory, the objective being to confirm data quality and reliability; review the AD and EFs adopted for each source category as a first step; review and check the calculation steps in the software; and ensure consistency over the time series.

Uncertainty Analysis

The uncertainty analysis has been performed using the tool available within the IPCC 2006 Software for the national inventory, excluding the Land sector. Based on the quality of the data and whether the EFs used were defaults or nationally derived, uncertainty levels were allocated for the two parameters and the combined uncertainty calculated. For the national inventory, Uncertainty, excluding the Land sector ranged from 5.6% to 6.5%. This is considered good and very much acceptable.

Key Category Analysis

The Key Category Analysis also was performed using the tool available within the IPCC 2006 Software for both level and trend assessment. There are five key categories in the trend assessment, four of these from the AFOLU sector, of which enteric fermentation from Livestock, three from Land category and the last one is Road Transportation from the Energy sector. The results changed slightly when considering the trend assessment. There are still 5 key categories but Road Transportation is replaced by Other Sectors-Liquid Fuels while the other four remained the same.

Archiving

All raw data collected for the inventory have been stored in a database and in the 2006 software data base after being processed and formatted for making estimates of emissions and removals. All documentation on the data processing and formatting have been kept in soft copies in the excel sheets with the summaries reported in the national inventory report (NIR). These versions will be managed in electronic format in at least three copies, two at the Ministry of Environment and Tourism and a third copy at the NSA.

Constraints, Gaps and Needs

Namibia, as a developing country, has its constraints and gaps that need to be addressed to produce better quality reports for reporting to the Convention. The main problems encountered during the preparation of the national inventory of GHG emissions were:

- Information required had to be obtained from various sources as no institution has been endorsed with the responsibility for collection of specific activity data (AD);
- Almost all of the AD were not in the required format for feeding in the software;
- End-use consumption data for all the sectors and categories were not always readily available;
- Reliable biomass data such as timber, fuelwood, wood waste and charcoal consumed or produced were not available;
- There were frequent inconsistencies when data were collected from different sources;
- Lack of solid waste characterization data, amount generated and wastewater generated; and
- Lack of EFs to better represent national circumstances and provide for accurate estimates;

National Inventory Improvement Plan (NIIP)

Based on the constraints and gaps and other challenges encountered during the preparation of the inventory, a list of the most urgent improvements have been identified. The most important ones are:

- Adequate and proper data capture, QC, validation, storage and retrieval mechanism;
- Further build capacity and strengthen the existing institutional framework;
- Further develop national emission factors (EFs) more representative of the national context;
- Implement fully the QA/QC system in order to reduce uncertainty and improve inventory quality;
- Establish a GHG inventory unit within DEA for inventory compilation and coordination;
- Institutionalize the archiving system;
- Implement new forest inventories to supplement available data on the LAND category;
- Review and correct inconsistencies existing for the recent land cover maps; and
- Produce new maps for 2005.

Mitigation

Introduction

Namibia, as a Non-Annex I country, has no obligation to reduce its GHG emissions as a signatory Party to the Convention. However, Namibia is committed to contribute to its maximum capability towards meeting Article 2, the ultimate objective of the Convention, namely *the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.* The Government of Namibia has thus developed various policies and strategies guiding its development agenda on a green low carbon economic path in line with sustainable development goals.

Assessment Method

Two major principles guided this mitigation assessment:

- Meet the ultimate objective of the Convention, namely Article 2 to stabilize the greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system; and
- Promote the socio-economic development of the country as per the policies and strategies in place presently and charting medium term plans and actions.

Thus, this analysis integrated the projected socio-economic conditions of the country, the level assessment of the last inventory year for determining the key categories and the trend assessment of emissions to determine activity areas gaining importance as major contributors of GHGs.

A Business as usual (BAU) scenario was developed for all categories and sub-categories assessed for their emissions and removals in the latest GHG inventory to provide for the carbon intensity of the country under the present development path. Activity areas offering the highest potential for action on the basis of the guiding principles and other factors enumerated above were then assessed for their mitigation potential by comparing emissions or removals of the different measures identified within the category or sub-category to its BAU scenario. The base year adopted for this mitigation analysis is 2010 and the time horizons 2025, 2040 and 2050 have been used for the projections.

Once the activity data have been generated for the different options such as fuel combusted, waste produced, wood removals or area reforested amongst others, these were fed in the IPCC 2006 software to compile emissions or removals for the year being assessed. The difference between the BAU and mitigation scenarios emissions or removals of the category under assessment gives the emission abatement or sink enhancement value of the potential measure.

Scope of the Assessment

All activity areas concerned with emissions or removals in a country can be targeted for mitigation analysis. However, this is very resource demanding and very often, it is not worth evaluating the marginal and minimal contributors of GHGs for their mitigation potential as it is not cost effective. Based on this principle and taking the level and trend assessment from the KCA, the electricity generation, road transportation and AFOLU categories were prioritised for the assessment. Due to its importance in relation to health and sustainable development, the waste sector has also been considered.

Socio-economic scenarios

Population size and growth

The population which stood at 1.410 million in 1991, was higher than that of the census year 1981 by 0.377 million, that is an increase of 36.5%. In the next two decades following the year 1991, the population growth slowed to reach 2.113 million in 2011. The increase was 29.8% for the decade 1991 to 2001 and 15.4% for the following one. Assuming that beyond 2011, the population will continue to increase at a rate similar to that which prevailed for the period 2001 to 2011, at an exponential growth rate of 1.01%, the projected population will reach 2.405 million in 2020. The three million mark will likely be met shortly after the year 2035. By 2050, it is projected that the population will expand to some 3.701 million.

Urbanization

Between 1991 and 2011, the increase in urban population largely outpaced the rural component of the total population. While the total population increased by 50% from 1.410 to 2.113 million, the number of urban dwellers rose by 236% from 0.382 to 0.904 million. A long-term profile (five year projections until 2050) for urbanization was developed on the basis of past recorded trends, initial projections as set out in Vision 2030 and NSA population projections of 2011. The main features are (i) from 2015 to 2030, urbanization rate would increase by 5% for every 5-year period, and (ii) between 2030 and 2050, the growth rate for every 5-year period would be 3.75%. Thus, by 2030 the urban population is projected to be 62% of the total population giving a number of persons living in towns amounting to 1.721 million. This represents an increase of 0.817 million over the year 2011. In the event urbanization level would reach 77% in 2050, this fraction of the population will stand at 2.849 million. The latter number will be practically three times that of 2011. The resultant will be that the rural population will progressively decline to reach 0.851 million in 2050, or 70% of that for 2011.

GDP and GDP per capita

Between 1981 and 2000, the annual growth rate for total GDP has been quite variable. For 11 years out of 20, it exceeded 3%. Total GDP in constant 2010 prices reached N$ 51 833 million in 2000. Subsequently, with a higher annual growth, often in excess of 4%, GDP in 2010 attained N$ 82 598 million representing an increase of 59% over the 2000 figure. Due to a 17% increase in the size of the population over the 2000-2010 decade, GDP per capita changed by only 36%, i.e. from 29 074 N$ to 39 677 N$ or from 3 546 US$ to 4 839 US$ on the basis of the average exchange rate for the years 2008 to 2010.

A conservative scenario has been built to picture GDP growth until 2050. The projected real growth rates are 4.0% for the period 2017 to 2031, 3.6% between 2032 and 2036 and 3.2% between 3037 and 2050. Under these projections, total GDP will grow to N$ 188 042 million in 2030, more than twice that of 2010. In 2050, it would be around N$ 362 746 million or 439% of the 2010 one. In the case of GDP per capita, the figure projected for 2030 and 2050 will be respectively, N$ 67 730 (US$ 8 260) and N$ 98 023 (US$ 11 954). These clearly suggest that by 2050, the living standard of the Namibian population will have considerably improved.

National mitigation potential

National level

Emissions stemming from the BAU scenarios for the base year 2010 and the projections for 2025, 2040 and 2050 are given in the Table below. Relative to the base year 2010, it is projected that the country will lose its sink capacity and becomes a net emitter of GHG. These will be 17 713, 30 649 and 34 162 in the years 2025, 2040 and 2050 compared to removals of 1339 in 2010. The major contributor will be the AFOLU sector followed by Energy, IPPU and Waste.

Different measures 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.

Emissions (Gg CO_2-eq) under the BAU scenario for the years 2010, 2025, 2040 and 2050

BAU	2010	2025	2040	2050
National emissions	-1339	17713	30649	34162
Energy	2904	5992	11101	11459
IPPU	302	544	924	1267
AFOLU emissions	-4691	10920	18200	20850
Waste	146	257	424	586

The abatement potential (Gg CO_2-eq) at the national level when compared with the BAU scenario and the contribution from the different sectors evaluated are presented in the table below The mitigation potential summed up to 12 702, 21 507 and 24 439 Gg CO_2-eq for 2025, 2040 and 2050 respectively. This represents 72, 70 and 72% of the BAU scenario of the respective year under assessment.

Mitigation potential (Gg CO_2-eq) for the years 2025, 2040 and 2050

	2025	2040	2050
BAU	17713	30649	34162
Energy Electricity	447	1584	3524
Road Transport	449	634	834
Waste	175	270	335
IPPU	36	36	36
AFOLU -Forest	11419	18548	19734
Total	12702	21507	24439
% BAU	72	70	72

Vulnerability and Adaptation

Introduction

This theme has been developed by the Vulnerability and Adaptation Multi-stakeholder Task Team, which selected four key sectors that are important to Namibia's economy and development, yet at risk of negative impacts of climate change. These four sectors are agriculture, health, tourism and water.

Framework of assessment of vulnerability and adaptation

This exercise follows the definition provided by the Intergovernmental Panel on Climate Change (IPCC) in its Fourth Assessment Report (AR4). To ensure comparability between sectors and within sectors over time, an indicator- based framework is used, where the exposure, sensitivity and adaptive capacity, as well as the outcome of vulnerability, is defined by indicators. To the extent that appropriate data was available, these indicators are quantitative and were identified by the Task Team.

Nature of climate exposure to climate change

Climate change in Namibia has already been observed. According to Reid (et al., 2007) ambient temperatures in Namibia have been rising at three times the global mean temperature increase reported for the 20th century. Rainfall received throughout the country has been low in the last 10 years, characterized by short duration high intensity rain storms (Dahlberg et al., 2008). Severe droughts have been experienced.

High resolution climate projections are available through downscaling GCMs. There are two methods for downscaling: statistical downscaling is based on statistical relationships between weather type and local weather variables. All projections show the change projected for 2036-2065 (relative to the 1961-2000 period) based on the A2 scenario (a fairly high emission scenario that reflects the current path of our emissions). 10 GCMs have been downscaled. Temperature is projected to increase across Namibia, with the greatest increases inland. These increases will range from 0.6-3.5^{o}C. The temperatures will increase across the year with the greatest increase in temperature in September-October-November. The seasons with the smallest increase in temperature are December-January-February and March-April-May. Projecting rainfall is subject to a greater range of uncertainty than temperature. The downscaling exercise shows that an increase in rainfall is likely for seasonal change. Here there is much more uncertainty; however for much of the northern and central parts of the country where most of the population is found, there will likely be an increase in September-October-November. Potential increase also exists for March-April-May, at the end of the usual rainy season.

The second method of downscaling is dynamical and results are generated here using six GCMs for the A2 scenario (same as the statistical downscaling) to generate projections for 2036-2065, relative to 1961-2000 (Davis, 2011). Dynamical downscaling also shows temperature increase is projected throughout

Namibia, from 0.9-3.8°C. The dynamical downscaling technique shows that mean annual rainfall across Namibia is likely to decrease. Decreases are projected across the country for all four seasons, with the greatest decrease in the interior for the latter part of the rainy season in the months of December-January-February. Dynamical downscaling was also used to assess projected change in annual frequency of extreme rainfall events. Overall Namibia is projected to have the same or slightly fewer extreme rainfall events.

Vulnerability of Key Sectors

Agriculture

Overview of the sector

Climate change effects on agriculture are also already being observed. Livestock and crop production under rainfed conditions has been declining by about 33% on average every year in the last few farming seasons. The year 2013 recorded the worst drought in 30 years and the GDP contribution by agriculture and its subsectors fell significantly with livestock farming recording the highest decline of 37.6%

Drivers of sensitivity

Rainfall is the main determinant of crop yield, grass biomass and livestock production in Namibia; but changing temperatures will also put pressure, both directly and through evapotranspiration rates. The nature of the soils, and how this changes under exposure to climate change, will determine shifts in vegetation. To take the example of livestock, cattle, as natural grazers, do best in areas where natural pastures are most abundant. The southern and western parts of the country offers little in the way of grass fodder. So small stock like sheep and goats, replace cattle in those arid areas. Changing soil conditions and pressure from human activities has contributed to the domination of invasive bush species which competes with grasses. While deforestation is modest in Namibia at 0.9%, forests account for less than 10% of the landscape. The expansion of agriculture puts pressure on forested areas.

Adaptive capacity

A number of factors will determine the extent to which agriculturalists of different scales and with different focal areas, whether livestock or crops, will be able to respond to the hazard exposure and sensitivity. Adaptive capacity can play a critical role in determining the extent of the vulnerability. The two key indicators of adaptive capacity are the extent of access to veterinary medicines and feed; and access to water.

Vulnerability and indicators

The main consequences of vulnerability of the agricultural sector are reduced food production capacity due to rangeland degradation, deforestation, biodiversity loss, droughts and flash flooding and climate change directly causing water scarcity, water pollution and unfavourable temperature humidity index. Based on the preceding sections which outlined exposure, and the nature of sensitivity and adaptive capacity in the agricultural sector, the vulnerability and adaptation assessment conducted for various value chain segments of the agricultural system in Namibia is summarized in the table below.

Vulnerability Assessment of Agricultural Sector in Namibia

Impact	Prevailing and Anticipated Hazards	Projected Climate Change	Vulnerability Assessment		
			Sensitivity	Adaptive Capacity	Vulnerability
Water supply	Summer drought	Increases in summer droughts due to warmer,	High - water supply and soil water table is very sensitive to changes in	Low - options for expanding water supply: - damming is limited and expensive,	Very High

Impact	Prevailing and Anticipated Hazards	Projected Climate Change	Vulnerability Assessment		
			Sensitivity	Adaptive Capacity	Vulnerability
		drier, shorter rainfall summers	rainfall patterns and vaporization.	mostly ephemeral dams, main supply rivers (Kavango, Zambezi, Orange rivers) found the north/ south borders of Namibia are far away from the people.	
Surface water run-off from Angola to NCAs of Namibia	When there is heavy storms which are more prevalent rivers in Angola overflows and emptying southwards causing flash floods in the NCAs of Namibia	More localized flooding in the open lands in the NCAs called Oshanas, water quality problems as flooding covers the sections Ruacana water canal.	High – Oshanas in NCAs flood easily, they are low lying & flat Rampant soil erosion and water logging dependent and sensitive to the intensity and frequency of rainstorms in Angola.	Low - attempts to divert water in Ongendiva City are proving costly to the municipality what more for local government authorities in NCAs who do not collect any revenue from the poor people.	High
Rangeland livestock farming and restoration	Bush encroachment, degradation of rangelands (loss of soil fertility, soil cover, loss of grazing areas) and loss of biodiversity during extreme droughts and short duration intense rain and heat events	Further deterioration of rangelands, more animal deaths, low livestock productivity. Problems with forestry fires. More bush thinning required, rangeland restorative measures imperative, over grass is necessary.	Very High - Namibia is already a semi-arid country with poorly developed soils and endemic problem of invasive plants creating serious bush encroachment e.g. by *Acacia Mellifera*	Medium - Hope rest on the effective implementation of the National Rangeland Management Policy & Strategy of 2012 which aims to restore Namibia's rangelands. It will be costly; dependent on country-wide advocacy especially to end users of natural resources.	Very High
Staple crops and cash crop production	Water stresses on rain-fed agriculture, water availability & accessibility for green scheme cash crops.	Low productivity, less nutritious crop commodities produced, input support will receive less attention due to pressures on national fiscus.	Very high - due to high temperatures hence high evaporative losses, wilting of plants, short duration rain not suited to hybrid seeds	Medium - hope rests on water harvesting from perennial rivers which are far away from the people. Underground water is saline so needs costly desalination.	Very High
Marketing of agricultural produce	Water & heat stress affecting amounts and quality of food produced and storage.	Investment in infrastructure wasted due to underutilization of auction pens, roads and food marketing hubs.	High - fulfilling supply contracts difficult.	Medium - need to reduce post-harvest losses, alternative plans to fulfill supply contracts, risk management.	High

Health

Overview of the current status of the sector

MoHSS has identified a number of key health challenges currently faced by the Namibian population through the National Health Policy Framework 2010-2020 '*towards quality health and social welfare services*'; aligned to National Development Plan 3, the Ministry of Health and Social Services Strategic Plan 2009–2013, and the WHO Millennium Development Goals. (MoHSS, 2010) The most significant priorities and how they will be affected by climate change are highlighted in the table below. Chief amongst these is the challenge of HIV/AIDS. Tuberculosis/HIV co-infection is also common. Overall, the leading causes of deaths in public health facilities remain HIV/AIDS, TB and diarrhoea (MoHSS, 2013).

Significant health priorities as outlined in the National Health Policy Framework, and how they may be affected by climate change

National Health Priority	Impact of Climate Change
HIV/AIDS	Interruption of ARV treatment due to migration and forced displacement of population. Increased transmission by increasingly mobile population
Sexually Transmitted Infections (STIs)	Increased transmission by increasingly mobile population.
Maternal, Neonatal and Child Health	Reduced access to antenatal and obstetric care during periods of flooding. Lack of continuity of care due to migration. Increased malnutrition amongst children. Increased incidence of water and vector borne diseases. Interruption of childhood vaccination schedule in mobile/displaced population.
Adolescent and School Health	Increased risk of mental health problems in young people due to pressures of climate change (reduced food security and employment opportunities, increased migration/forced displacement) and exposure to extreme weather events. Damage to sanitation and water facilities on school premises during flooding leading to outbreaks of water borne diseases.
Nutrition	Reduced food security leading to increased malnutrition
Endemic Diseases	Lengthening of malaria transmission season in some areas. Spread of diseases (e.g. malaria, schistosomiasis) to non-endemic areas. Increase in drug-resistant Tuberculosis due to interrupted treatment regimes.
Mental Health and Disability	Increased mental health problems due to loss of livelihoods, forced migration and pressure of maintaining agricultural output.
Lifestyle- Related Problems	Increased abuse of alcohol in populations where livelihoods/employment is lost due to climate change.
Disease Outbreaks, Disaster Related Health Problems and Emerging Diseases	Increased epidemics of water and vector borne diseases. Re-emergence of previously eliminated diseases
Health and Environment	Increasing environmental health problems. Pressure on water and sanitation systems during drought increases incidence of disease. Damage to these facilities during flooding has similar consequences.
Other Common Health Problems	Increased incidence of skin disorders due to flooding. Reduced access to primary care for chronic disorders during extreme weather events and as a result of migration/displacement.
Social Welfare	Increased reliance on 'drought relief' food supplies. Reduced access to social services and welfare systems by migrant/displaced populations.

Another major challenge to the healthcare system, which will also influence the way in which the sector responds to the challenges of climate change, is the widely distributed population. This makes healthcare infrastructure and staffing problematic. Infrastructure availability is already poor, and effectiveness is impeded by the distances. Maintenance of infrastructure, coordination of the state ambulance service, and specialist referrals are therefore often problematic.

Drivers of sensitivity

A number of factors affect the sensitivity of the healthcare system to climate change – and the extent to which exposure to changes in temperatures, rainfall patterns, extremes such as floods, and bush fires, will affect the health status of the Namibian population. Physiological sensitivity exists for extreme weather events such as bush fires, storms and flooding. On an individual level this may include the effects of death or injury from fire, floodwater or landslides, which are likely to rise as climate variability increases.

It is likely that the incidence of heat stress will increase, causing an increase in mortality, as was demonstrated in the European heat-wave of 2003. Prolonged heat exposure can be a direct cause of death, particularly in the elderly, very young and others unable to preserve their natural thermal homoestasis. Areas at greatest sensitivity to increasing incidence of extreme high temperatures are north and central Namibia, which include the most populous areas of the country.

River floodplains will also be sensitive to the increased incidence of flooding due to extreme rainfall events in the north and west of the country - including Zambezi, Kavango, Ohangwena, Omusati and Oshikoto. Khomas and Omaheke have a medium level sensitivity relative to other areas. In May 2013, 12 000 people were evacuated to 13 temporary camps in the Zambezi Region due to flooding of the Zambezi River (Reliefweb International, 2013.) These forced displacements, combined with heavy rainfall and contaminated water supplies are likely to increase the incidence and transmission of waterborne diseases such as cholera, typhoid fever, leptospirosis, cryptosporidium, *E.coli*, giardia, shigella and hepatitis A. As well as with cholera, physiological sensitivity varies among different groups of the population with regard to food security. High levels of food insecurity are already experienced in parts of the north of Namibia, including Omusati, Kavango, Otjozondjupa, Omaheke, Kunene and Erongo. Mothers, women of child bearing age and children are particularly sensitive to malnutrition, meaning that many babies have a low birth weight and do not benefit from good quality breast milk. HIV/AIDS is also responsible for increasing rates of malnutrition amongst young children who are orphaned or are themselves infected with the disease.

Increasing temperatures and changes in rainfall availability will also alter the locations which are sensitive to vector-borne diseases such as malaria, dengue fever and schistosomiasis, also known as bilharzia, through affecting the habitat range for the vector (Husain et al., 2008; Chaves, 2010). Population is largely concentrated in the Northern regions, while the southern regions have a very low population density. Transmission rates are much higher in the north of the country, and these areas that are sensitive to malaria will likely expand under climate change, exposing a greater proportion of the population. Vector control measures have been expanded across affected areas, as has the distribution of long-lasting insecticide treated nets. 85% of malaria deaths continue to occur in children under five, making them a particularly sensitive group of the population (*Ibid*).

Quantitative data means that indicators of sensitivity can be created, highlighting the geographical sensitivity of various regions of Namibia to climate change. Three indicators are used: malaria transmission, relative food security and prevalence of diarrhoea in children. Malaria transmission was included as areas where it is already present are vulnerable to an increasing burden of disease should the transmission season become longer. Regions where the disease is present, but transmission rates relatively low, such as Omaheke, are likely to be greatly affected. Relative food insecurity is used as areas of high insecurity are most vulnerable to malnutrition as a consequence of drought. Prevalence of diarrhoea in children is used as a proxy since information on the regional incidence of a disease such as cholera is not currently available.

Adaptive capacity

Despite the sensitivity of different regions and groups of the population to climate exposure, different levels of adaptive capacity will also determine the levels of vulnerability to the health impacts of climate change. Four main categories affect the levels of adaptive capacity. These are poverty incidence, illiteracy, HIV prevalence, malnutrition, access to water and sanitation, and access to healthcare.The regions with the least adaptive capacity according to this index are Kunene, followed by Kavango, Ohangwena, Oshikoto and Omaheke.

Vulnerability and indicators

Regional vulnerabilities arise from the fact that some areas experience more health-related consequences of climate change than others. Some regions have higher sensitivity to climate change and some have lower adaptive capacity than others. In Namibia the northern regions experience the highest vulnerability to the health-related consequences of climate change. Based on a combination of the indicators of sensitivity and adaptive capacity to calculate vulnerability, it can be seen that Kunene is the most vulnerable region, followed by Kavango, Omaheke, Oshikoto and Ohangwena.

Social vulnerabilities arise from the fact that different socio-economic and demographic groups have different levels of sensitivity and adaptive capacity when exposed to climate change. In Namibia this includes the elderly and children, disabled, homeless, marginalized groups and those suffering from chronic disease such as HIV/AIDS. Remote and rural communities also experience an increased level of social vulnerability.

When looking at the numbers of people that are vulnerable to climate change, it is possible to look at both current and projected future population figures, which gives an insight into how vulnerability is likely to change into the future. The areas experiencing most exposure *at the current time* (based on the 2011 census) are Ohangwena, Kavango, Omusati and Oshikoto, with Khomas in 5th place. If population in these regions reaches anticipated levels by 2041 then the highest levels of exposure will still be in Kavango and Ohangwena but Khomas will have moved from 5th of 3rd place due to migration and assuming that sensitivity and adaptive capacity in all regions remains the same as it is currently.

Tourism

Overview of the sector

Tourism is one of the fastest growing sectors within the economy. The drivers of growth includes the country's unique landscapes and biodiversity coupled with socioeconomic and political stability. The Etosha National Park is the most visited National Park, with 22% of all tourists travelling there, and 53% of all holiday tourists. International tourism predominates in Namibia, with a steady increase in arrivals from the mid-1990s to 2012, and dwarves the role of domestic tourism.

Tourism exposure index

Exposure, is conceptualized here, as the degree or magnitude to which the multisystem (tourism sector and the human system in Namibia) is exposed to the climate change related stimuli droughts, floods and extreme temperature. For estimation of the tourism vulnerability index, exposure was further contextualized into current and future exposure.

Indicators used for current exposure are:

- The frequency of drought events for the period 1949 to 2009 in each of the 13 regions of Namibia; and
- The frequency of flood events for the period 1949 to 2009 in each of the 13 regions of Namibia.

For future exposure, the following indicators were used:

- The aridity index (AI) for the period 2035 to 2065; and
- Tourism Climate Index (TCI) for the period 2035 to 2065 which is used as a proxy for the suitability of the climate resource of an area for outdoor tourism activities.

Drivers of sensitivity

The climate change impacts that affect tourism destinations, their competitiveness and sustainability can be classified into four broad categories – i.e. direct climate impacts, indirect environmental impacts, impacts of mitigation policies on tourist mobility and indirect societal change impacts.

Climate is a principal resource for tourism, and it codetermines the suitability of locations for a wide range of tourist activities. Increases in the frequency or magnitude of certain weather and climate extremes (e.g.

heat waves, droughts, floods, tropical cyclones) are likely as a result of projected climate change. National or international mitigation policies – that is policies that seek to reduce GHG emissions – may have an impact on tourist flows. Climate change is thought to pose a risk to future economic growth and to the political stability of some nations. Any such reduction of global GDP due to climate change would reduce the discretionary wealth available to consumers for tourism and have negative implications for anticipated future growth in tourism. Since there is high dependence on international tourism, Namibia is sensitive to global economic growth and its effects on disposable income in source countries. Other indirect impacts may include changes in landscape (including the climate) – the "capital" of tourism, which might lead potential tourists to perceive Namibia as less attractive and consequently to seek new destinations elsewhere.

Adaptive capacity

Adaptive capacity is defined as the ability of a system [human or natural] to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. The following are the adaptive capacity indicators that were used:

Poverty incidence. The proportion of the population identified as poor. Poverty reduces the adaptive capacity of an individual, household and the community. The higher the poverty incidence the lower the adaptive capacity, and hence the greater the vulnerability.

The proportion of tourism households with a single source of income. Household with diversified sources of livelihoods have a high adaptive capacity. The higher the proportion of households with a single source of income lower the adaptive capacity, and hence the higher the vulnerability.

The proportion of the population that cannot read and write. Research shows that literate people have high adaptive capacity compared to illiterate people. The higher the proportion of illiterate population the lower the adaptive capacity, and hence the higher the vulnerability.

Deprived Access Index. This index was estimated as the proportion, expressed in percentage terms, of the population with deprived access to a radio, television set and/or cell phone. The higher the proportion of deprivation the lower the adaptive capacity, and hence the higher the vulnerability.

Human Development Index (HDI). HDI was used as a proxy to show comparative development across the regions. The higher the HDI the higher the adaptive capacity, and hence the lower the vulnerability. Therefore the inverse of the HDI index is used in the estimation of tourism vulnerability.

The Adaptive Capacity sub-index indicates that Khomas, Erongo, Karas, Hardap and Omusati have tourism sectors that have high adaptive capacity to climate change. Tourism sectors in the Oshana, Ohangwena, Kavango and Zambezi have low adaptive capacity. Regional tourism sectors with low adaptive capacity are likely to be largely affected by climate change impacts, while those with high adaptive capacity are likely to be more resilient to climate change impacts.

Current assessment of spatial vulnerability hotspots for the Namibian Tourism Sector (NTS) were identified using the estimated CCVI-NTS for the current time, combining exposure, and sensitivity and adaptive capacity. The current vulnerability hotspots for the tourism sector in Namibia were identified to be the Omaheke, Zambezi, Kavango, Omusati and Kunene regions. These regions' tourism sectors have high current exposure, high sensitivity and low adaptive capacity to climate stressor relative to the other regions. Therefore it can be concluded that the tourism sector is relatively highly vulnerable in these five regions, compared to other regions in Namibia.

The tourism sector in the Oshana, Otjozondjupa, Karas, Ohangwena, Hardap and Oshikoto regions have medium vulnerability to climate change related stressors since they have high adaptive capacity relative to the regions with high vulnerability. The regions with low vulnerability to climate change related stressors are Khomas and Erongo due to the regions' high adaptive capacity relative to the other regions. Since the Erongo and Khomas regions are the top most destinations for both international and domestic tourism, it can be concluded that the tourism sector in Namibia is to some extent resilient to climate change impacts. The second conclusion is that in the medium term the results can be used to allocate tourism adaptation investments in regions, with priority given to regions with high vulnerability.

Future vulnerability was also estimated using climate projections for 2045-2065 (an ensemble of 9 Global Climate Models), assuming that sensitivity and adaptive capacity do not change. On the basis of the estimated CCVI-NTS, the future vulnerability hot spots for the tourism sector in Namibia were identified to be the same five regions as currently, namely Kavango, Kunene, Zambezi, Omaheke and Omusati regions. However, it is expected that climate change will exacerbate the vulnerability degree of these regions. The degree of vulnerability of the tourism sector is expected to increase in the regions of Erongo (29% increases), Hardap (40% increase), Karas (13% increase), Kavango (100% increase), Khomas (17% increase) and Kunene (86% increase) from the current period to the mid-century period. The largest vulnerability intensifications are projected in the Kavango and Kunene regions, primarily because of relative low adaptive capacity in the regions. The observed decrease in vulnerability in the Omaheke region can be attributed to the low sensitivity of the region's socioeconomic system to climate change impacts on the tourism sector.

Water

Overview of the sector

Namibia has no perennial rivers in the interior, as perennial rivers occur only on the northern and southern borders. For the supply of water, the country relies on dams on the ephemeral river systems and groundwater. These are supplemented to a limited extent by unconventional sources such as reclaimed water in the central area and desalination at the coast. Natural water sources are therefore totally reliant on rainfall to feed ephemeral rivers and recharge aquifers. In this arid climate, only 2% of the rainfall ends up as surface runoff, and 1% becomes available to recharge groundwater (Heyns et al*.,* 1998). The balance of 97% of the rainfall is lost through evaporation (83%), and used by plants in transpiration (14%). The main consumers of water are Agriculture, the domestic sector and mining. MAWF projects that the demand will increase from 334 Mm^3 in 2008 to 772 Mm^3 in 2030. Most of the basins are actually meeting their demand, even as far as the year 2030, except for the Omaruru-Swakop (i.e. the Windhoek-Okahandja area), and the Tsondab-Koichab Basin (i.e. Lüderitz). Climate change is likely to limit the availability of water for the various sectors in these basins.

Drivers of sensitivity

Sensitivity of rural livelihoods, especially for the poor

The northern regions (especially Zambezi, Kavango East and West, Ohangwena and Omusati) also have the highest figures for lack of access to safe water and adequate sanitation. The lower rainfall predicted for these regions will make them sensitive to access to safe water, as many rural residents rely on naturally occurring water sources. Persistent droughts will result in falling groundwater tables and reduced surface water flows. This can lead to wells drying up, extending distances that rural people must walk to collect water, and increasing water source pollution. The poor will be affected the most.

Sensitivity of irrigation schemes

Irrigation demand currently (2008) stands at 135 Mm^3/annum, and is expected to more than treble by the year 2030, to 497 Mm^3/annum (MAWF, 2010). If developed to this extent, irrigation will use 65% of

Namibia's total water demand by 2030. The expected expansion of irrigation farming will be directly impacted by climate change. For example, reduced runoff of the Kunene, Okavango and Zambezi Rivers will lead to reduced availability of water.

Sensitivity of urban people and industries

The predicted temperature increase and droughts will result in water scarcity, which in turn may trigger increases in the cost of water (especially piped water) and sanitation provision. This will be mostly felt by poorer sections of the population, such as those living in informal settlements.

Sensitivity to more extreme flood events

Further indirect effects of climate change on domestic water supply and sanitation situation include the impacts of energy interruptions caused by floods, increasing the unreliability of piped water and sewerage services. In times of floods, unimproved water sources (e.g. rivers and wells) are vulnerable to contamination. Additionally, poor sanitary conditions (e.g. from 'bush toilet' and livestock dung) can contaminate clean water sources.

Sensitivity of wetlands and reduced performance of ecosystem services

The added stress of climate change is likely to further exacerbate the ability of Namibia's wetlands to provide valuable ecological services such as water retention, purification and flood attenuation (Dirkx et al., 2008). In addition, the mouths of the Kunene and Orange rivers (both awarded Ramsar site status) are likely to suffer severe ecological impacts as a result of reduced flow regimes and over-abstraction in future decades.

Adaptive capacity

MAWF itself recognises there are considerable challenges facing the water sector (MAWF, 2010). The following points apply to the physical infrastructure:

- Upgrading of existing and construction of new infrastructure to meet growing demands. Funds need to be provided to keep pace with demands.
- Maintaining existing infrastructure. Maintenance has fallen behind what is required for the efficient operation of water supply schemes. Funding and capacity building are the main concerns.

Government has fully committed to implementing Integrated Water Resources Management (IWRM) (MAWF, 2010), which includes the principles of preparing and adapting to the realities of climate change. However, at the same time, it is recognized that human capacity to fully implement IWRM is lacking in Namibia. Government has also introduced a bold policy for improving drought preparedness, the National Drought Policy and Strategy, in 1997. Unfortunately, it is poorly implemented and indirectly encourages reliance of farmers on drought relief, so that there is little incentive for drought preparedness.

Vulnerability and indicators

Even without the threat of climate change, Namibia already faces water scarcity in some of its river basins when the potential of the water resources are considered. Namibia is therefore considered to be highly vulnerable to climate change (DRFN 2008).

The three areas of Namibia that are most water-stressed are the central area, the Walvis Bay – Swakopmund coastal area, and the Cuvelai area with its high density of rural people in north-central Namibia. All these areas have very limited, local water resources, but they are 'rescued' from absolute water shortage by the complex water supply schemes that have been put in place over the years. Yet they remain highly vulnerable to climate change due to the water demand rising to levels where the sources for further increase might also be inadequate, due to population growth and climate change.

Certain socio-economic and demographic groups exhibit particular vulnerability in the face of climate change. These include women and female heads of household, children and the elderly, the chronically sick, and indigenous people. Experiences from the Small Grants Program Namibia shows that characteristics such as wealth, gender, ethnicity, religion, class, caste, or profession can act as social barriers for some to adapt successfully or acquire the required adaptive capacities. Levels of vulnerabilities among individual members in a community are further differentiated when these characteristics intersect (Angula, pers. com).

Adaptation in Key Sectors

Across all sectors, adaptation needs to be considered at the institutional level within the sector itself, as well as at the individual level in response to the various vulnerabilities (e.g. agriculture, health, tourism and water). As well as sector-specific adaptations that exist or are proposed, there are a number of prerequisites for adaptation that exist within Namibia, regardless of the sector. These include raising public awareness of climate change and behavioural adaptation measures, improving data collection to link observed phenomena with climate drivers and thus better be able to determine and monitor changes in vulnerability (e.g. surveillance systems), improved access to information (to inform timely and for adaptive decision-making processes) and implementing effective early warning systems such as the Famine Early Warning System, which worked effectively during the 2013 drought.

Enabling such adaptations will require the removal of existing barriers to adaptation, which exist at institutional level and affect governance structures and individual behaviour. At institutional level, these include lack of technical knowledge on vulnerability and adaptation options, poor cross-sectoral communication and liaison across horizontal and vertical governance structures. At individual level, recognition is increasing that understanding psychological factors such as mind-sets and risk perceptions is crucial for supporting adaptation. Cognitive barriers to adaptation include alternative explanations of extreme events and weather such as religion (God's will), the ancestors, and witchcraft, or seeing these changes as out of people's own control. Climate uncertainty, high levels of variability, lack of access to appropriate real-time and future climate information, and poor predictive capacity at a local scale are commonly cited barriers to adaptation from the individual to national level.

Agriculture

Adaptation measures implemented since the Second National Communication

A number of policies have been developed and operationalized, including the Policy for the Eradication of Trans-boundary Animal Diseases in the Northern Communal Areas (NCA), the National Rangeland Management Policy and Strategy (NRMPS), 2012, and the National Policy on Climate Change, 2011. These policies recognize the importance of prudent sustainable management of natural resources and make provision on how best to fund vulnerability and adaptation measures.

As well as "green schemes", crop-based agriculture such as pearl millet, maize, sorghum, dryland rice are also receiving attention through provision of timely inputs, breeding programs, extension, and farmer training and mentoring.

To encourage adaptation among the livestock sector, a number of feasibility studies have been undertaken for improved marketing; and also improved export opportunities. Following the launch in 2014 of a booklet on Community Based Rangeland and Livestock Management (CBRLM), communal farmers have shown keen interest in embracing adaptive practices by implementing timely bush thinning, preventing rangeland degradation through correct stocking and restoring rangelands through reforestation, gully reclamation and fodder grass planting.

Proposed adaptation measures

Additional adaptation policies, plans (projects), priorities, climate smart agriculture approaches, and agricultural management options are available for building effective resilience to climate change impacts. These proposed adaptations relate to improved soil management and land management, and post-harvest production. The adaptive practice of spreading risk of vulnerability by planting a mix of traditional and hybrid seed varieties have largely been supported by indigenous knowledge systems and the extension service. This also involves overlapping the growing periods through a time combination of early and late planting.

Preventive measures through anti-soil erosion programs should be out-scaled emphasizing the participation of natural resources end users apart from government efforts through the MAWF and the MET. At the same time, soil fertility and fertilizer management has been at the centre of preserving and boosting soil fecundity in Namibia.

Land management for livestock systems included the need for fodder flow systems and bush thinning. Fodder flow systems through fodder conservation for all year feeding of livestock is a technique more popular on commercial farms and communal farmers need to adopt this so as to improve their adaptive capacity to seasonal livestock feed supply fluctuations.

Having food loss in the maize and pearl millet subsectors need attention through adapting to post harvest technologies that minimizes wastage caused by pest damage or spoilage.

Health

Adaptation measures implemented since the Second National Communication

These include disaster risk management and preparedness, proactive management in forced migration situations, improved cholera outbreak and malaria control, and commitments to improved nutrition.

A post-disaster needs assessment carried out after the 2009 floods in northern Namibia acknowledged the need for long-term and sustainable disaster risk reduction, and recognized the fact that the country is likely to experience increased incidence of extreme weather events as a result of climate change (GRN, 2009). Recommendations from this report include:

- Strengthening the capacity of health professionals in Epidemic Preparedness and Response;
- Recruitment and training of community health workers to provide emergency first aid;
- Improvements in disease surveillance;
- Increased nutrition surveillance;
- Better staff training on prevention and treatment of malnutrition;
- Improved security of water supply at health facilities;
- Strengthening transport and communication between health facilities; and
- Provision of solar power at health facilities vulnerable to disruption of power supply.

Disease response programs have also supported adaptation to climate change. In Namibia there is a designated Cholera Outbreak Response Team, led by the director of Primary Health Care, Deputy Director of Epidemiology and Deputy Director of the Family Health Division.

Current policy for the control of malaria in Namibia is embodied in the National Malaria Strategic Plan 2010-2016 (MoHSS, 2010). The aim of this policy is to move from a disease control program to an eradication program by 2016, with the goal of achieving total eradication of indigenous transmission of the disease by 2020.

Proposed adaptation measures

The implementation and/or expansion of a number of adaptation measures would help to address the identified vulnerability of the health sector to climate change. These include:

- Undertaking scenario development and pro-active planning to address both fast-onset and slow-onset climate-induced events;
- Strengthening policies to effectively address both slow-onset and catastrophic events;
- Improved data collection and surveillance to prepare for climate-induced changes;
- 'Climate-proofing' the public health system to deal with adverse health repercussions and outcomes from climate-related changes; and
- Ensuring that water and sanitation systems are strengthened.

Tourism

Adaptation measures implemented since the Second National Communication

The SNC proposed three broad climate change adaptation strategies (SNC, 2011). The first broad strategy was that Namibia should respond to climate change challenges by taking advantage of the growing demand for sustainable tourism; the second highlighted the opportunity to promote wildlife land use systems to achieve better value from land (under tourism) than would be achieved from agriculture; and the third was to improve the National Conservancy Information System to include other valuable information or indicators (i.e., such as water resources, ecosystems and biodiversity, *inter alia*), which could be used for effective monitoring of climate change adaptation strategies in the tourism sector (SNC, 2011).

Proposed adaptation measures

With respect to additional adaptation measures, a review of literature shows that there are a number of gaps in terms of policy and growth strategy for the tourism sector. For instance, the National Policy on Tourism for Namibia does not adequately address the climate change, which fundamentally poses a threat to the growth of the sector. Therefore, there is need to harmonise and streamline the National Policy on Tourism and the National Climate Change Policy.

The impacts of climate change on Namibia's climate resource, could potentially result in the reduction in the number of international tourists, visiting the country. Therefore there is need to growth both the domestic and regional demand for Namibia tourism products so as to counter the effects of the expected reduction in international tourists.

The promotion of CBNRM program through the establishment of conservancy, should be accompanied by technologies that not only increase land productivity, but also technologies that reduce human-wildlife conflict. Without carefully balancing these two aspects, there is a possibility that CBNRM through conservancies might be a maladaptation strategy because experience shows that wildlife and other natural resources conservation objectives are difficult to achieve if they threaten livelihoods, at the community levels.

Other adaptation gaps identified for tourist destinations include: the integration of climate factors into conservation and tourism management plans of protected areas; establishment of monitoring survey programmes to assess ecosystem changes, their relation with tourism activities, and take necessary protection measures; opening up new 'micro destinations' and attractions within and adjacent to an already popular national park or heritage site; carry out re-design or redefinition of protected areas, for example creation of migratory corridors; and adjust tourism programmes accordingly; and improve visitors and congestion management to prevent overuse of sites and physical impacts of visitation.

Water

Adaptation measures implemented since the Second National Communication

Due to its dry climate and unpredictable rainfall, challenges in the water sector need to be addressed through efficient water resources management. This must include technical, institutional, financial and social aspects. Namibia's Second National Communication (MET, 2011) proposed that adaptation to climate change in the water sector should focus particularly on measures to reduce evaporation and to enhance the efficiency of the utilization of water resources. Five main adaptation measures were proposed:

- Conjunctive use of surface and groundwater resources;
- Improving water demand management;
- Controlling the use of groundwater;
- Improving the policy and legal framework for water management; and
- Expanding stakeholder engagement.

Proposed adaptation measures

The possibility to harvest water from fog along the Namib Desert coast has been investigated, but apart from a few localized applications, the yields are inadequate for large-scale use. On-conventional resources, water reclamation, artificial recharge of aquifers and desalination of both saline inland resources and seawater are the adaptive strategies that will require urgent implementation. Optimization of existing resources through Water Demand Management, conjunctive use of resources and further water reuse for non-potable demand, has to be institutionalized and made mandatory for all demand centres.

The predicted higher intensity rainfall events, will have a positive effect on runoff into dams on ephemeral rivers, which could relieve some stress on existing supply strategies, but high intensity runoff will at the same time reduce concentration times with reduced infiltration to groundwater aquifers and lower recharge of soil moisture needed for fodder growth. This might place additional stress on farming conditions and stock watering from ground water.

The main adaptive measures recommended would therefore be:

- Finalise the promulgate the Regulations for the Water Resources Management Act;
- Place emphasis on unconventional water resources;
- Institutionalise the reuse of water in all demand centres, both potable and non-potable applications;
- Institutionalise water Demand Management and incentivise all demand centres to implement;
- Ensure that ephemeral surface impoundments can cope with high intensity runoff predicted;
- Protect all surface and groundwater resources from pollution through regulating discharges;
- Reduce the evaporation from surface impoundments through innovative measures such as water banking and conjunctive use;
- Prioritise the development of the Ohangwena II aquifer to supply the Cuvelai;
- Prioritise the implementation of augmentation to the Central Areas of Namibia;
- Prioritise seawater desalination to augment supply to the Central Namib area and new Uranium Mines;
- Use water to promote high value addition industries only;
- Use water only for irrigation of high value crops;
- Put emphasis on importing virtual water through fresh produce rather than to cultivate crops in areas where water use is extremely inefficient through high temperatures and evaporation; and
- Institutionalise efficient irrigation practices.

Other Information Considered Relevant to the Achievement of the Convention

Transfer of Technologies

The transfer of, and access to, environmentally sound technologies and know-how, the development and enhancement of endogenous capacities, technologies and know-how, and measures relating to enhancing the enabling environment for development and transfer of technologies are critical to the achievement of both adaptation and mitigation to achieve the objective of the Convention. Hence, Namibia pays particular attention to this issue and provided for it in the CCSAP under the item *"Promote and support development of technologies for mitigation and adaptation"*.

Namibia has yet to complete a full extensive study on its technology needs and transfer. This exercise is being done piecemeal within the national communications framework and this is delaying both the exhaustive assessments on technology needs and transfer for adaptation to and mitigation of climate change, and the associated cross-cutting issues. This is impeding on the development of adaptation and mitigation plans to inform the stakeholders, especially the private sector for partnering and funding implementation.

With regards to adaptation, there is also the need for a multitude of technologies for the various economic sectors. The sectors necessitating most urgent action to safeguard livelihood and welfare of the poorer most vulnerable segment of the population are agriculture and water resources. The prioritized technologies for agriculture are irrigation and water harvesting, conservation agriculture, crop diversification, use of improved indigenous crop germ plasm, use of well adapted indigenous livestock breeds, increased seed and fertilizer (incorporating organic fertilizers) availability, shared water resource management, early warning systems, drought mitigation measures, restoration of rangelands and improved livestock management policies and strategies. Adaptation in the water resources sector include water recycling, water use efficiency, water harvesting and desalination amongst others.

Research and systematic observation

Though the scientific evidence is accepted, climate change and its impacts are still not well understood by major components of the population of Namibia. There exists the need to undertake research to quantify the potential impacts at the local, national and regional levels to enable the proper development of practical solutions for adaptation and mitigation. The strategy aims at the following:

- Collect data and model climate change and national, regional & local levels;
- Monitor ecosystem and biodiversity changes and their impacts;
- Conduct climate-proof research;
- Undertake research on sea level rise;
- Establish a centre for research and training on climate change;
- Conduct inventories on traditional / indigenous knowledge and coping practices;
- Undertake studies on the cost of adaptation and mitigation; and
- Study macroeconomic and sectoral impacts of climate change.

Education, Training and Public awareness

Climate change is of such importance nowadays that the population have to be properly educated on its cause and effects to enable them to address these at their respective levels. Thus, education has to be formal and informal. Presently, climate change is only part of the tertiary curriculum as modules of some disciplines. Namibia intends to gradually include climate change as a component of the primary and secondary curricula and extend it in the tertiary curriculum to remedy to the present shortcoming. Concurrently, climate change will be introduced in the vocational training programmes and informal education will be resorted to with the support of NGOs and CSOs.

Public awareness programmes implemented up to now have been insufficient to meet the present climate change threat as a result of lack of resources. It is planned to enhance public awareness programmes to maximize outreach, the final objective being to cover all segments of the population countrywide. The strategy on this aspect will target the following actions:

- Awareness raising and public education on climate change;
- Promote and facilitate development of public awareness materials on climate change;
- Facilitate access of climate change information to the public; and
- Promote public participation in addressing climate change and develop adequate responses.

Capacity Building

Namibia's successful implementation of the Convention demands for substantial capacity building. Technical capacity building concerns mainly mitigation and adaptation technologies earmarked in the respective chapters for the measures that are most prominent and prioritized in this communication and other reports submitted to-date. Capacity building also concerns overarching issues. As a developing country, Namibia needs robust institutional structures to take on and implement programmes and activities on climate change. Building human and institutional capacity to address climate change will be a fundamental component of the Namibian strategy on climate change. Capacity building for climate change will thus include further development and strengthening of personal skills, expertise and of relevant institutions and organizations on adaptation, mitigation and reporting. Capacity building will involve a wide group of stakeholders, including the government, NGOs, research institutions, local communities and international organizations.

Information and networking

It is recognized that climate change is a global problem and that it requires the cooperation of all to tackle this issue successfully. Namibia is a Party to the Multilateral Environmental Agreements and various other Protocols and Agencies with the aim to preserving the environment within a sustainable development programme. This is also the aim of the Convention. In line with this objective, the action plan has identified the following actions.

- Strengthen and enhance international collaboration, linkages and networking among stakeholders involved in environment and climate change related issues;
- Participate in regional and international cooperation programs and activities on climate change;
- Promote international North-South and South-South collaborative research that will facilitate generation of climate change adaptation and mitigation evidence-based information; and
- Facilitate achievement of UN environment international obligations under various Conventions especially UNFCCC and Treaties.

Constraints and Gaps, and Related Financial, Technical and Capacity Needs

Reporting

The enhancement of the reporting requirements demands for higher standards and a permanent framework to enable the sustainable production of the reports to the UNFCCC. In addition, there is a need to develop and establish permanent systems for monitoring, reporting and verifying (MRV) mitigation actions and other activities related to the Convention.

During the exercise of strengthening of the existing institutional arrangements, numerous and very daunting challenges cropped up. The most urgent ones were:

- Insufficient capacity of the coordinating body as well as lack of institutional and technical skills within the different thematic areas of the NC;
- To maintain a motivated permanent coordinating body and/or personnel;
- Staff scarcity / unavailability in collaborating institutions due to their already overloaded schedules and staff turn-over; and
- Lack of incentives and adequate funds to develop and maintain the system in place.

The national experts in the various departments will need capacity building for implementation, follow-up, quality control and reporting. New recruits to perform independent validation and verification will have to be trained. Unless technical assistance is provided, the country will have to look for alternatives, such as outsourcing resource persons to provide for these capacity building needs. Financial resources are also lacking to develop and implement the framework for sustainable reporting and the MRV system.

GHG inventory

Namibia, as a developing country, has its constraints and gaps that need to be addressed to produce better quality reports for reporting to the Convention. Problems encountered during the preparation of the national inventory of GHG emissions related to information required for the inventory not being in a centralized archiving system, AD not in the required format for feeding in the software, end-use consumption data not always readily available, reliable biomass data not readily available, inconsistencies of data collected from different sources, lack of waste characterization data and amount, EFs have to be derived to better represent national circumstances, and national experts need more training on the GHG estimation software.

Mitigation and Adaptation

Implementation of mitigation and adaptation measures and actions is a major challenge for the country in view of the multiple constraints and gaps that exist in various areas, namely at the institutional, organizational and individual levels. There is a need to create the enabling environment in the country. Needs also exist for improving the technological assessment and transfer for mitigation and the technical capacity of national experts. Further assessments still have to be undertaken to identify more prominent measures and actions as well the prioritize those with the highest potential for successful implementation.

The appropriate funding amounts and timing are important features to take into consideration when these measures and actions, especially the implementation aspect, are aligned with the country's development strategy and agenda. Implementation is even more difficult as a result of the significant amounts of sustained funding required to develop and implement mitigation and adaptation projects. There is need for these shortcomings to be corrected through further consolidation of the Green Climate Fund for the latter to fully fulfil its role. It is also expected that new instruments will be developed to assist Non Annex I Parties play their role in implementing the Convention urgently because of their higher exposure and vulnerability to the impacts of climate change.

Financial Needs

For the country to meet its reporting obligations and implement the Convention requires substantial funding. Namibia as a developing country with its challenges to feed its population and provide the minimum requirements to it is not able to allocate the funding required to meet the climate change agenda. Avenues concerning funding have been identified in the NCCP and detailed in the CCSAP.

The NCCP highlighted that government consider and explore a range of multi- and bilateral funding options including grants, concessional and non-concessional loans, as well as market-based instruments. The NCCP also emphasises the importance of evidence-based strategies and action plans, and observes that “Climate change research needs to be properly coordinated, and its benefits optimised to meet the needs of decision-makers in Namibia”.

The CCSAP on the other hand identified the need to maximise government financing instruments at the national and local levels; leverage private sector investment; and access scaled-up, new and additional (external) financial resources. The need also exists to develop assessment tools to inform decision-making, and to establish partnerships among national and local government agencies, business, professional and other private groups, community based organisations, academic and scientific organisations and civil society organisations in order to realise its objectives. It is expected that Public Private Partnerships will contribute both monetary and human resource capacity to implement the required actions. Up to now, Namibia has not tapped much funding to support its mitigation and adaptation strategies. There is need for these shortcomings to be corrected and a list of urgent actions requiring funding is provided in the INDC up to the 2030 time horizon for mitigation and adaptation, including technology transfer for these actions.

Reporting has become more stringent and has to be supported by sufficient background studies to reflect the status of the country and its efforts in implementing activities to meet the objectives of the Convention. While it is recognized support is provided through the GEF, the amounts are insufficient and there are often problems in the timing for the release of the funds that prevents the country to meet the frequency of submission of the national reports.

1. Introduction

Namibia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1995 as a Non-Annex 1 Party. In doing so, Namibia has to abide to the obligations of the Convention, namely reporting according to Article 4, paragraph 1 and to implement the Convention through development of policies and measures designed to mitigate and to adapt to climate change. The Global Environment Facility (GEF) through the United Nations Development Program (UNDP) country office provided funding for the production of Namibia's Initial National Communication (INC), Second National Communication (SNC) as well as the present Third National Communication (TNC) to the UNFCCC, which are requirements of the country to fulfill its obligations under the Convention. Over and above the two national communications that have been submitted previously to the UNFCCC, Namibia has also met its commitments, further to decisions of the Conference of Parties, in preparing and submitting its First Biennial Report (BUR1) and Intended Nationally Determined Contribution (INDC) according to the time schedules.

Namibia is committed to bring its contribution to the pooling of efforts of the international community for combating climate change. In this context, the country has put up in place the required institutional arrangements to tackle mitigation of climate change towards stabilizing greenhouse gases in the atmosphere at a the level not detrimental to the proper functioning of natural ecosystems as earmarked in Article 2 while investing on adaptation to climate change to build resilience of the population in the medium to longer term. These institutional arrangements are more fully described later in this national communication as well as measures and steps taken and planned to meet the objectives of the Convention. This is so despite Namibia not having any obligation to reduce its emissions as a Non-Annex I signatory Party.

The TNC project built on and continued the work done under the INC, SNC, BUR1 and INDC of Namibia. The situation has not evolved significantly as the Namibian economy remains natural resource based and is extremely sensitive to climate change impacts. The direct effects of climate change on the various economic sectors have been seriously felt in recent years in thematic areas such as water, agriculture, fisheries, ecosystems, biodiversity, tourism, coastal zone, health and energy. These impacts stemmed from prolonged droughts and in turn affected the economy and resulted in lower than normal Gross Domestic Production (GDP). This situation is not expected to improve in the future but rather to worsen, given that the global temperature increase projected in the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) is above the critical limit of 2^{o}C that will disrupt the proper functioning of natural ecosystems.

Namibia intends to maintain these efforts so as to fully transform its economic development to one with a low carbon footprint while consolidating investments to increase its resilience in light of the AR5 projections. However, resources are lacking to implement planned measures and steps. It is thus primordial that the international community arrives at a global agreement during COP 21 in Paris which provides for sustainable support in a timely manner to Non-Annex I Parties to enable them meet their obligations and commitments for successfully addressing the threat posed by climate change.

2. National Circumstances

2.1. Introduction

Namibia's development is guided by its long-term National Policy Framework, Vision 2030, which transcribes into National Development Plans for 5 year periods. The country is currently in its fourth NDP that privileges sustainability within the economic development agenda and aims at a low carbon economy. The vision is to have a prosperous and industrialized Namibia, developed by its human resources, enjoying peace, harmony and political stability.

This section presents the national circumstances of Namibia, detailing the national development priorities, objectives and circumstances that serve as the basis for addressing issues relating to climate change.

2.2. Convention Obligations

Namibia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1995 as a Non-Annex 1 Party, and as such, is obliged to report certain elements of information in accordance with Article 4, paragraph 1 of the Convention. These elements include:

(a) A national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHG) not controlled by the Montreal Protocol, to the extent its capacities permit, using comparable methodologies to be promoted and agreed upon by the Conference of the Parties (COP);

(b) A general description of steps taken or envisaged by the Party to implement the Convention; and

(c) Any other information that the Party considers relevant to the achievement of the objective of the Convention and suitable for inclusion in its communication, including, if feasible, material relevant for calculations of global emission trends.

In order to meet its reporting obligations, Namibia has submitted two national communications (NCs) - the initial national communication in 2002 and the second national communication in 2011 with support from the Global Environmental Facility (GEF) through the United Nations development Programme (UNDP) country office. The Cancun Agreements arrived at during COP 16 in 2011 stipulated that NC reports by non-Annex I Parties, including national GHG inventories, be enhanced to include information on mitigation actions and their effects as well as support received. It was also decided that developing countries, consistent with their capabilities and the level of support provided for reporting, should submit Biennial Update Reports (BURs). BURs, containing updates of national GHG inventories, inventory report and information on mitigation actions, needs and support received and Institutional Arrangements are produced every two years, with the first one due in December 2014 as decided in COP 17. Namibia also met this obligation and submitted its BUR1 during COP 20 in Lima in 2014. Reporting guidelines, adopted during COP 8 for the preparation of national communications from Parties not included in Annex I to the Convention and contained in decision 17/CP.8 have been adopted for the preparation of this report.

The National Climate Change Committee (NCCC), chaired by the Ministry of Environment and Tourism (MET) and comprising a wide representation of stakeholders, provided the overall oversight and advisory role for the implementation of the TNC project. Coordination was done by the Climate Change Unit of the MET and its Directorate of Environmental Affairs (DEA), Division of Multilateral Environmental

Agreements, which is responsible for overseeing the coordination of Climate Change issues in Namibia in its role as national focal point of these Conventions.

2.3. Institutional Arrangements

The Cabinet of Namibia is the Government entity entrusted with the overall responsibility for the development of Policies, including those on Climate Change. The NCCC oversees the implementation of the climate change policy, including the preparation of the reports for submission to the Convention and also plays an advisory role to Government on climate change issues. It comprises representatives of the various ministries and other stakeholders such as the private sector and NGOs amongst others. The NCCC was established in 1999 by the MET to follow up on further obligations to the UNFCCC and plan accordingly to enable the country to meet them. MET, the official government agency acting as national focal point of the Convention, is responsible for coordinating and implementing climate change activities, including the preparation of both the National Communications and Biennial Update Reports to enable the country to meet its reporting obligations. This is done through the Climate Change Unit (CCU) established within the DEA. Being a formalized and multi-sectoral committee, the NCCC provides the necessary support to the CCU by advising and guiding it for sector-specific and cross-sector implementation and coordination of climate change activities.

The NCCC is chaired by the MET and the deputy chair is the National Meteorological Service of the Ministry of Works and Transport. The NCCC reports to the Permanent Secretary of the MET via the head of the DEA. The NCCC has the powers to establish working groups and subcommittees as required for implementing and conducting specific climate change activities. Such working groups have been active and very useful for overseeing and providing guidance on the different thematic areas during the preparation of previous national communications. Given that climate change has a bearing on all socio-economic sectors, various Ministries, Organizations and Agencies actively address climate change related issues either solely or in collaboration with other stakeholders as required. The CCU within the MET usually directly assists these different bodies with planning, development, implementation and coordination of the activities at the local, regional and national levels. The collaboration of existing local and regional structures is secured for supporting implementation and coordination at the level required.

These existing arrangements worked well for the preparation of the two submitted national communications. Preparation of these national communications was on an *ad-hoc* basis and did not require a permanent set-up that would have proven too onerous for the country being given the scarcity of resources. Thus, reporting on the different thematic areas was outsourced and the CCU of MET catered for the whole process until the final report had been circulated, reviewed and approved by all stakeholders concerned for submission to the Cabinet for final clearance and submission to the COP. With the enhancement of the reporting requirements that came into force since the last few years and also the required higher standards of the national communication, these past institutional arrangements have become outdated. The present situation demands for a permanent structure to enable the sustainable production of these reports while guaranteeing their quality. In addition, there is a need to develop and establish permanent systems for monitoring, reporting and verifying mitigation actions (MRV) and other activities related to the Convention so that Namibia may honour its MRV engagements on both the national and international fronts.

Conscious that the existing institutional arrangements are no longer appropriate and suitable under these new circumstances, the MET embarked on a full exercise of reviewing the existing set-up towards developing and implementing new and more robust institutional arrangements for meeting the enhanced and more frequent reporting obligations, including the production of BURs.

One important decision was to shift from outsourcing the different elements of the Convention reports to having them produced in-house. The exercise started after the decision taken during COP 17 in 2012. While the NCCC and CCU were kept in place, an institutional mapping was done by the latter, which kept the responsibility of coordinating the production of the reports, to identify all stakeholders who would have a role and contribution to bring in the production of better quality NCs, the new BURs and eventual development of the MRV system. A round of one on one institutional consultations to engage stakeholders was made and this was followed by formalization through official letters inviting nominations of representatives. Nominees were then called for a brainstorming session to present them the new needs for meeting reporting standards, to discuss implications for the institutions and agree on their role, contribution and responsibilities, namely for the major GHG inventory component. It became evident during these consultations that there existed a serious lack of capacity. The consensus was to make an attempt at producing firstly the BUR, fully or partially, followed by future reports in-house, with minimal outsourcing. Concurrently, this will serve for capacity building to enable the stakeholders assume their new responsibilities.

Within the planned institutional arrangements, there will be a sharing of responsibilities with the coordinating body taking on most of the planning, preparation, quality control, archiving, evaluation and validation and the other stakeholders concentrating on the preparation of the more technical components, including data collection and validation, performing technical tasks like compilation of the GHG inventory, producing draft reports and documenting these.

During the exercise of strengthening of the existing institutional arrangements, numerous and very daunting challenges cropped up. The most urgent ones were:

- Insufficient capacity of the coordinating body as well as lack of institutional and technical skills within the different thematic areas of the NC;
- To maintain a motivated permanent coordinating body and/or personnel;
- Staff scarcity / unavailability in collaborating institutions due to their already overloaded schedules and staff turn-over; and
- Lack of incentives and adequate funds to develop and maintain the system in place.

It was also evident that the development and implementation of robust institutional arrangements will take considerable time to become fully operational to run smoothly. It is anticipated that this will take two to three rounds of BURs and NCs.

The revamped institutional arrangement is presented at Figure 2.1.

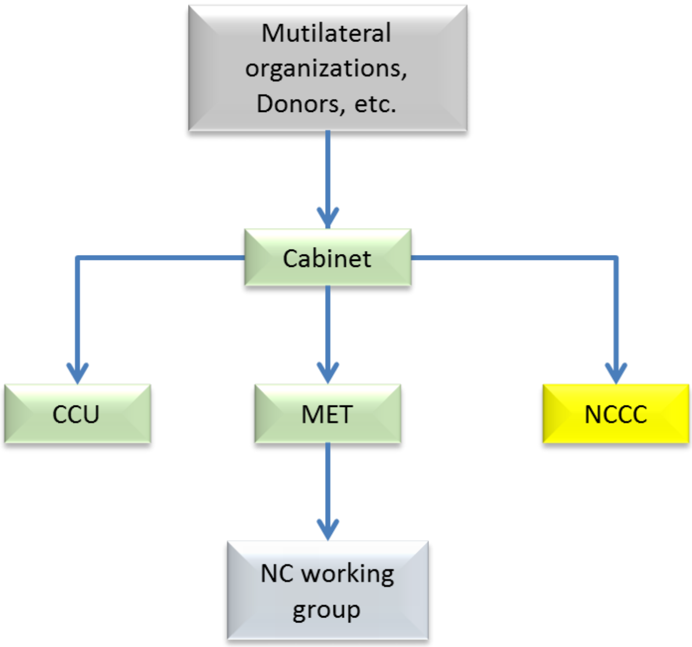


Figure 2.1. Institutional arrangements for implementing climate change activities

2.4. Geographical Characteristics

Namibia is situated in the Southwestern region of the African continent and lies between latitude 17° and 29°S and longitude 11° and 26°E. The country covers a land area of 825 418 km^2 and has a 1500 km long coastline on the South Atlantic Ocean. It is sandwiched between Angola to the North and South Africa to the South and also borders with Zambia to the far North, and Botswana to the East.

The physical geographic context of Namibia is determined by its position at the border of the continental shelf of the Southern African subcontinent in the climatic sphere of influence of the Tropic of Capricorn and the cold Benguela Current. The land surface ascends from the Namib Desert to the mountains of the continental border range with peaks at 2 606 metres above mean sea level (mamsl). To the East and North the country then descends into the Kalahari basin with a mean altitude of 1000 mamsl.

2.5. Climate

Namibia is one of the biggest and driest countries in sub-Saharan Africa. It is characterized by high climatic variability in the form of persistent droughts, unpredictable and variable rainfall patterns, variability in temperatures and scarcity of water. The climate of Namibia is a consequence of the country's location on the Southwestern side of the African continent, situated at the interface between different climate systems. The cold Benguela Current along the West coast and Namibia's position, straddling the sub-tropical high-pressure belt, determine the main features of the climate. The Benguela Current brings in cold water to its western shores. The climate of the Northern part of the country is influenced by the Inter-Tropical Convergence Zone (ITCZ) and the Mid-Latitude High Pressure Zone, while the Southern part of the country lies at the interface between the Mid-Latitude High Pressure Zone and the Temperate Zone.

The different seasons experienced in Namibia are driven by the northward and southward movements of these zones, in response to the apparent movement of the sun.

The cold water from the Western shores (Benguela Current) is adverted from the South and is partly driven by a high-pressure system over the South Atlantic. The combination of cold water and high pressures leads to subsidence of cold dry air over much of the country which commonly suppresses rainfall. This situation is dominant during most of the year, except in summer when heating of the continent is greatest and the southerly position of the ITCZ draws moisture and rainfall from the tropics over northern and eastern Namibia. Therefore, the ITCZ and the Temperate Zone bring rainfall, while the Mid-Latitude High Pressure Zone brings drier conditions.

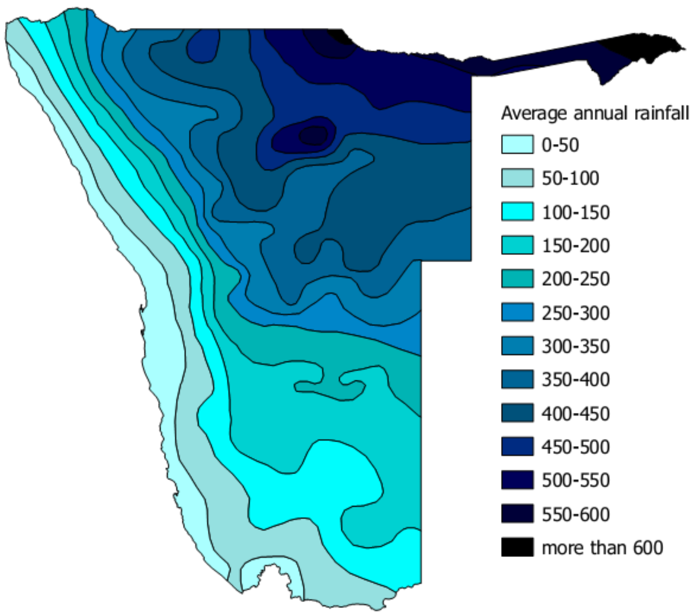


Figure 2.2. Distribution of average annual total rainfall in Namibia

The movement of the ITCZ towards the south during the Namibian summer results in the rainfall season, normally starting in November and ending in April. In the far south, the Temperate Zone is moving northwards during the winter, resulting in the winter rains that occur in the far Southwest of the country. Small variations in the timing of these movements result in the considerable differences in the weather experienced in Namibia from one year to another.

The mean annual rainfall ranges from just above 600 mm in the Northeast to less than 25 mm in the Southwest and West of the country (Figure 2.2). The rainfall isohyets generally follow a gradient from the North-East to the Southwest. There are exceptions from this general pattern, e.g. the maize triangle of Tsumeb, Grootberg and Otavi receives more rainfall than would be expected in that geographic location. The reason for this is the undulating topography, which gives rise to orographic rainfall. On the other hand, the coastal zone receives almost no rainfall at all.

Most rain occurs in the summer months of November to April in the form of localized showers and thunderstorms. In the extreme Southwest, winter rain and even snow can be expected between June and August. The inter-annual coefficient of variation of rainfall is very high, ranging from 25% in the Northeast to >80% in the southwest. At some places in the Southern parts of the country, winter rains account for up to 50% of annual rainfall. In the Western part of the Namib Desert, coastal fog is an important source of water for the desert fauna and flora. Fog precipitation is five times greater than that of rain and is far more predictable.

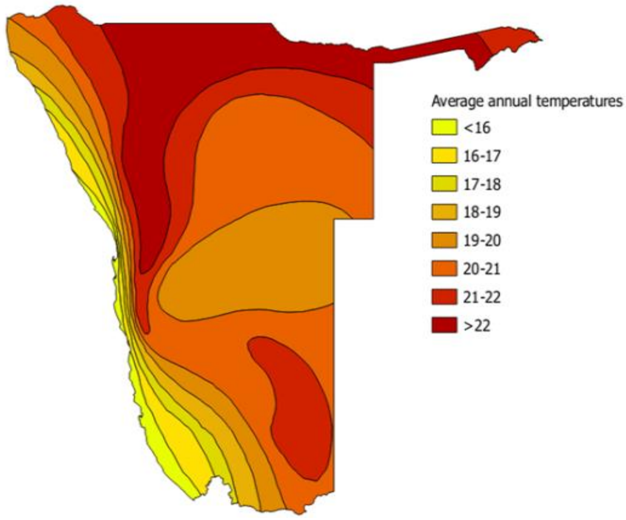


Figure 2.3. Average annual temperature in Namibia

Namibia is characterized by high temperatures (Figure 2.3). Apart from the coastal zone, there is a marked seasonal temperature regime, with the highest temperatures occurring just before the wet season in the wetter areas or during the wet season in the drier areas.

The lowest temperatures occur during the dry season months of June to August. Mean monthly minimum temperatures do not, on average, fall below 0°C. However, several climate stations in the central and southern parts of Namibia have recorded individual years with negative mean minimum monthly temperatures, and individual days of frost occur widely.

From a hydrological point of view, Namibia is an arid, water deficient country. High solar radiation, low humidity and high temperature lead to very high evaporation rates, which vary between 3800 mm per annum in the south to 2600 mm per annum in the north. Over most of the country, potential evaporation is at least five times greater than average rainfall. In those areas where rainfall is at a minimum, evaporation is at a maximum. Surface water sources such as dams are subjected to high evaporation rates.

Wind speeds are generally low in Namibia, only at the coast do mean wind speeds exceed 3 m/s, and it is only at isolated climate stations inland, e.g. Keetmanshoop, that the mean wind speeds exceed 2 m/s. These winds, and the occasional stronger gusts, do not cause any real problem apart from some wind erosion in the drier parts of the country during the driest part of the year. Away from the coast, relative humidity averages between 25% and 70%. The humidity does change over the seasons with the dry season being less humid than the wet.

2.6. Biodiversity

In spite of its very dry climate, Namibia holds a remarkable variety of species, habitats and ecosystems ranging from deserts to subtropical wetlands and savannas. Namibia is one of the very few countries in Africa with internationally-recognized "biodiversity hotspot". Namibia's most significant "biodiversity hotspot" is the Sperrgebiet, which is the restricted diamond mining area in the Succulent Karoo floral kingdom, shared with South Africa. The Succulent Karoo is the world's only arid hotspot. It constitutes a refuge for an exceptional level of succulent plant diversity, shaped by the winter rainfall and fog of the Southern Namib Desert. A large portion of its plants is endemic (MET, 2001).

2.7. Water Resources

Namibia is the driest country in Southern Africa. Water is a scarce resource and one of the major primary limiting factors to development in Namibia. The effects of climate change, rapid population growth, and rural exodus pose additional challenges and threaten people's livelihoods as well as the balance of the ecosystems. Namibia's rainfall is skewed, with the Northeast getting more that the West and Southwestern parts of the country. Namibia's international boundaries, both northern and southern are marked by the Kunene River in the northwest, the Okavango River in the central north and the Zambezi and Kwando rivers in the northeast. The Orange River marks Namibia's southern border. It is only in these rivers that perennial surface water resources are found. These rivers are all shared with neighbouring riparian states with an obligation for them to be managed and used in terms of the relevant rules of international water law.

Of the water that Namibia receives as precipitation, it is estimated that only 2% ends up as surface run-off and a mere 1% becomes available to recharge groundwater. The balance of 97% is lost through direct evaporation (83%) and evapotranspiration (14%). Rainfall often evaporates before it reaches the ground. Another source of moisture comes from fog in the cooler coastal regions where it is an extremely valuable source of moisture to desert animals and plants.

The primary sources of water supply are perennial rivers, surface and groundwater (alluvial) storage on ephemeral rivers, and groundwater aquifers in various parent rocks. Additionally, unconventional water sources have been adopted to augment the limited traditional sources. About 45% of Namibia's water comes from groundwater sources, 33% from the Border Rivers, mainly in the north, and about 22% from impoundments on ephemeral rivers (Christelis and Struckmeier, 2001).

2.8. Agriculture and Forestry

Agriculture, fisheries and forestry accounted for 7.1% of the GDP in 2013. Despite its modest contribution the GDP, agriculture impacts directly on the livelihood of 70% of the population. The production of white maize, wheat, pearl millet and livestock including cattle, goat and sheep is divided in the intensive commercial production units and the extensive communal production system. The commercial sector though occupying 44% of land involves only 10% of population while the communal sector occupies 41% of the land and involves 60% of the population.

Approximately 48% of Namibia's rural households depend on subsistence agriculture (NDP4). The majority of rural communities, particularly in the higher rainfall areas of the North, depend directly on forest resources for use as fuel wood, building materials, fodder, food and medicine. It is necessary to ensure the systematic management and sustainability of forest resources.

The variability of climate particularly rainfall has a profound impact on the availability aspect of food security. The recent droughts at the start of this decade have highlighted this important feature of the Namibian society. A recent 2013 survey by the FAO has revealed that 330 000 people particularly in the poor north-western areas are food insecure and a further 447 000 moderately food insecure. This situation also puts pressure on forest resources.

2.9. Fisheries

Namibia has one of the most productive fishing grounds in the world, primarily due to the presence of the Benguela current. The up-welling caused by the current brings nutrient-rich waters up from the depths that stimulate the growth of microscopic marine organisms. These in turn support rich populations of fish, which form the basis of the marine fisheries sector. As is the case in other up-welling systems, relatively few species dominate and their abundance can vary greatly in response to changing environmental conditions. Over 20 commercially important fish species are landed using various fishing methods. The off-shore commercial fishery represents the largest component of the fishing industry. Small pelagic (open-water) species (pilchard, anchovy and juvenile mackerel) and lobster are fished along the shallower onshore waters on the continental shelf. Large pelagic species including adult mackerel, demersal (bottom dwelling) hake and other deep-sea species, such as monkfish, sole and crab, are fished in the waters further offshore.

Since independence in 1990, the fishing industry has grown to become one of the pillars of the Namibian economy. The commercial fishing and fish processing sectors significantly contribute to the economy in terms of employment, export earnings, and contribution to GDP. The fishery sector contributed 4.6% in 2009, compared to 3.7% in 2010, representing a 20% reduction. The sector is a substantial export earner, with over 85% of Namibia's fish output destined for international markets.

2.10. Tourism

Namibia's unique landscapes and biodiversity support a rapidly developing tourism sector. Travel and tourism's contribution to the Namibian economy is illustrated by the combined direct and indirect impact of the travel and tourism. In 2014, the direct impact of tourism contributed N$3.8 billion to GDP, equivalent to 3.0%, while the direct and indirect impact of tourism amounted to N$18.4 billion to GDP or 14.9% (WTTC, 2015).

2.10.1. Communal-area conservancies

Community conservation in Namibia covers over 159 755 km^2 which is about 52.2% of all communal land with about 172 000 residents. Of this area, communal-area conservancies manage 158 247 km^2 which is about 19.2% of Namibia. Since 1991 until 2012, community conservation has contributed about N$2.9 billion to Namibia's net national income. During the year 2012 alone, community conservation generated over N$58.3 million for local communities. In the same year, community conservation facilitated 6477 jobs in 2012 and 55 conservancies had a total of 99 enterprises based on natural resources (NACSO, 2012).

2.10.2. Community forests

At the end of 2012 there were 32 registered community forests in Namibia. The use of all indigenous plant resources is regulated by the Directorate of Forestry (DoF) within the Ministry of Agriculture, Water and Forestry. The Forestry Act of 2001 and the Forestry Amendment Act of 2005 enable the registration of community forests through a written agreement between the Directorate and a committee elected by a community with traditional rights over a defined area of land. The agreement is based on an approved management plan that outlines the use of resources. All residents of community forests have equal access to the forest and the use of its produce. Community forests have the right to control the use of all forest produce, as well as grazing, cropping and the building of infrastructure within the classified forest (NACSO, 2012).

2.11. Mining

Namibia is known world-wide for producing gem quality rough diamonds, uranium oxide, special high-grade zinc and acid-grade fluorspar, as well as a producer of gold bullion, blister copper, lead concentrate, salt and dimension stone. Mining is one of the major contributor of Namibia's national economy with 13.0% of the country's Gross Domestic Product (GDP) in 2014 from 12.6% in 2013.

2.12. Manufacturing

Namibia's manufacturing sector is inhibited by a small domestic market, dependence on imported goods, limited supply of local capital, widely dispersed population, small skilled labour force and high relative wage rates, and subsidized competition from South Africa. The manufacturing sector, a priority sector under the NDP4, is estimated to have recorded a constant growth of 1.2% in both years 2011 and 2012. Growth in the sector can mainly be attributed to the sub-sector "other food product and beverages" that recorded an increase of 6.5%. Other manufacturing that recorded a positive growth in output was textiles, plastic products and diamond processing.

2.13. Energy

On the supply side, Namibia currently has three electricity power stations, these include: the Ruacana hydroelectric power station with a generation capacity of 240 MegaWatts (MW), which depends on the in-flow of rainfall from the catchment areas in Angola; the Van Eck coal power station with a production capacity of 120 MW, with coal imports from South Africa; and the Paratus diesel plant with a capacity of 20 MW. This translates to 380 MW in total. The local supply does not meet the demand. Currently, Namibia imports most of this difference from South Africa and other Southern Africa Development Community (SADC) member states. A special arrangement between the Namibian power utility NamPower and Eskom, the South African Power utility, enables Namibia to buy and utilize the surplus energy from South Africa at affordable rates, with ZESCO in Zambia providing most of the remaining balance. NamPower also imports on a smaller scale from Zambia for supply to the Caprivi region and exports on a small scale to Angola and Botswana (Annual National Accounts, 2012).

2.14. Transport

Namibia's road network is regarded as one of the best on the continent with road construction and maintenance being at international standards. Namibia has a total road network of more than 64,189 km, including 5 477 km of tarred roads which link the country to the neighbouring countries Angola, Botswana, South Africa, Zambia and Zimbabwe. The management and maintenance of the national road network is the responsibility of the Roads Authority under the Roads Authority Act, 1999 (Act 18 of 1999).

The country has two ports handling imported and exported merchandise, and servicing the fishing industry. The only deep-sea harbour is Walvis Bay in the Erongo Region. The other harbour is Luderitz in the Karas Region. The Port of Walvis Bay receives approximately 3 000 vessels each year and handles about 5 million tonnes of cargo.

Passenger transport is mainly carried out by minibuses and sedans and is increasing in intensity. For business people and tourists, air travel has become a more important means of transport to bridge the long distances. As of December 2013, Namibia had a total of 300 045 vehicles, representing an increase of 66 405 as compared with March 2007, when there was a total of 233 640. Out of the total number of vehicles 43.8% of them are light passenger motor vehicle (less than 12 persons), closely followed by light load vehicle (GVM 3500 kg or less), with 43.5%.

The railway network comprises 2382 km of narrow gauge track with the main line running from the border with South Africa via Keetmanshoop to Windhoek, Okahandja, Swakopmund and Walvis Bay. Omaruru, Otjiwarongo, Otavi, Tsumeb and Grootfontein are connected to the northern branch of the railway network.

2.15. Waste

Namibia, as a medium income country with a growing wealthy urban middle class and significant urban drift, is feeling the pressure of amounts of waste generated on its facilities throughout the country and more especially in the urban areas. Solid municipal waste are dumped in landfills or open dumps while almost all urban settlements are connected to reticulated waste water treatment systems. Management of the landfills and dumps are not at the highest standards and very often, the waste is burnt in the open dumps to reduce the volume or reduce health risks. Additionally, in most areas there is no segregation of waste and no separate landfills or dumps implying that industrial waste is dumped along with municipal waste.

2.16. Economic Growth

According to the National Accounts estimates, compiled by NSA in 2013, the domestic economy is estimated to have expanded by 5.0% during 2012, compared to 5.7% in 2011. This decline was attributed to the secondary industry that recorded a slower growth of 3.9% in value added compared to 4.7% registered in 2011. The primary and tertiary industries on the other hand recorded increases of 12.8% and 6.4% in value added, respectively. The slow growth in the secondary industry was primarily owed to the construction that decelerated by recording growth of 12.5% in 2012 from the 19.3% growth registered in 2011.

Gross National Income (GNI) measures national income generated by Namibian factors of production, which are labour, land and capital, both inside and outside of Namibia. Between 2002 and 2012, Gross National Disposable Income (GNDI) has been higher than the GNI because of net inflows in current transfers that have been influenced mainly by high SACU receipts. GNI stood at N$ 107 088 million in 2012 as compared to N$ 92 544 million recorded in 2011. GNDI improved to N$ 124 668 million in 2012 from N$ 104 304 million of the preceding year.

2.17. Population

According to the 2011 Namibia National Population and Housing census, the total population of Namibia was estimated at 2 113 077 people. Woman outnumbered man with 1 091 165, compared to 1 021 912. The age composition of the Namibia population indicates that, 14% of the population is under 5 years, 23% between the ages of 5 and 14, 57% between the ages of 15 - 59 years, and only 7% is 60 years and above. A total of 43% of Namibia's population lived in urban areas, while 57% of the population lived in rural areas. The urban population grew by 49.7% between 2001 and 2011, while the rural population decreased by 1.4% over the same period. This trend illustrates the high rates of rural-urban migration in Namibia. The population density is low at 2.6 people per square kilometre in the Khomas Region, where the nation's capital is situated and has the highest population, followed by the northern regions. In Namibia 56% of households are headed by males and 44% by females.

2.18. Health

Namibia's provision of health services is shared between the public and the private sector, the latter focusing on urban areas. Infant and child mortality is comparatively low, but the maternal mortality ratio has increased, despite the fact that over 70% of births are delivered in hospitals. General life expectancy has not improved, partly because of the HIV/AIDS epidemic. Malnutrition levels in children under the age of five years are as high as 38% in some regions. The five leading causes of inpatient deaths (all age groups) are HIV/AIDS, diarrhoea, tuberculosis, pneumonia and malaria.

Malaria is one of the major health problems. However, year-on-year incidences of malaria are highly variable, and closely correlated with the prevailing temperature, rainfall and humidity. Malaria is endemic in parts of the north-central and north-eastern regions. In contrast, in north-western and parts of central Namibia, malaria transmission is seasonal and follows the onset of rains; these unstable occurrences increase the risk of malaria epidemics. Approximately 15% of the total Namibian population aged 15-49 is living with HIV/AIDS, but the infection level appears to have stabilized. Seven per cent of all people living with HIV/AIDS are under the age of 15, and 60% are women. The very high incidence of tuberculosis in Namibia is fuelled by the HIV/AIDS epidemic, which has reduced life expectancy from 62 years in 1991 to 49 years.

3. General Description of Steps Taken or Envisaged to Implement the Climate Change Convention

3.1. Introduction

Namibia as a young country, which gained independence some two decades ago, has witnessed major challenges since then in its development, including climate change which has impacted quite heavily on it in addition to the economic downturns that recently hit the world economy. Natural resource based economic development engines such as the agriculture, forestry, fishing and tourism sectors, have a direct bearing on the implementation of the Convention as they are highly vulnerable to climate change and variability. Additionally, the country has experienced the impacts of climate change on the different sectors of the economy with serious setbacks on the GDP growth and the welfare of the population. Recurrent climate changes experienced at the local level include more importantly prolonged and severe droughts and a more variable climate with new rainfall patterns coupled with the higher temperatures which affected agriculture, energy sources and ecotourism. Climate changes at the regional and international levels are being felt locally, namely, in terms of its food security as about 70% of Namibia's population practice subsistence farming. Namibia has thus felt the urgent need to increase its resilience towards producing more food to increase its food security. Another key area of concern is energy as the country imports about 80% of its electricity needs from neighbouring countries which are themselves facing shortages and the dependency on biomass as the major source of domestic fuel as these two components has to be addressed to meet the ultimate objective of the Convention. Government of Namibia has thus reviewed the development approach in light of these climate change challenges towards one with a low carbon footprint while coping with the impacts of climate change and building a resilient economy.

3.2. Steps Taken or Envisaged to Implement the Convention

Namibia has stood up to its promise since it ratified the Convention and other working instruments through various steps that have been taken to implement the Convention to-date and the numerous actions envisaged within the country's development programme for further implementation in the medium and longer terms in line with COP decisions and international agenda.

The first tangible action taken for implementing the Convention was the creation up of a cross-sectoral National Climate Change Committee (NCCC) in 1999 to oversee all climate change related activities. This Committee is under the responsibility of the MET Action which is the focal point of the Convention and comprises representatives of the other ministries, government implementing institutions, the private sector and, civil society and non-governmental organisations. The NCCC reports to the cabinet of Namibia, the sole entity responsible for approving national policies including those on climate change.

Since the inception of the NCCC, the country has worked to tackle climate change in a somewhat disaggregated manner. Efforts for a better holistic approach were undermined by various factors. The main ones were limited awareness and knowledge of the various key stakeholder groups on climate change, lack of studies quantifying the impacts on the different sectors of the economy, restricted financial and capacity means, which led to inadequate incorporation of climate change in the national development and planning processes. However, the shortcomings were remedied through the development of a National Climate Change Policy (NCCP) which was approved by Cabinet in 2011 for proper mainstreaming of climate change in the development process.

The NCCP observed that many of Namibia's sector-specific policies were developed without due consideration of climate change, because at their time of development, climate change was not regarded as a serious threat. The policy states that it is imperative that all sectors evaluate the impacts of climate change and identify adaptation and mitigation strategies – and that government make sectoral budgetary provisions based on needs assessments of such strategies to ensure adequate resources at all times.

Based on the regulatory and implementation framework provided by the NCCP, the MET has developed, using an extensive stakeholder consultative process, a Climate Change Strategy and Action Plan (CCSAP) for the period 2013 to 2020 to implement the NCCP. The CCSAP is organised around the three key areas of adaptation, mitigation and cross-cutting issues – where relevant actions and activities are covered. The Action Plan provides a framework listing activities, time frames, lead and partner agencies responsible.

The CCSAP has been developed on the guiding principles outlined in the NEW Delhi Work programme and outcomes of the Bali Action Plan. It is therefore guided by the principles enumerated below:

- Mainstreaming climate change into the policy and legal framework, and development planning of the country;
- Sustainable development and ensuring environmental sustainability of national resources;
- Country-driven and specific climate change interventions for maximum effectiveness;
- Stakeholder participation in climate change policy implementation;
- Awareness raising, education, training and capacity building;
- Cost effectiveness;
- Sustainable and equitable use of natural resources;
- Human rights-based development;
- Transparent planning and decision making to promote good governance;
- Mainstreaming gender, children and the vulnerable groups; and
- Significant vulnerability of the country.

The CCSAP proposes basic strategic aims under the three areas Adaptation, Mitigation and Cross-cutting issues for both adaptation and mitigation. The strategy will address each aspect using a thematic approach.

3.3. Programmes and Measures to Facilitate Adaptation under the CCSAP

Adaptation is addressed through the priority theme food security and sustainable resource base, sustainable water resources, human health and well-being, and infrastructure. These key areas include the sectors agriculture, water, coastal zones, health, infrastructure, biodiversity and ecosystems, forestry, energy, urban management and tourism.

3.3.1. Food security and sustainable resource base

Climate change is projected to severely impact food availability and supply, thereby threatening food security and the natural resource base of the country. The poor and vulnerable segments of the population, particularly women and children will be severely affected. Therefore, under the theme of food security and sustainable resource base, the following strategic aims shall be addressed:

Agriculture

- Development of climate resilient cropping/ agriculture / production systems;
- Development of climate resilient crop varieties / cultivars;
- Diversification of agriculture and livelihoods;
- Development of climate resilient livestock breeds; and

- Adaptation against drought.

Forestry

- Conservation, utilisation and sustainable development of forest resources.

Fisheries and aquaculture

- Conservation, utilisation and sustainable development of fisheries and aquaculture (incl. marine and freshwater aquaculture).

Coastal zone

- Conservation, utilisation and sustainable development of the coastal zone and its resources.

Biodiversity and ecosystems

- Conservation, utilisation and development of biological resources and maintenance of ecosystems to ensure environmental sustainability.

3.3.2. Sustainable water resources

Water is a vital resource in Namibia as a result of its primordial importance in economic sectors such as agriculture, households, livestock, fishing, mining, manufacturing, and other services. The projections of the rise in temperature, potential reduction in precipitation and changed pattern in rainfall due to climate change will adversely affect water resources. The need for integrated water resources management therefore cannot be overemphasized. The CCSAP will therefore aim at implementing the following actions with respect to water resources:

- Conserve and manage watershed / catchment areas;
- Promote integrated development and management of water resources;
- Promote conservation and sustainable utilisation of water resources;
- Improve trans-boundary cooperation regarding water resources; and
- Support institutional and human capacity building in water resources management and use.

3.3.3. Human health and well-being

Climate change is anticipated to increase the prevalence of some vector-borne diseases (e.g. malaria); result in pronounced vulnerability to water, food or person-person borne diseases (e.g. cholera); cause a decline in quantity and quality of drinking water which will affect good health. Poor sanitary conditions resulting from predicted floods in some areas as well as lower agricultural production and hence availability of food will increase malnutrition and namely child mortality. The strategy thus aims at the following:

- Adaptation to climate change related health risks;
- Assessment of impacts of climate change on human health and well-being;
- Expansion of health facilities and network to remote areas;
- Improve capture, management, storage and dissemination of health information;
- Improve access to sanitation and water;
- Increase human resources capacity and improve efficiency; and
- Support action plans against HIV/AIDS.

3.3.4. Infrastructure

Climate change in Namibia is predicted to affect infrastructure to varying intensities including residences, buildings, roads, railways, dams, water pipes, electricity transmission, sewerage, communication and drainage systems. High sea level rise will inundate coastal towns while also impacting on the only deep water harbour of Walvis Bay and the diamond and fishing harbour of Lüderitz with enhanced indirect impacts on the population and economy. The highly populated areas of north central and north east Namibia are flood-prone. Hence, houses will be more frequently destroyed and roads damaged, restricting access to homesteads. Impacts of climate change on infrastructure will further be severe where housing and settlements are poorly planned and developed. The strategy shall therefore aim at addressing climate change impacts on the coastal zone, the transport sector, housing and settlement.

(a) Coastal zone

- Develop a climate change infrastructure risk assessment guidelines and methodology;
- Improve drainage and sanitation facilities in rural and urban areas;
- Adaptation to floods; and
- Adaptation against future sea level rise;

(b) Housing and settlement

- Improve infrastructure spatial planning and development in urban and rural areas;
- Improve formal and informal settlement patterns and housing; and
- Climate-proof existing and future housing and other infrastructure.

3.4. Programmes and Measures to Mitigate under the CCSAP

Namibia is a net sink of GHGs but this situation is expected to change by the mid-2020s when Namibia will potentially be a net emitter on the BAU scenario. On the other hand, the recent Fifth Assessment Report of the IPCC presents a bleak picture of the level of GHGs in the atmosphere that is dangerously indicating a temperature rise heading beyond 2^{o}C unless drastic measures are adopted very quickly by the international community. Namibia has submitted its Intended Nationally Intended Contribution (INDC) to the secretariat, aiming at an overall reduction of 89% of its emissions projected under a BAU scenario in 2030 inclusive of the AFOLU sector. Sustainable energy, transport and AFOLU will be the major areas to achieve this INDC mitigation objective.

3.4.1. Sustainable energy and low carbon development

AFOLU is the major emitter of GHGs in the country and are those identified for the best investments for reduction of emissions or removals of GHGs. More details are provided on the measures identified in the mitigation chapter of this TNC.

- Improve efficiency of energy production and use;
- Develop and improve renewable energy;
- Reduce GHG emissions from the Agriculture (crops and livestock) sector;
- Reduce GHG emissions from land use, land-use change and Forestry;
- Enhance GHG sinks; and
- Improve management of rural and urban waste.

3.4.2. Transport

Another key category of the Inventory is the transport sector, namely road transportation. This category also has received particular attention for mitigation In the TNC as earmarked in the national plans.

- Promote the development of alternative modes of service delivery that will reduce carbon emissions;
- Promote development of climate change resilient transport infrastructure;
- Diversify transport energy sources;
- Improve motor vehicle fuel efficiency; and
- Promote use of public transport.

3.5. Cross-Cutting Issues for Adaptation and Mitigation under the CCSAP

Numerous cross-cutting issues have to be addressed to tackle climate change while implementing the Convention. The themes are listed below but only two, namely disaster reduction and risk management, and legislative development are discussed here as the others will be taken up in other chapters of this communication. The themes are:

- Capacity building, training and institutional strengthening;
- Research and information needs;
- Public awareness, participation and access to information;
- Disaster reduction and risk management;
- Financial, resource mobilisation and management;
- International cooperation and networking;
- Technology development and transfer; and
- Legislative development.

3.5.1. Research and information needs

Though the scientific evidence indicates that climate has changed significantly over and above that caused by natural variability due to man-made (anthropogenic) interference in the climate system, (IPCC, 2014) climate change and its impacts are still not well understood by major components of the population of developing countries. There exists the need to undertake research to quantify the potential impacts at the local, national and regional levels to enable the proper development of practical solutions for adaptation and mitigation. The strategy aims at the following:

- Collect data and model climate change and national, regional & local levels;
- Monitor ecosystem and biodiversity changes and their impacts;
- Conduct climate-proof research;
- Undertake research on sea level rise;
- Establish a centre for research and training on climate change;
- Conduct inventories on traditional / indigenous knowledge and coping practices;
- Undertake studies on the cost of adaptation and mitigation; and
- Study macroeconomic and sectoral impacts of climate change.

3.5.2. Public awareness, participation and access to information

Public awareness is primordial for effectively addressing climate change adaptation and mitigation. The public needs to have access to the latest information to buy them in the process and enable them to successfully participate in actions to be implemented. The strategy on this aspect will target the following actions:

- Awareness raising and public education on climate change;
- Promote and facilitate development of public awareness materials on climate change;
- Facilitate access of climate change information to the public; and
- Promote public participation in addressing climate change and development of adequate responses.

3.5.3. Disaster reduction and risk management

Namibia has lately experienced natural disasters such as floods and droughts. In 2009, many communities were severely affected by floods in the north central regions, Kavango region and the Caprivi region with consequent severe damage to property, loss of agricultural production and human life as well. Climate change projections tend more towards an in increase in the frequency and severity of these disasters. For Government and other stakeholders to prepare for and respond to disasters while providing

Enough support to victims and the local communities in disaster-prone regions, CCSAP has provided for the following actions.

- Improvement of disaster forecasting and early warning systems;
- Improvement of disaster preparedness and post-disaster recovery;
- Manage risk against loss of income, property and livelihoods;
- Develop climate change impact and risk assessment programme; and
- Institutionalize and strengthen risk disaster management, create mechanism and capacities at all levels of government and communities.

3.5.4. Financial resource mobilization and management

The Bali Action Plan stipulates that adequate and timely flow of funds are important for investment within the framework of food, energy, water and livelihood security. Since adaptation and mitigation activities will require financial and other resources as earmarked in the INC, SNC and BUR1, the national strategy will:

- Identify resource requirements including funding to support implementation of climate change activities; and
- Facilitate access to and efficient management and use of resources(credit, education, decision-making) including funds for climate change adaptation and mitigation.

3.5.5. International cooperation and networking

It is recognized that climate change is a global problem and that it requires the cooperation of all to tackle this issue successfully. This is in fact the aim of the Convention. In line with this objective, the action plan has identified the following actions.

- Strengthen and enhance international collaboration, linkages and networking among stakeholders involved in environment and climate change related issues;
- Participate in regional and international cooperation programs and activities on climate change;
- Promote international North-South and South-South collaborative research that will facilitate generation of climate change adaptation and mitigation evidence-based information; and
- Facilitate achievement of UN environment international obligations under various Conventions especially UNFCCC and Treaties.

3.5.6. Technology development and transfer

The development and transfer of technology are critical to the achievement of both adaptation and mitigation as advocated in the Bali action plan. Hence, Namibia pays particular attention to this issue and provided for it in the CCSAP under the items:

- Promote and support development of technologies for mitigation and adaptation; and
- Promote and support technology transfer for mitigation and adaptation.

3.5.7. Legislative development

Having an appropriate legal framework is a must for implementation of adaptation and mitigation strategies. Namibia is committed to address climate change under all possible angles and one of these is the legal framework. Namibia has identified the actions given below to ensure the appropriate legal framework exists for implementing the Convention.

- Review and update existing legislation to reflect climate change issues; and
- Develop new sector or national policies that address emerging climate change issues.

3.6. Reporting under the Convention

Namibia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1995 as a Non-Annex 1 Party, and as such, is obliged to report certain elements of information in accordance with Article 4, paragraph 1 of the Convention. These elements include:

(a) A national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHG) not controlled by the Montreal Protocol, to the extent its capacities permit, using comparable methodologies to be promoted and agreed upon by the Conference of the Parties (COP);

(b) A general description of steps taken or envisaged by the Party to implement the Convention; and

(c) Any other information that the Party considers relevant to the achievement of the objective of the Convention and suitable for inclusion in its communication, including, if feasible, material relevant for calculations of global emission trends.

In order to meet its reporting obligations, Namibia has submitted two national communications (NCs); the initial national communication in 2002 and the second national communication in 2011 with support from the GEF through UNDP. The adoption of the Cancun Agreements at COP 16 in 2011 stipulated that reporting by non-Annex I Parties in national communications, including national GHG inventories, be enhanced to include information on mitigation actions and their effects, and support received. As well, it was also decided that developing countries, consistent with their capabilities and the level of support provided for reporting, should submit Biennial Update Reports (BURs). BURs, containing updates of national GHG inventories, inventory report and information on mitigation actions, needs and support received and Institutional Arrangements are produced, every two years with the first one due in December 2014 as decided in COP 17. Namibia also met this requirement and it was a landmark for the country being the first Non-Annex I Party to submit its BUR in Lima during COP 20. Further reporting as adopted during COP 19 requested all Parties to provide their intended contribution towards reducing emissions for tackling the cause of global warming and the resulting climate change as stipulated in Article 2 of the Convention. This is essential for developing a new agreement and prevent the dangerous rise of 2°C or more. Namibia met the deadlines and submitted its INDC in September 2015.

Concurrently, Namibia is working on the implementation of an MRV system to enhance the quality of its reports to the Convention. As a Non-Annex I country with limited resources, the country will need substantial support to develop, establish and implement the MRV system for domestically supported NAMAs and for enhancing reporting. The coordination body, namely the CCU of MET staff will need training, more so that it will most probably have to recruit additional personnel. Support will be required to address problems encountered with the institutional arrangements, namely to strengthen it to acquire enough robustness to meet the requirements to deliver efficiently and successfully. Lack of technical capacity for making appropriate measurements and data collection, their processing and reporting will have to be addressed urgently. As well, the national experts in the various departments will need capacity building for implementation, follow-up, quality control and reporting. New recruits to perform independent validation and verification will have to be trained. Unless technical assistance is provided, the country will have to look for alternatives, such as outsourcing resource persons to provide for these capacity building needs.

Financial resources are also lacking to implement the MRV system. Already, government budget is strained due to the numerous national priorities and it may prove difficult to allocate enough funds to cover all these expenses. It is hoped that funds will be made available through the multilateral organizations like the Global Environment Facility to support activities, including the very urgent capacity building needs, to enable Namibia to develop, establish and implement a permanent sustainable MRV system to support its domestic NAMAs and reporting within the framework of the Convention.

4. National Greenhouse Gas Inventory

4.1. Introduction

Namibia has submitted three inventories so far as components of its first and second national communications, and its first Biennial Update Report. These inventories have been compiled and submitted in line with Article 4.1 (a) of the Convention whereby each party has to develop, periodically update, publish and make available to the Conference of the Parties (COPs), in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol. These inventories have been produced to the extent of the countries capabilities and using recommended methodologies of the IPCC agreed upon by the Conference of the Parties.

4.2. Coverage (period and scope)

Namibia compiled and published GHG inventories for the years 1994, 2000 and 2010, each one being on a stand-alone basis for the requirement of individual reports. IPCC methodologies have evolved to capture the latest scientific advances and for this fourth inventory, special efforts have been invested to create a consistent series while using the latest IPCC 2006 software and Guidelines. Thus, the one compiled for the year 2000 has been recalculated to make it comparable to the 2010 one published in the BUR1 of 2014. Additionally, Namibia took the challenge and made special efforts to compile and make available in this present inventory, estimates of emissions and sinks for the time period 2000 to 2010.

The inventory covered the full territory of the country and has been compiled at the national level. It addressed the IPCC sectors Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry, and Other Land Use (AFOLU) and Waste subject to AD availability.

4.3. Institutional arrangements and GHG inventory system

Namibia outsourced its two previous inventories and participated actively in the production of its inventories published in the BUR1. This exercise continued with the inventory of the TNC to further improve, implement and consolidate the GHG inventory system being put in place. The process of preparation of GHG inventories by the newly formed team remained a very laborious exercise as resources and human capacities continued to be limiting factors. Implementation of the different steps of the inventory cycle was staged over about two years (Figure 4.2) instead of a longer period to fit the decision taken on in-house compilation. Thus, it is obvious that there still exist some shortcomings in this inventory but the country is committed to continue strive to raise the quality of future GHG inventories through strengthening of the national GHG inventory system.

The Climate Change Unit (CCU) of the Ministry of Environment and Tourism is entrusted with the responsibility for the production of reports to the Convention, including the GHG inventories in its capacity as National Focal Point of the Convention. The same framework adopted for the previous inventory compilation was adopted and all stakeholders agreed to pursue with sharing the responsibilities for the compilation exercise between different departments of the key ministries as for the BUR1. The mapping of national institutions and organizations was reviewed to identify other stakeholders that would contribute in one way or the other for the inventory compilation. Thus data providers and possible institutions and organizations to support derivation of emission factors to suit national circumstances and enable moving to Tier 2 were consolidated. The existing collaboration streams were adhered to as it is working satisfactorily and official formal engagements such as MOUs were not warranted. An international consultant was appointed to deliver capacity building and to guide the team until the production of the final input which is the National Inventory Report and its summarization into the chapter for the TNC. Capacity building of all inventory team members continued on the different steps of the inventory cycle as well as on data management, the 2006 IPCC software, analysis of outputs and reporting to the Convention. All members were introduced to the consistency component of the inventory as a full series over the period 2000 to 2010 was covered for the first time, including recalculations for the years 2000 and 2010.

The responsibilities allocated within the institutional arrangements were:

- The CCU of Ministry of Environment and Tourism responsible for inventory coordination, compilation and submission;
- Ministry of Mines and Energy in charge of the Energy sector;
- Ministry of Trade and Industry took the lead for the IPPU sector;
- Ministry of Agriculture Water Affairs and Forestry was responsible for AFOLU;
- City Council of Windhoek led the Waste sector;
- Namibia National Statistics Agency was entrusted with Archiving including provision of quality controlled activity data;
- The CCU of the Ministry of Environment and Tourism acted as QA/QC coordinator;
- An external consultant performed QA and capacity building;
- The Uncertainty Analysis coordinator is yet to be decided as the sectoral teams are not yet ready for this; and
- The CCU of the Ministry of Environment and Tourism acted as the GHG inventory specialist to track capacity building needs, follow the IPCC process and COP decisions for application.

4.4. Methodology

4.4.1. Guidelines and software

The present national GHG inventory has been prepared in accordance with the IPCC 2006 Guidelines for National Greenhouse Gas Inventories and using the IPCC 2006 software for the compilations. As the IPCC 2006 Guidelines do not extensively cover all the GHGs, it has been supplemented with the European Monitoring and Evaluation Program/European Environment Agency (EMEP/EEA) air pollutant emission inventory guidebook for compiling estimates for nitrogen oxides (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2).

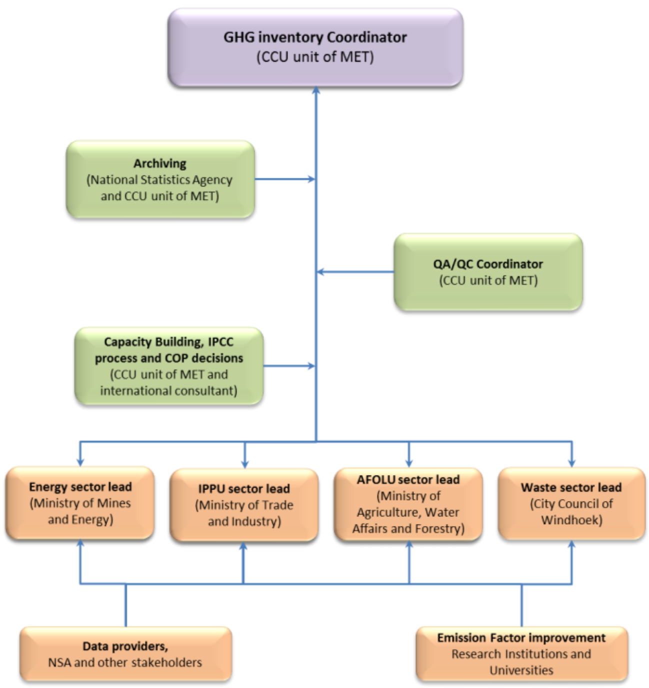


Figure 4.1. Institutional arrangements for the GHG inventory preparation

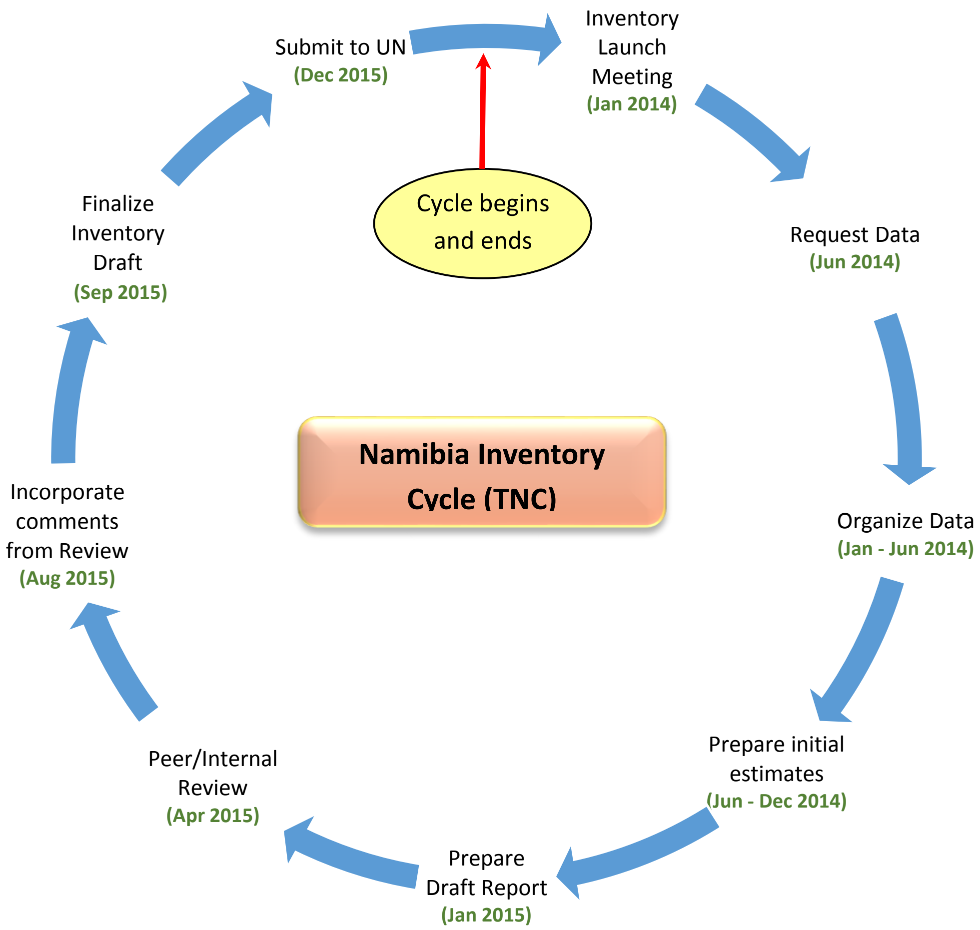


Figure 4.2. Inventory cycle for the TNC

Generally, the method adopted to compute emissions involved multiplying activity data (AD) by the relevant appropriate emission factor (EF), as shown below:

Emissions (E) = Activity Data (AD) x Emission Factor (EF)

All the methodologies and tools recommended by IPCC within the inventory cycle have been used and followed to be in line with Good Practices.

As the IPCC 2006 Guidelines do not address compilations at the Tier 2 level also, the Agriculture and Land Use Software of the Colorado State University (CSU) was adopted for estimating emissions at the Tier 2 level partially for the AFOLU sector as this is a key category. Thus, the inventory has been compiled using a mix of Tiers 1 and 2. This is good practice and improved the accuracy of the emission estimates, thus reducing the uncertainty level.

4.4.2. Gases

The gases covered in this inventory are the direct gases carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) and the indirect gases nitrogen oxides (NO_x), carbon monoxide (CO), non-methane organic volatile compounds (NMVOCs) and sulphur dioxide (SO_2).

AD and important information required to allow on the choice of the EFs on the carbon fluorocarbons (CFCs), hydro-fluorocarbons (HFCs) and perfluorocarbons (PFCs) were missing and thus estimates of emissions have not been made for these gases. As well, Sulphur hexafluoride (SF6) has not been estimated since AD were not available.

4.4.3. GWPs

Global Warming Potentials (GWP) as recommended by the IPCC have been used to convert GHGs other than CO_2 to the latter equivalent. Based on decision 17/CP.8, the values adopted were those from the IPCC Second Assessment Report for the three direct GHGs, namely;

Gas	GWP
Carbon Dioxide	1
Methane	21
Nitrous Oxide	310

4.5. Activity Data

Country-specific AD pertaining to most of the socio-economic sectors are collected, quality controlled and processed to produce official national statistics reports by the National Statistics Agency (NSA) for government and other public uses. These data are then entered in a database and archived within the existing statistical system. Thus, data collected at national level from numerous public and private institutions, organizations and companies, and archived by the NSA provided the basis and starting point for the compilation of the inventory. Additional and/or missing data, required to meet the level of disaggregation for higher than the Tier I level, were sourced from both public and private institutions by the inventory team members and coordinators through direct contacts. Data gaps were filled through personal contacts and/or from results of surveys, scientific studies and by statistical modelling. Expert knowledge was resorted to as the last option. For the LAND sector, remote sensing technology was used whereby maps were produced from LandSat satellite imagery for the years 2000 and 2010. These maps were then used to generate land use changes from the land covers obtained for these two time steps and annualized for yearly values.

The methods used to generate missing AD are provided for in details in the full National Inventory Report (NIR) and under the section for the individual sectors.

4.6. Emission Factors

Country emission factors were derived for the Tier 2 estimation of GHGs for some animal classes for both enteric fermentation and manure management. A similar exercise was performed for the LAND sector where stock factors have been derived to suit national circumstances. This is Good Practice towards enhancing the quality of the inventory and especially as these activity areas were major emitters from previous inventory results. Additionally, default IPCC EFs for the remaining source categories were screened for their appropriateness before adoption on the basis of the situations under which they have been developed and the extent to which these were representative of national ones. More information on the country specific and default EFs are provided in the sectoral reports and the NIR.

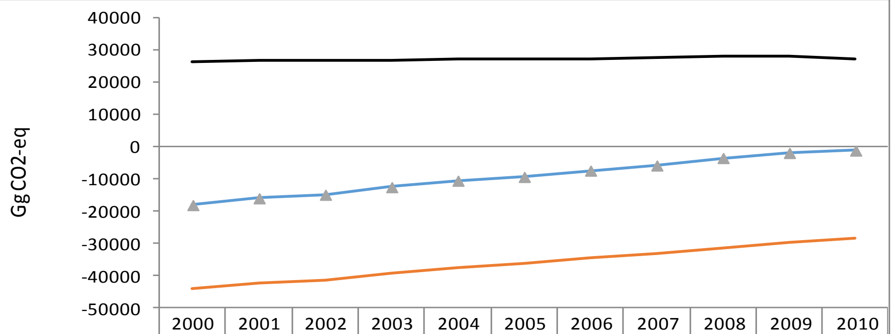
4.7. Recalculations

The inventory for the years 2000 and 2010 were recalculated to provide for a consistent time series. The scope of the 2000 inventory has been widened to include the IPPU sector and as well the 2006 IPCC Guidelines has been used instead of the Revised 1996 IPCC Guidelines to be consistent with the compilation for the period 2001 to 2010. The latter was also recalculated as inadvertently some categories, namely the metal industry, were included as activity areas when they did not occur in the country. Moreover, when importing the database, the emissions in the LAND sector doubled in the IPCC 2006 software resulting in an overestimation of the sink capacity of the country for this inventory. This problem has been reported to the IPCC Technical Supporting Unit for appropriate action.

4.8. Inventory Estimates

4.8.1. Aggregated emissions

Namibia remained a net GHG sink over the whole period 2000 to 2010 as a result of the AFOLU sector turning out to be a sink. However, the sink capacity declined by 36% over this period. The net removal of CO_2 thus decreased from 18 278 Gg to 1339 Gg, result of the AFOLU removals falling from 44 459 Gg CO_2-eq in 2000 to 28 534 Gg in 2010.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Emissions	26180	26569	26433	26817	26999	26866	27204	27281	27976	27978	27195
Removals	-44459	-42739	-41501	-39532	-37707	-36402	-34781	-33264	-31641	-30075	-28534
Net removals	-18278	-16171	-15069	-12716	-10708	-9536	-7577	-5983	-3664	-2096	-1339

Figure 4.3. National emissions, removals and net removals (Gg CO_2-eq) from 2000 to 2010

Total national emissions ranged from 26 180 Gg CO_2-eq in the year 2000 to 27 195 Gg CO_2-eq in 2010, representing an increase of 3.9% over these 11 years. The AFOLU sector remained the leading emitter throughout this period followed by Energy, Waste and IPPU for most of the years under review. AFOLU, with an aggregated emission of around 24 000 Gg CO_2-eq over that period, accounted for nearly 92% of the country's emissions in 2000 and this fell by 4% by the year 2010. Energy emissions increased from 1995 Gg CO_2-eq (7.6%) of national emissions in 2000 to 2904 Gg CO_2-eq (10.7%) in 2010. The IPPU sector emissions is on the rise as a result of industrial development in the country and increased substantially from 25 to 302 Gg CO_2-eq. Waste on the other hand varied slightly over this period with the tendency for a slight increase over time.

Table 4.1. National GHG emissions (Gg, CO_2-eq) by sector for the period 2000 to 2010.

SOURCE CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Energy	1995	2157	2269	2455	2562	2695	2795	2897	2981	2986	2904
Industrial Processes	25	25	26	110	235	260	255	294	291	303	302
AFOLU	24064	24290	24038	24141	24089	23790	24030	23969	24573	24550	23843
Waste	96.18	98	99	110	113	120	123	121	131	139	146
Total emissions	**26180**	**26569**	**26433**	**26817**	**26999**	**26866**	**27204**	**27281**	**27976**	**27978**	**27195**

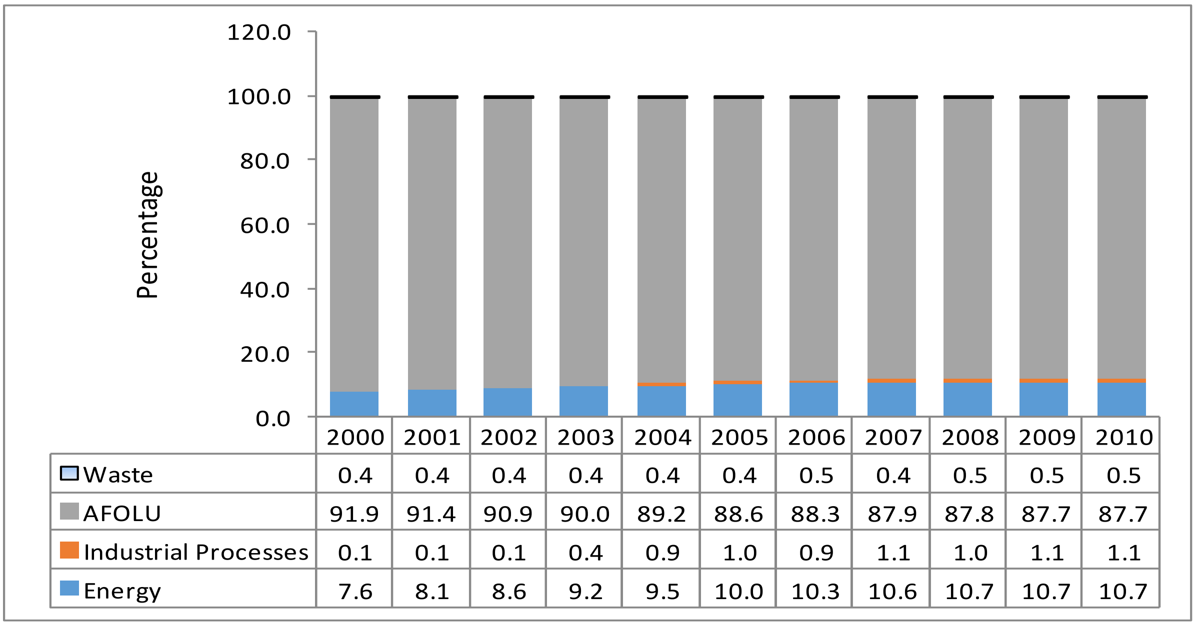


Figure 4.4. Share of national emissions (%) by sector for the period 2000 to 2010

4.8.2. Emissions by gas

The major gas emitted for all years remained CO_2 followed by CH_4 and N_2O. The amount of CO_2 increased slightly from 20 197 to 21 366 Gg for an average annual increase of 0.6%. CH_4 and N_2O varied around an average of 4584 Gg CO_2-eq and 1492 Gg CO_2-eq respectively during this period.

Table 4.2. National emissions and removals (Gg, CO_2-eq) by gas for the period 2000 to 2010

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average annual change (%)
CO_2	20197	20359	20470	20736	20965	21121	21215	21353	21433	21449	21366	0.6
CH4 (CO_2-eq)	4651	4694	4505	4599	4545	4319	4504	4446	4928	4899	4336	-0.5
N2O (CO2-eq)	1331	1516	1457	1482	1489	1425	1486	1483	1616	1630	1493	1.3
Total GHG emissions (CO2-eq)	**26180**	**26569**	**26433**	**26817**	**26999**	**26866**	**27204**	**27281**	**27976**	**27978**	**27195**	0.4
Removals (CO_2)	-44459	-42739	-41501	-39532	-37707	-36402	-34781	-33264	-31641	-30075	-28534	-4.3
Net removals (CO2-eq)	**-18278**	**-16171**	**-15069**	**-12716**	**-10708**	**-9536**	**-7577**	**-5983**	**-3664**	**-2096**	**-1339**	-22.0

CO_2 increased from 77.1% in the year 2000 total aggregated national emissions to 78.6% in 2010. The other two gases, CH_4 and N_2O, varied at around 17% and 5.5% over this period of 11 years.

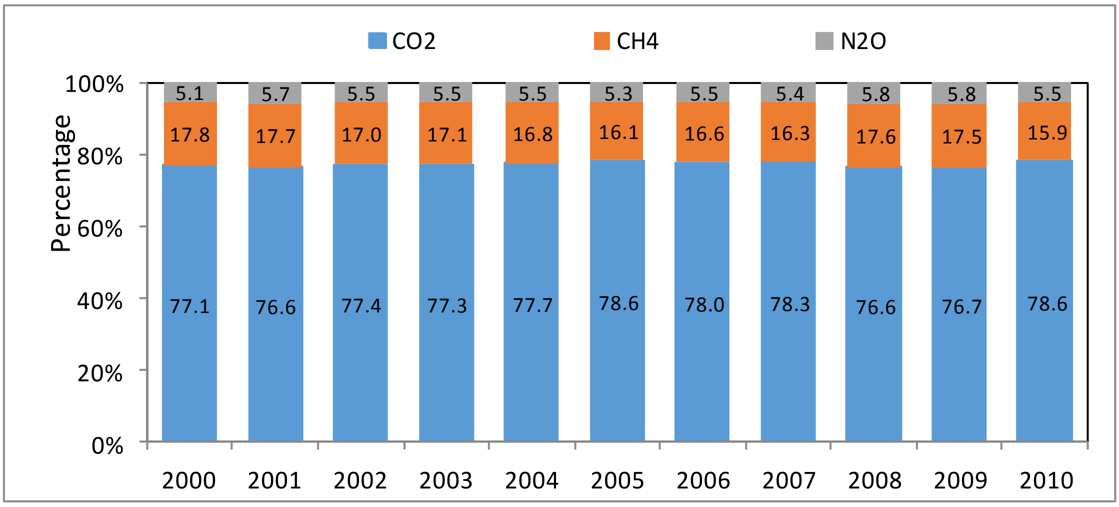
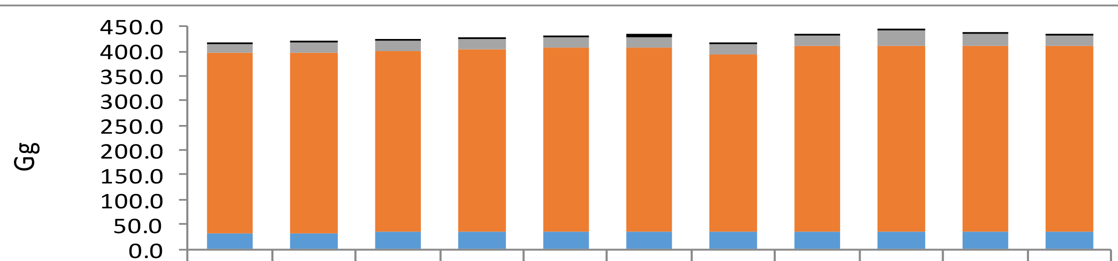


Figure 4.5. Share of total aggregated emissions (%) by gas for the period 2000 to 2010

Among the GHG precursors, CO largely exceeded the others in emissions with an increase from 365 to 375 Gg from 2000 to 2010. NMVOCs varied between 19.5 and 32.9 Gg while SO_2 dwindled between 2.2 and 4.0 Gg. NO_x increased from 31.5 Gg to 35.2 over this same period with inter-annual variations and a peak of 36.5 in 2005. The emissions by gas and share at national level are presented in Table 4.3.

Table 4.3. Emissions (Gg) of GHG precursors and SO_2 during the period 2000 to 2010



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SO2	2.2	2.4	2.8	3.1	3.6	3.8	4.2	4.0	4.2	3.7	2.8
NMVOC	19.5	20.6	20.5	20.8	21.2	21.1	20.5	21.9	32.9	23.0	22.0
CO	364.9	365.6	366.9	368.7	371.6	373.1	360.2	375.5	375.6	375.9	375.3
NOx	31.5	32.6	34.7	35.8	36.0	36.5	33.5	34.6	34.6	35.5	35.2

4.8.3. Summary result for the year 2010

Only one summary result sheet from the software is presented in the chapter. The full sets are provided in the full NIR. Based on the 2010 compilations, most CO_2 were emitted in the AFOLU sector with some 18 000 Gg. Concurrently, this sector acted as a sink of about 28 400 Gg to be a net sink of -10266 Gg for the year 2010. The Energy sector came next with emissions of 2793 Gg for the year 2010.

CH_4 emanated mainly from the AFOLU sector also, followed by the Waste sector. Emissions were 198 Gg (96%) and 5 Gg for the year 2010 for these two sectors respectively. The Energy sector was responsible for 3 Gg of CH4 emissions in 2010.

N_2O emissions, 4.57 Gg, were linked to the AFOLU sector primarily and represented more than 98% of national emissions.

Among the indirect GHGs, the AFOLU sector was the highest emitter of CO at 75% of national emissions with 283 Gg, followed by Energy, 85 Gg and Waste with 7 Gg. Energy emitted 60% of national NO_x emissions with 21 Gg and AFOLU was responsible for 14 Gg. The Energy and AFOLU sectors contributed 51%and 47% of national emissions of NMVOCs which stood at 22 Gg.

With regard to SO_2 emissions, 2.75 Gg emanated from the Energy sector out of a total of 2.76 Gg, the remainder coming from the Waste sector.

Table 4.4. Summary of national emissions and removals in 2010

Categories	Emissions (Gg)						
	Net CO_2 (1)(2)	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
National Emissions	-7168.06	206.46	4.82	35.19	375.34	21.96	2.76
1 - Energy	2793.43	3.09	0.15	21.11	85.65	11.23	2.75
1.A - Fuel Combustion Activities	2793.43	3.09	0.15	21.11	85.65	11.23	2.75
1.A.1 - Energy Industries	35.50	5.E-04	5E-04	0.08	4E-03	4E-04	0.30
1.A.2 - Manufacturing Industries and Construction	186.36	0.02	3E-03	0.73	1.10	0.20	0.89
1.A.3 - Transport	2210.41	0.55	0.11	13.91	48.91	5.09	0.02
1.A.4 - Other Sectors	320.35	2.51	0.04	5.97	35.54	5.92	1.53
1.A.5 - Non-Specified	40.81	2.E-03	2.E-03	0.43	0.10	0.02	2.E-04
2 - Industrial Processes and Product Use	302.32	0	0	0	0	0	0
2.A - Mineral Industry	15.25	0	0	0	0	0	0
2.A.2 - Lime production	15.25						
2.B - Chemical Industry	0	0	0	0	0	0	0
2.B.1 - Ammonia Production							
2.B.2 - Nitric Acid Production							
2.C - Metal Industry	260.90	0	0	0	0	0	0
2.C.6 - Zinc Production	260.90						
2.D - Non-Energy Products from Fuels and Solvent Use	26.17	0	0	0	0	0	0
2.D.1 - Lubricant Use	8.19						
2.D.2 - Paraffin Wax Use	17.97						
3 - Agriculture, Forestry, and Other Land Use	-10266.30	198.01	4.57	13.69	282.82	10.31	0
3.A - Livestock	0	187.13	0.81	0	0	10.31	0
3.A.1 - Enteric Fermentation	0	181.20	0	0	0	0	0
3.A.2 - Manure Management	0	5.93	0.81	0	0	10.31	0
3.B - Land	-10266.35	0	0	0	0	0	0
3.B.1 - Forest land	-28428.58	0	0	0	0	0	0
3.B.2 - Cropland	163.08	0	0	0	0	0	0
3.B.3 - Grassland	17999.14	0	0	0	0	0	0
3.C - Aggregate sources and non-CO_2 emissions sources on land	0.08	10.88	3.76	13.69	282.82	0	0

Categories	Emissions (Gg)						
	Net CO_2 (1)(2)	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
3.C.1 - Emissions from biomass burning	0	10.88	0.83	13.69	282.82	0	0
3.C.2 - Liming	0						
3.C.3 - Urea application	0.08						
3.C.4 - Direct N2O Emissions from managed soils			1.01				
3.C.5 - Indirect N2O Emissions from managed soils			1.16				
3.C.6 - Indirect N2O Emissions from manure management			0.75				
4 - Waste	2.47	5.36	0.10	0.39	6.87	0.43	0.01
4.A - Solid Waste Disposal		3.38	0	0	0	0.28	
4.C - Incineration and Open Burning of Waste	2.47	0.80	0.01	0.39	6.87	0.15	0.01
4.D - Wastewater Treatment and Discharge	0	1.18	0.09	0	0	1.E-06	0
Memo Items (5)							
International Bunkers	252.34	0.01	0.01	4.22	0.75	0.26	1.01
1.A.3.a.i - International Aviation (International Bunkers)	98.13	7E-04	3E-03	0.40	3E-02	0.02	0.03
1.A.3.d.i - International water-borne navigation (International bunkers)	154.22	0.01	4E-03	3.82	0.71	0.25	0.98
1.A.5.c - Multilateral Operations							

4.9. Quality Assurance and Quality Control (QA/QC)

Namibia has in place its own quality control (QC) system for data collected by different institutions. The data are quality controlled at different stages of the collection process until they reach the National Statistics Agency where the final quality assurance (QA) is made by before archiving in national databases. The private sector also implements its own QC/QA before archiving the data collected. Thus the QC system is not fully monitored by the GHG inventory compiler. However, there are national standards to be met and as well the GHG inventory compiler performs also a QC on the AD before they are used in the software.

QC and QA procedures, as defined in the IPCC 2006 Guidelines (IPCC, 2007) were implemented. Whenever there were inconsistencies or possible transcription errors, the responsible institution was queried and the problem discussed and solved. QC was implemented through,

- Routine and consistent checks to ensure data integrity, reliability and completeness;
- Routine and consistent checks to identify errors and omissions;
- Accuracy checks on data acquisition and calculations;
- The use of approved standardized procedures for emissions calculations; and
- Technical and scientific reviews of data used, methods adopted and results obtained.

QA was undertaken by independent reviewers who were not involved with the preparation of the inventory, the objective being to

- Confirm data quality and reliability;
- Review the AD and EFs adopted for each source category as a first step;
- Review and check the calculation steps in the software; and
- Ensure consistency over the time series.

Even if QA/QC procedures have been followed throughout the inventory process, systematic records as per the IPCC 2006 Guidelines have not been kept. This resulted from the lack of personnel, time, and insufficient capacity since the inventory management system was being implemented for the first time in the country. This is a major challenge and will take time to be fully operational.

4.10. Completeness

The source by source category analysis conducted before the preparation of the inventory of the BUR1 was reviewed as a few errors inadvertently crept in, especially in the IPPU sector in the case of the metal industry. Being new to the process, export of scrap metals were mistaken for production by the sector lead and their emissions accounted for. The revised completeness table depicting the scope of the inventory is provided in Table 4.5. Rows, where activity is not occurring, have been deleted for ease of presentation and understanding.

Table 4.5. Completeness of the 2000 to 2010 inventories

Categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
1.A - Fuel Combustion Activities							
1.A.1 - Energy Industries	X	X	X	X	X	X	X
1.A.2 - Manufacturing Industries and Construction	X	X	X	X	X	X	X
1.A.3 - Transport	X	X	X	X	X	X	X
1.A.4 - Other Sectors	X	X	X	X	X	X	X
1.A.5 - Non-Specified	X	X	X	X	X	X	X
1.B - Fugitive emissions from fuels	NO	NO	NO	NO	NO	NO	NO
1.C - Carbon dioxide Transport and Storage	NO	NO	NO	NO	NO	NO	NO
2 - Industrial Processes and Product Use							
2.A - Mineral Industry							
2.A.2 - Lime production	X	NA	NA	NA	NA	NA	NA
2.B - Chemical Industry	NO	NO	NO	NO	NO	NO	NO
2.C - Metal Industry							
2.C.6 - Zinc Production	X	NA	NA	NA	NA	NA	NA
2.D - Non-Energy Products from Fuels and Solvent Use							
2.D.1 - Lubricant Use	X	NA	NA	NA	NA	NA	NA
2.D.2 - Paraffin Wax Use	X	NA	NA	NA	NA	NA	NA
2.D.3 - Solvent Use	NE	NE	NE	NE	NE	NE	NE
2.E - Electronics Industry	NO	NO	NO	NO	NO	NO	NO
2.F - Product Uses as Substitutes for Ozone Depleting Substances							
2.F.1 - Refrigeration and Air Conditioning	NE	NE	NE	NE	NE	NE	NE
2.F.2 - Foam Blowing Agents	NO	NO	NO	NO	NO	NO	NO
2.F.3 - Fire Protection	NE	NE	NE	NE	NE	NE	NE
2.F.4 - Aerosols	NE	NE	NE	NE	NE	NE	NE
2.F.5 - Solvents	NE	NE	NE	NE	NE	NE	NE
2.F.6 - Other Applications (please specify)	NO	NO	NO	NO	NO	NO	NO
2.G - Other Product Manufacture and Use							
2.G.1 - Electrical Equipment	NE	NE	NE	NE	NE	NE	NE
2.G.2 - SF6 and PFCs from Other Product Uses	NO	NO	NO	NO	NO	NO	NO
2.G.3 - N2O from Product Uses	NE	NE	NE	NE	NE	NE	NE
2.G.4 - Other (Please specify)	NO	NO	NO	NO	NO	NO	NO
2.H - Other							
2.H.2 - Food and Beverages Industry	NE	NE	NE	NE	NE	NE	NE
3 - Agriculture, Forestry, and Other Land Use							
3.A - Livestock							
3.A.1 - Enteric Fermentation	NA	X	NA	NA	NA	NA	NA
3.A.2 - Manure Management	NA	X	X	NA	NA	X	NA
3.B - Land							
3.B.1 - Forest land	X	NA	NA	NA	NA	NA	NA
3.B.2 - Cropland	X	NA	NA	NA	NA	NA	NA
3.B.3 - Grassland	X	NA	NA	NA	NA	NA	NA
3.B.4 - Wetlands	NE	NE	NE	NE	NE	NE	NE
3.B.5 - Settlements	NE	NE	NE	NE	NE	NE	NE
3.B.6 - Other Land	NO	NO	NO	NO	NO	NO	NO
3.C - Aggregate sources and non-CO_2 emissions sources on land							
3.C.1 - Emissions from biomass burning	NA	X	X	X	X	NA	NA
3.C.3 - Urea application	NA	X	X	X	NA	NA	NA
3.C.4 - Direct N2O Emissions from managed soils	NA	NA	X	NA	NA	NA	NA

Categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
3.C.5 - Indirect N2O Emissions from managed soils	NA	NA	X	NA	NA	NA	NA
3.C.6 - Indirect N2O Emissions from manure management	NA	NA	X	NA	NA	NA	NA
3.D - Other							
3.D.1 - Harvested Wood Products	NE	NE	NE	NE	NE	NE	NE
4 - Waste							
4.A - Solid Waste Disposal	NO	X	NA	NA	NA	X	NO
4.C - Incineration and Open Burning of Waste	X	X	X	X	X	X	X
4.D - Wastewater Treatment and Discharge	NO	X	X	NA	NA	NA	NA
5 - Other							
Memo Items (5)							
International Bunkers							
1.A.3.a.i - International Aviation (International Bunkers)	X	X	X	X	X	X	X
1.A.3.d.i - International water-borne navigation (International bunkers)	X	X	X	X	X	X	X
1.A.5.c - Multilateral Operations	NO	NO	NO	NO	NO	NO	NO

X = Estimated, NA = Not Applicable, NO = Not Occurring, NE = Not Estimated, EE = Estimated Elsewhere

4.11. Uncertainty Analysis

The uncertainty analysis has been performed using the tool available within the IPCC 2006 Software for the national inventory, excluding the Land sector. Based on the quality of the data and whether the EFs used were defaults or nationally derived, uncertainty levels were allocated for the two parameters and the combined uncertainty calculated. For the national inventory, Uncertainty, excluding the Land sector ranged from 5.6% to 6.5%. This is considered good and very much acceptable.

Table 4.6. Uncertainty for the period 2000 to 2010

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Uncertainty	6.5	6.4	6.4	6.2	6.1	5.9	5.8	5.6	5.7	5.8	5.7

4.12. Key Category Analysis

The Key Category Analysis also was performed using the tool available within the IPCC 2006 Software for both level and trend assessment. There are five key categories in the trend assessment, four of these from the AFOLU sector, of which enteric fermentation from Livestock, three from Land category and the last one is Road Transportation from the Energy sector. .

Table 4.7. Key Category Analysis for 2010 - Approach 1 Level Assessment

A	B	C	D	E	F	G
IPCC Category code	IPCC Category	Greenhouse gas	2010 Ex,t (Gg CO2 Eq)	|Ex,t| (Gg CO2 Eq)	Lx,t	Cumulative Total of Column F
3.B.1.a	Forest land Remaining Forest land	CARBON DIOXIDE (CO2)	-27362.6	41817.1	0.59	0.594
3.B.3.b	Land Converted to Grassland	CARBON DIOXIDE (CO2)	17999.1	18254.6	0.26	0.853
3.A.1	Enteric Fermentation	METHANE (CH4)	3805.2	3805.2	0.05	0.907
1.A.3.b	Road Transportation	CARBON DIOXIDE (CO2)	2136.7	2136.7	0.03	0.937
3.B.1.b	Land Converted to Forest land	CARBON DIOXIDE (CO2)	-1066.0	1066.4	0.02	0.952

The results changed slightly when considering the trend assessment. There are still 5 key categories but Road Transportation is replaced by Other Sectors-Liquid Fuels while the other four remained the same.

Table 4.8. Key Category Analysis for 2010 - Approach 1 Trend Assessment

B	C	D	E	F	G	H
IPCC Category	Greenhouse gas	2000 Year Estimate Ex0 (Gg CO2 Eq)	2010 Year Estimate Ext (Gg CO2 Eq)	Trend Assessment (Txt)	% Contribution to Trend	Cumulative Total of Column G
Forest land Remaining Forest land	CARBON DIOXIDE (CO2)	-43137.90	-27362.60	0.42	0.58	0.58
Land Converted to Grassland	CARBON DIOXIDE (CO2)	17999.14	17999.14	0.21	0.28	0.86
Enteric Fermentation	METHANE (CH4)	4163.68	3805.24	0.05	0.07	0.93
Land Converted to Forest land	CARBON DIOXIDE (CO2)	-1065.97	-1065.97	0.01	0.02	0.95
Other Sectors - Liquid Fuels	CO2	416.04	320.35	0.01	0.01	0.96

4.13. Archiving

All raw data collected for the inventory have been stored in a database and in the 2006 software data base after being processed and formatted for making estimates of emissions and removals. All documentation on the data processing and formatting have been kept in soft copies in the excel sheets with the summaries reported in the NIR. These versions will be managed in electronic format in at least three copies, two at the Ministry of Environment and Tourism and a third copy at the National Statistics Agency.

4.14. Constraints, Gaps and Needs

Namibia, as a developing country, has its constraints and gaps that need to be addressed to produce better quality reports for reporting to the Convention. The following problems were encountered during the preparation of the national inventory of GHG emissions:

- Information required for the inventory had to be obtained from various sources as no institution has been endorsed with the responsibility for collection of specific activity data (AD) needed for the estimation of emissions according to UNFCCC;
- Almost all of the AD, including those from the NSA were not in the required format for feeding in the software to make the emission estimates;
- End-use consumption data for all the sectors and categories were not always readily available and had to be generated on the basis of other scientific and consumption parameters;
- Reliable biomass data such as timber, fuelwood, wood waste and charcoal consumed or produced were not available and had to be derived from statistical modelling or on the basis of household surveys and censuses;
- There were frequent inconsistencies when data were collected from different sources;
- Information on the technologies associated with production in the different industries were not available and this led to overestimation of emissions as technologies with highest EFs were chosen as good practice;
- Lack of solid waste characterization data, amount generated and wastewater generated from the industrial sector were not regularly measured and had to be derived on the basis of production and demographic data amongst others;
- Lack of EFs to better represent national circumstances and provide for accurate estimates;
- Emissions for a few categories have not been estimated due to lack of AD and time; and
- Capacity of national experts to take over despite one round of training on running the IPCC 2006 software was not possible.

4.15. National Inventory Improvement Plan (NIIP)

Based on the constraints and gaps and other challenges encountered during the preparation of the inventory, a list of the most urgent improvements have been identified. This is listed below and will be addressed during the preparation of the NC4 and the BUR2 inventories.

- Adequate and proper data capture, QC, validation, storage and retrieval mechanism are required and need to be firmly established to facilitate the compilation of future inventories;
- There is a necessity to further build capacity and strengthen the existing institutional framework that are well equipped to provide improved coordinated action for reliable data collection and accessibility;
- Further develop national emission factors (EFs) more representative of the national context;
- Implement fully the QA/QC system in order to reduce uncertainty and improve inventory quality;
- Establish a GHG inventory unit within DEA to be responsible for inventory compilation and coordination;
- Institutionalize the archiving system;
- Collect information on production technology used in the IPPU sector;
- Start data collection for categories not covered in this exercise;
- Implement new forest inventories to supplement available data on the LAND category;
- Review and correct inconsistencies existing for the recent land cover maps with additional overlays with previous maps and ground referencing;
- Produce new maps for 2005 to refine land use change data over 5 years as opposed to the decadal one available now;
- Refine data collection for determining country specific weights for dairy cows, sheep and goats;
- Develop the digestible energy (DE) factor for livestock as country specific data is better than the default IPCC value to address this key category fully at Tier 2.

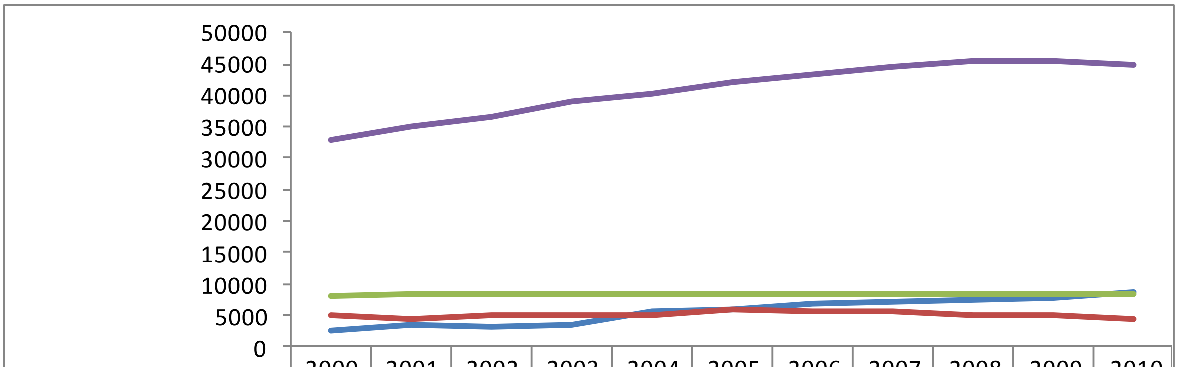
4.16. Sectoral Reports

4.16.1. Energy

Namibia is not a producer of fossil fuels on its own and does not refine or process any fuel. Therefore, only imported fossil fuel consumed and combusted in the country has been used to estimate emissions in the energy sector under Fuel Combustion Activities. All IPCC source categories have been covered. However, due to unavailability of disaggregated data to enable a well demarcated consumption in the different source categories, some fuels may have been burned in another category but finally the emissions have been captured within the sector. In line with IPCC Good Practice, both the reference and sectoral approaches have been adopted for compiling emissions as recommended. As well both international aviation and water-borne navigation bunkering have been covered.

The evolution of the energy mix of the country for the period 2000 to 2010 is presented in Figure 4.6 and Table 4.9. Fossil fuels constituted the major share of the energy requirements of the country throughout this period with more than 60% followed by renewable sources comprising primarily biomass along with marginal amounts of solar and wind. Electricity imports increased its share from 6% in 2000 to 15% in 2010 while hydro declined from 12.3% to 7.6% over this same period of time.

Table 4.9. Energy (TJ) requirements for year 2010



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Electricity imports	2466	3589	3197	3571	5555	6019	6885	7219	7559	7684	8586
Hydro	5026	4360	5123	5108	4921	5962	5443	5551	5023	5072	4489
Renewables	8193	8304	8308	8339	8340	8339	8365	8361	8355	8348	8338
Fossil fuels	32950	34986	36555	38902	40260	42093	43229	44552	45356	45620	45003

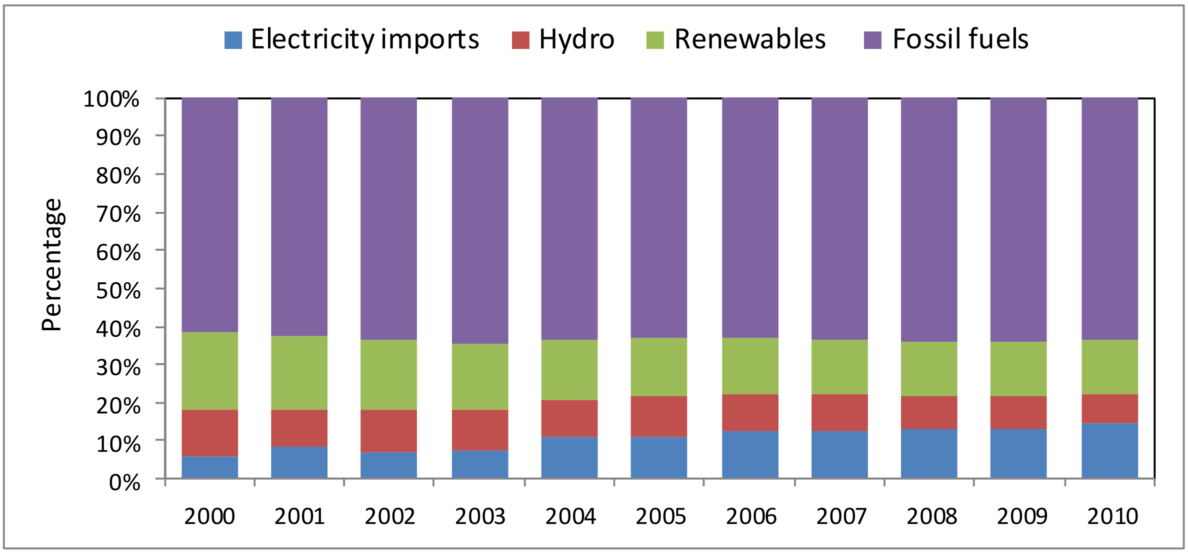
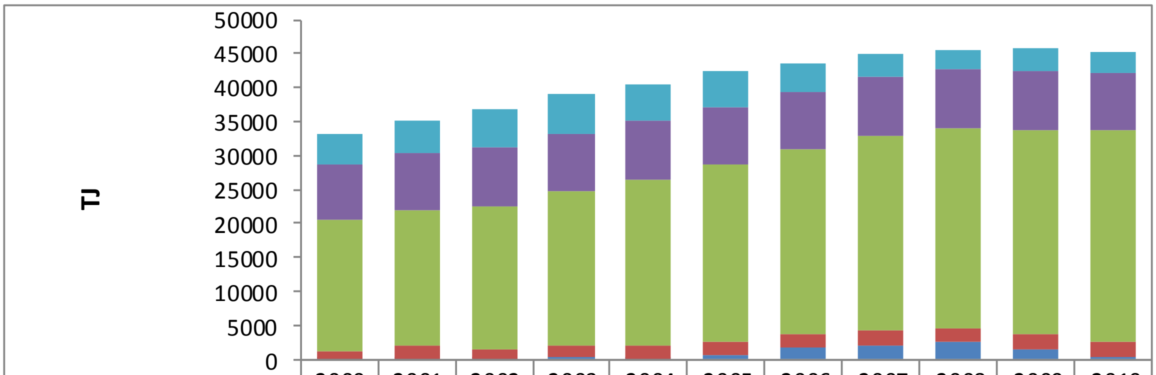


Figure 4.6. Fuel mix of the energy requirements for the period 2000 to 2010

The evolution of fossil energy used by the different economic sectors of the country for the period 2000 to 2010 is given in Table 4.10 and the % used in Figure 4.7 for the year 2010. The transport sector is by far the highest consumer of energy and the amount used steadily increased over that time period. Next after transport comes the residential, agriculture and fishing and manufacturing industries and construction sectors as the main users. These four sectors consumed 68%, 19%, 7% and 5% of the total fossil energy used in the country in 2010. Energy industries that include electricity generation had a share of only 1% in 2010.

Table 4.10. Fossil energy (TJ) use by economic sector for the period 2000 to 2010



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agriculture and fishing	4360	4755	5665	5845	5379	5172	4091	3291	3032	3460	3111
Residential	8418	8530	8542	8578	8583	8566	8623	8622	8596	8580	8507
Transport	19314	20013	21102	22668	24541	26182	27069	28710	29405	30166	31029
Manufacturing	1015	1827	1476	1847	1998	1863	1987	2144	2123	2194	2268
Energy industries	78	98	6	230	24	576	1753	2080	2496	1514	383

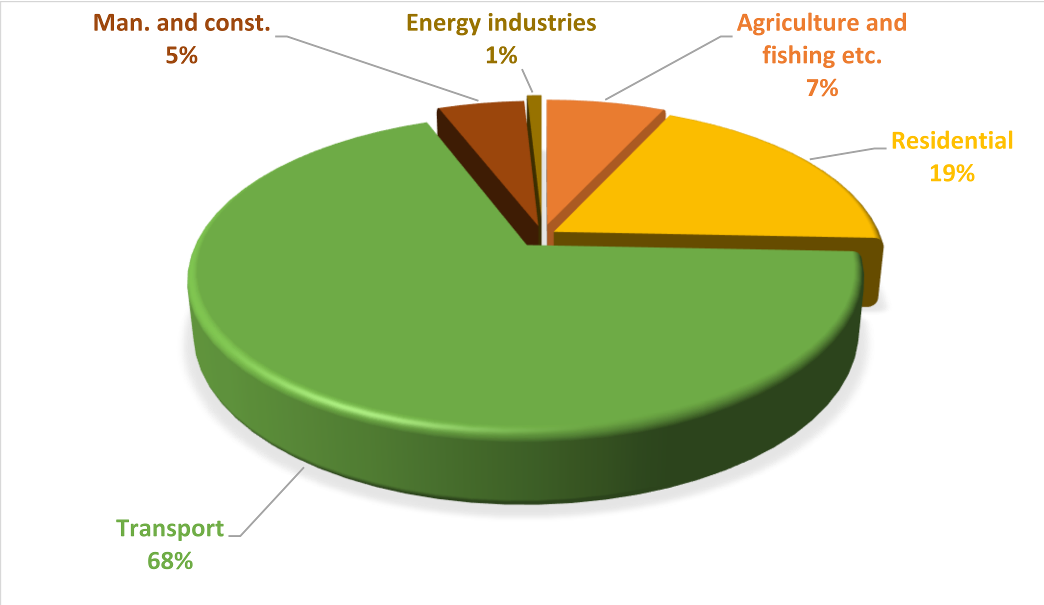


Figure 4.7. Fossil energy use by sector for the year 2010

4.16.1.1. 1.A. - Fuel Combustion Activities

1.A.1 - Energy Industries

This sub-category is confined to the production of electricity from a mix of liquid and solid fossil fuels. The amount used is however minimal in the energy balance since the country generates a high proportion of its electricity from hydro and approximately 50% is imported from South Africa, the South African Power Pool (SAPP) and Zimbabwe to meet the current demand, which reached a peak of 534 MW in 2012 (http://africa-energy-forum.com/webfm_send/201).

Namibia's total installed electricity generation capacity in 2010 was about 384 MW for a peak demand of some 500 MW. Hydro contributed about 240 MW in this, making the country highly dependent on energy imports. The fossil fuel generation plants are mainly used to supplement the imports during peak demand time. Solar and wind potential exists but are tapped only marginally at the moment.

1.A.2 - Manufacturing Industries and Construction

Fossil fuel inputs are primarily used for generating process heat within the mining sector but not extensively as the two main companies in operation imported electricity directly from the neighbouring countries. The construction industry is highly diversified and detailed information was not available.

1.A.3 - Transport

The transport sector comprised domestic aviation, road transportation and railways. All three sub-categories have been covered in the inventory as well as fuel combusted for international bunkering.

1.A.4 - Other Sectors

Sub-categories covered under other sectors included Residential and Fishing as AD were not available for Commercial/Institutional, Stationary combustion and Off-road vehicles and other machinery within the Agriculture and Forestry sectors.

The main sources of energy, used within the residential sector by households for cooking purposes, are wood/charcoal (54%) and electricity (33%), the remainder being LPG and cow dung. The main sources of energy used for lighting purposes are paraffin and waxes (50%) and electricity (43%). Nearly 50% of households utilize wood/charcoal for heating purposes and 30% have recourse to electricity.

Fishing is an important activity in Namibia, with a fleet of 160 fishing vessels (Ministry of Works and Transport, Maritime Affairs, 2010) operating out of a total of 208 registered ships. Thus special attention was given to this sub-category to collect AD and estimate emissions.

4.16.1.2. Memo items

International bunkers cover international aviation and navigation according to the IPCC Guidelines. Both activity areas were covered as they consume significant amounts of fossil fuel imported in the country and the emissions have been compiled and reported in this inventory.

4.16.1.3. Methodology

It is Good Practice to estimate emissions by the Reference and Sectoral approaches. During this exercise, estimates were compiled using both approaches. The top down Reference approach was carried out using import-export, production and stock change data for making the energy balance of the country. The Sectoral Approach is a bottom up one and generally involves determining fuel consumption from end use data by the different sector source categories and using the IPCC conversion and emission factors to determine GHG emissions. The Sectoral approach covered all the IPCC source categories.

The basic equations used to estimate GHG emissions are given below:

Emissions = Σ (Fuel Consumption j • Emission Factor j)

where j = type of fuel

4.16.1.4. Activity Data

AD for working out the reference approach was obtained from the energy database of the NSA on imports and exports of energy products. For the bottom up sectoral approach, AD were sourced from the end-users of fossil fuels. Data on biomass used were derived from data on consumption of different fuels by households collected in the censuses conducted by the NSA. The same approach was used to determine the amount of cow dung burned and charcoal used. The data collection covered all solid, liquid and gaseous fossil fuels, fuelwood and charcoal.

AD were not always available and in the format required as well as at the level of disaggregation needed. Gaps were filled using statistical methods such as trend analysis and extrapolation as appropriate. In some cases, fuels had to be allocated or determined according to the activity area such as amount of fuel used in the fishing sector being directly related to fishing vessel campaigns. Fuel use for sectors like agriculture, forestry and institutional amongst others could not be traced and even generated. Thus fuels from these sectors were eventually allocated in different sectors based on distributed and consumed amounts.

4.16.1.5. Emission factors

In the absence of national emission factors the greenhouse gas emissions were computed on the basis of IPCC default emission factors as per Table 4.11.

Table 4.11. List of emission factors used in the Energy sector

Energy Source	Emission Factor			Source		
Fuel	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Motor gasoline	69300	3.0	0.6	Vol. 2, table 2.2	Vol. 2, table 2.2	Vol. 2, table 2.2
""	""	3.3	3.2	Vol. 2, table 2.2	Vol. 2, table 2.2.3	Vol. 2, table 2.2.3
""	“”	10.0	0.6	Vol. 2, table 3.5.2	Vol. 2, table 3.5.3	Vol. 2, table 3.5.3
Aviation gasoline	69300	0.5	2.0	Vol. 2, table 2.2	Vol. 2, table 2.2	Vol. 2, table 2.2
Jet kerosene	71500	0.5	2.0	Vol. 2, table 2.2	Vol. 2, table 2.2	Vol. 2, table 2.2
Other kerosene	71900	10.0	0.6	Vol. 2, table 2.2	Vol. 2, table 2.2	Vol. 2, table 2.2
Gas/Diesel oil	74100	3.0	0.6	Vol. 2, table 2.2	Vol. 2, table 2.2	Vol. 2, table 2.2
""	""	3.9	3.9	Vol. 2, table 3.2.2	Vol. 2, table 2.2.3	Vol. 2, table 2.2.3
""	""	7.0	2.0	Vol. 2, table 3.5.3	Vol. 2, table 3.5.3	Vol. 2, table 3.5.3
""	""	10.0	0.6	Vol. 2, table 3.5.2	Vol. 2, table 3.5.3	Vol. 2, table 3.5.3
Residual fuel oil	77400	3.0	0.6	Vol. 2, table 2.2	Vol. 2, table 2.2	Vol. 2, table 2.2
Liquefied petroleum gases	63100	5.0	0.1	Vol. 2, table 2.2	Vol. 2, table 2.2	Vol. 2, table 2.2
Paraffin waxes	73300	10.0	0.6	Vol. 2, table 2.2	Vol. 2, table 2.2	Vol. 2, table 2.2
Other bituminous coal	94600	1.0	1.5	Vol. 2, table 2.2	Vol. 2, table 2.2	Vol. 2, table 2.2
""	""	10.0	1.5	Vol. 2, table 2.2	Vol. 2, table 3.4.1	Vol. 2, table 3.4.1
Waste oils	73300	30.0	4.0	Vol. 2, table 2.2	Vol. 2, table 2.2	Vol. 2, table 2.2
Wood	112000	300.0	4.0	Vol. 2, table 2.2	Vol. 2, table 2.2	Vol. 2, table 2.2
Charcoal	112000	200.0	1.0	Vol. 2, table 2.2	Vol. 2, table 2.2	Vol. 2, table 2.2

4.16.1.6. Comparison of the Sectoral Approach (SA) with the Reference Approach (RA)

Estimates of emissions of CO_2 made with the reference approach compared very well with those generated from the Sectoral approach (Table 4.10). Slightly higher estimates are obtained under the reference approach for all the years of the period under review. The difference between the two approaches stands at a marginal 0.3 to 0.5% less for the whole period except for 2001 when it reached 4.7%. The results are thus very consistent with the two approaches.

Table 4.12. Comparison of the Reference and Sectoral Approaches for period 2000 to 2010 (Gg CO_2)

Approach	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Reference Approach	1812.6	2051.8	2162.6	2345.3	2449.2	2580.2	2678.9	2777.6	2861.0	2867.6	2779.4
Sectoral Approach	1902.2	2061.6	2172.4	2355.4	2459.3	2590.5	2689.3	2788.2	2871.4	2875.9	2793.4
Difference (%)	-4.7	-0.5	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3	-0.5

4.16.1.7. Sectoral Approach

Total aggregated emissions are given in Table 4.13 while the share of emissions by category is depicted in Figure 4.8 for the five IPCC source categories for the years 2000 to 2010. Total emissions resulting from Fuel Combustion Activities amounted to 1995 in 2000 to climb to 2904 Gg CO_2-eq in 2010.

Table 4.13. Emissions for Fuel Combustion Activities (Gg CO_2-eq) for period 2000 to 2010

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Fuel Combustion Activities	**1995**	**2157**	**2269**	**2455**	**2562**	**2695**	**2795**	**2897**	**2981**	**2986**	**2904**
Energy Industries	7	9	0	21	2	54	165	196	237	143	36
Manufacturing In	79	156	123	157	169	156	165	174	170	180	188
Transport	1429	1481	1561	1676	1814	1935	2000	2121	2172	2229	2297
Residential	155	157	163	165	177	166	161	162	177	177	153
Agriculture/Fishi	324	353	421	435	400	384	304	244	225	257	231

Transport contributed the major share of these emissions, between 68 and 79%, followed by Agriculture/Fishing with between 8 and 19%. Emissions from transport increased by 7% over these 11 years while that from Agriculture/Fishing declined by 8% over the same period. Emissions from Manufacturing Industries and Construction stayed at around 6% of the Energy sector emissions while the residential sub-sector shows a slight decreasing trend from an initial 8% in 2000 to 5% in 2010. Energy industries emissions varied significantly because local electricity generation is only to supplement import deficits and lower production from the hydro generation plants. Emissions from the Energy Industries category did hit a maximum of 8% in 2008.

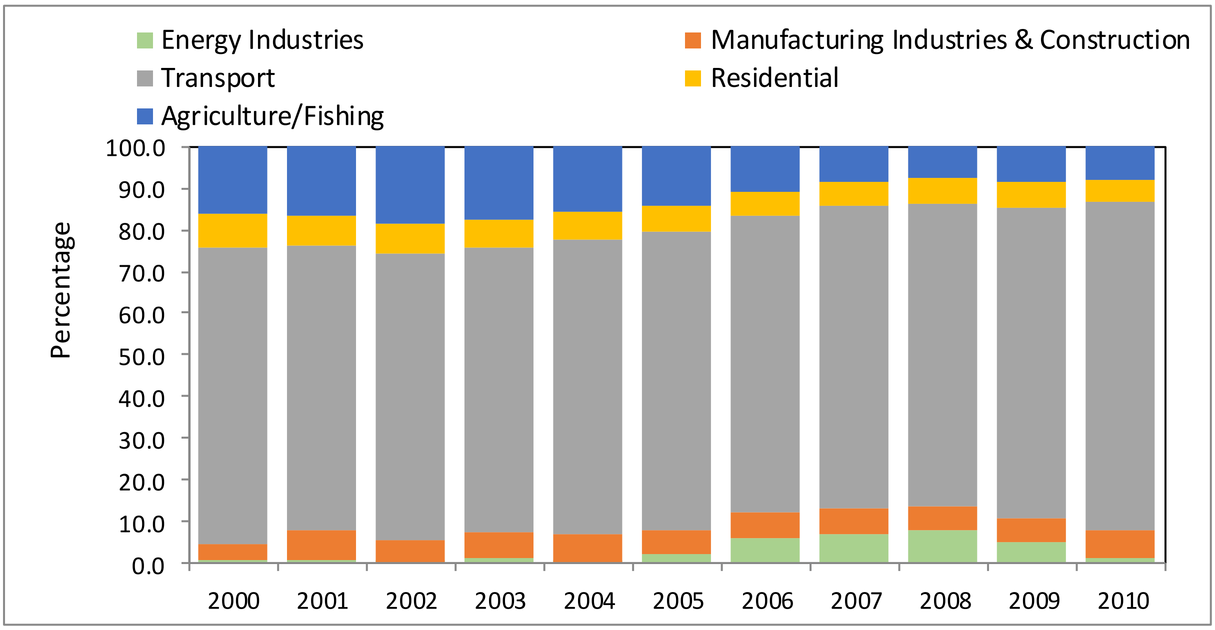


Figure 4.8. Share of GHG emissions by Energy sub-sectors, 2000 to 2010

The evolution of emissions of all gases in the Energy sector is presented in Table 4.14. In 2010, the main GHG emitted in Namibia in the energy sector was carbon dioxide (CO_2), accounting for 96% of the total aggregated GHG emissions. CO_2 remained the leading gas emitted during the whole period 2000 to 2010 followed by CH_4 and N_2O. Among the indirect gases, CO remained the main gas emitted over the whole period of time followed by NO_x and NMVOCs. The emissions increased over time for most gases due to more intense activity.

Table 4.14. Emissions by gas for the Energy sector for the period 2000 to 2010 (Gg)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
CO_2-eq	1994.8	2156.7	2269.4	2455.1	2561.6	2695.1	2795.5	2896.7	2981.0	2986.2	2904.1
CO_2	1902.2	2061.6	2172.6	2355.4	2459.3	2590.5	2689.3	2788.2	2871.4	2875.9	2793.4
CH_4	2.9	2.9	3.0	3.0	3.0	3.0	3.1	3.1	3.1	3.1	3.1
N_2O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NO_x	17.5	18.6	20.7	21.8	22.0	22.4	21.1	20.5	20.5	21.5	21.1
CO	70.4	71.6	73.4	75.7	79.2	81.3	82.3	84.6	85.0	85.8	85.6
NMVOC	9.4	9.6	9.8	10.1	10.5	10.8	10.9	11.1	11.2	11.3	11.2
SO_2	2.2	2.4	2.8	3.0	3.6	3.8	4.2	4.0	4.2	3.7	2.7

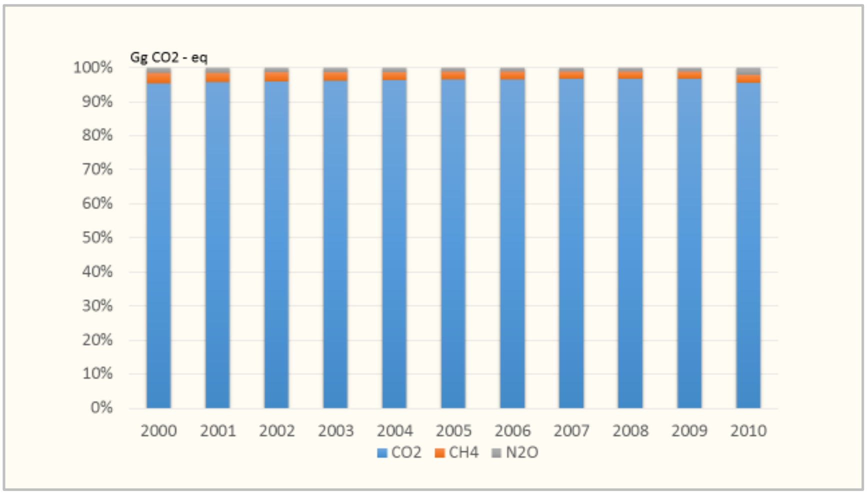


Figure 4.9. Evolution of emissions (%) of the direct GHG gases over the period 2000 to 2010

Table 4.15. Energy Sector emissions in 2010

	Emissions (Gg)						
Categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1 - Energy	2793.43	3.09	0.15	21.11	85.65	11.23	2.75
1.A - Fuel Combustion Activities	2793.43	3.09	0.15	21.11	85.65	11.23	2.75
1.A.1 - Energy Industries	35.50	5E-04	5E-04	0.08	4E-03	4E-04	0.30
1.A.1.a - Main Activity Electricity and Heat Production	35.50	5E-04	5E-04	0.0771	4E-03	4E-04	0.30
1.A.1.a.i - Electricity Generation	35.50	5E-04	5E-04	0.08	4E-03	4E-04	0.30
1.A.2 - Manufacturing Industries and Construction	186.36	0.02	0.00	0.73	1.10	0.20	0.89
1.A.2.i - Mining (excluding fuels) and Quarrying	184.17	2E-02	3E-03	0.71	1.10	0.19	0.89
1.A.2.m - Non-specified Industry	2.19	9E-05	2E-05	0.02	2E-03	8E-04	1.E-03
1.A.3 - Transport	2210.41	0.55	0.11	13.91	48.91	5.09	0.02

	Emissions (Gg)						
Categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
1.A.3.a - Civil Aviation	21.94	2E-04	6E-04	0.05	4.32	0.07	0.01
1.A.3.a.i - International Aviation (International Bunkers) (1)							
1.A.3.a.ii - Domestic Aviation	21.94	2E-04	6E-04	0.05	4.32	0.07	7E-03
1.A.3.b - Road Transportation	2136.72	0.55	0.11	13.00	44.41	4.94	0.02
1.A.3.b.i - Cars	507.53	0.21	0.02	1.56	11.65	1.39	0.01
1.A.3.b.i.1 - Passenger cars with 3-way catalysts	163.86	0.07	0.01	0.51	3.77	0.45	2E-03
1.A.3.b.i.2 - Passenger cars without 3-way catalysts	343.67	0.14	0.02	1.05	7.88	0.94	4E-03
1.A.3.b.ii - Light-duty trucks	928.17	0.30	0.04	4.12	30.73	3.03	9E-03
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts	696.13	0.23	0.03	3.09	23.05	2.27	0.01
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts	232.04	8E-02	0.01	1.03	7.68	0.76	2E-03
1.A.3.b.iii - Heavy-duty trucks and buses	698.74	0.04	0.04	7.32	1.66	0.42	2E-03
1.A.3.b.iv - Motorcycles	2.27	1E-03	1E-04	5E-03	0.37	0.10	0
1.A.3.c - Railways	51.76	2E-03	4E-04	0.86	0.18	0.08	1E-04
1.A.3.d.i - International water-borne navigation (International bunkers) (1)							
1.A.4 - Other Sectors	320.35	2.51	0.04	5.97	35.54	5.92	1.53
1.A.4.b - Residential	90.88	2.48	0.03	0.65	32.17	4.82	0.09
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	229.47	0.03	0.00	5.32	3.37	1.10	1.44
1.A.4.c.iii - Fishing (mobile combustion)	229.47	0.03	0.00	5.32	3.37	1.10	1.44
1.A.5 - Non-Specified	40.81	2E-03	2E-03	0.43	0.10	0.02	2.E-04
1.A.5.b - Mobile	40.81	2E-03	2E-03	0.43	0.10	0.02	2.E-04
1.A.5.b.iii - Mobile (Other)	40.81	2E-03	2E-03	0.43	0.10	0.02	2E-04
1.B.2 - Oil and Natural Gas	0	0		0	0	0	0
1.B.3 - Other emissions from Energy Production				0	0	0	0
Memo Items (3)							
International Bunkers	252.34	0.01	7E-03	4.22	0.75	0.26	1.01
1.A.3.a.i - International Aviation (International Bunkers) (1)	98.13	7E-04	3E-03	0.40	0.03	0.02	0.03
1.A.3.d.i - International water-borne navigation (International bunkers) (1)	154.22	0.01	4E-03	3.82	0.71	0.25	0.98
1.A.5.c - Multilateral Operations (1)(2)				0	0	0	0
Information Items							
CO_2 from Biomass Combustion for Energy Production	933.66						

4.16.2. Industrial Processes and Product Use

4.16.2.1. Description of IPPU sector

Greenhouse gas emissions are produced from a wide variety of industrial activities. Emissions arise from industrial processes during the chemical or physical transformation of materials (for example, in the blast furnace in the iron and steel industry, ammonia and other chemical products manufactured from fossil fuels used as chemical feedstock and the cement industry where significant amounts of CO_2 are released). During these processes, other greenhouse gases, including methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), can also be produced (IPCC 2006 Guidelines V3_1, Ch 1). Other gases emitted in different sub categories include SF_6 and NMVOCs.

Activities occurred in two out of the eight categories of the IPPU sector and emissions were estimated for these two source categories, namely lime production under mineral industry, and zinc production under metal industry. Emissions from lubricants and paraffin wax use under non-energy products from fuel and solvents use were also estimated.

Quite a number of activity areas have not been included as activity data were not available to compile estimates. These sources are:

- Product used as substitutes for ozone depleting substances
  - Refrigeration and air conditioning
  - Fire protection
  - Aerosols
  - Solvents
- Other products manufacture and use
  - Disposal of electric equipment
  - SF6 in military applications
  - N_2O from medical applications and propellant for pressure and aerosol products.
- Food and beverage industry
  - Beer manufacture
  - Bread production
  - Fishmeal production

4.16.2.2. Methods

The method adopted is from the IPCC 2006 Guidelines, the Tier 1 level due to unavailability of reliable information on the technologies used in the production processes. Only the three main GHGs CO_2, CH_4 and N_2O were estimated as per the IPCC 2006 software. Other gases are not emitted in the categories reported.

4.16.2.3. Activity Data

Activity data for the IPPU sector were obtained mainly from the NSA. Both the outputs from the production units and annual report of the Chamber of Mines were used to supplement the import and export data AD from the NSA. All AD from the different sources were compared and quality controlled to identify the most reliable sets which were then used in the software for generating emissions. AD for lubricants and paraffin wax use were derived from the mass balance of imports and exports data.

4.16.2.4. Emission factors

In the absence of information on technology used, all EFs used were IPCC defaults, with those giving the highest emissions adopted as per Good Practice. When the choice was linked to the country development stage, the factor attached with developing countries was adopted. The EFs used for the different source categories are listed in Table 4.16.

Table 4.16. Emission Factors for the IPPU sector

Category	IPPC Guideline volume	Table and page
Liming	V3_2_Ch2 Mineral Industry	Table 2.4 Page 2.22
Ammonia	V3_3_Ch3 Chemical Industry	Table 3.1 Page 3.15
Nitric acid	V3_3_Ch3 Chemical Industry	Table 3.3 Page 3.23
Iron and steel	V3_4_Ch4 Metal Industry	Table 4.1 Page 4.25

Category	IPPC Guideline volume	Table and page
Ferroalloys	V3_4_Ch4 Metal Industry	Table 4.5 Page 4.37
Aluminium	V3_4_Ch4 Metal Industry	Table 4.10 Page 4.47
Lead	V3_4_Ch4 Metal Industry	Table 4.21 Page 4.73
Zinc	V3_4_Ch4 Metal Industry	Table 4.24 Page 4.80
Lubricant	V3_5_Ch5 Non Energy Products	Table 5.2 Page 5.9
Paraffin wax	V3_5_Ch5 Non Energy Products	Chapter 5.3.2.2 Page 5.12

4.16.2.5. Emission estimates

Aggregated emissions for the IPPU sector (Table 4.17) amounted to 25.0 Gg CO_2-eq in the year 2000, increased sharply in 2003 and 2004 when zinc production started and steadily thereafter to reach 302.3 Gg CO_2-eq in 2010. The metal industry category then became the highest emitter of this sector and contributed 86.3% in 2010. Use of paraffin wax followed with emissions ranging between 16.1 to 21.2 Gg CO_2-eq during that period. The remaining two sources are lime production and lubricant use which stood in 2010 at 15.2 and 8.2 Gg CO_2-eq respectively. These represented 2.7% and 5.0% of the sector emissions for the year 2010.

Table 4.17. Aggregated emissions by IPPU source categories (CO_2-eq)

SOURCE CATEGORY	GHG	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
TOTAL	**CO_2-eq**	**25.0**	**24.6**	**26.3**	**110.2**	**235.2**	**260.3**	**255.1**	**294.3**	**291.1**	**302.5**	**302.3**
2.A.2 - Lime production	CO_2	7.1	8.3	8.6	9.5	9.7	10.0	10.4	11.2	11.9	13.6	15.2
2.C.6 - Zinc Production	CO_2	0.0	0.0	0.1	81.6	205.0	228.4	223.4	259.4	250.1	258.7	260.9
2.D - Non-Energy Products from Fuels	CO_2	17.9	16.4	17.6	19.1	20.5	21.8	21.2	23.8	29.2	30.3	26.2
2.D.1 - Lubricant Use	CO_2	0.6	0.3	0.2	1.2	0.3	3.7	4.1	6.6	8.8	9.1	8.2
2.D.2 - Paraffin Wax U	CO_2	17.3	16.1	17.4	17.9	20.2	18.1	17.1	17.2	20.4	21.2	18.0

4.16.3. Agriculture, Forest and Other Land Use (AFOLU) Sector

4.16.3.1. Description of sector

The AFOLU sector comprises activities responsible for emissions and removals linked to Agriculture (crops and livestock), changes in land use among and between the 6 IPCC land use categories, Forestry, soil organic matter, fertilizers and management of land categories. Emissions and removals were estimated for activity areas falling under the four IPCC categories.

Country specific emission and stock factors derived for the country and used in the BUR1 report for the livestock and forestry activities were adopted while some additional amendments have been made to better represent the land subcategories within the national context.

4.16.3.2. Emission estimates for AFOLU sector

Overall, the AFOLU sector remained a net sink over the full inventory period on account of the land sub-category. However, the net removals decreased constantly over this period from 20 394 Gg CO_2-eq in the year 2000 to 4691 in 2010 (Table 4.18). This is a fivefold reduction on account of deforestation and wood removals notably. Emissions from livestock remained more or less constant while a small increase is observed for aggregate sources and non-CO_2 emissions from land. The land sub-category removed 26 191

Gg CO_2 in 2000 and this potential fell to 10 266 Gg in 2010. This represents an overall decline in the sink capacity of the land sub-category by 61% over this period at an annual rate of some 6% (Figure 4.10).

Table 4.18. Aggregated emissions (CO_2-eq) from the AFOLU sector

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Livestock	4,513	4,598	4,390	4,478	4,420	4,172	4,367	4,309	4,820	4,785	4,182
Land	-26,191	-24,471	-23233	-21,264	-19,439	-18134	-16,513	-14,996	-13,372	-11,807	-10,266
Aggregate and non CO_2 sources from land	1,283	1,423	1,380	1,395	1,401	1,350	1,395	1,392	1,486	1,497	1,394
Total	-20,394	-18,450	-17,463	-15,391	-13,618	-12,611	-10,751	-9,295	-7,067	-5,525	-4,691

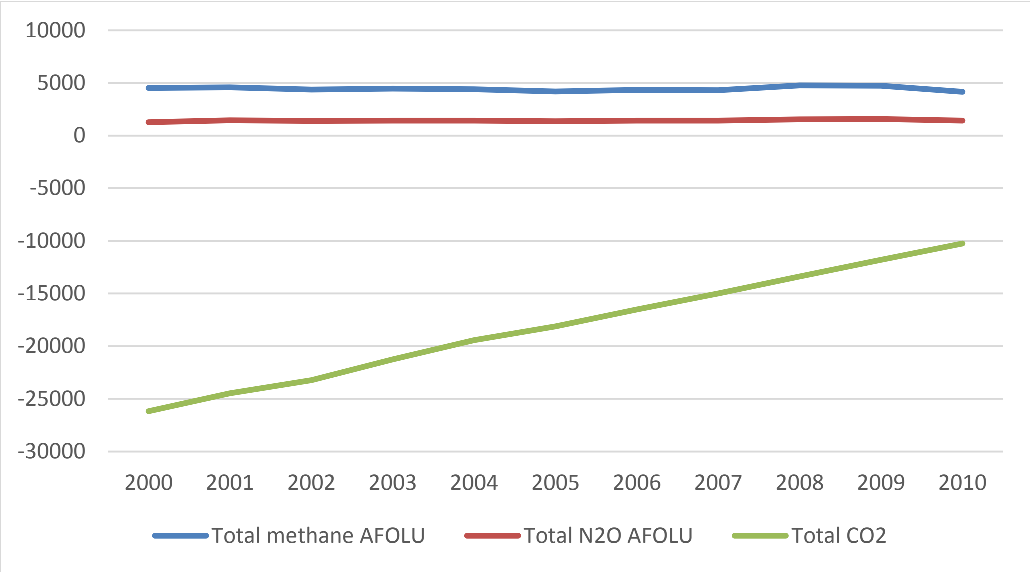


Figure 4.10. Emissions by gas (CO_2-eq) of the different sub-categories of the AFOLU sector

4.16.3.3. Livestock

Livestock is an important activity of the Namibian economy. Cattle rearing is the dominant component of the sector followed by the smaller ruminant goats and sheep. Commercial chicken production is in its infancy while farmers are phasing out ostrich farming.

Methods

Tier 2 level has been adopted for cattle and dairy cows and Tier 1 for the remaining animal groups. Available country specific data on live weight, pregnancy and other parameters were collected and used with missing ones generated, as described in the EF section later in this chapter. Derivation of methane EFs were done with the ALU software that uses the same IPCC principles and methods while the computation of nitrogen excretion rates for the different animal groups has been done using an Excel spreadsheet and the formula provided in the IPCC 2006 Guidelines.

Activity Data

Information from the NSA and annual surveys done by the Ministry of Agriculture was used. The few missing data points were generated using statistical modelling techniques, interpolation or trend analysis. Table 4.19 gives the number of animals for the years 2000, 2005 and 2010

Table 4.19. Number of animals in 2000, 2005 and 2010

Animals	2000	2005	2010
Total cattle	2,504,930	2,219,330	2,389,891
Sheep	2,446,146	2,663,795	1,378,861
Goats	1,849,569	2,043,479	1,690,467
Horses	61,885	47,429	49,852
Mules and asses	167,548	140,291	141,588
Swine	23,148	55,931	63,498
Poultry	476,331	998,278	777,480
Camels	54	63	43

Emission factors

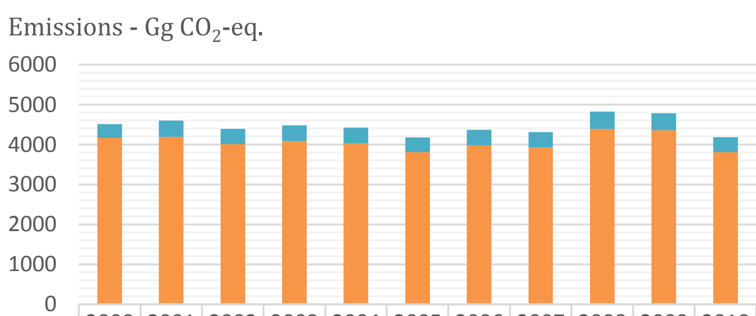
Emissions for cattle were estimated using a Tier 2 approach as IPCC GPG and reproduced in the ALU software. For all other animal groups, default factors (1996 IPCC Guidelines, Table 4-3 to 4-5, p. 4.10 to 4.12) for developing countries have been used. The EFs for enteric and manure CH_4 have been derived with the use of the ALU software while EFs for manure N_2O was obtained using the live weights and default nitrogen excretion rates in the IPCC 2006 software. Country specific values were thus derived for making emission estimates. The datasets enumerated above were used to calculate the maximum methane production capacity for the cattle sub-groups while default EFs from the IPCC 2006 Guidelines were used for the other animal groups.

The feeding situation is based on information available from the census and surveys while manure management system (MMS) for cattle are based on country expert judgment and on information in the farming system guide (NNFU, 2006).

The digestible energy is taken from the IPCC 2006 Guideline (chapter 10, annex table 10A2) for animals in large grazing areas and based on feed characteristics obtained from Feed Master Ltd, the sole company producing feeds in the country for dairy cows. The average daily work for commercial and communal cattle has been assumed as 6 hours/day for the whole year, based on expert judgment of members of the GHG inventory team for mature male castrates only as the other animal groups do not perform any work.

Emission estimates

Aggregate emission estimates for the enteric fermentation and manure management subcategories are presented in Figure 4.11.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Manure management	350	407	384	391	389	365	383	379	429	428	376
Enteric fermentation	4164	4191	4006	4086	4031	3807	3984	3930	4391	4357	3805

Figure 4.11. Emissions from subcategories of livestock category (Gg CO_2 eq)

Enteric fermentation remained the highest contributor for both subcategories and varied as a function of the number of animals recorded in that year. Enteric fermentation contributed about 4000 Gg CO_2-eq representing about 91% of emissions of the livestock category and manure management the difference. The evolution of emissions of the three gases CH_4, N_2O and NMVOCs emitted by the livestock category given in Table 4.20.

Table 4.20. Total emission from Livestock sub category (Gg)

GHG	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
CH_4	204.089	206.050	197.032	200.973	198.297	187.289	195.970	193.345	215.885	214.164	187.131
N_2O	0.734	0.874	0.814	0.830	0.825	0.771	0.812	0.803	0.923	0.928	0.812
NMVOCs	9.924	10.809	10.405	10.412	10.473	9.987	10.609	10.409	11.351	11.266	10.306

Methane varied in the range 187.3 to 215.9 Gg while nitrous oxide varied between 0.73 and 0.93 Gg. NMVOCS dwindled around 10 Gg annually.

A typical summary report from the software for the emissions for the year 2010 with the contribution from each sub category and animal group is presented in Table 4.21.

Table 4.21. Summary of emissions from the Livestock sector

Categories	Emission (Gg)					
	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
3.A - Livestock	187.13	0.81	0	0	10.31	0
3.A.1 - Enteric Fermentation	181.20	0	0	0	0	0
3.A.1.a - Cattle	163.48	0	0	0	0	0
3.A.1.a.i - Dairy Cows	0.13					
3.A.1.a.ii - Other Cattle	163.35					
3.A.1.b - Buffalo	0					
3.A.1.c - Sheep	6.89					
3.A.1.d - Goats	8.45					
3.A.1.e - Camels	2.E-03					
3.A.1.f - Horses	0.90					
3.A.1.g - Mules and Asses	1.42					
3.A.1.h - Swine	0.06					
3.A.1.j - Other (please specify)	0		0	0	0	0
3.A.2 - Manure Management (1)	5.93	0.81	0	0	10.31	0
3.A.2.a - Cattle	4.85	0.81	0	0	8.62	0
3.A.2.a.i - Dairy cows	0.10	0	0	0	0.01	
3.A.2.a.ii - Other cattle	4.74	0.81	0	0	8.60	
3.A.2.b - Buffalo	0.00	0	0	0	0.00	
3.A.2.c - Sheep	0.29	0	0	0	0.23	
3.A.2.d - Goats	0.37	0	0	0	0.92	
3.A.2.e - Camels	0.00	0	0	0	0.00	
3.A.2.f - Horses	0.11	0	0	0	0.21	
3.A.2.g - Mules and Asses	0.17	0	0	0	0.21	
3.A.2.h - Swine	0.13	0	0	0	0.04	
3.A.2.i - Poultry	0.02	0	0	0	0.08	
3.A.2.j - Other (please specify)	0	0	0	0	0	

4.16.3.4. Land

The whole Namibian territory has been classified under the six IPCC land categories and treated as managed land. Thus they have all been accounted for in the compilation of emissions and removals. Land use has been derived from the land covers attributed on the maps generated from satellite images.

The six land categories are:

3.B.1 - Forestland
3.B.2 - Cropland
3.B.3 - Grassland
3.B.4 - Wetlands
3.B.5 - Settlements
3.B.6 - Other land

Methods

Estimation of the emissions by sources and removals by sink for the LAND sector has been done using Approach 2 with a mix of Tier 1 and Tier 2 levels. Most of the stock factors have been derived from past forest inventories and other available in-country resources.

Activity Data

AD used for the LAND categories are summarized in this section together with assumptions and sources of information. AD for the land use changes have been generated from geospatial maps produced for two time steps, the years 2000 and 2010 and then annualized as described in more details in the NIR. Maps were generated from LandSat satellite images, 30 m resolution for the years 2000 and 2010. Climate and soil maps of the country were overlaid on the land cover land use maps to generate the combined Climate-Soil-Land classifications to meet IPCC requirements.

Deriving land use from land cover maps using the remote sensing technology has been a major challenge. Some land use changes between classes were not obvious at all such as settlements being converted to Forestland or still Cropland. As these did not reflect the reality, adjustments were made a first time to cater for these inconsistencies as reported in the BUR1. Moreover, some of the areas allocated to some classes did not match with existing data from previous mapping exercises and land surveys. The initial areas from the maps have been adjusted to be in line with other resources such as annual agricultural surveys to determine the extent under cultivation for food security purposes and to remove inconsistencies mentioned previously. Initial areas of 2000 and 2010 and annual change used in land matrices are given in Table 4.22.

Table 4.22. Total land use adjusted area and annual change used in land matrix

Land Type category	Area (ha)			
	Year 2000	Year 2010	Annual gain	Annual loss
Forestland	8,404,206	6,791,276	321,475	482,768
Cropland	403,178	283,818	23,067	35,003
Grassland	60,731,438	62,463,728	306,489	133,260
Wetlands	657,613	657,613	-	-
Settlements	31,163	31,163	-	-
Other land	11,682,154	11,682,154	-	-

Furthermore, due to the mapping inconsistencies mentioned previously, it was assumed that no changes occurred in the Wetland, Other Land and Settlement categories and between the land type categories in the minor soil types by climate combinations which represent altogether less than 3% of the territory.

Deforestation

Initial deforestation rate estimated at 275 703 ha annually is considered far higher than those reported in the FAO database (74 000 ha/year) which confirmed the inaccuracy of the maps. Inconsistencies were corrected and the deforestation rate fell to 161 293 ha/year which is more realistic. This rate is still high but nevertheless considered sustainable and adopted for this inventory pending reviewed maps.

Forest land stratification

Forests were divided in two sub-categories:

- Forest-Forests (FL): tree height of 5 m and a canopy cover of more than 20%
- Forest-Woodlands (WD): tree height of 5 m and a canopy cover between 10% and 20%

The forest category is further subdivided by age classes using data from forest inventories, namely <20 years and >20 years. These age classes have been derived on the basis of the diameter at breast height (dbh) of the most abundant species (Mendelson and Obeid, Forests and woodlands of Namibia, 2007).

Cropland stratification

Cropland areas were not stratified and were considered as Annual Cropland since perennial crops cover a marginal area of total cropland, about 0.001% only. The annual crop management systems assessed are wheat, millet, sorghum, and maize grown under commercial and communal set-ups.

Grassland stratifications

Grassland that was sub-divided into three sub-categories in the BUR1 inventory was merged and the whole area considered as a single category. Woody biomass present on the shrubland sub-class area was averaged on the whole grassland area when computing estimates.

Wetlands stratification

The wetlands have not been further subdivided. It was also assumed that there was no change in this land category over the inventory period.

Settlements stratification

This land also has not been further subdivided. It was also assumed that there was no change in this land category over the inventory period.

Other Land stratification

This land was further subdivided into bare land, rock outcrops and desert sand. For the purpose of this inventory, these sub-classes were not taken into consideration as there is no activity leading to emissions or removals. It was also assumed that there was no change in this category over the inventory period.

Emission and other stock factors

Emission and other stock factors have been analyzed, screened, adopted and generated so as to be representative of circumstances of Namibia. Where an EF is not country specific, the most appropriate default value contained in the IPCC 2006 software or Guideline has been used.

The volume of fuelwood was calculated from the amount used by households in the rural and urban areas (NHIES main report 2009-2010) and fuelwood production from the publication woodchips in Namibia.

Charcoal exported was estimated from the mass balance of imports and exports plus a fixed national consumption of 8000 t from 2000 to 2002, 9000 t from 2003 to 2005 and 10 000 t onwards annually over the inventory period (2000-2010). Volume of poles, representing timber harvested, was based on the report on low cost dwellings in Namibia (Iteaa M, 2010) to calculate use per household and frequency as well as the amount used for kraals in relation to the number of households from the NHIES report. A density of 0.7 t dm/m^3 for fuelwood was used. BCEF default values provided in the IPCC table (Vol 4, chapter 04, p 4.51) has been used, namely 0.89 for growing stock level of 41-60 m^3, 2.11 for 21-40 m^3 and 5.55 for 10-20 m^3. Figure 4.12 gives an overview of the final volumes extracted from forestland and woodland for fuelwood and poles.

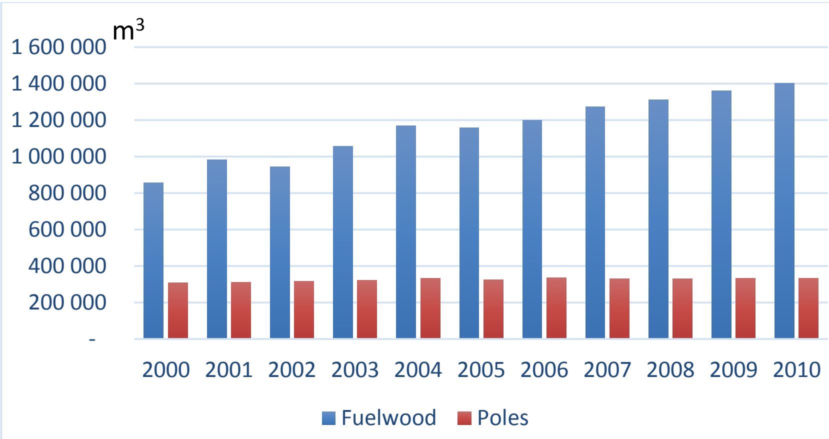


Figure 4.12. Volume of woody biomass removal from forestland and woodland

Above ground biomass stock and growth

(a). *Forestland*

The above ground biomass stock (Bm) (t dm/ha) and annual growth rate (Iv) (m^3/ha/year) in forests was estimated for:

- Forests younger and older than 20 years
- Woodland younger and older than 20 years

No below ground biomass (BGB) has been derived, and the default ratios between Bm and BGB has been taken from the IPCC 2006 Guidelines.

Two regions, Okongo and Oshikoto were also characterized for their landcover under sub-classes Forest, Closed Woodlands, Open Woodlands, Thicket, closed Shrubland and Bushland amongst 13 regions covered by a full forest inventory. Above ground biomass (equation below) was derived by multiplying the growing stock volume by the weighted average density of all species calculated from data from the NFI of Okongo forest as the dominating species are not very different in the country. Wood density was obtained from the Global Wood Density Database of Zanne et al. (2009) and the density of *Acacia flechii* was taken from the African wood density database (Local data for wood density ref No. 16a. http://cdm.unfccc.int/filestorage/. ICRAF species switchboard). The average density has been taken as 0.7 t dm/ha.

Bm (t dm/ha) = Growing Stock (m^3/ha) x Density (t dm/m^3)

Then, the above ground biomass for each age class was derived by using a default ratio of BM>20 years/Bm<20 years of 70/30, taken from table 4.8 tropical dry forest plantation ratio for young and aged trees and the distribution of species by dbh class. It was calculated that 45% of the trees are <20 years and 55% are >20 years. The Bm for forest with age <20 year was estimated at 21.44 t dm/ha and Bm for forest with age >20 year at 50.03 t dm/ha. The above ground biomass excluded herbaceous biomass. The age classes have been derived from the dbh distribution (Mendelsohn, 2007).

The biomass growth rate was estimated on the basis of the individual above ground biomasses divided by the average age for each class. These were then adjusted to account for woody biomass increase from the Grassland class. Woody biomass in grassland was estimated at 6.88 t dm on 14 million ha of shrubland and averaged over the whole grassland area. Harvest of the invasive bush was calculated for 2010 for charcoal and fuelwood use and this area was estimated to be the average yearly value harvested. For herbaceous biomass an estimation of 2 t dm/ha has been adopted. A summary of Bm and Iv used for forests and woodlands in the inventory is given in Table 4.23.

Table 4.23. Above ground biomass and growth rate by tree age classes

Sub-category	Above ground Biomass (t dm/ha)	Iv (t dm/ha/year)	Adjusted Iv (t dm/ha/year)
Forest <20y	21.44	2.14	3.18
Forest >20y	50.03	0.90	1.94
Woodlands <20	12.97	1.80	2.84
Woodlands >20	42.08	1.17	2.21
Saplings	2.00	NA	NA
Herbaceous biomass	2.00	NA	NA

(b). ***Cropland***
Since there are only annual crops, no woody biomass growth factors have been assigned.

(c). ***Grassland***
Stock factors for grassland are shown in Table 4.24. Herbaceous biomass is taken as 2.3 t dm/ha, which is the IPCC default for grasslands. The Bm after conversion for the same year has been assumed different from the IPCC default, that is 0 t dm/ha. After conversion woody biomass is 0.18 t dm/ha and herbaceous biomass is 2.0 t dm/ha.

Table 4.24. Above ground biomass for grassland (t dm/ha)

	Bm woody	Bm herbaceous	Bm woody after conversion	Bm herbaceous after conversion
Grassland	2.40	2.3	0.18	2.00

Similarly as for woody biomass stocks, annual increments cannot be accounted for in the IPCC 2006 software under Grassland remaining Grassland. Annual growth of woody biomass in grasslands is derived by dividing the standing stock by the average age derived from the forest inventory. The annual growth of shrubland was based on an annual average age of 10 years because of the regular harvest for making charcoal and providing fuelwood. Based on this, a fixed value of 1.04 t dm/ha/yr was added to the growth rate of forestland and woodland.

(d). ***Disturbances***
In the category forest land remaining forest land, a total of 3% of the area is burned through disturbance every year with a fraction of biomass loss of 10% lost based on documents published by the department of forest on burnt areas determined from scars from MODIS data. The grass layer present is also estimated to be lost through burning. The same 3% estimate has been adopted for grassland burned and the

herbaceous layer only is considered to be affected. Table 4.25 gives the biomass amounts burned in the different land categories and subcategories.

Table 4.25. Biomass lost during fire disturbances

Category	Biomass (t dm/ha) lost through fire
Forestland less than 20 years	4.14
Forestland more than 20 years	6.00
Woodland less than 20 years	3.30
Woodland more than 20 years	5.21
Grassland	2.00

(e). *Management factors*

For forestland, no management has been accounted for. Therefore, the land use management and input stock factors are taken as 1.

The grassland stock factors have been taken respectively as 1 and 0.67 to reflect the national circumstances of moderate degradation obtained from expert judgement.

For croplands, the land use stock factor is 0.58 and the management and input factors are 1 for annual crops. Set aside factors adopted are respectively 0.93 and 1.17 for land use and management, and input.

4.16.3.5. Results

In 2010, the LAND sector acted as a net sink, with a total net removal of -10 266 Gg of CO_2. Forestland acted as a sink for 28 429 Gg CO_2 while Grassland emitted 17 999 Gg and Cropland 163 Gg. Over the inventory period 2000 to 2010, the sink capacity of forests decreased by some 16 000 Gg CO_2 from 44 204 to 28 429.

Table 4.26. Emissions (CO_2) for the LAND sector for period 2000 to 2010

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3.B.1 - Forest land	-44,204	-42,386	-41,112	-39,336	-37,553	-36,213	-34,663	-33,036	-31,520	-29,960	-28,429
3.B.2 - Cropland	14	-84	-120	73	115	81	151	41	148	155	163
3.B.3 - Grassland	17,999	17999	17,999	17,999	17,999	17,999	17,999	17,999	17,999	17,999	17,999
Total net	-26,191	-24,,471	-23,233	-21,264	-19,439	-18,134	-16,513	-14,996	-13,372	-11,807	-10,266

The summary of results for the year 2010 from the software is presented in Table 4.27

Table 4.27. Emissions and removals from the LAND category for 2010

Category	Emissions (Gg)						
	Net CO_2 (1)(2)	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
3.B - Land	-10266.35	0	0	0	0	0	0
3.B.1 - Forest land	-28428.58	0	0	0	0	0	0
3.B.1.a - Forest land Remaining Forest land	-27362.60						
3.B.1.b - Land Converted to Forest land	-1065.97	0	0	0	0	0	0
3.B.1.b.i - Cropland converted to Forest Land	-7.27						
3.B.1.b.ii - Grassland converted to Forest Land	-1058.71						
3.B.2 - Cropland	163.08	0	0	0	0	0	0
3.B.2.a - Cropland Remaining Cropland	-55.66						
3.B.2.b - Land Converted to Cropland	218.74	0	0	0	0	0	0
3.B.2.b.i - Forest Land converted to Cropland	97.12						

Category	Emissions (Gg)						
	Net CO_2 (1)(2)	CH_4	N_2O	NO_x	CO	NMVOCs	SO_2
3.B.2.b.ii - Grassland converted to Cropland	121.62						
3.B.3 - Grassland	17999.14	0	0	0	0	0	0
3.B.3.a - Grassland Remaining Grassland							
3.B.3.b - Land Converted to Grassland	17999.14	0	0	0	0	0	0
3.B.3.b.i - Forest Land converted to Grassland	18049.33						
3.B.3.b.ii - Cropland converted to Grassland	-50.19						

4.16.3.6. Aggregated Sources and Non-CO_2 Emission Sources on land

Description of category

Aggregated sources and non-CO_2 emissions on land in Namibia covered all the IPCC categories, namely

3.C.1 - biomass burning
3.C.4 - direct emissions from managed soils
3.C.5 - indirect emissions from managed soils
3.C.6 - indirect emissions from manure management

Methods

Methods are according to the IPCC 2006 Guidelines and the 2006 IPCC Software has been used to compute emissions for this sub-sector.

Activity data

The activity data are those adopted for computing direct emissions for the land and livestock categories which are used by default by the software to aggregate emissions from different sources. AD for fertilizers and urea are from the mass balance of imports and exports data from the NSA.

Emission factor

All biomass burning was estimated to occur because of wildfires. Default emission factors were used for all gases in forestland including woodland and grassland burning, except for the combustion factor in forestland and woodland that was considered as 0.85.

Default emission factors were used for estimating emissions from urea application. Estimates of indirect emissions from managed soils and manure management were also made using default EFs.

Emissions estimates

Aggregated emission for aggregate sources and non-CO_2 emissions on land varied between 1283 for the year 2000 to 1394 for 2010 with peaks at about 1497 for 2003 and 2009. It is considered that there has been no real increase or decrease in emissions in this category as estimates are related to activity that witnessed no major change during the inventory period.

Table 4.28. Aggregated emissions (Gg) by gas for aggregate sources and non-CO_2 emissions on Land

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total emissions 3C. Gg CO_2 Eq	1283	1423	1380	1395	1401	1350	1395	1392	1486	1497	1394

The major gas emitted in this category remained CH_4 throughout the period followed by N_2O. Carbon dioxide emissions were minimal for all years.

Table 4.29. Emissions (Gg) by gas for aggregate sources and non-CO_2 emissions on Land

Gas	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
CO_2	0.52	3.01	2.06	0.87	0.59	0.20	0.14	0.28	0.05	0.17	0.08
CH_4	11.25	11.21	11.18	11.14	11.10	11.07	11.03	10.99	10.96	10.92	10.88
N_2O	3.37	3.82	3.69	3.74	3.76	3.60	3.75	3.74	4.05	4.09	3.76

The summary result from the software is given in Table 4.30.

Table 4.30. Emissions from Aggregate sources and non-CO_2 emissions on land

Categories	Net CO_2 emissions / removals	Emissions(Gg)				
		CH_4	N_2O	NO_x	CO	NMVOCs
3.C - Aggregate sources and non-CO_2 emissions sources on land (2)	0.08	10.88	3.76	13.69	282.82	0
3.C.1 - Emissions from biomass burning	0	10.88	0.83	13.69	282.82	0
3.C.1.a - Biomass burning in forest lands		4.50	0.25	2.88	102.55	
3.C.1.b - Biomass burning in croplands		0	0	0	0	
3.C.1.c - Biomass burning in grasslands		6.38	0.58	10.82	180.27	
3.C.2 - Liming	0					
3.C.3 - Urea application	0.08					
3.C.4 - Direct N_2O Emissions from managed soils (3)			1.01			
3.C.5 - Indirect N_2O Emissions from managed soils			1.16			
3.C.6 - Indirect N_2O Emissions from manure management			0.75			

4.16.4. Waste Sector

(i) Description of Sector

In Namibia, solid waste is generated by domestic, industrial, commercial and agricultural activities whereas waste water is generated mostly through domestic, industrial and commercial activities. As in other countries, waste generation is directly related to population growth, industrialization rate and urbanization trend, the latter being an important impacting factor. GHG emission in the waste sector is also affected by the type of disposal mechanisms and the level of management exercised.

During the period under review, the waste categories from which emission data were captured were:

- 4.A.3 - Solid Waste Disposal
- 4.C.2 - Open Burning of Waste
- 4.D.1 - Domestic Wastewater Treatment and Discharge
- 4.D.2 - Industrial Wastewater Treatment and Discharge

4.16.4.1. Methodology

GHG emissions originating from the Waste Sector were estimated using a Tier 1 approach as per the IPCC 2006 Guidelines for National Greenhouse Gas Inventories and compiled using the IPCC 2006 software.

4.16.4.2. Activity Data

Solid waste

Data from municipal councils coupled with population census statistics were first used to estimate solid waste generation for "high-income" urban and "low-income" urban regions for 2010. The need for this categorization has been prompted by the sustained and significant population migration from rural to urban regions with the emergence of fast expanding suburbs to the main cities where the dwellers lifestyle is of the urban type but with a relatively lower purchasing power.

Estimates of solid waste generation for rural regions for 2010 were subsequently worked out by discounting solid wastes which are typically generated by urban dwellers based on landfill data available on waste characterization. These solid waste generation potentials were compared with those in the 2006 IPCC Guidelines (Volume 5: Waste, Page 2.5, Table 2.1) and found in line with these also.

Using the 2010 baseline, population census data (interpolated for non-census years) and adjusting for socio-economic factors, estimates for solid waste generation were then made for the period 2000 to 2010.

The process of calculating solid waste generation was not straightforward because of the lack of data. Furthermore, no official data was available on waste categorization which would have enabled more accurate compilation of GHG emissions.

The fraction of solid waste which is open burnt was calculated by multiplying the total solid waste estimated by the percentage of the population whose wastes are so treated as evidenced from the NPHC 2011 statistics.

The amount of sludge generated per capita for 2010 was estimated using that year's data for Windhoek City Council. Using this factor and urban population, the amount of sludge generated for the period 1990 to 2009 was then estimated for the other urban areas.

Wastewater

The actual amount of domestic wastewater generated was not available at country level. However, the different types and usage levels of treatment or discharge as per the NPHC 2011 census report were used as well as default MCFs from the IPCC 2006 Guidelines (Vol 5.3 Ch 3 Table 3.1).

Exploitable data on industrial waste water production were available only for the meat (beef and sheep) (source Meatco factories, Agric Stats 2009, AGRA) and fish (Pilchard and Mackerel processing) industries (source: Ministry of Fisheries, Annual report 2005, Source for 2006 to 2010 - Preliminary census 2011 data). The total meat industry product and the amount of waste water as provided by local authorities were used in accordance with the respective IPCC 2006 Guidelines (Vol 5.3 Ch 3 Table 3.1) defaults for calculation of emissions. It is to be noted that an average daily protein intake of 67 g (source: World Bank, Namibia open data for Africa) per capita was used to feed the per capita protein consumption in the IPCC software.

4.16.4.3. Emission factors

In the absence of country specific emission factors, the default values provided within the IPCC 2006 software and IPCC 2006 Guidelines ((Vol 5.3 Ch 3 Table 3.3) were used for estimating GHG emissions.

4.16.4.4. Emission estimates

Aggregated emissions

Aggregated emissions by category for the waste sector are presented in Table 4.31. In 2000, the major contributor to emissions from the Waste Sector was the Wastewater Treatment and Discharge category with 54.0 Gg CO_2-eq (56.1% of emissions). However, by 2010 emissions from Waste Water Treatment and Discharge declined while those from the Solid Waste Disposal category increased to reach 70.9 Gg CO_2-eq (48.7% of emissions) as the major contributor.

Table 4.31. Aggregated Emissions by Categories for Waste Sector (Gg CO_2-eq)

Waste Categories	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4 - Waste	96.2	97.8	99.4	110.3	113.1	119.8	123.2	121.2	131.1	139.5	145.6
4.A - Solid Waste Disposal	27.9	30.9	34.3	37.8	41.6	45.7	50.1	54.7	59.8	65.1	70.9
4.C - Incineration and Open Burning of Waste	14.3	15.2	15.8	16.4	17.1	17.7	19.0	19.6	20.8	21.4	22.6
4.C.2 - Open Burning of Waste	14.3	15.2	15.8	16.4	17.1	17.7	19.0	19.6	20.8	21.4	22.6
4.D - Wastewater Treatment and Discharge	54.0	51.7	49.4	56.0	54.4	56.4	54.2	46.9	50.5	52.9	52.0
4.D.1 - Domestic Wastewater Treatment and Discharge	31.3	31.4	31.9	32.5	33.2	33.9	34.3	35.3	36.0	36.8	37.5
4.D.2 - Industrial Wastewater Treatment and Discharge	22.7	20.2	17.5	23.5	21.2	22.5	19.9	11.5	14.5	16.1	14.6

Aggregated emissions by gas for the waste sector are presented in Table 4.32. In terms of CO_2-eq, the total contributions to emissions increased from 96.17 Gg in 2000 to 145.62 Gg in 2010, that is, a 51.4% increase. The gas contributing most to emissions from the waste sector was CH_4.

Table 4.32. Aggregated Emissions by GHG for Waste Sector (Gg CO_2-eq)

GHG	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	% Change	Average increase per year
Total	96.17	97.76	99.42	110.26	113.12	119.82	123.19	121.18	131.06	139.48	145.62	51.4	4.50
CO_2	1.56	1.65	1.72	1.79	1.86	1.93	2.07	2.14	2.27	2.34	2.47	58.3	0.08
CH_4	68.98	69.86	71.02	81.35	83.69	89.89	92.57	90.04	99.23	107.12	112.57	63.2	3.96
N_2O	25.63	26.24	26.68	27.12	27.56	28.00	28.55	29.01	29.56	30.02	30.58	19.3	0.45

Emissions by gas

GHG emissions for the waste sector for the 2000 to 2010 period were as follows:

- CO emissions increased from 4.34 Gg in 2000 to 6.87 Gg in 2010, at an average rate of 0.25 Gg.
- CH_4 emissions increased from 3.28 Gg in 2000 to 5.36 Gg in 2010, at an average rate of 0.208 Gg.
- CO_2 emissions increased from 1.56 Gg 10 2000 to 2.47 Gg in 201, at an average rate of 0.091 Gg.
- NMVOCs emissions increased from 0.206 Gg in 2000 to 0.428 Gg in 2010, at an average rate of 0.0223 Gg.
- NO_x emissions increased from 0.247 Gg in 2000 to 0.391 Gg in 2010, at an average rate of 0.014 Gg.

- NO_2 emissions increased from 0.083 Gg in 2000 to 0.099 Gg in 2010, at an average rate of 0.002 Gg.
- SO_2 emissions increased from 0.009 Gg in 2000 to 0.014 Gg in 2010, at an average rate of 0.0005 Gg

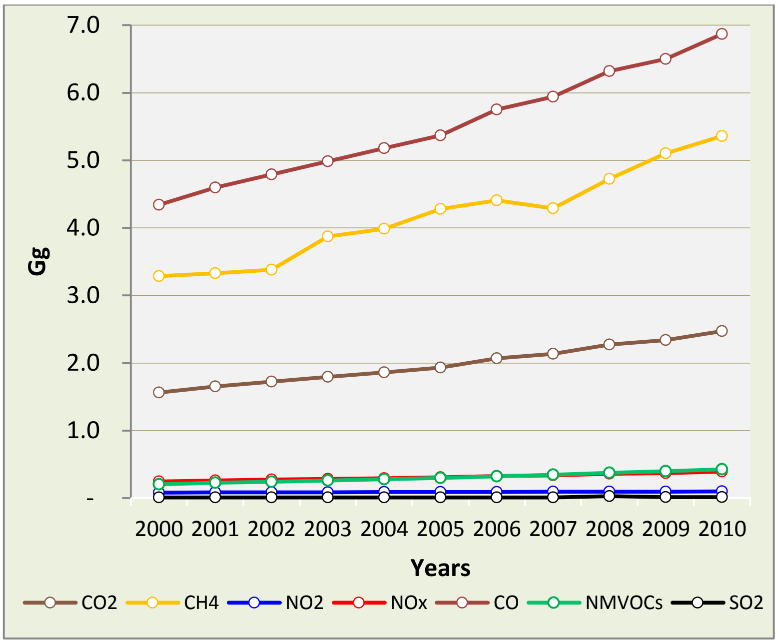


Figure 4.13. GHG emissions from the Waste sector

CO, CO_2, and NO_x emissions that have been inventoried for the Waste Sector originated from Open Burning of Waste. SO_2 emissions came from Open Burning of Waste and Waste Incineration activities.

From 2000 to 2010, the percentage increase in emission for CO_2, NO_x, and CO was 58% respectively and that of SO_2 was 57.0%.

Table 4.33. CO, CO_2, NO_x and SO_2 Emissions from Waste Sector (Gg)

Waste Category	GHG	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4.C.2 - Open Burning of Waste	CO_2	1.56	1.65	1.72	1.79	1.86	1.93	2.07	2.14	2.27	2.34	2.47
4.C.2 - Open Burning of Waste	NO_x	0.247	0.262	0.273	0.284	0.295	0.306	0.328	0.338	0.360	0.370	0.391
4.C.2 - Open Burning of Waste	CO	4.34	4.60	4.79	4.99	5.18	5.37	5.75	5.94	6.32	6.50	6.87
4.C.1 - Waste Incineration	SO_2	-	-	-	-	-	-	-	-	0.013	-	-
4.C.2 - Open Burning of Waste	SO_2	0.009	0.009	0.009	0.010	0.010	0.011	0.011	0.012	0.014	0.013	0.014

CH_4 emissions originated from Solid Waste Disposal, Open Burning of Waste, Domestic Wastewater Treatment & Discharge and Industrial Wastewater Treatment & Discharge activities.

The activity contributing the most towards emissions was Solid Waste Disposal.

CH_4 emissions increased by 63.2% from 2000 to 2010.

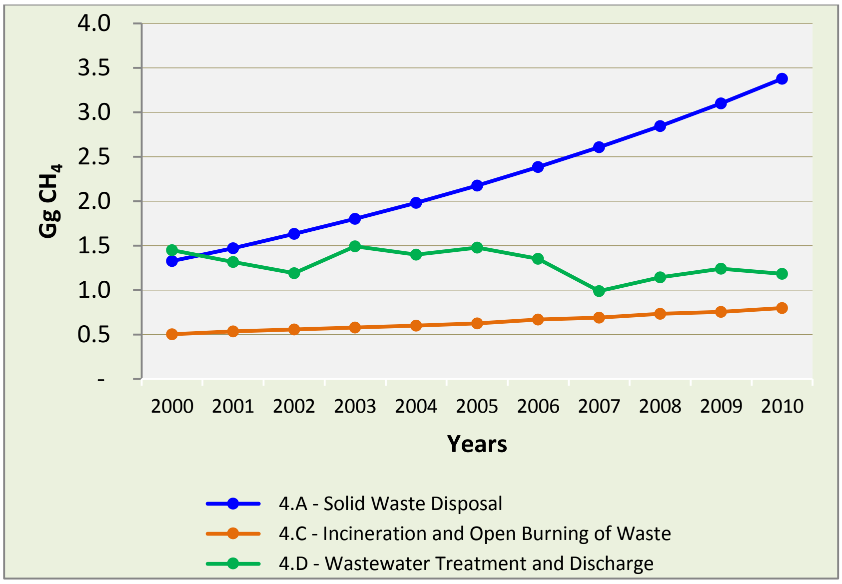


Figure 4.14. CH_4 emissions from different waste categories

Table 4.34. CH_4 Emissions from Waste Sector (Gg)

Categories	Years										
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4 – Waste	3.285	3.327	3.382	3.874	3.985	4.280	4.408	4.287	4.725	5.101	5.360
4.A - Solid Waste Disposal	1.328	1.473	1.632	1.801	1.983	2.177	2.384	2.607	2.846	3.102	3.378
4.C - Incineration and Open Burning of Waste	0.505	0.535	0.558	0.581	0.603	0.625	0.670	0.691	0.736	0.757	0.800
4.C.2 - Open Burning of Waste	0.505	0.535	0.558	0.581	0.603	0.625	0.670	0.691	0.736	0.757	0.800
4.D - Wastewater Treatment and Discharge	1.451	1.318	1.192	1.492	1.400	1.479	1.354	0.989	1.144	1.242	1.183
4.D.1 - Domestic Wastewater Treatment and Discharge	0.371	0.355	0.359	0.374	0.389	0.406	0.407	0.440	0.455	0.474	0.489
4.D.2 - Industrial Wastewater Treatment and Discharge	1.080	0.963	0.833	1.118	1.011	1.073	0.947	0.549	0.689	0.769	0.694

NMVOCs emissions originated from Managed Waste Disposal Sites, Open Burning of Waste, Domestic Wastewater Treatment & Discharge and Industrial Wastewater Treatment & Discharge activities.

The categories contributing most towards emissions in decreasing order of importance were Managed Waste Disposal Sites and Open Burning of Waste. Emissions from these two categories increased by 151.7% and 58.4% respectively from 2000 to 2010.

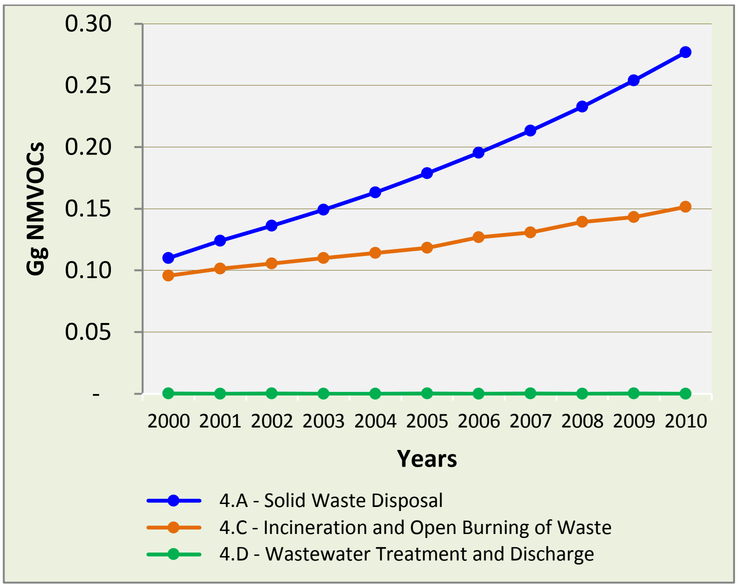


Figure 4.15. NMVOCs Emissions from different waste categories

Table 4.35. NMVOCs Emissions from Waste Sector (Gg)

Waste Categories	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4 - Waste	0.21	0.23	0.24	0.26	0.28	0.30	0.32	0.34	0.37	0.40	0.43
4.A - Solid Waste Disposal	0.11	0.12	0.14	0.15	0.16	0.18	0.20	0.21	0.23	0.25	0.28
4.C - Incineration and Open Burning of Waste	0.10	0.10	0.11	0.11	0.11	0.12	0.13	0.13	0.14	0.14	0.15
4.D - Wastewater Treatment and Discharge	1.3E-06	1.3E-06	1.2E-06	1.3E-06	1.3E-06	1.3E-06	1.3E-06	1.2E-06	1.2E-06	1.2E-06	1.2E-06

NO_2 emissions originated from Open Burning of Waste and Domestic Wastewater Treatment & Discharge categories.

The category contributing most towards NO_2 was Wastewater Treatment and Discharge (Domestic). From 2000 to 2010. NO_2 emission increased by 19.3% from 2000 to 2010.

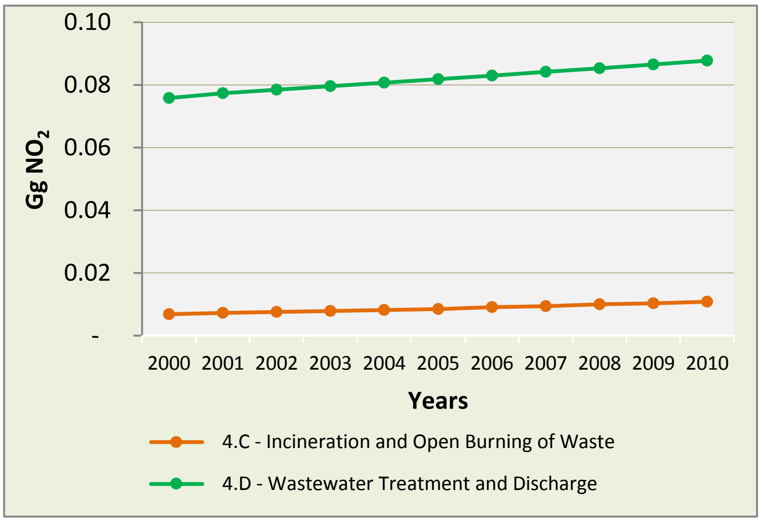


Figure 4.16. NO_2 Emissions from Waste Sector

Table 4.36. NO_2 Emissions from Waste Sector (Gg)

Categories	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4 - Waste	0.083	0.085	0.086	0.087	0.089	0.090	0.092	0.094	0.095	0.097	0.099
4.C - Incineration and Open Burning of Waste	0.007	0.007	0.008	0.008	0.008	0.009	0.009	0.009	0.010	0.010	0.011
4.D - Wastewater Treatment and Discharge	0.076	0.077	0.078	0.080	0.081	0.082	0.083	0.084	0.085	0.087	0.088

5. Mitigation

5.1. Introduction

Namibia, as a Non-Annex I country, has no obligation to reduce its GHG emissions as a signatory Party to the Convention. However, Namibia is committed to contribute to its maximum capability towards meeting Article 2, the ultimate objective of the Convention, namely *the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.* The Government of Namibia has thus developed various policies and strategies guiding its development agenda on a green low carbon economic path in line with sustainable development goals. Namibia has embarked on various projects and activities aiming at curbing GHG emissions and increasing its sink capacity for more than a decade now. This analysis addresses additional options which present the highest potential for mitigation for their abatement potential based on the year 2010 up to the 2050 time horizon.

5.2. Assessment Method

Two major principles guide this mitigation assessment:

- Meet the ultimate objective of the Convention, namely Article 2 to stabilize the greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system; and
- Promote the socio-economic development of the country as per the policies and strategies in place presently and charting medium term plans and actions.

Thus, this analysis integrates the projected socio-economic conditions of the country, the level assessment of the last inventory year for determining the highest emitting categories and sinks, the trend assessment of emissions to determine activity areas gaining importance as contributors of GHGs and confident in the mitigation option to be successful according to national circumstances.

A Business as usual (BAU) scenario was developed for all categories and sub-categories assessed for their emissions and removals in the latest GHG inventory to provide for the carbon intensity of the country under the present development path. Activity areas offering the highest potential for action on the basis of the guiding principles and other factors enumerated above were then assessed for their mitigation potential by comparing emissions or removals of the different measures identified within the category or sub-category to its BAU scenario. The base year adopted for this mitigation analysis is 2010 and the time horizons 2025, 2040 and 2050 have been used for the projections. GHG projections have not been done on estimates obtained from the compilation in the inventory time series but on the evolution of the variables usually responsible for emissions or removals, except for the IPPU sector. Some of these variables are fuel demands to meet the future energy requirements, projected number of vehicles, expected land use changes and amount of waste generated. Projections on the BAU basis for industrial production is associated with GDP growth rather as it is such a dynamic sector with new industries starting operations and others closing down as a country progresses.

Once the activity data have been generated for the different options such as fuel combusted, waste produced, wood removals or area reforested amongst others, these were fed in the IPCC 2006 software to compile emissions or removals for the year being assessed. The difference between the BAU and mitigation scenarios emissions or removals of the category under assessment gives the emission abatement or sink enhancement value of the potential measure. If several measures can contribute to mitigation in a single category, their values were added to provide for the full mitigation potential of that particular activity area. The emissions and removals from all categories were then summed to give the abatement potential for the different time steps under consideration for the sectors and finally at the national level.

5.3. Scope of the Assessment

All activity areas concerned with emissions or removals in a country can be targeted for mitigation analysis. However, this is very resource demanding and very often, it is not worth evaluating the marginal and minimal contributors of GHGs for their mitigation potential as it is not cost effective. Moreover, priority changes with time and development of a country which results in activity areas gaining or losing importance as contributors of GHGs. Thus, the exercise should be kept dynamic and the ones offering the highest mitigation potential, coupled with a high success rate for implementation were treated with priority. Based on this principle and taking the level and trend assessment from the KCA, the electricity generation, road transportation and LAND categories were prioritised for the assessment. Due to its importance in relation to health and sustainable development, the waste sector also has been considered.

5.4. Socio-economic scenarios

5.4.1. Population size and growth

The trend for the period 1981 to 2011 and the projections over five-year time spans until the 2050 time horizon for the population of Namibia is given in Figure 5.1. The population which stood at 1.410 million in 1991, was higher than that of the census year 1981 by 0.377 million, that is an increase of 36.5%. In the next two decades following the year 1991, the population growth slowed to reach 2.113 million in 2011. The increase was 29.8% for the decade 1991 to 2001 and 15.4% for the following one.

Assuming that beyond 2011, the population will continue to increase at a rate similar to that which prevailed for the period 2001 to 2011, at an exponential growth rate of 1.01%, the projected population will reach 2.405 million in 2020. The three million mark will likely be met shortly after the year 2035. By 2050, it is projected that the population will expand to some 3.701 million. This projection is close to that made by United Nations Population Division in 2012, namely 3.744 million individuals in 2050.

Alternatively, if the projections are based on the annual growth rate of 1.0205% registered during the period 1991 to 2011, the population of Namibia would then reach 4.654 million in 2050.

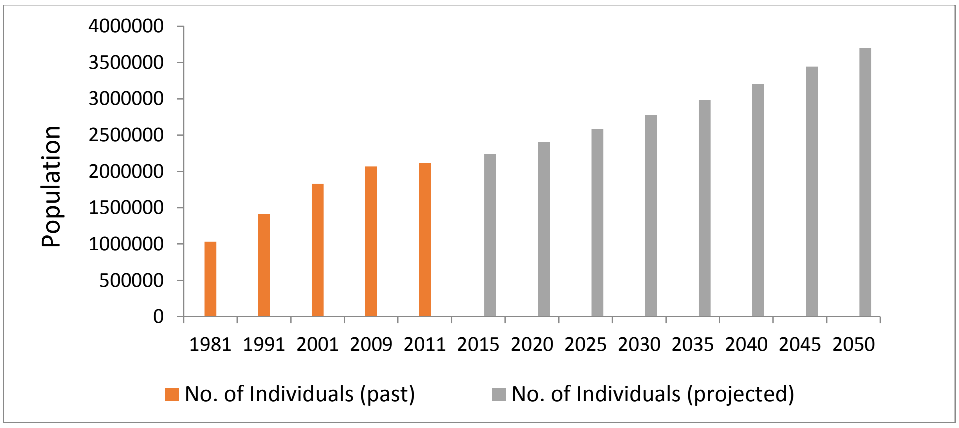


Figure 5.1. Namibia population statistics (1981-2011) and projections (2015-2050)

5.4.2. Urbanization

Between 1991 and 2011, the increase in urban population largely outpaced the rural component of the total population. While the total population increased by 50% from 1.410 to 2.113 million, the number of urban dwellers rose by 236% from 0.382 to 0.904 million. This rapid rise in the urban population is largely due to the continuous migration of the rural youth to seek employment in the prosperous towns.

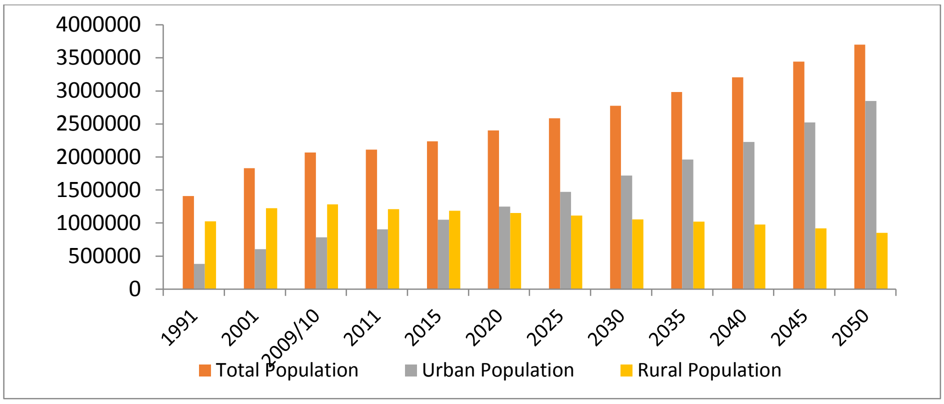


Figure 5.2. Urbanization level in Namibia

There is no doubt that the rural-urban movement will continue to amplify over time, as since the early 2000's, it has been government's vision and policy to promote the country as a highly industrialized and highly urbanized one. In the Vision 2030 document published in 2004, it is estimated that by 2006, the urban population of Namibia will reach 43%. Subsequently, for years 2010, 2020 and 2030, the then projected fraction will reach 50, 60 and 75% respectively.

A long-term profile (five year projections until 2050) for urbanization was developed on the basis of past recorded trends, initial projections as set out in Vision 2030 and NSA population projections of 2011. The main features are (i) from 2015 to 2030, urbanization rate would increase by 5% for every 5-year period, and (ii) between 2030 and 2050, the growth rate for every 5-year period would be 3.75%.

Thus, by 2030 the urban population is projected to be 62% of the total population giving a number of persons living in towns amounting to 1.721 million. This represents an increase of 0.817 million over the year 2011. In the event urbanization level would reach 77% in 2050, this fraction of the population will stand at 2.849 million. The latter number will be practically three times that of 2011. The resultant will be that the rural population will progressively decline to reach 0.851 million in 2050, or 70% of that for 2011.

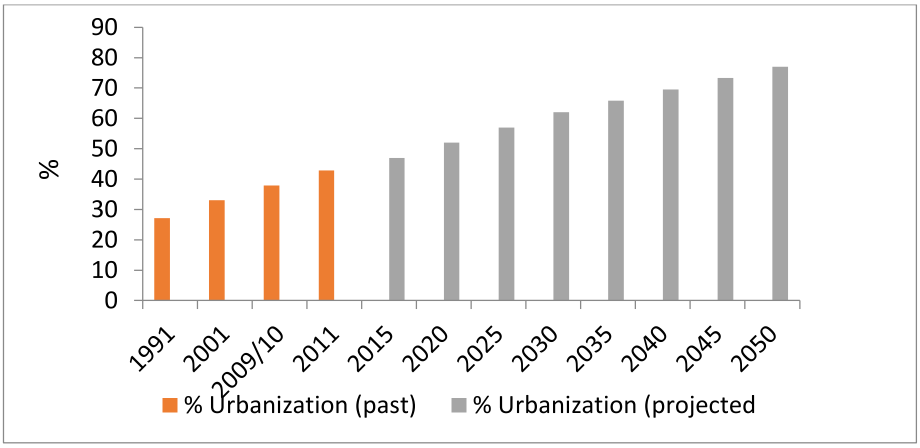


Figure 5.3. Past and projected urbanization rate in Namibia

5.4.3. GDP and GDP per capita

Between 1981 and 2000, the annual growth rate for total GDP has been quite variable. For 11 years out of 20, it exceeded 3%. Total GDP in constant 2010 prices reached N$ 51 833 million in 2000. Subsequently, with a higher annual growth, often in excess of 4%, GDP in 2010 attained N$ 82 598 million representing an increase of 59% over the 2000 figure. Due to a 17% increase in the size of the population over the 2000-2010 decade, GDP per capita changed by only 36%, i.e. from 29 074 to 39 677 N$, from 3 546 to 4 839 US$ on the basis of the average exchange rate for the years 2008 to 2010.

The Namibian government is fully committed to the transformation of the economy into a high income one. Already, in Vision 2030 document published in 2004, it was announced that in order to achieve the high income goal, government would have to target real GDP annual growth rates of 6% or higher. However, average growth rates realized under 5-year development plans NDP2 (2001-2005) and NDP3 (2006-2010) has been lower. Further, on account of the knock on effects of the recession and the crisis in the Euro zone, the average growth rate for the ambitious NDP4 (2011-2016), has been revised downwards to 4.6%.

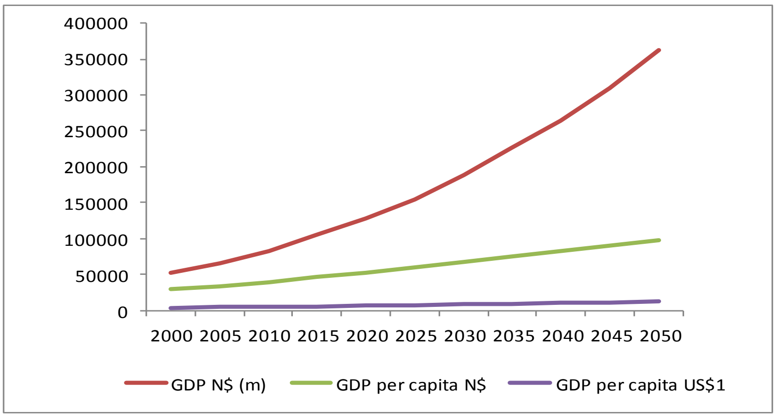
Considering these short and long-term difficulties, a conservative scenario has been built to picture GDP growth until 2050. The projected real growth rates are given in Table 5.1.

Table 5.1. GDP growth rates

Period	Annual growth rates
2017-2031	4.0%
2032-2036	3.6%
2037-2050	3.2%

Under these projections, total GDP will grow to N$ 188 042 million in 2030 (Figure 5.4), more than twice that of 2010. In 2050, it would be around N$ 362 746 million or 439% of the 2010 one. In the case of GDP per capita, the figure projected for 2030 and 2050 will be respectively, N$ 67 730 (US$ 8 260) and N$ 98 023 (US$ 11 954). These clearly suggest that by 2050, the living standard of the Namibian population will have considerably improved.

Alternatively, if the annual growth rates for the years 2017 to 2050 were increased by 10% (e.g. 4.4% instead of 4.0%), the GDP per capita for 2050 will change to 13 455 US$. This figure will likely be higher than the GNI of 12 745 US$ required by the World Bank in 2015 for classification of a country as one with a high income economy.



[1] Average exchange rate for the years 2008-2010

Figure 5.4. GDP and GDP per capita in constant 2010 prices

5.5. National mitigation potential

5.5.1. National level

Emissions stemming from the BAU scenarios for the base year 2010 and the projections for 2025, 2040 and 2050 are given in Table 5.2. Relative to the base year 2010, it is projected that the country will lose its sink capacity and becomes a net emitter of GHG. These will be 17 713, 30 649 and 34 162 in the years 2025, 2040 and 2050 compared to removals of 1339 in 2010. The major contributor will be the AFOLU sector followed by Energy, IPPU and Waste.

Table 5.2. Emissions (Gg CO_2-eq) under the BAU scenario for the years 2010, 2025, 2040 and 2050

BAU	2010	2025	2040	2050
National emissions	-1339	17713	30649	34162
Energy	2904	5992	11101	11459
IPPU	302	544	924	1267
AFOLU emissions	-4691	10920	18200	20850
Waste	146	257	424	586

Different measures 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. The abatement potential (Gg CO_2-eq) at the national level when compared with the BAU scenario and the contribution from the different sectors evaluated are presented in Table 5.3. The mitigation potential summed up to 12 702, 21 507 and 24 439 Gg CO_2-eq for 2025, 2040 and 2050 respectively. This represents 72, 70 and 72% of the BAU scenario of the respective year under assessment.

Table 5.3. Mitigation potential (Gg CO_2-eq) for the years 2025, 2040 and 2050

	2025	2040	2050
BAU	17713	30649	34162
Energy Electricity	447	1584	3524
Road Transport	449	634	834
Waste	175	270	335
IPPU	36	36	36
AFOLU -Forest	11419	18548	19734
Total	12702	21507	24439
% BAU	72	70	72

5.5.2. Energy sector mitigation assessment

5.5.2.1. Electricity generation sector

NamPower, the national utility company, operates three main businesses, generation, trading and transmission of electricity. Its domestic power sources are the Coal fired Van Eck Power station outside Windhoek (120MW), the hydroelectric plant at Ruacana Falls in the Kunene Region (332MW), the Stand by diesel driven Paratus Power station (24MW) at Walvis Bay and the Diesel plant at Anixas (22.5MW). With a peak demand of 535MW in June 2012, the internal resources are clearly not sufficient to meet demand.

The 1998 White paper on energy policy outlined that Government aimed that at least 75% of electricity generation would be from internal sources by 2010, but this goal has not been reached as more than 80% of the electricity demand was still being met from imports.

5.5.2.2. Energy Policy 2050

The Namibian energy policy to the 2050 horizon (2007) was used in economic and demographic projections to chart the roadmap for the electricity sector, with focus on the level of engagement of the Namibian Government and the level of cooperation between Namibia, regional and international Governments and organizations. The production of energy was confined to the electricity and biomass fuel sectors with a total capacity of 400 MW. Fossil fuel imports account for two thirds of the country's energy supply. It was estimated that more than 75% of urban and 12% of rural households were connected to the national electricity grid. The consumption has risen by 70% in the period 1990 to 1998 and in 2007 accounted for half of the electricity consumption. Demand was estimated to grow at a rate between 3 to 5% annually.

5.5.2.3. NIRP and forecast assumptions

Based on the Energy policy, the ECB completed the National Integrated Resource Plan (NIRP) to cover the next 20 years in April 2013. The NIRP comprised four tasks, namely:

- Task 1 - Key Assumptions, October 2011;
- Task 2 - Load Forecast, March 2012;
- Task 3 - Planning Parameters and Generation Options, July 2012; and
- Task 4 - Development and Analysis of Policy Implementation Scenarios, February 2013.

Its aim is to provide an indication of the of Namibia's electricity demand and how it could be supplied. The NIRP does not deal explicitly with the overall energy supply but focuses only on electricity. The NIRP used the detailed load forecast worked out in March 30, 2012. Table 3.1 of the NIRP report provides a summary for the Reference, Low and High scenarios of energy and capacity demand for the period 2012 to 2031 with recorded values for the period 2008 to 2011. Demand load factors vary from 72% to 79% to stabilize at 75% in the end. The overall demand growth for the first ten years, from 2011 to 2021 is projected to be on average at an annual growth rate of 5.8% for the capacity and 6.7% for the energy component. For the 2011 to 2031 period, average annual growth rates of 4% for capacity and 4.3% for energy have been projected. Under the reference case scenario, the peak demand is expected to grow from an observed value of 511.7 MW in 2011 to 900 MW in 2021 and 1124 MW in 2031. Similarly, the energy requirement is expected to grow from 3231 GWh in 2011 to 6173 GWh in 2021 and 7433 GWH in 2031. Under a high growth case, these figures may be 25% higher as per the Vision 2030 target.

5.5.2.4. Electricity generation action plan

For the purpose of this assignment, the National Integrated Resource Plan (NIRP) reference case has been considered and has been extrapolated from 2031 to 2050 for the energy demand. The generation scenarios have been developed on the basis of a series of assumptions and using probabilistic simulations. The scenarios have also been ranked based on qualitative multi-criteria based on initial capital investment, reliance on import, use of renewables, location concentration, operating complexity, and indigenous resources. Out of the 37 generation expansion scenarios of the NIRP detailed section 6.3 of the report, five have been selected to represent a range of mix of fossil and renewable sources in line with the Energy policy and Vision 2030.

The main assumptions from the NIRP are:-

- ***Ruacana Hydro plant***, (Commissioned in 1998 with 3 X 80 MW to be upgraded to 3 X 83.7 and 1 X 92 MW added in 2012). Hydrology assumed at 90% probability of exceedance instead of 95% due to interconnection availability. An average energy output of 910.6 GWh, Table 2-1 P 21.

- ***Van Eck Coal Plant**,* (4 X 30 MW commissioned in 1973. Output limited to only 50 MW due to ageing and burning only 3500 tons of coal weekly to stay within environment norms and limits. Available for 11 months (8016 hrs.), and average energy generation of 400.8 GWh, Table 2-2 p 23. Rehabilitated to 4 X 27 MW but with only 81 MW counted as available. Heat Rate of 15400 kJ/kwh and 70% Load Factor (496.69 GWh) as from January 2015 for the next 10 years assuming that a new coal plant will be in place by 2020. Will be retired end 2024.

- ***Paratus Diesel*, (**4 X 6 MW as from 1976 but now delivers only 12 MW. Heat Rate 10600 KJ/KWh and 70% capacity factor 73.6 GWh annually. Will be retired by end 2016).

- ***Anixas Diesel*,** (3 X 7.5 MW started operation in July 2011. Heat rate 8500 KJ/KWh, Energy is 185.76 Gwh, plant is in good condition).

- ***Imports*** from EDM Mozambique (30 MW hydro short-term supply contract reviewed annually, ESKOM South Africa (200 MW supplement until 2016 only), ZESCO Zambia (50 MW 2010 to 2020 at 92% capacity factor), ZESA Zimbabwe (150 MW from 2008 to 2014 only), and STEM South Africa (short term).

- ***Renewables*,** Solar PV and Wind are assumed at 30% capacity utilization factor average annually.

- ***Biomass gasification*,** as from 2012 and will grow further till 2050 with the invasive bush harvesting.

- ***Natural Gas*,** the Kudu 2 X 200 MW gas project will be available for only 15 years (lifetime of the gas field) and end in 2032.

- ***Coal plant*,** 2 X 150 MW can last till 2050.

The expansion plan of the NIRP assumes 4.3% energy growth rate till 2031. Based on this value and the socio-economic factors described earlier in this analysis, a growth rate of 3.87% has been adopted till 2040 and thereafter 3.29% till 2050. The energy balance has been worked out for the years 2012 till 2050 for all the scenarios. In this assignment, the NIRP has been followed till 2031 and thereafter renewable energy only has been assumed to be installed. By this horizon the renewable energy technologies will be mature and affordable. Also large scale battery storage or other systems are expected to be available by then to manage intermittencies of solar and wind and there will be no limit to integration.

5.5.2.5. Mitigation assessment

Business As Usual scenario

For the BAU scenario, the electricity demand was adopted from the NIRP for the 2025 time step and then projections made for 2040 and 2050 on the basis of the socio-economic factors described earlier. The present mix of hydro, coal and fuel oil was used for the three time horizons. The contribution of hydro was kept constant with a mix of 15% fuel oil and 85% coal to determine the demand for the years 2025, 2040 and 2050. The emissions from this fuel mix were then calculated using the IPCC 2006 software. Other GHGs were converted to their CO_2-eq using the same GWPs adopted for the inventory.

The demand increased nearly four times (Table 5.4) from 2010 to 2050 representing rates of 73% to 2025, 178% to 2040 and 285% to 2050. Emissions increased from the base year value of 36 Gg CO_2-eq in 2010 to 1309 in 2025, 2622 in 2040 and 3950 in 2050. This drastic increase over time is due to the phasing out of imports of electricity.

Table 5.4. Electricity demand (TJ) for the base year 2010 and assessment years 2025, 2040 and 2050

	2010	2025	2040	2050
		Demand		
Hydro	4489	9072	9072	9072
Coal	338	12032	24104	36307
Fuel oil	46	2123	4254	6407
Imports	8587	0	0	0
Total	13460	23227	37430	51786

Mitigation scenarios

An energy supply-demand balance exercise was performed for all scenarios and the amounts of fuel by source calculated. The demand is balanced by generation in priority order with Hydro, Coal, Diesel, Imports and Renewables. The firm energy considered for hydro is according to a hydrology of 90% probability of exceedance. Coal and Diesel plants are dispatched to 70% utilization factor as they are mainly used to serve the semi-base and peak demands. Imports have been assumed at 90% capacity utilization factor from all power providers. Biomass plant availability is dispatched at 85% and all intermittent renewables, Solar and Wind power, at 30% capacity utilization factor. All imports ceases as from 2020 and only renewables are added as from 2032 onwards till 2050.

The NIRP being a least cost plan, 5 scenarios were selected, the extremes and intermediate ones to be in line with sustainable development and different targets of a low carbon economy. Hence, scenario 7 (Renewable), scenario 10 (Coal-Renewable), scenario 24 (Coal-moderate Renewable), scenario 32 (Coal-Gas-Renewable) and scenario 37 (Gas-moderate Renewable) have been selected for analysis in this assignment. The share of the different energy sources are presented in Figure 5.5 for the 5 mitigation and BAU scenarios for the three time steps as the additions and phasing out of generation plants become effective. The increase in the share of renewables comprising hydro, solar, wind and biomass can be easily depicted in Figure 5.5. It is also very visible of the country phasing out electricity imports to practically nil already in all the scenarios in 2025 and completely after that year.

5.5.2.6. Emission estimates

The fuel amounts derived from the electricity demand of the various scenarios and BAU were fed in the IPCC 2006 software to compute emissions. The difference in emissions between the BAU and each individual mitigation scenario provides its abatement potential. This exercise has been performed for the 2025, 2040 and 2050 time horizons and compared to the 2010 baseline.

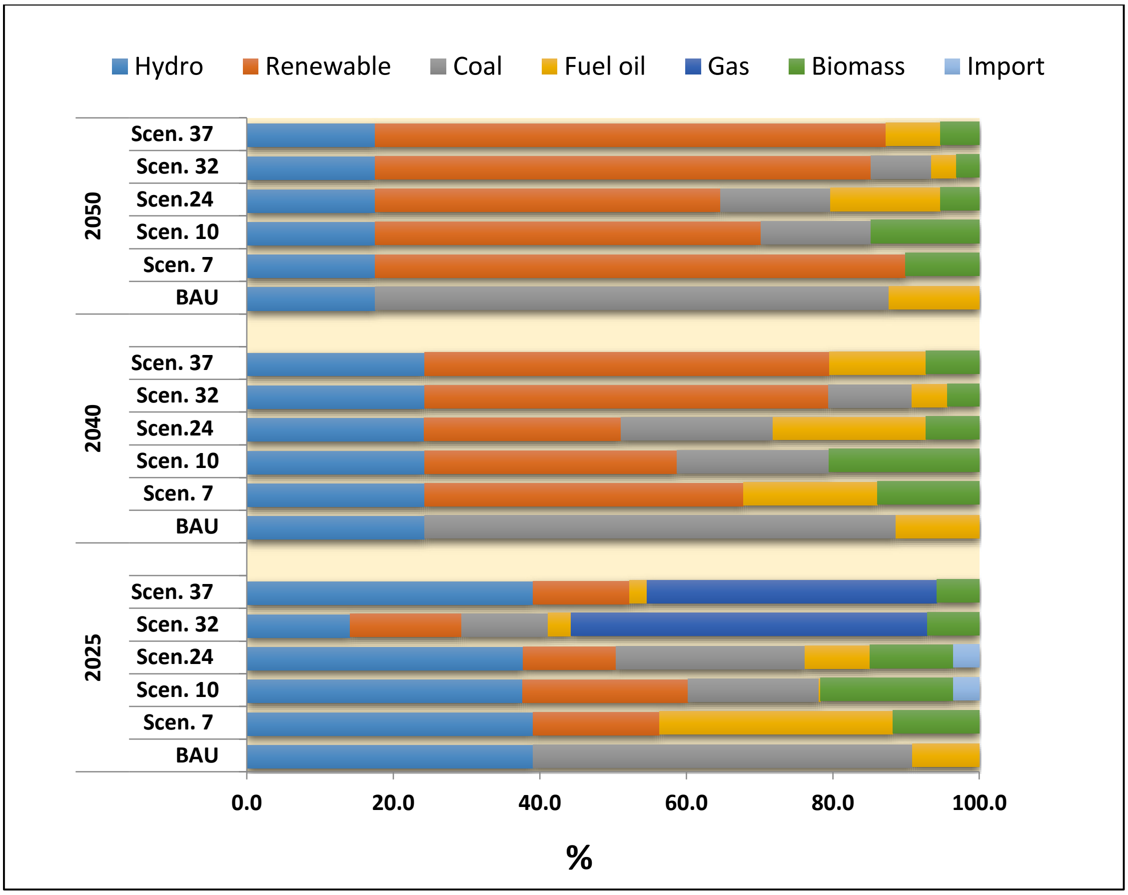


Figure 5.5. Share of different energy sources for the years 2025, 2040, 2050 and BAU scenarios

Emissions and mitigation potential of the different scenario compared to BAU are depicted in Figures 5.6 to 5.10. Under the BAU scenario, the emissions will stand at 1309 Gg CO_2eq in 2025, 2622 Gg CO_{2}-eq in 2040 and as high as 3950 Gg CO_{2}-eq in 2050. The mitigation scenarios assessed emitted in Gg CO_2-eq between 715 to 1143 in 2025, 699 to 1661 in 2040 and 592 to 1661 in 2050.

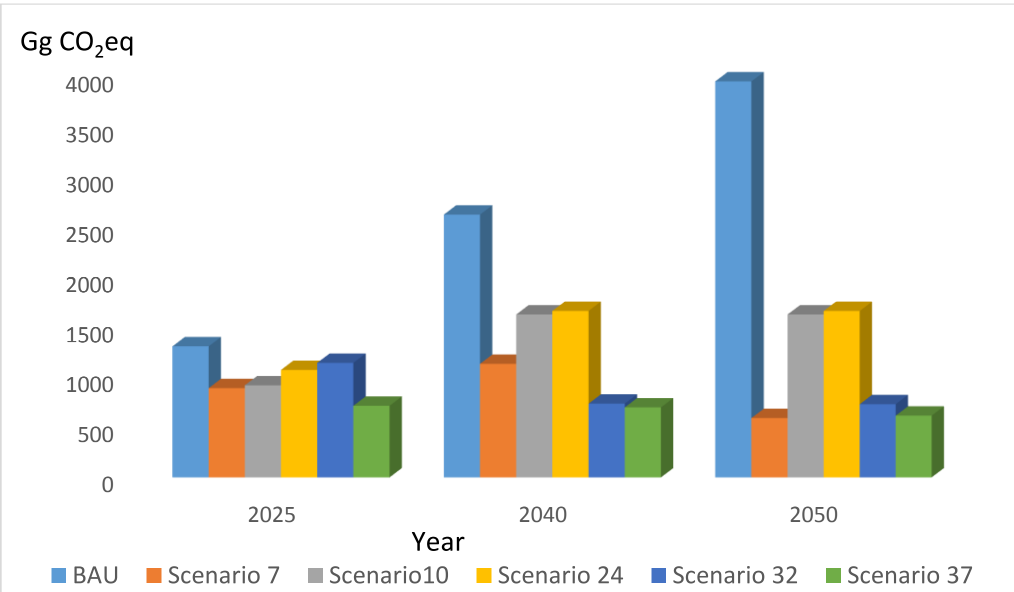


Figure 5.6. Emissions ($GgCO_2$-eq) for BAU and mitigation scenarios

These represent a varying range of abatement potential according to the energy mix used in the scenario as shown in Figure 5.7. Scenario 37 and 7 offer the highest mitigation potential in 2025 but this situation changed and scenarios 32 and 37 took over in 2040 to evolve again in 2050 when the 3 scenarios are close. This is the case when including the emissions from biomass. The reductions in the emissions for scenario 37 and 7 amounted to 594 and 418 in 2025 as shown in Figure 5.7. The potential in 2040 is 1923 and 1885 Gg CO_2-eq for scenarios 37 and 32 which reached 3333 and 3219 in 2050. For the same year, scenario 7 showed the highest potential with 3358 Gg CO_2-eq. The worst case, scenario 32 in 2025 improved its rank by 2050 to third and lagged behind scenario 7 and 37 by only 139 and 114 Gg CO_2-eq respectively.

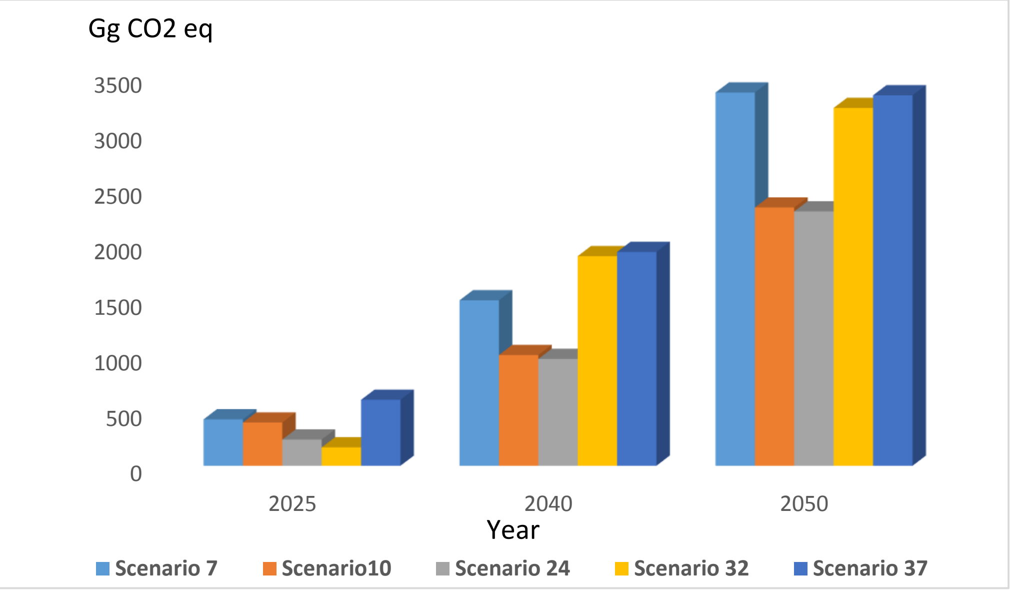


Figure 5.7. Emission reduction (Gg CO_2-eq) of mitigation scenarios compared to BAU

5.5.3. Road transport mitigation assessment

(i) Description of sector

Namibia's transport is dominated by the road component for both passengers and goods. In 2010, there was a total of 249 421 vehicles. This fleet increased by 86 500 vehicles between 2000 and 2010 indicating an average growth of 5% since 2000. In a BAU scenario, the fleet will increase to 400 017 vehicles in the year 2025 and to 636 887 vehicles in the year 2050, representing a 155% hike over the base year, 2010.

The transport sector as a whole consumes more energy than any other productive sector of the Namibian economy. Liquid petroleum fuels for transport constituted over 70% of Namibia's total energy demand. This high percentage is explained by the fact Namibia uses only minimal amounts of fossil fuel in electricity production as it imports that energy. In 2010, road transport consumed 333 000 tons of gasoline and 361 000 tons of diesel. These volumes are expected to increase cumulatively up to 5% for gasoline and by a staggering 330% for diesel in 2050. This change from gasoline predominance in the energy profile to diesel has been perceptible for some time with changes in vehicle technology; higher energy intensity of that fuel and its lower cost at retail. This trend will keep on accentuating in the future.

The Business as usual Scenario

The BAU scenario for the road transport sector has been developed on the basis of the socio-economic scenarios described earlier. It has thus been assumed that light passenger motor vehicles will continue to penetrate the market and remain the predominant means of passenger transport as will be light goods vehicle for freight transport. It has as well been assumed that the GDP growth with its resulting improvement in the standard of living of the population coupled with government's vision to propel

Namibia into the cluster of developed countries will spur the mobility needs for commuting more and over longer distances. To that effect, estimated annual vehicle kilometre run has been kept almost constant in spite of the fact that the projected increase in the number of such vehicles, as compared to the year 2010 is by an average of 5% annually up to the 2050 time horizon. The past and estimated vehicle population for the years 2025, 2040 and 2050 is provided in Table 5.5.

Table 5.5. Past and projected vehicle population.

Vehicle Class	2000	2010	2025	2040	2050
Motorcycle, Tricycle and quadracycle	3100	5593	10,146	14,465	17,344
Light passenger motor vehicles	72 500	108 467	178 281	241 212	283 166
Heavy passenger motor vehicles	2150	3452	5556	7624	9003
Light load vehicles	70 000	110 300	174 593	237 946	280 181
Heavy load vehicles (not equipped to draw)	7700	9748	13 134	16 250	18 328
Heavy load vehicles (equipped to draw)	3250	6879	12 018	17 373	20 943
Special vehicles	4200	4982	6289	7268	7922
Total	162 900	249 421	400 017	542 138	636 887

Between 2010 and 2025, the vehicle population is expected to increase by 60%. This increase will be of the order of 117% in 2040 and 155% in 2050 for the same base year (2010) when the vehicle population stood at 249 421 vehicles. The fleet of light passenger vehicles and light load vehicles will constitute 88% of the total number of registered vehicles based on the projections. Improvements in vehicle technology and fuel consumption have to a certain extent been taken into account to reflect future progress in vehicle construction and use. The trend observed between 1994 and 2006 whereby gasoline use has shown a much lower average increase of 2.8% annually as compared to 4.7% for diesel (Namibia Energy Review for the UNFCCC). The ratio of vehicles using diesel to gasoline has been reviewed for light passenger vehicles from 1:9 to 3:7 to reflect the current world development trend. However, for light load vehicles this change is projected to be more significant with diesel being the predominant fuel in 2025, 2040 and 2050 with the projected ratios to be 7:3, 8:2 and 9:1 respectively.

Based on these assumptions, , it is projected that fuel consumption in the road transport sector under the BAU scenario will increase very rapidly for diesel as opposed to gasoline as the ratio of vehicles running on these fuels changes in the future. Thus, based on the year 2010, gasoline is projected to increase by 6% in 2025, a further 16% in 2040 and another 5% by 2050. Diesel consumption is expected to shoot up in 2025 to 130% of the amount used in 2010, 241% in 2040 and 330% by 2050 as depicted in Table 5.6. The evolution of gasoline and diesel used for the period 2000 to 2050 is given in Figure 5.8.

Table 5.6. Projected Fuel Consumption (tons) for the BAU scenario

	2000	2010	2025	2040	2050
Gasoline	233707	333283	353250	387460	349420
Diesel	195493	361616	832520	1232470	1556620
% increase gasoline			6	16	5
% increase diesel			130	241	330

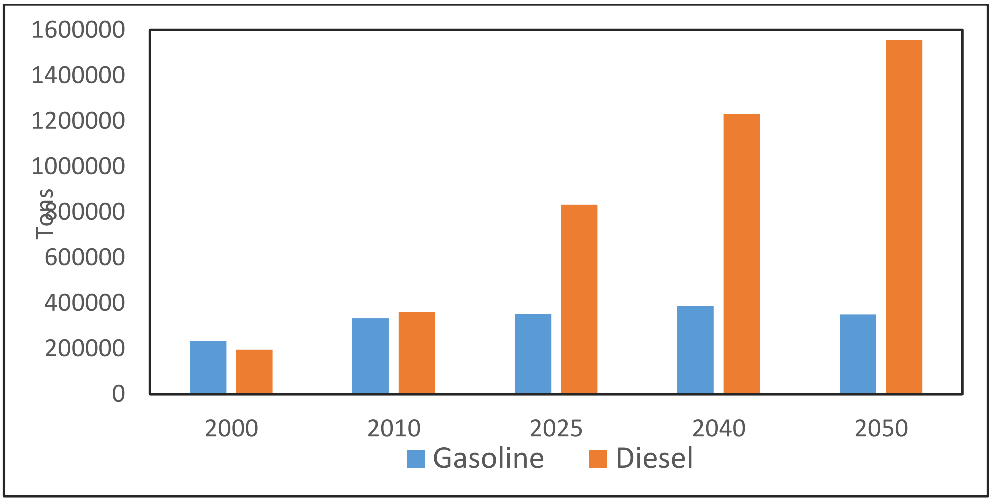


Figure 5.8. Past and future use of gasoline and diesel in Namibia

In the absence of any mitigation initiatives, this amount of fuel burnt in the road transport sector will constitute a substantial share of national emission. This consumption trend will lead to aggregate emissions of 2223 Gg in the base year 2010, 3812 Gg in 2025, 5216 Gg in 2040 and 6147 Gg in 2050 respectively. These will represent increases of the order of 71%, 135% and 177% for these three time steps. The road transport sector emissions will represent 64% of national emissions of the energy sector in 2025, 47% in 2040 and 54% in 2050.

Mitigation Options

Previous reports (Energy Policy Scenarios for Namibia 2007-2050) on energy needs in Namibia confirmed that due to its greater flexibility, road transport will continue to influence the socio-economic development of the country. Within the time frame 2050, the mode of transport cannot be changed without impairing the long term vision of the country albeit the type of fuels used. This change is however a must when seen in an environmental perspective while meeting the requirements of the international agenda with respect to climate change. It has been observed that Namibia's economy by itself cannot take up fully the latest technologies developed in the road transport sector. However, there is an urgent need to consider ways and means to improve on the road transport system to meet the latest environmental standards while minimizing the country's heavy reliance on liquid fossil fuels which are imported at 100%. To that effect, a series of mitigation measures have been identified, namely

- Fuel switching from petrol to LPG;
- Use of biodiesel by mixing 5% crop-oil to diesel;
- Use of ethanol as E85;
- Use of bio ethanol from woody biomass;
- Improving vehicle fuel use efficiency;
- Management of demand by pooling and bulk loading;

Additional no cost measures that can easily be implemented include

- New legislations to limit speed;
- New taxation policies on import duties and licenses.

None of these options has however been expounded and assessed in depth to indicate each option's effectiveness in achieving the objective of abating emissions of greenhouse gases. Further assessment on the scope of success of these measures, their economic viability as well as the cost to the country remains to be done.

Choice of Mitigation Option

The choice of mitigation options is based on factors such as availability (even if the option involves additional cost), accessibility, affordability, acceptability and government strategies in place. Above all, government's will to intervene directly or indirectly to encourage and drive the desired changes will be essential to achieve the required impact on reduction of emissions.

Though the initial identification of mitigation permitted six potential measures within the Namibian context, only the most prominent ones that are deemed most applicable will be further analyzed. Road transport in Namibia will continue to rely mainly on fossil fuels as no other means of transport can at this stage of the country's development replace rail transport for goods and road transport for commuting passengers in addition to goods. This situation is not expected to change significantly up to 2050.

Taking into consideration the factors enumerated above, the options identified as those with the highest pay-offs have been assessed for their mitigation potential in the medium and longer term. These are:

- The introduction of new generation diesel or CNG propelled buses having EURO 3 or 4 emission standards with the objective of reducing the demand for light passenger vehicles by at least 30% for the three mitigation time horizons of 2025, 2040 and 2050;
- Conversion of 25% light load vehicles and light passenger vehicles into dual fuel vehicles using LPG and gasoline; and
- Encouraging pooling and bulk loading in internal transport of goods with incentives to increase registration of ≤15 tons GVM goods vehicles by 20% in 2025, 30% in 2040 and 30% in 2050, thus causing a reduction in the forecast fleet of light load vehicles.

Shift from light passenger vehicles to buses for passenger transport

(a). ***Introduction of new generation diesel Heavy Passenger vehicles (Scenario 1a)***

Passenger transport in Namibia is mainly catered for by light passenger vehicles of less than 12 seats. Based on 2010 data, the estimated total number of light passenger vehicles registered was 108 467, representing 43% of the total vehicle population. These vehicles incur an average of 20 000 km yearly with an estimated fuel consumption of 10 L/100 km irrespective as to whether the fuel type is gasoline or diesel. Revised data also set out that 85% of passenger vehicles use gasoline. In 2025, the number of light passenger vehicles is projected to reach almost 178 281. The yearly kilometre has been estimated to remain at 20 000 km and the estimated fuel consumption at 10 L/100 km. However, the ratio of vehicles using gasoline to diesel is projected to change from 85:15 to 80:20

Based on the assumption that these vehicles will operate over 300 days annually, they will cover a distance of 66 km daily. This mileage has been adopted despite the fact that it appears to be on the low side for a country of Namibia's magnitude and in the absence of a public transport system. It is also assumed, in the absence of proven data on vehicle occupancy, that these vehicles will on average transport a minimum of 1.0 m passengers having mobility needs daily on the basis of projections that in 2025, Namibia will have a projected population of 2.584 million of which 57% will be urban. On the basis of these assumptions the fuel intensity of light passenger vehicles works out to 56 passenger kilometre/litre of gasoline.

Heavy passenger vehicles with Euro 3 or 4 emission standards have a seating capacity of 60 passengers. While operating on fixed schedules and along well defined routes to provide a satisfactory service level, these vehicles are expected to perform 8 trips daily and transport a total of 350 passengers at an average occupancy of 72% per trip. In 2025, these vehicles are assumed to run 100 000 km annually or 303 km daily at a rate of 330 days of service. The estimated fuel consumption in 2025 is 16L/100 km. The fuel intensity of heavy duty passenger vehicles is therefore 2186 passenger kilometre/litre.

To reduce the growth of light passenger vehicles by 30% in 2025, there is need to meet the demand for 2 995 440 passenger kilometres which would necessitate the operation of 53 490 of these light passenger vehicles. With regard to the fuel intensity of heavy passenger vehicles, the number required will therefore be 1370 in order to meet an equivalent demand. At the rate of fuel efficiency of 16 L/100 km used in the projections, the latter vehicles will consume a total of 66 445 litres of diesel daily. Concurrently, a corresponding reduction in the use of gasoline amounting to 356 778 litres is expected per day.

Similarly, for the years 2040 and 2050, the ratio of vehicles using gasoline to diesel has been forecast to change further to 75:25 and 70:30 respectively as well as the annual kilometres operated which have been estimated to be 19 000 km and 18 000 km. All other operating parameters have otherwise been kept constant. With these assumptions, there is need to meet the demand for 4 486 506 and 5 252 724 passenger kilometres in 2040 and 2050 which would have been performed by 72 363 and 99 108 light passenger vehicles. Using the same fuel intensity of heavy passenger vehicles, the number of such vehicles required to meet that demand works out to be 2052 in 2040 and 2403 in 2050.

The annual diesel consumed and gasoline avoided in litres will be as follows:

	2025	2040	2050
Volume of diesel used (litres)	21 926 850	32 832 000	38 448 000
Volume of gasoline avoided (litres)	107 033 400	137 489 700	178 394 400

(b). ***Use of CNG propelled Heavy passenger vehicles (Scenario 1b)***

In the context of Namibia, the Kudu gas field development may in the medium term offer the possibility to provide the energy needs of the road transport sector at least for a period of 15 years during which the exploitation is expected to last.

CNG inherently has lower CO_2 emissions compared to diesel. Considering the fact that 100% of the diesel requirement for transport fuel needs has to be imported, the total fuel cycle GHG emissions of diesel would be extremely high. Given that CNG could be available at a much lower cost and it is a fuel which has the most potential for competing as an alternative to diesel for heavy duty vehicles, the option to introduce CNG buses in lieu of diesel buses is as well explored to assess its mitigation potential.

CNG buses cost more than diesel buses but the savings accruing from the cost of CNG as compared to imported diesel will quickly payback the incremental cost initially incurred in the acquisition of these buses. The normal payback period is 3-4 years out of a usual lifespan of 15 years for these buses. The fuel consumption of CNG buses is higher than that of diesel buses by about 25% under similar operating conditions because of the lower energy density of CNG to diesel and the lower average engine efficiency of natural gas buses.

Taking these parameters into consideration, the substitution of diesel by CNG buses will give the following consumption results for the three time horizons:

	2025	2040	2050
CNG consumed (litres)	27 408 562	41 040 000	48 060 000
Gasoline avoided (litres)	107 033 400	137 489 700	178 394 400

Conversion of 25% of light load and light passenger vehicles into dual-fuel vehicles using LPG and gasoline (Scenario 2)

Rationale behind choosing dual fuel vehicles rather than LPG only

As at 2006, only one company in Namibia was able to convert cars to run on LPG and only 400 vehicles had been so converted. Namibia is a sizable country and there is need to travel over long distances within and between its urban and rural areas. Vehicles solely fuelled with LPG will be limited to areas having LPG dispensing facilities and this will restrict vehicle use and operation. Conversion of vehicles to use LPG and facilities for supply of that fuel are being provided by private companies. There is low expectation that the number of converting companies and dispensing facilities will increase so rapidly in the next decade to enable vehicle owners to rely solely on that fuel type.

The conversion of petrol vehicles into dual fuel vehicles provides the assurance for any motorist to undertake trips irrespective of the distance knowing that in the event that LPG fuel is used up, the journey may still be pursued using gasoline for which replenishment facilities are available countrywide. The incentive to revert to LPG use will always prevail being driven by savings achievable on fuel costs which on average works out to over 20% in spite of the fact that LPG consumption per unit distance is higher than gasoline due to its lower energy content.

Data from the vehicle dealers indicated that in 2006, 95% of passenger sedan vehicles and 74% of light load vehicles were running on gasoline. Based on this and the vehicle development trend, it is estimated that these percentages have shifted to 85% and 70% in 2010. In the forecast for the BAU scenario it has been estimated that by 2025, these percentages will change, with a higher number of vehicles registered between now and 2025 running on diesel. As such, it has been projected that in 2025, 80% of the estimated passenger sedan fleet will be running on gasoline and only 30% of light load vehicles will then be using gasoline. This is expected to evolve and reach 75% and 20% in 2040 to increase further to 90% and 10% in 2050.

The annual vehicle kilometre run has also been estimated to increase from 15 000 km to 20 000 km for light passenger vehicles while light load vehicles are projected to cover 25 000 km annually from the present 20 000 km. The fuel consumption has been kept unchanged for both types of vehicles at 10L and 12L per 100 km respectively as it is expected that technology improvements will nullify other external factors such as traffic jams.

The number of vehicles anticipated to be converted for the three time horizons are:

	2025	2040	2050
Light passenger vehicles	35 650	63 318	79 286
Light goods vehicles	13 100	16 656	11 207

Based on these assumptions, it is estimated that gasoline consumption which will be avoided by each type of vehicle will be:

	Gasoline (1000 L)		
	2025	**2040**	**2050**
Light passenger vehicles	71 300	126 636	158 572
Light goods vehicles	39 300	49 968	33 621
Total	110 600	176 604	192 193

For the purpose of this report, international standards, indicating that LPG has a 20% higher consumption rate than gasoline, will be adopted for working out the mitigation potential. The LPG consumption for both light passenger vehicles and light load vehicles will therefore be 10 L + 20% per 100 km and 12 L + 20% per 100 km run respectively.

All dual fuel vehicles operate on gasoline when the engine is cold. As well, for reflecting situations of LPG depletion requiring the vehicles to switch to gasoline, a 10% correction has been applied in the total LPG consumption to reduce the amount consumed. This ensures more reliable data for making the mitigation assessment.

Assuming all other parameters stay unchanged, the option to convert 25%, 35% and 40% of light passenger vehicles and light load vehicles in 2025, 2040 and 2050 will result in the LPG consumptions provided below instead of the amount of gasoline aforementioned:

	LPG (1000 L)		
	2025	**2040**	**2050**
Light passenger vehicles	77 004	136 766	171 258
Light load vehicles	42 444	53 965	36 310
Total	119 448	190 731	207 568

Pooling and bulk loading in internal transport of goods leading to a 20% increase in goods vehicles ≤ 15 tons (Scenario 3)

Light load vehicles ≤GVM 3500 kg constitute 42% of the total vehicle population in Namibia. In 2006, there was 98 276 such vehicles registered and it was showing an average growth of 5.8% per year. The estimated number of light load vehicles in 2025 is 174 593, representing an increase of 78%.

The estimated kilometres incurred by these vehicles annually has been changed in the BAU Scenario to 25 000 km and the estimated fuel consumption has been kept constant at 12 L/100 km. There is no reference at all to their effective payload in any source. It is therefore assumed that each such vehicle has a payload of 2 tons and performed one trip a day with a 75% load. The return leg is considered to be effected empty. It is also assumed that they have 330 days operation in a year. With these assumptions, it is estimated that light load vehicles have a fuel intensity of 16.6 ton-kilometre per litre of diesel consumed.

The option will focus on reduction of diesel consumption as the share of diesel for this category of vehicles has been foreseen to change from 20% diesel in 2000 to 70% in 2025. In 2025, more than 122 000 light load vehicles are therefore expected to be using diesel as fuel.

Goods vehicles with a GVM of ≤15 tons have a payload of 11 tons and a standard fuel consumption of 18L/100 km. With pooling of goods to be transported both for collection and delivery, it is assumed that these vehicles will run up to 40 000 km a year as per data provided by relevant authorities. The effective load carried will be one way and amount to 80% of the payload i.e. 8.8 tons. The number of days of operation is assumed to be 330 days i.e. same as light load vehicles.

The fuel intensity of vehicles with a GVM of ≤15 tons using the above parameters therefore works out to be 48.9 ton-kilometre per litre. The fleet of heavy goods vehicles not equipped to draw is expected to be 13 134 in 2025. With a 20% increase in 2025 for this option, the expected additional number of such vehicles will be 2 627 vehicles. The total ton-kilometres to be incurred by these vehicles is 924 992 970 and this volume is equivalent to the ton-kilometres otherwise incurred by a fleet of 30 735 light load vehicles. Similarly, with 25% in 2040 and 30% in 2050, the expected number of heavy load vehicles will reach 4062 and 5497 while the number of light load vehicles will be 47 524 and 64 313 respectively

The reduction in diesel consumed taking 18 L/100 km as the average fuel consumption is as follows:

	Diesel (1000 L)		
	2025	2040	2050
Diesel consumed by 30735 light load vehicles	92 205	152 572	192 939
Diesel consumed by 2627 load vehicles GVM ≤15 tons	18 914	29 246	39 578
Reduction in volume of diesel consumed yearly	73 291	113 326	153 361

Total abatement potential of all options analysed for road transport varies in relation to whether diesel or CNG buses are adopted under scenario 1. Total mitigation value ranges from 436 to 856 Gg CO_2-eq in the road transport sub-sector.

Table 5.7. Mitigation potential of the different scenarios (Gg CO_2-eq)

Year	2010	2025	2040	2050
Transport BAU	2223	3812	5216	6147
Transport Scenario 1a		187	227	306
Transport Scenario 1b		212	264	350
Average Scenarios 1a and 1b		199	245	328
Transport Scenario 2		46	74	80
Transport Scenario 3		203	315	426
Total - Transport Scenario 1a_2_3		436	616	812
Total - Transport Scenario 1b_2_3		461	653	856

5.5.4. LAND mitigation assessment

5.5.4.1. Description of sector

The AFOLU sector includes four categories and except for Harvested Wood products, the remaining three enumerated below were covered in this inventory.

3 – Agriculture, Forestry, and Other Land Use
3.A – Livestock
3.B – Land
3.C – Aggregate sources and non-CO_2 emissions sources on land

The methodologies are based on the IPCC 2006 Guidelines and the IPCC 2006 software was used to estimate emissions and removals. Since the IPCC 2006 Guidelines do not estimate emissions at the Tier 2 level, the Agriculture and Land Use software has been partially used as a supplement for the Livestock category. Otherwise, it was a very difficult exercise to accommodate higher than Tier 1 with the IPCC 2006 Guidelines and significant work had to be accomplished in Excel worksheets and then used in the software. Some detailed information on management systems of certain land classes could not be assigned in the IPCC 2006 software.

5.5.4.2. BAU scenario

The AFOLU sector stayed on top of the list of key categories for Namibia during the whole TNC period. The sink capacity of the sector however gradually decreased mainly due to loss of forest biomass. Net sink capacity of LAND is estimated to have declined by 1570 Gg CO_2-eq annually from a high of 20 394 Gg in

2000 to 4691 Gg in 2010 as shown in Figure 5.9 On this trend, Namibia's land sector will become CO_2 neutral by 2022.

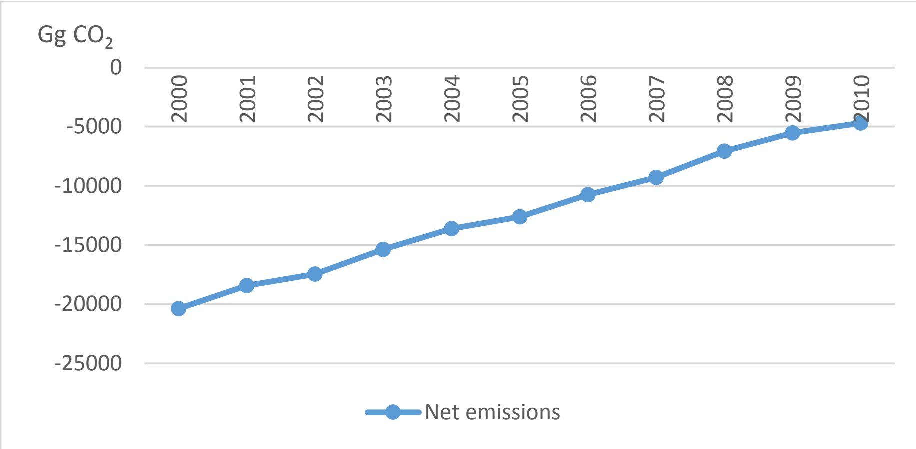


Figure 5.9. Net CO_2 emissions from AFOLU from 2000 to 2010

This gradual decrease is linked with three activities that have a direct impact on Namibian forest:

- Removal of poles for the construction of houses and fences;
- Removal of fuelwood; and
- Forest degradation by fires and other human activities leading to deforestation.

It is estimated that the younger part of the forests and woodlands, that are less than 20 years, are lost quicker than the older, more than 20 years. Annual growth rates of the younger trees are higher and the loss of sink capacity is thus further exacerbated when using the gain loss method for estimating emissions.

5.5.4.3. Mitigation in the AFOLU sector

Options for mitigation in Agriculture

There are various measures and actions that can reduce emissions or increase sink capacity in the agriculture sector. The following options have been assessed as they are being seriously envisaged in the short to medium term because of the productivity increase associated with these practices.

- Fattening 100 000 cattle in feedlots prior to slaughtering; and
- Agroforestry for sustainable use of resources.

Fattening 100 000 cattle in feedlots prior to slaughtering

The direct impact of fattening cattle will be reduced enteric fermentation. The manure management system will also change accordingly and produce less methane. This measure is viable in the commercial sector which represents 41% of all emissions form the livestock category. A 10% reduction in the amount of methane released is expected. Since animal numbers are forecasted to stay the same, the average mitigation potential from this measure is estimated at about 200 Gg CO_2-eq annually.

Agroforestry for sustainable use of resources

A large area of more than 150 000 ha is kept as cropland set aside each year. This options takes into consideration that 5000 ha of this land is planted as from 2018 with fruit / high value trees that will be kept for production of various agricultural products. This option fits well with the agricultural strategy towards food security while providing jobs and income to the rural population.

Inclusive of soil carbon gain the expected removals in terms of Gg CO_2-eq are 326, 1037 and 1403 for the years 2025, 2040 and 2050 respectively.

5.5.4.4. Options for mitigation in LAND sector

Numerous options exist for mitigation within the LAND sector but only those having a potential to be successfully implemented and closely associated with the national circumstances have been assessed. These options are listed below:

- Wood removals mainly as poles for construction of rural homes and kraals;
- Fuelwood used directly or for making charcoal; and
- Deforestation

Removal of poles for the construction of houses

The sink capacity of forests and woodlands decreased at an average rate of 1570 Gg CO_2 annually from 2000 to 2010. Timber removals for construction of rural houses and fences for pastures represented an emission of 1552 Gg CO_2 in 2025 and estimated to 1487 Gg CO_2 in 2040. Estimates of future removals of timber and poles are given in Table 5.8.

Table 5.8. Estimates of timber and poles removals from forests

Year	Estimated timber and poles (m^3) removals from forests	Gg CO_2 equivalent lost	Gg CO_2 lost if removals decrease by 50%
2025	319 563	1552	776
2040	244 082	1487	744
2050	159 790	744	372

Removal of poles and timber is thus expected to decrease with declining rural population. However, these removals can further be decreased by substituting use of poles for construction of dwellings by iron sheets or other non-biomass building materials. Depending on the rate of replacement and accessibility to resources, discouraging the removal of timber and poles by at least 50% will have a direct impact on the CO_2 balance as shown in Table 5.8.

Deforestation

Deforestation is of concern in the country as there is a net deforestation rate of 161 912 ha annually obtained from the remote sensing generated maps for the period 2000 to 2010. Thus, the BAU scenario has adopted this annual deforestation rate while reforestation rates have also been worked as a percentage of this value for enhancing removals and reduce atmospheric CO_2 levels.

5.5.4.5. BAU scenario

The BAU scenario emissions include biomass lost on account of deforestation and wood removals for other purposes including charcoal production and fuelwood. An increase is observed over time as the emissions of -4691 Gg CO_2 for the base year 2010 rises to 20 850 Gg CO_2 for the year 2050 (Table 5.9).

5.5.4.6. Mitigation options

Three possibilities have been assessed, namely;

- Scenario 1: Gradual increase in mitigation action;
- Scenario 2: Lowest mitigation potential; and
- Scenario 3: Highest mitigation potential.

In scenario 1, the removal of woody biomass (poles) has been reduced by 50, 60 and 75% for the time steps 2025, 2040 and 2050 while deforestation rates decreased by the same rates over the same time horizons.

In scenario 2, a constant reduction of 25% has been applied for both activities over the years 2025, 2040 and 2050.

In scenario 3, a constant reduction of 75% in the two same activities has been considered.

The reduction in emissions stemming from these scenarios ranged from 6007 to 8733 for the scenario with the lowest potential and 16 143 increasing to 18 130 for the one with the highest potential.

Table 5.9. Emissions under BAU (2010) and mitigation scenarios for the years 2025, 2040 and 2050

Scenario	2010	2025	2040	2050
AFOLU BAU	-4691	10920	18200	20850
AFOLU Scenario 1		10892	17310	18130
AFOLU Scenario 2		6007	7887	8733
AFOLU Scenario 3		16143	17480	18130

One reforestation option has been assessed, namely reforesting 20 000 ha annually as from 2018 up to 2050. This is capable of sequestering an additional 4035 Gg CO_2 annually up to 2050, thus raising the overall mitigation potential.

5.5.5. Waste mitigation assessment

5.5.5.1. Description of sector

In Namibia, urbanized areas have collection and separation systems for the management of MSW and industrial waste. Materials such as metal, plastic and paper are removed and recycled in regions like Windhoek and Walvis Bay. Sand and inert building wastes are removed and the remainder is sent to landfills. Sewers are present in high urban areas while septic tanks are used in houses of low urban areas. Industrial liquid waste is generated during fish processing and in abattoirs. Sludge from domestic wastewater management systems is sent to landfills. Most waste produced in rural areas are open burned.

5.5.5.2. Business As Usual Scenario

Urban dwellers produce a higher amount of waste while the poorer rural population have a lower waste generation rate. Figure 5.10 shows the average waste produced per capita (t/yr) and the evolution in population in urban high, urban low and rural areas.

The change in lifestyle and growth of the urban population will result in an increase of the amount of waste to be managed every year. Burning and landfilling are not considered sustainable options as landfilling provides GHG emissions over a long period as the decomposition occurs at a slow rate.

It is therefore important to assess the potential of managing the waste differently and at the same time mitigate GHG emissions if current practices are changed.

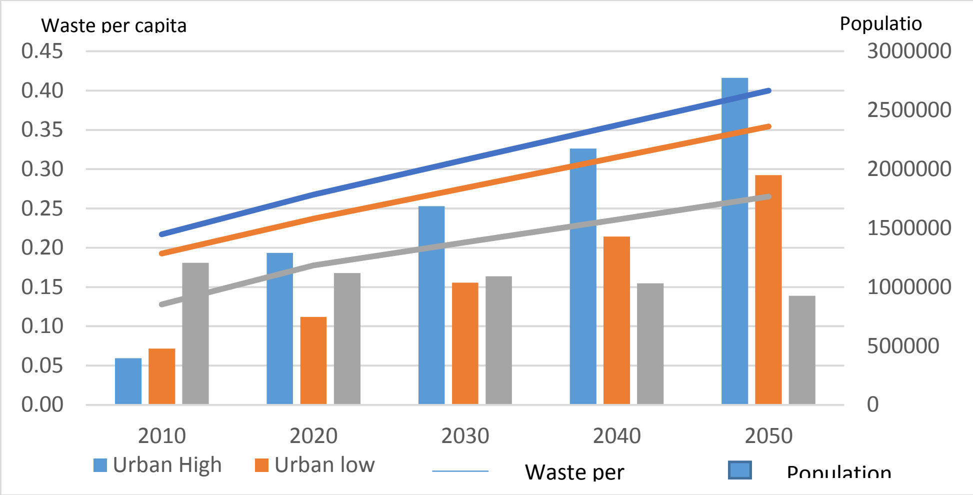


Figure 5.10. Waste generation for 2025, 20240 and 2050

Since Namibia has an extensive territory, transporting waste over long distances is not a sustainable option. Potential MSW from the urban high regions of Walvis Bay, Swakopmund and Windhoek represent the major portion of waste generated in the country and is thus, the primary source of input for mitigation purposes. The projected amount of MSW for these three regions is given in Table 5.10.

Table 5.10 Forecasted amount of MSW from urban high regions

Year	Amount of MSW (t)
2025	172 395
2040	266 348
2050	330 946

5.5.5.3. Mitigation options

There are numerous options for the valorisation of waste as a source of energy or raw material such as compost, metals or plastic. These include:

- Recycling of plastic and metal portions after segregation;
- Composting through various fermentation pathways;
- Waste to energy projects via various channels and technologies;
- Production of biogas.
- Systems coupling two or all four above options can be adopted for a holistic management of MSW and enabling the best management practice.

5.5.5.4. Choice of Mitigation Option

Out of the various options presented above, the most straightforward one which is mass burning of waste has been selected for this initial assessment. Further work is warranted to assess other options of dealing with waste as well as the latest technologies for converting waste to energy such as pyrolysis. Additionally, the mitigation potential of solid waste in the rural areas has to be assessed. As well, there exist the potential of exploiting industrial and domestic waste water to produce energy. This can reduce the dependence of the country on fossil fuels for electricity production while curbing down GHG emissions.

In the present analysis, only mass burning of MSW has been considered. It offers two possibilities, namely avoiding CH_4 emissions and reducing emissions from burning of fossil fuels for electricity generation.

5.5.5.5. Avoiding methane emissions

The BAU of sending MSW to a landfill was simulated. The methane production resulting from 100 Gg MSW annually during 10 years was calculated for a period of 21 years. No amendments were made to change the waste composition used for the BAU despite the fact that most recyclable parts would have been removed prior to burning.

Waste deposition started in year 0 and stopped in year 10. The amount of methane emitted is shown in Figure 5.11. After 11 years of MSW deposited, annual emissions of methane reached 29.75 Gg CO_2-eq.

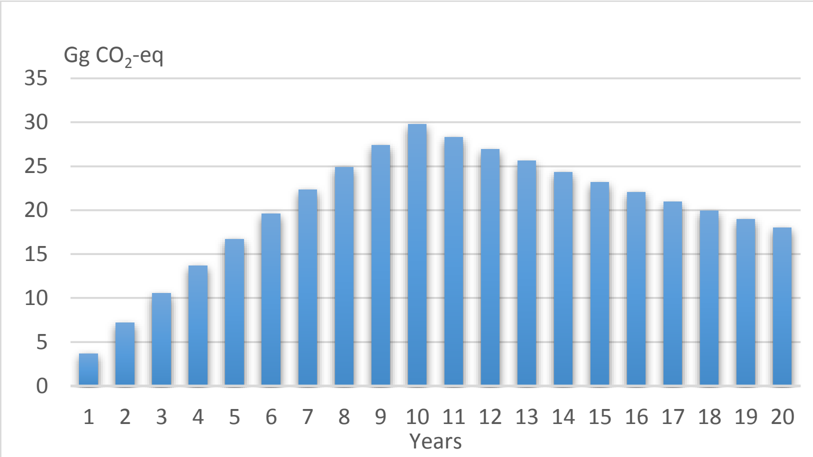


Figure 5.11. Methane emissions from landfill in Gg CO_2 equivalents

Thus, if 100 Gg of MSW is burned, the abatement is of the order of 29.75 Gg CO_2-eq.

5.5.5.6. Reducing fossil fuel consumption for electricity production – Conversion of MSW to electricity

Mass burning of MSW to produce electricity has been simulated to assess its mitigation potential. The module for electricity generation in the IPCC 2006 software contains the default values for burning biomass and non-biomass parts of MSW for electricity generation. The simulation was done using this module. Energy equivalents of burning coal or diesel were compared for CO_2 mitigation.

For simplicity purposes a base quantity of 100 000 tonnes (100 Gg) of MSW has been considered. This base value can further be used for cost-evaluating technologies available for sustainable burning of waste. The 100 Gg of MSW is considered as the resultant of the recycling practiced on land fill sites whereby most of the recyclable parts such as metal and glass have been recovered. The final burned MSW is estimated to be constituted of 90% biomass and 10% non-biomass parts. Energy content and emissions are presented in Table 5.11 below for each 100 Gg of MSW burned.

Table 5.11. Emissions from MSW, coal and diesel for generating equivalent amount of energy

Source		Amount (Gg)	Energy (TJ)	CO_2 (Gg) emitted
MSW	Biomass	90	1044	-
	Non Biomass	10	100	9.17
Coal			1144	109.94
Diesel			1144	84.77

Burning of 100 Gg of MSW produces 1144 TJ of energy and emits 9.17 Gg of CO_2. Using Coal or diesel to produce the same amount of energy would result in 109.94 or 84.77 Gg CO_2 emissions respectively. This gives a mitigation potential of 100.77 Gg CO_2-eq in case coal is the fossil fuel used and 75.6 in case of diesel.

5.5.5.7. Combined mitigation potential

Based on the above workings, the annual mitigation potential of mass burning 100 000 tonnes of MSW consisting of biomass and non-biomass parts in the ratio of 9:1 instead of sending it to an uncategorized landfill is presented is given in Table 5.12.

The mitigation potential varies according to the year of start of operation of the system and the landfill situation. It ranged from 75.58 if a new landfill site is starting its operation and maximizes at 130.50 Gg CO_2-eq annually in case the landfill continued its operation over the next 11 years.

Table 5.12. Mitigation potential of mass burning 100 g of MSW compared to using coal or diesel for electricity production

(All values are in Gg CO_2 equivalents)

Year	Avoided from land fill	Amount avoided from		Emitted from mass burning	Total mitigation potential	
		Coal	Diesel		Coal	Diesel
Year 0		109.94	84.77	9.19	100.75	75.58
Year 1	3.69	109.94	84.77	9.19	104.44	79.27
Year 2	7.19	109.94	84.77	9.19	107.94	82.77
Year 3	10.53	109.94	84.77	9.19	111.28	86.11
Year 4	13.7	109.94	84.77	9.19	114.45	89.28
Year 5	16.72	109.94	84.77	9.19	117.47	92.30
Year 6	19.59	109.94	84.77	9.19	120.34	95.17
Year 7	22.33	109.94	84.77	9.19	123.08	97.91
Year 8	24.92	109.94	84.77	9.19	125.67	100.5
Year 9	27.4	109.94	84.77	9.19	128.15	102.98
Year 10	29.75	109.94	84.77	9.19	130.50	105.33

Mitigation potential with respect to forecasted MSW amounts from urban high region is given in table 5.13. The emission from the energy produced in the BAU scenario is a 75% coal to 25% diesel mix. The amount of MSW used for energy generation in 80% of the expected volume as waste composition may vary in function of the lifestyle and consumption pattern of the population.

Table 5.13. Projected MSW, amount used for mitigation and abatement values (Gg)

Year	Forecasted MSW (Gg)	Amount MSW (Gg) used for energy generation	Amount CO_2 (Gg) mitigated with 85:15 coal to diesel BAU
2025	172	138	174.9
2040	266	213	269.9
2050	330	264	334.6

6. Vulnerability and Adaptation

6.1. Vulnerability

6.1.1. Introduction

This chapter addresses the current nature of vulnerability and adaptation in Namibia, and highlights some ongoing gaps in adaptation that should be addressed in order to reduce the adverse impacts of climate change. The chapter has been developed by the Vulnerability and Adaptation Multi-stakeholder Task Team, which selected four key sectors that are important to Namibia's economy and development, yet at risk of negative impacts of climate change. These four sectors are agriculture, health, tourism and water.

6.1.2. Conceptual framework and methods for assessing vulnerability and adaptation

There are various ways of conceptualising vulnerability but this exercise follows the definition provided by the Intergovernmental Panel on Climate Change (IPCC) in its Fourth Assessment Report (AR4). In this framework, vulnerability is the outcome that is the function of a system's exposure and sensitivity to climate stimuli, and its capacity to adapt to their (adverse) effects (also known as adaptive capacity) (IPCC, 2007) (see Figure 6.1). Sensitivity is the degree to which a system, region or individual has the potential to be affected, either adversely or beneficially, by the effects of climate change. Adaptive Capacity is *'the potential or capability of a system to adapt to (to alter to better suit) climatic stimuli or their effects or impacts'* (Fifth Assessment Report (AR5) of the IPCC). Adaptive capacity is a function of available resources in a given country, region, community or household. These may be may be material, financial or human resources and their availability will influence adaptation options.

Adaptation to climate change refers to an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC 2007b). Adaptation can be pursued by societies, institutions, individuals, governments and can be motivated by economic, social or environmental drivers through many mechanisms, for example social activities, market activities, local or global interventions (Adger et al*.,* 2007). Adaptive capacity is the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behaviour and in resources and technologies.

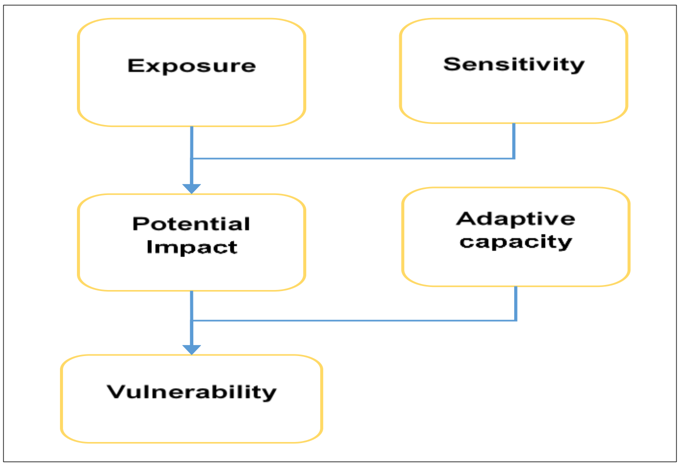
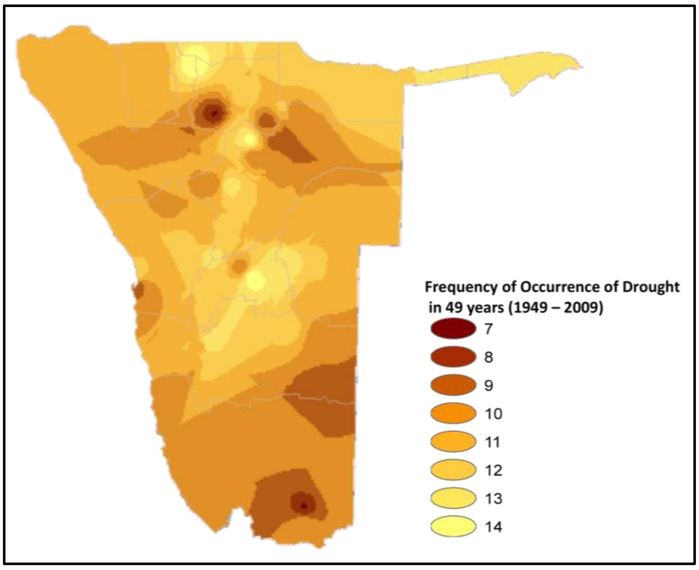


Figure 6.1. Diagrammatic representation of the conceptual framework of vulnerability

In an effort to ensure comparability (between sectors, and within sectors over time), an indicator- based framework is used, where the exposure, sensitivity and adaptive capacity, as well as the outcome of vulnerability, is defined by indicators. To the extent that appropriate data was available, these indicators are quantitative and were identified by the Task Team.

6.1.3. Nature of climate exposure to climate change

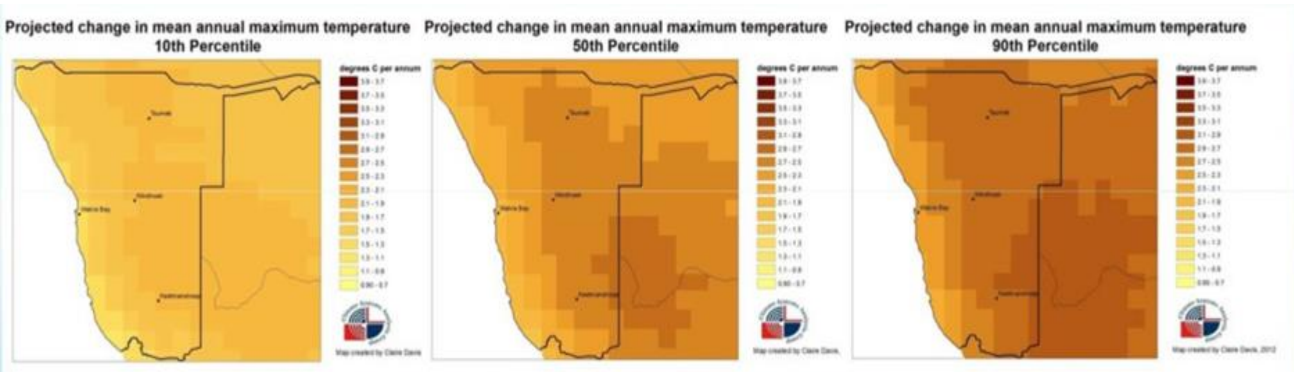
Climate change in Namibia has already been observed. According to Reid (et al., 2007) ambient temperatures in Namibia have been rising at three times the global mean temperature increase reported for the 20th century. Rainfall received throughout the country has been low in the last 10 years, characterized by short duration high intensity rain storms (Dahlberg et al., 2008). Severe droughts have been experienced which the meteorologists attribute to the disturbance and shifts in the global circulation patterns and the El Nino effect (Dahlberg et al., 2008). Figure 6.2 highlights the incidence of drought from 1949-2009.



Source: Gilau et al., 2011

Figure 6.2. Frequency of Occurrence of Drought 1949 - 2009

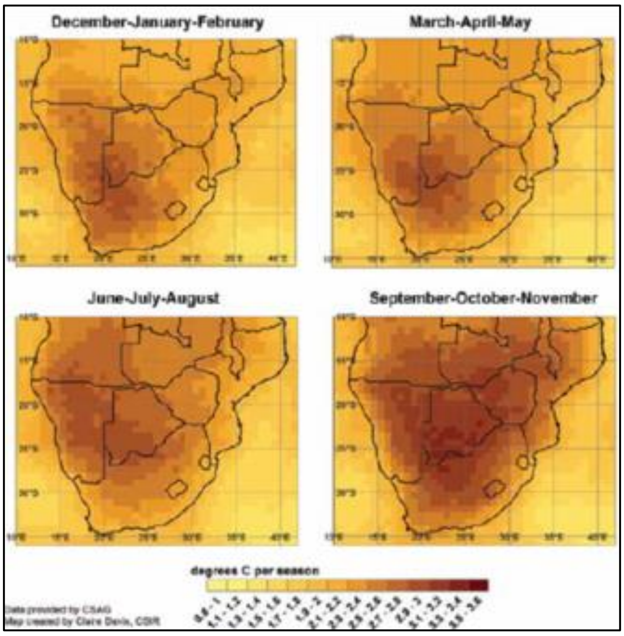
Observed changes are projected to increase into the future. High resolution climate projections are available through downscaling GCMs. There are two methods for downscaling: statistical downscaling is based on statistical relationships between weather type and local weather variables. The Climate Systems Analysis Group at the University of Cape Town have created downscaled climate projections for Namibia. All projections show the change projected for 2036-2065 (relative to the 1961-2000 period) based on the A2 scenario (a fairly high emission scenario that reflects the current path of our emissions). 10 GCMs have been downscaled. Since the results of each are slightly different, we show here the 10^{th}, 50^{th} (average) and 90^{th} percentile, so that the range of change (known as an envelope) is clear. Figure 6.3 shows projected mean annual maximum temperature change. What we can say from these diagrams is that we are 90% certain that annual maximum temperature change will exceed the 10^{th} percentile, and 90% certain that it will be less than the 90^{th} percentile. Temperature is projected to increase across Namibia, with the greatest increases inland. These increases will range from 0.6-3.5°c.



Source: Davis, 2011

Figure 6.3. Projected mean annual maximum temperature change based on statistical downscaling

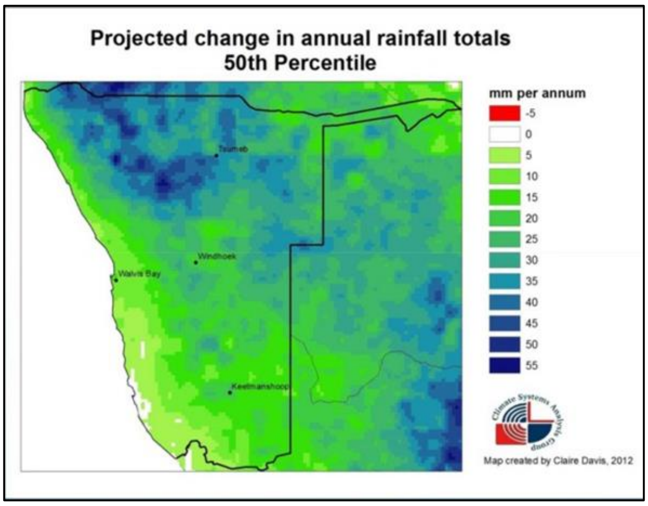
Figure 6.4 shows that the temperatures will increase across the year with the greatest increase in temperature in September-October-November. This has implications since it is the traditional planting season in Namibia. The seasons with the smallest increase in temperature are December-January-February and March-April-May.



Source: Davis, 2011

Figure 6.4. Projected seasonal temperature change based on statistical downscaling

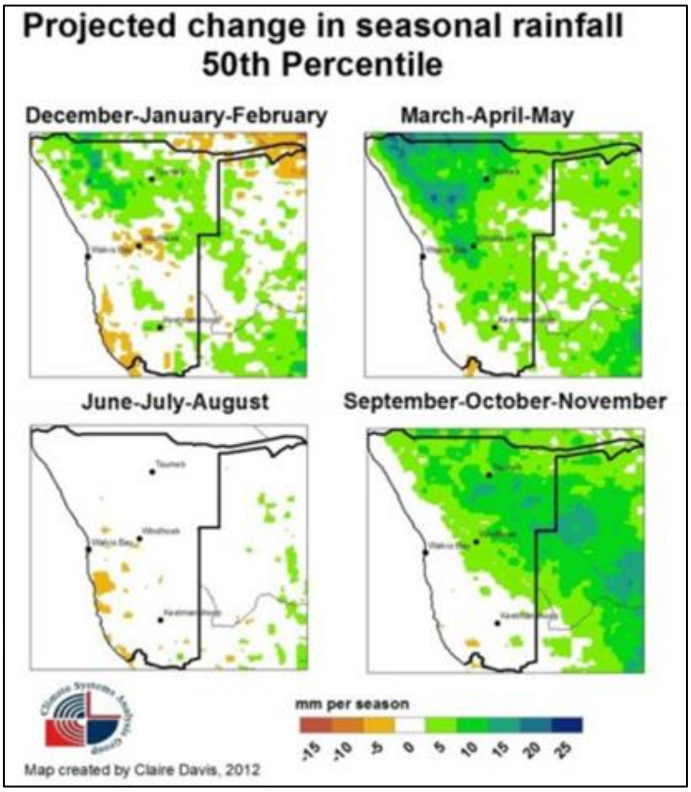
Projecting rainfall is subject to a greater range of uncertainty than temperature. Figure 6.5 shows projected change in mean annual rainfall based on statistical downscaling. Since downscalings are based on GCMs, the same limitations apply. Since there is such variation in GCMs for rainfall, it is important to interpret this as a representation of the direction of change as opposed to the extent of change (since if 5 models project an increase, and 5 project a decrease, the median figure will show no change). As a result, median figures here should only be used to show direction of change (because they are the median of a range which may include less rain to more rain within the same model). The areas shown in white in Figure 6.5 are those where the average change is close to 0 – which is often due to disagreement in the models (i.e. some project an increase, and others project a decrease).



Source: Davis, 2012

Figure 6.5. Projected change in mean annual rainfall based on statistical downscaling

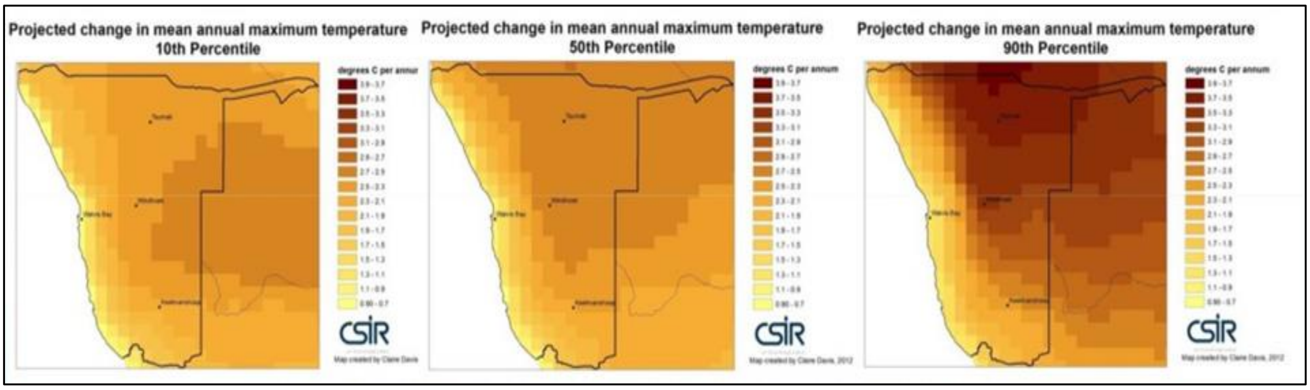
Figure 6.6 shows that an increase in rainfall is likely for seasonal change. Here there is much more uncertainty (shown by the areas in white); however for much of the northern and central parts of the country where most of the population is found, there will likely be an increase in September-October-November. Potential increase also exists for March-April-May, at the end of the usual rainy season.



Source: Davis, 2012

Figure 6.6. Projected change in seasonal rainfall based on statistical downscaling

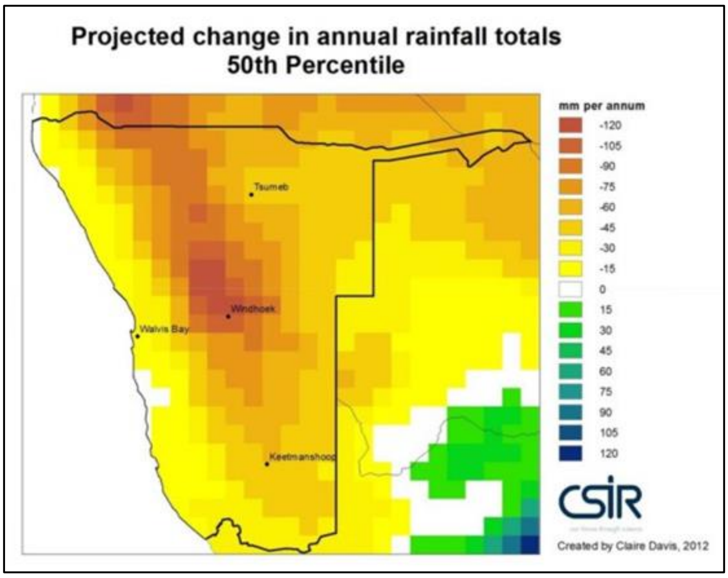
The second method of downscaling is dynamical. The Council for Scientific and Industrial Research (CSIR) are the African leaders in dynamical downscaling, and generated the results here using six GCMs for the A2 scenario (same as the statistical downscaling) to generate projections for 2036-65, relative to 1961-2000 (Davis, 2011). As Figure 6.7 shows, dynamical downscaling also shows temperature increase is projected throughout Namibia, from 0.9-3.8°C.



Source: Davis, 2011

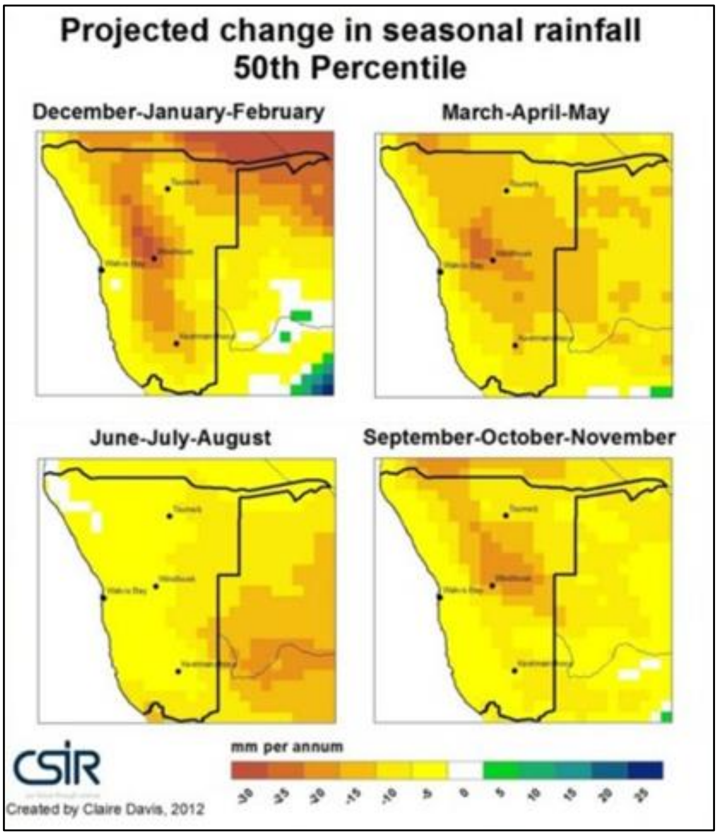
Figure 6.7. Projected mean annual maximum temperature increase based on dynamical downscaling

Figure 6.8 shows projected change in annual rainfall. The dynamical downscaling technique shows that mean annual rainfall across Namibia is likely to decrease. Decreases are projected across the country for all four seasons, with the greatest decrease in the interior for the latter part of the rainy season in the months of December-January-February (Figure 6.9). The fact that statistical and dynamical downscaling produce such different results with the same input data highlights the challenges of projecting rainfall. In terms of the climate change in the country, there is likely to be an increase in temperature but a change in rainfall patterns – with no certainty as to what that change will be.



Source: Davis, 2012

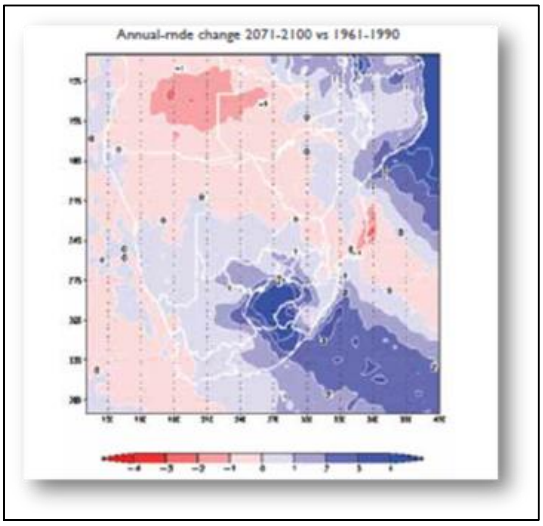
Figure 6.8. Projected change in annual rainfall based on dynamical downscaling



Source: Davis, 2012

Figure 6.9. Projected seasonal change in rainfall based on dynamical downscaling

Dynamical downscaling was also used to assess projected change in annual frequency of extreme rainfall events (Figure 6.10). The darker the colour, the greater the number of events. Overall Namibia is projected to have the same or slightly fewer extreme rainfall events.



Source: Davis, 2011

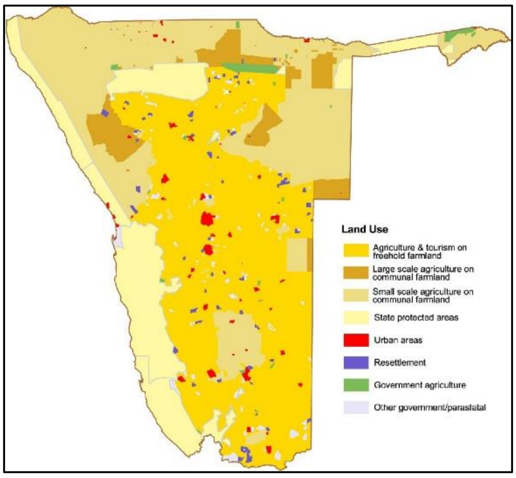
Figure 6.10. Projected change in annual frequency of extreme rainfall events

6.1.4. Agriculture

6.1.4.1. Overview of the current status of the sector

Namibia is semi-arid and, as such, crop production is second to livestock in importance due to low rainfall that favours the predominant presence of perennial grass species which are resistant to moisture stress. Only 2% of the country's total surface area is arable, 46% is appropriate for perennial natural pasture and 22% is forest and the rest arid. The agricultural sector happens to be the major user of water in Namibia, consuming about 75% of it. Irrigation potential is only along the perennial rivers and where dams feed irrigation schemes far from the areas inhabited by people.

There are mainly two agriculture production systems in Namibia: commercial ("freehold") comprising 14.5 million hectares, and communal ("traditional") comprising 17 million hectares (Figure 5.11). The commercial sub-sector is well developed, capital-intensive, and export oriented, and occupies 52% of the grazing land. Communal farmers utilize the remaining 48% (Sweet and Burke 2000). Table 6.1 highlights the contribution of the agricultural sector to GDP.



Source: (http://www.nnf.org.na/SKEP/skep_pics/map_landuse.jpg

Figure 6.11. Land Use Map of Namibia

Table 6.1. Agricultural Sector Contribution to GDP – Current Prices (% to GDP)

Sector	2010	2011	2012	2013	2014
Agriculture and Forestry	5.1	5.0	4.9	2.9	3.2
Livestock Farming	3.0	3.2	3.0	1.5	1.7
Crop Farming and Forestry	2.1	1.8	1.9	1.4	1.5
Fishing and processing on board	3.5	3.2	3.1	2.9	2.4

Source: NSA, 2014

At least 70% of Namibia's 2.1-2.3 million people practice a subsistence farming model where individual farmers in the NCAs have exclusive rights to small areas surrounding their homes. The three main staple cereals grown are; pearl millet (locally known as *mahangu*), sorghum and maize. Cattle are reared for draught power, meat, and milk and for financial and social security.
Various challenges are facing the agricultural sector. Bush encroachment has increased over the last 30 years, negatively affected livestock productivity by reducing grazing capacities to 16 ha/LSU on commercial ranches and 30 ha/LSU in communal rangelands. In 1957 it was reported that some 4.56 million hectares were infested with encroacher bush and this had increased to some 26 million hectares by 2002 (de Klerk, 2004).

Climate change effects on agriculture are also already being observed. Livestock and crop production under rainfed conditions has been declining by about 33% on average every year in the last few farming seasons. This has been evident since the turn of the century, especially the 2011/2012 2012/2013 2013/2014 seasons, mainly caused by high ambient temperatures and below normal rainfall. The year 2013 recorded the worst drought in 30 years and the GDP contribution by agriculture and the subsectors of agriculture recorded significant negative changes with livestock farming recording the highest decline of 37.6% (Table 6.2).

Table 6.2. Agricultural Sector Contribution and Possible Climate change effects on GDP

Sector	Current Contribution to GDP	Changes Expected Due to Climate Change	Effect on GDP N$ millions	Confidence in range of change
Cereal Production	0,5%	Decrease (10 - 20%)	Loss of 16 to 32	Low to Medium
Cash Crop Production	1,0%	Decrease (10 - 20%)	Loss of 32 to 65	Low to Medium
Livestock Production	3.51%	Decrease (20 - 50%)	Loss of 264 to 660	Medium
Traditional Agriculture	1,5%	Decrease (40 - 80%)	Loss of 197 to 395	Medium to high
Fishing	4,4%	Increase (30%)/decrease (50%)	Loss of 0 to 990	Low
Forests + *	No data	Unchanged	0	Low
Water	No data	Unchanged	0	Low

Source: Reid, et al., 2007; Humavindu, and Stage 2013 and Computations from 10 year averages from national accounts

6.1.4.2. Drivers of sensitivity

Table 6.3 outlines the sensitivity of the agricultural system to various climate parameters. Rainfall is the main determinant of crop yield, grass biomass and livestock production in Namibia; but changing temperatures will also place pressure, both directly and through evapotranspiration rates.

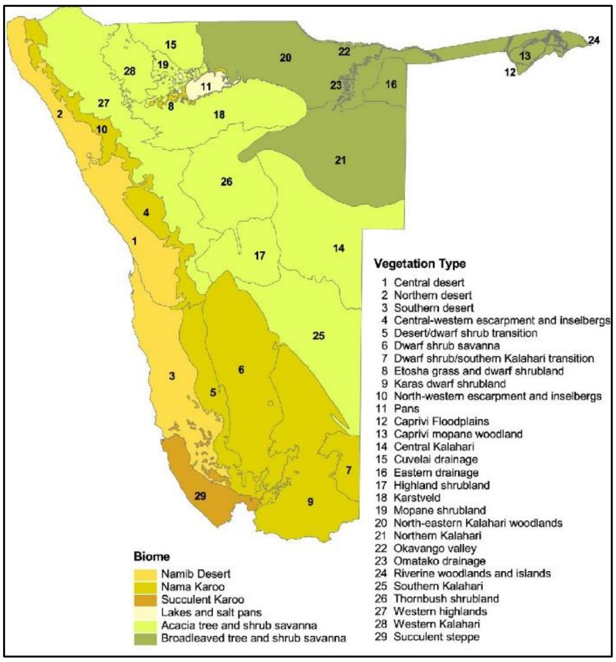
Table 6.3. Sensitivity of the agricultural sector to climate change

Climate parameters	Sensitivity for the Agriculture Sector in Namibia
Warmer temperatures	Increased incidences of heat stress on plants and animals (especially exotic breeds), for example the animal cooling costs for the 3000 cow super dairy in Mariental (and other intensive livestock operations elsewhere in the country) increase. Hot conditions also cause changes in biodiversity.

Climate parameters	Sensitivity for the Agriculture Sector in Namibia
Increased rainfall intensity within a short period (i.e. late onset of rains and early winters)	Rain fed crops wilt and fail to reach maturity hence low yields obtained. Less grass biomass for livestock. Food security is affected and the national food importation bill increases
Reduced precipitation and increased evaporation in some regions	Water shortages, competition over water use between humans and animals and, desertification accelerates, more outbreaks of veld fires.
Increased frequency of flash floods in the NCAs	Waterlogging of crops and rangeland plant life. Spoilage of harvested crops.
Loss of essential insects	Loss of natural pollination of plants leading to low seed production and plant species facing extinction.
Deterioration of soil attributes (such as moisture levels, erosion and acidity)	Loss of yields per hectare of arable land or grazing productivity plummets on rangelands.

The nature of the soils, and how this changes under exposure to climate change, will determine shifts in vegetation. Figures 6.11 and 6.12 show the main land use activities throughout the country. To take the example of livestock, cattle, as natural grazers, do best in areas where natural pastures are most abundant. The southern and western parts of the country offers little in the way of grass fodder. So small stock like sheep and goats, replace cattle in those arid areas.

As well as soil quality and water resources, the existing state of land degradation and deforestation also determines the sensitivity of the environment in response to exposure to climate hazards. High soil fertility loss has been worsened by human population and animal population pressure especially in the densely populated NCAs, giving rise to higher rates of soil erosion (Klintenberg et al., 2004). Changing soil conditions and pressure from human activities has contributed to the domination of invasive bush species. While deforestation is modest in Namibia at 0.9%, forests account for less than 10% of the landscape. The expansion of agriculture puts pressure on forested areas.



Source: http://www.nnf.org.na/SKEP/skep_pics/map_veg.jpg

Figure 6.12. Vegetation Map of Namibia

6.1.4.3. Adaptive capacity

A number of factors will determine the extent to which agriculturalists of different scales and with different focal areas, whether livestock or crops, will be able to respond to the hazard exposure and sensitivity. Adaptive capacity can play a critical role in determining the extent of the vulnerability. The two key indicators of adaptive capacity are the extent of access to veterinary medicines and feed; and access to water.

6.1.4.4. Vulnerability and indicators

The main consequences of vulnerability of the agricultural sector are reduced food production capacity due to rangeland degradation, deforestation, biodiversity loss, droughts and flash flooding and climate change directly causing water scarcity, water pollution and unfavourable temperature humidity index. Based on the preceding sections which outlined exposure (6.1.4), and the nature of sensitivity and adaptive capacity in the agricultural sector, Table 6.4 summarizes the vulnerability and adaptation assessment conducted for various value chain segments of the agricultural system in Namibia.

Table 6.4. Vulnerability Assessment of Agricultural Sector in Namibia.

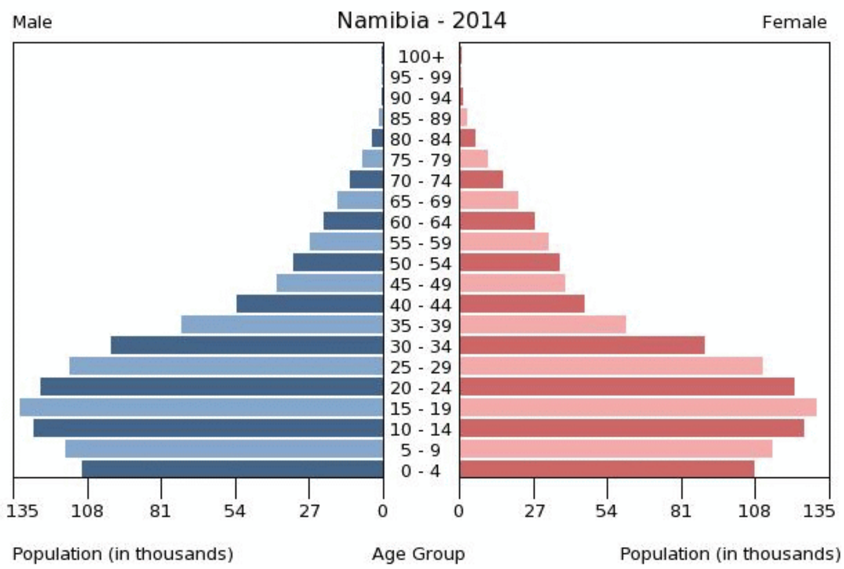
Impact	Prevailing and Anticipated Hazards	Projected Climate Change	Vulnerability Assessment		
			Sensitivity	Adaptive Capacity	Vulnerability
Water supply	Summer drought	Increases in summer droughts due to warmer, drier, shorter rainfall summers	High - water supply and soil water table is very sensitive to changes in rainfall patterns and vaporization.	Low - options for expanding water supply: - damming is limited and expensive, mostly ephemeral dams, main supply rivers (Kavango, Zambezi, Orange rivers) found the north/ south borders of Namibia are far away from the people.	Very High
Surface water run-off from Angola to NCAs of Namibia	When there is heavy storms which are more prevalent rivers in Angola overflows and emptying southwards causing flash floods in the NCAs of Namibia	More localized flooding in the open lands in the NCAs called Oshanas, water quality problems as flooding covers the sections Ruacana water canal.	High – Oshanas in NCAs flood easily, they are low lying & flat Rampant soil erosion and water logging dependent and sensitive to the intensity and frequency of rainstorms in Angola.	Low – attempts to divert water in Ongendiva City are proving costly to the municipality what more for local government authorities in NCAs who do not collect any revenue from the poor people.	High
Rangeland livestock farming and restoration	Bush encroachment, degradation of rangelands (loss of soil fertility, soil cover, loss of grazing areas) and loss of biodiversity during extreme droughts and short duration intense rain and heat events	Further deterioration of rangelands, more animal deaths, low livestock productivity. Problems with forestry fires. More bush thinning required, rangeland restorative measures imperative, over grass is necessary.	Very High – Namibia is already a semi-arid country with poorly developed soils and endemic problem of invasive plants creating serious bush encroachment e.g. by *Acacia Mellifera*	Medium – Hope rest on the effective implementation of the National Rangeland Management Policy & Strategy of 2012 which aims to restore Namibia's rangelands. It will be costly; dependent on country-wide advocacy especially to end users of natural resources.	Very High
Staple crops and cash crop production	Water stresses on rain-fed agriculture, water availability & accessibility for green scheme cash crops.	Low productivity, less nutritious crop commodities produced, input support will receive less attention due to pressures on national fiscus.	Very high – due to high temperatures hence high evaporative losses, wilting of plants, short duration rain not suited to hybrid seeds	Medium – hope rests on water harvesting from perennial rivers which are far away from the people. Underground water is saline so needs costly desalination.	Very High

Impact	Prevailing and Anticipated Hazards	Projected Climate Change	Vulnerability Assessment		
			Sensitivity	Adaptive Capacity	Vulnerability
Marketing of agricultural produce	Water & heat stress affecting amounts and quality of food produced and storage.	Investment in infrastructure wasted due to underutilization of auction pens, roads and food marketing hubs.	High – fulfilling supply contracts difficult.	Medium – need to reduce post-harvest losses, alternative plans to fulfill supply contracts, risk management.	High

6.1.5. Health

6.1.5.1. Overview of the current status of the sector

Namibia has a relatively young population (Figure 6.13). In terms of life expectancy, there is significant regional variation (NSA, 2014a). Overall life expectancy has increased since 2001, however it remains lower than in 1991 (Table 6.5). This is primarily due to the AIDS epidemic. The AIDS epidemic has also contributed to an increase in maternal mortality, from 225 deaths per 1000 live births in 1992 to 604 deaths per live births in 2012 (Namibia Statistics Agency, 2011). Over the same time period, the Infant Mortality Rate (IMR) in Namibia is declining although not sufficiently to meet WHO targets (MDG 4, reduction in child mortality). The IMR is significantly higher in rural areas (WHO, 2014d). Diarrhoea and pneumonia remain the leading causes of infant and child mortality, followed by HIV/AIDS. The high prevalence of diarrhoea is largely due to poor sanitation and hygiene practices (MoHSS, 2008).



(Index Mundi 2014)

Figure 6.13. Population Pyramid, 2014

Table 6.5. Life Expectancy by Region (Namibia 2011 Census Mortality Report)

Area	2011		2001*		1991*	
	Male	Female	Male	Female	Male	Female
Namibia	53.3	60.5	47.6	50.2	59.1	62.8
Urban	57.0	62.6	51.2	52.4	-	-
Rural	49.4	58.0	46.7	49.5	-	-

MoHSS has identified a number of key health challenges currently faced by the Namibian population through the National Health Policy Framework 2010-20 '*towards quality health and social welfare services*'; aligned to National Development Plan 3, the Ministry of Health and Social Services Strategic Plan 2009–2013, and the WHO Millennium Development Goals. (MoHSS, 2010.) Table 6.6 highlights the most significant priorities and how they will be affected by climate change. Chief amongst these is the challenge of HIV/AIDS. Tuberculosis/HIV co-infection is also common. Overall, the leading causes of deaths in public health facilities remain HIV/AIDS, TB and diarrhoea (MoHSS, 2013)

Table 6.6. Significant health priorities and how they may be affected by climate change

(as outlined in the National Health Policy Framework)

National Health Priority	Impact of Climate Change
HIV/AIDS	Interruption of ARV treatment due to migration and forced displacement of population. Increased transmission by increasingly mobile population
Sexually Transmitted Infections (STIs)	Increased transmission by increasingly mobile population.
Maternal, Neonatal and Child Health	Reduced access to antenatal and obstetric care during periods of flooding. Lack of continuity of care due to migration. Increased malnutrition amongst children. Increased incidence of water and vector borne diseases. Interruption of childhood vaccination schedule in mobile/displaced population.
Adolescent and School Health	Increased risk of mental health problems in young people due to pressures of climate change (reduced food security and employment opportunities, increased migration/forced displacement) and exposure to extreme weather events. Damage to sanitation and water facilities on school premises during flooding leading to outbreaks of water borne diseases.
Nutrition	Reduced food security leading to increased malnutrition
Endemic Diseases	Lengthening of malaria transmission season in some areas. Spread of diseases (e.g. malaria, schistosomiasis) to non-endemic areas. Increase in drug-resistant Tuberculosis due to interrupted treatment regimes.
Mental Health and Disability	Increased mental health problems due to loss of livelihoods, forced migration and pressure of maintaining agricultural output.
Lifestyle- Related Problems	Increased abuse of alcohol in populations where livelihoods/employment is lost due to climate change.
Disease Outbreaks, Disaster Related Health Problems and Emerging Diseases	Increased epidemics of water and vector borne diseases. Re-emergence of previously eliminated diseases
Health and Environment	Increasing environmental health problems. Pressure on water and sanitation systems during drought increases incidence of disease. Damage to these facilities during flooding has similar consequences.
Other Common Health Problems	Increased incidence of skin disorders due to flooding. Reduced access to primary care for chronic disorders during extreme weather events and as a result of migration/displacement.
Social Welfare	Increased reliance on 'drought relief' food supplies. Reduced access to social services and welfare systems by migrant/displaced populations.

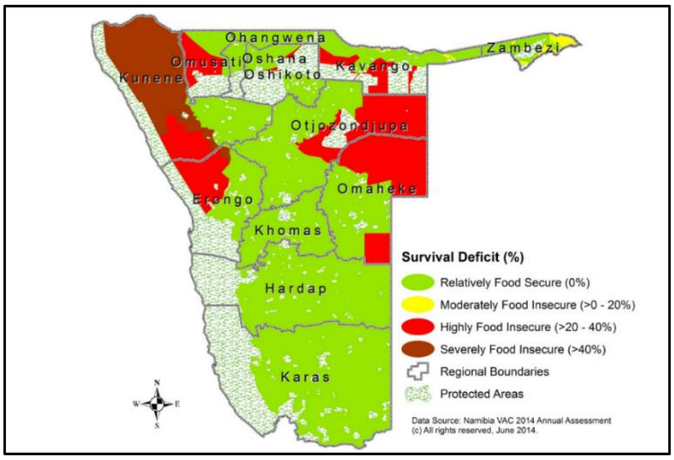
One of the major challenges to the healthcare system, which will also influence the way in which the sector responds to the challenges of climate change, is the widely distributed population. This makes healthcare infrastructure and staffing problematic. Infrastructure availability is already poor, and effectiveness is impeded by the distances. Maintenance of infrastructure, coordination of the state ambulance service, and specialist referrals are therefore often problematic.

6.1.5.2. Drivers of sensitivity

A number of factors affect the sensitivity of the healthcare system to climate change – and the extent to which exposure to changes in temperatures, rainfall patterns, extremes such as floods, and bush fires, will affect the health status of the Namibian population. Physiological sensitivity exists for extreme weather events such as bush fires, storms and flooding. On an individual level this may include the effects of death or injury from fire, floodwater or landslides. Incidence of these is likely to rise as climate variability increases.

It is likely that the incidence of heat stress will increase, causing an increase in mortality, as was demonstrated in the European heat-wave of 2003. Prolonged heat exposure can be a direct cause of death, particularly in the elderly, very young and others unable to preserve their natural thermal homeostasis. Areas at greatest sensitivity to increasing incidence of extreme high temperatures are north and central Namibia, which include the most populous areas of the country.

River floodplains will also be sensitive to the increased incidence of flooding due to extreme rainfall events. Typically the north and west of the country is most affected - including Zambezi, Kavango, Ohangwena, Omusati and Oshikoto. Khomas and Omaheke have a medium level sensitivity relative to other areas. In May 2013 12,000 people were evacuated to 13 temporary camps in the Zambezi Region due to flooding of the Zambezi River (Reliefweb International, 2013). These forced displacements, combined with heavy rainfall and contaminated water supplies are likely to increase the incidence and transmission of waterborne diseases such as cholera, typhoid fever, leptospirosis, cryptosporidium, *E. coli*, giardia, shigella and hepatitis A. As well as with cholera, physiological sensitivity varies among different groups of the population with regard to food security. As Figure 6.14 shows, high levels of food insecurity are already experienced in parts of the north of Namibia, including Omusati, Kavango, Otjozondjupa, Omaheke, Kunene and Erongo. Children are particularly at risk of food insecurity. Mothers and women of child bearing age are also particularly sensitive to malnutrition, meaning that many babies have a low birth weight and do not benefit from good quality breast milk. HIV/AIDS is also responsible for increasing rates of malnutrition amongst young children who are orphaned or are themselves infected with the disease.

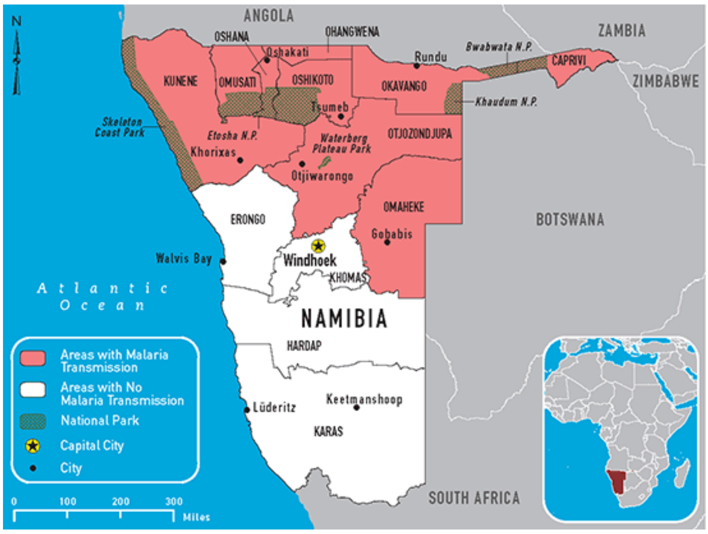


Source: UNOCHA, 2014

Figure 6.14. Existing levels of food insecurity (survival deficit)

Increasing temperatures and changes in rainfall availability will also alter the locations which are sensitive to vector-borne diseases such as malaria, dengue fever and schistosomiasis, also known as bilharzia (a parasitic disease caused by trematode flatworms of the genus *Schistosoma*), through affecting the habitat range for the vector (Husain et al., 2008; Chaves, 2010). As already discussed, population is largely concentrated in Northern regions, while southern regions have a very low population density. These sparsely populated, arid, southern regions have a malaria incidence of <1 case per 100 000 people. However, transmission rates are much higher in the north of the country, particularly (Figure 6.15).

These areas that are sensitive to malaria will likely expand under climate change, exposing a greater proportion of the population. Vector control measures have been expanded across affected areas, as has the distribution of long-lasting insecticide treated nets. 85% of malaria deaths continue to occur in children under five, making them a particularly sensitive group of the population (*Ibid*).



(CDC, 2013)

Figure 6.15. Malaria Transmission in Namibia

Quantitative data means that indicators of sensitivity can be created, highlighting the geographical sensitivity of various regions of Namibia to climate change. Three indicators are used: malaria transmission, relative food security and prevalence of diarrhoea in children. Malaria transmission was included as areas where it is already present are vulnerable to an increasing burden of disease should the transmission season become longer. Regions where the disease is present, but transmission rates relatively low, such as Omaheke, are likely to be greatly affected. Relative food insecurity is used as areas of high insecurity are most vulnerable to malnutrition as a consequence of drought. Prevalence of diarrhoea in children is used as a proxy since information on the regional incidence of a disease such as cholera is not currently available. Table 6.7 highlights the absolute and relative rankings by region based on these indicators.

Table 6.7. Regional sensitivity of the health sector to climate change

(top 5 regions in red)

Regions	Stable Malaria Transmission	Relative Food Insecurity	Diarrhoea in children	Health Sensitivity Index	Rank
Source	**CDC 2013**	**UN Office for Coordination of Humanitarian Affairs 2014**	**NSA 2014b (NDHS)**	**Computed**	**Computed**
Erongo	0.0%	50.0%	10.1%	20.0%	10
Hardap	0.0%	0.0%	7.5%	2.5%	11
Karas	0.0%	0.0%	9.6%	3.2%	12
Kavango	**100.0%**	**50.0%**	**31.8%**	**60.6%**	**2**
Khomas	0.0%	50.0%	16.4%	22.1%	9
Kunene	**100.0%**	**100.0%**	**12.4%**	**70.8%**	**1**
Ohangwena	100.0%	0.0%	15.0%	38.3%	6
Omaheke	**100.0%**	**50.0%**	**14.9%**	**55.0%**	**5**
Omusati	**100.0%**	**50.0%**	**19.2%**	**56.4%**	**3**
Oshana	100.0%	0.0%	10.2%	36.7%	8
Oshikoto	100.0%	0.0%	14.7%	38.2%	7
Otjozondjupa	**100.0%**	**50.0%**	**14.9%**	**55.0%**	**5**
Zambezi	**100.0%**	**25.0%**	**32.3%**	**52.4%**	**4**

Table 6.8. Indicators of adaptive capacity, by region in Namibia

(top 5 regions in red)

Regions	Poverty Incidence	Illiteracy rate	HIV Prevalence	Malnutrition in children < 5	Pop. w/o access to sanitation	Pop. w/o access to safe water	Pop. w/o access to health facility	% of health posts vacant	Adaptive Capacity	Adaptive Capacity Rank
	% of the population identified as poor, i.e. below a poverty line of N$377.96	% of population aged 15 and above who are illiterate	% of population 15-49 years infected with HIV	Weight for age	% of population without a toilet facility	% of HHs without access to safe drinking water	(% of HHs without access to hospital or clinic within 10 km distance)	% of health posts in clinics vacant (nurses)	Average of 8 indicators	Rank of Mal-Adaptive Capacity
Source	Poverty Dynamics 2012	2011 Pop & Housing Census	NDHS 2013	NDHS 2013	2011 Pop & Housing Census	2011 Pop & Housing Census	NHIES 09/10	Human Resources for Health 2013, 11:64	Computed	Computed
Kunene	**30.20%**	**35.10%**	**9.70%**	**14.30%**	**63.20%**	**32.90%**	**51.00%**	**76.00%**	**39.10%**	**1**
Kavango	**55.20%**	**20.60%**	**17.00%**	**17.30%**	**74.70%**	**33.90%**	**17.40%**	**36.00%**	**34.00%**	**2**
Ohangwena	**30.10%**	**13.70%**	**15.60%**	**20.60%**	**80.00%**	**43.60%**	**24.60%**	**34.00%**	**32.80%**	**3**
Oshikoto	**44.20%**	**11.80%**	**13.40%**	**25.90%**	**68.90%**	**30.30%**	**34.20%**	**28.00%**	**32.10%**	**4**
Omaheke	**31.10%**	**26.70%**	**7.30%**	**23.30%**	**60.20%**	**14.90%**	**52.30%**	**39.00%**	**31.90%**	**5**
Omusati	19.10%	12.40%	17.40%	16.50%	77.90%	48.40%	16.90%	29.00%	29.70%	6
Zambezi	50.20%	16.30%	23.70%	11.40%	73.50%	26.80%	16.20%	0.00%	27.30%	7
Otjozondjupa	33.70%	16.80%	12.00%	8.00%	38.90%	5.50%	36.30%	25.00%	22.00%	8
Oshana	19.40%	4.50%	16.10%	9.50%	46.40%	15.80%	12.00%	33.00%	19.60%	9
Hardap	26.00%	8.90%	8.20%	23.50%	34.90%	6.70%	30.30%	13.00%	18.90%	10
Karas	26.90%	3.40%	12.40%	13.60%	23.30%	7.60%	40.30%	3.00%	16.30%	11
Erongo	7.10%	3.30%	12.50%	10.80%	10.60%	3.70%	8.30%	21.00%	9.70%	12
Khomas	10.70%	2.60%	11.90%	10.20%	19.90%	1.10%	6.10%	0.00%	7.80%	13
Namibia	28.7%	11.30%	14.0%	16.1%	48.6%	20.0%	21.0%	23.0%	22.8%	
Urban	14.6%	4.4%	13.3%	10.5%	22.4%	2.3%	1.1%		9.8%	
Rural	37.4%	17.4%	15.0%	19.1%	74.0%	37.2%	36.4%		33.8%	

6.1.5.3. Adaptive capacity

Despite the sensitivity of different regions and groups of the population to climate exposure, different levels of adaptive capacity will also determine the levels of vulnerability to the health impacts of climate change. Four main categories affect the levels of adaptive capacity. These are poverty incidence, illiteracy, HIV prevalence, malnutrition, access to water and sanitation, and access to healthcare.

Table 6.9 shows the results of the indicators of adaptive capacity, by region in Namibia. The regions with the least adaptive capacity according to this index are Kunene, followed by Kavango, Ohangwena, Oshikoto and Omaheke.

6.1.5.4. Vulnerability and indicators

Regional vulnerabilities arise from the fact that some areas experience more health-related consequences of climate change than others. Some regions have more sensitivity to climate change and some have less adaptive capacity than others. In Namibia the northern regions experience the highest vulnerability to the health-related consequences of climate change. This is highlighted in Table 6.9, which combines the indicators of sensitivity and adaptive capacity to calculate vulnerability. It can be seen that Kunene is the most vulnerable region, followed by Kavango, Omaheke, Oshikoto and Ohangwena.

Table 6.9. Vulnerability of the health by region

(top 5 regions in red)

Regions	Health Sensitivity	Adaptive Capacity	Vulnerability	Rank
	Average of 3 indicators	Average of 8 indicators	Average of 11 indicators	
Source	Computed 1	Computed 2	Computed 3	Computed 4
Kunene	**70.8%**	**39.1%**	**47.7%**	**1**
Kavango	**60.6%**	**34.0%**	**41.3%**	**2**
Omaheke	**55.0%**	**31.9%**	**38.2%**	**3**
Oshikoto	**38.2%**	**32.1%**	**33.8%**	**4**
Ohangwena	**38.3%**	**32.8%**	**34.3%**	**5**
Omusati	56.4%	29.7%	37.0%	6
Zambezi	52.4%	27.3%	34.1%	7
Otjozondjupa	55.0%	22.0%	31.0%	8
Oshana	36.7%	19.6%	24.3%	9
Hardap	2.50%	18.9%	14.5%	10
Karas	3.2%	16.3%	12.7%	11
Erongo	20.0%	9.7%	12.5%	12
Khomas	22.1%	7.8%	11.7%	13

Social vulnerabilities arise from the fact that different socio-economic and demographic groups have different levels of sensitivity and adaptive capacity when exposed to climate change. In Namibia this includes the elderly and children, disabled, homeless, marginalized groups and those suffering from chronic disease such as HIV/AIDS. Remote and rural communities also experience an increased level of social vulnerability. A lack of basic infrastructure and support contributes to poor adaptive capacity. Those reliant on their immediate environment to sustain their livelihoods (such as farmers, fishermen or those reliant on veld food) are also more sensitive to change in ecosystems.

When considering the numbers of people that are vulnerable to climate change, it is possible to look at both current and projected future population figures, which gives an insight into how vulnerability is likely to change into the future. Table 6.10 shows that the areas experiencing most exposure *at the current time* (based on the 2011 census) are Ohangwena, Kavango, Omusati and Oshikoto, with Khomas in 5th place. Over time this will change as a result of population expansion and migration (Table 6.11). If population in these regions reaches anticipated levels by 2041 then the highest levels of exposure will still be in Kavango and Ohangwena but Khomas will have moved from 5th of 3rd place. This is assuming that sensitivity and adaptive capacity in all regions remains the same as it is currently.

Table 6.10. Current health vulnerability of the population

(top 5 regions in red)

Regions	Sensitivity	Adaptive Capacity	Vulnerability	Vulnerability Rank	Population 2011	Exposed Population	Rank
Source	**Computed 1**	**Computed 2**	**Computed 3**	**Computed 4**	**Census**	**Computed 5**	**Computed 6**
Erongo	20.0%	9.7%	12.5%	12	150,338	18,779	11
Hardap	2.5%	18.9%	14.5%	10	79,584	11,504	12
Karas	3.2%	16.3%	12.7%	11	77,518	9,873	13
Kavango	**60.6%**	**34.0%**	**41.3%**	**2**	**224,102**	**92,473**	**1**
Khomas	22.1%	7.8%	11.7%	13	340,997	39,959	8
Kunene	**70.8%**	**39.1%**	**47.7%**	**1**	**87,019**	**41,516**	**6**
Ohangwena	**38.3%**	**32.8%**	**34.3%**	**5**	**249,451**	**85,539**	**3**
Omaheke	**55.0%**	**31.9%**	**38.2%**	**3**	**71,478**	**27,272**	**10**
Omusati	56.4%	29.7%	37.0%	6	244,146	90,290	2
Oshana	36.7%	19.6%	24.3%	9	177,005	42,948	7
Oshikoto	**38.2%**	**32.1%**	**33.8%**	**4**	**182,435**	**61,597**	**4**
Otjozondjupa	55.0%	22.0%	31.0%	8	144,248	44,730	5
Zambezi	52.4%	27.3%	34.1%	7	90,756	30,973	9

Table 6.11. Projected health vulnerability of the population in 2041

(top 5 regions in red)

Regions	Sensitivity	Adaptive Capacity	Vulnerability	Vulnerability Rank	Population 2041	Exposed Population (Future)	Future Exposure Rank
Source	**Computed 1**	**Computed 2**	**Computed 3**	**Computed 4**	**Census**	**Computed 5**	**Computed 6**
Erongo	20.0%	9.7%	12.5%	12	349,631	43,672	10
Hardap	2.5%	18.9%	14.5%	10	125,653	18,163	12
Karas	3.2%	16.3%	12.7%	11	127,925	16,293	13
Kavango	**60.6%**	**34.0%**	**41.3%**	**2**	**314,500**	**129,774**	**1**
Khomas	22.1%	7.8%	11.7%	13	827,619	96,982	5
Kunene	**70.8%**	**39.1%**	**47.7%**	**1**	**162,453**	**77,505**	**6**
Ohangwena	**38.3%**	**32.8%**	**34.3%**	**5**	**314,469**	**107,834**	**2**
Omaheke	**55.0%**	**31.9%**	**38.2%**	**3**	**83,765**	**31,960**	**11**
Omusati	**56.4%**	**29.7%**	**37.0%**	**4**	**284,887**	**105,356**	**4**
Oshana	36.7%	19.6%	24.3%	9	251,506	61,025	7
Oshikoto	38.2%	32.1%	33.8%	7	263,828	89,078	3
Otjozondjupa	55.0%	22.0%	31.0%	8	195,836	60,727	8
Zambezi	52.4%	27.3%	34.1%	6	141,637	48,337	9

6.1.6. Tourism

6.1.6.1. Overview of the current status of the sector

Tourism is one of the fastest growing sectors within the economy. The drivers of growth includes the country's unique landscapes and biodiversity coupled with socioeconomic and political stability. The tourism sector directly and indirectly contributed 3.9% and 15.7%, respectively, to national GDP; and 5.3% and 19.7% to employment in 2011 (Namibian Tourism Satellite Account, 2012). International tourism predominates in Namibia, with a steady increase in arrivals from the mid-1990s to 2012, and dwarves the role of domestic tourism. Based on official statistics 2012/13 statistics, Table 6.12 shows the number of foreign tourist arrivals disaggregated by country of residency and purpose of visiting Namibia.

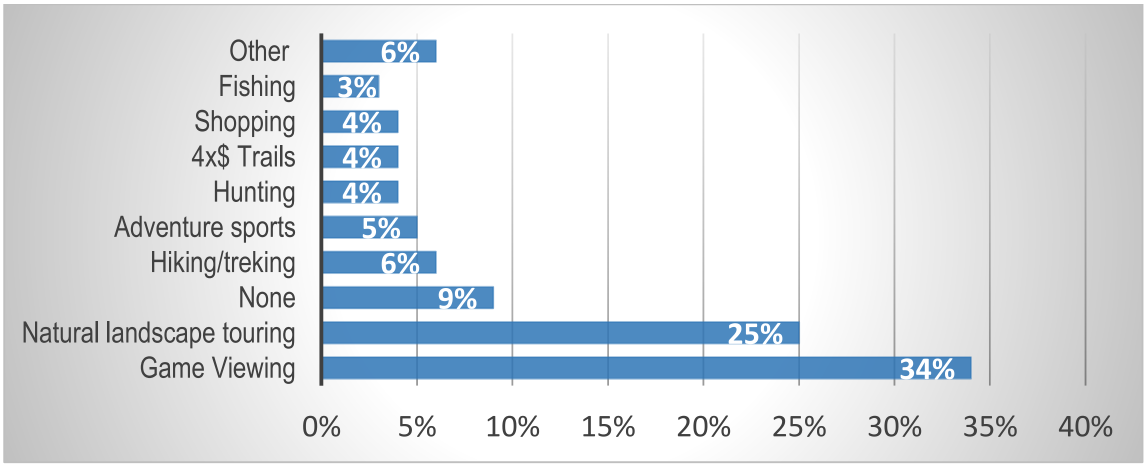
Table 6.12. Numbers of foreign tourist arrivals by country of residency and purpose of visit

Country of Residency	Total	Holiday	VFR	Business	Medical	Other
RSA	28.3%	36.3%	35.7%	19.2%	0.1%	6.2%
Botswana	3.6%	0.8%	6.3%	4.9%	1.0%	9.5%
Angola	35.8%	10.2%	37.7%	51.4%	98.9%	69.0%
Zimbabwe	4.1%	0.8%	3.2%	10.9%	0.0%	2.3%
United Kingdom	1.9%	3.4%	0.6%	1.5%	0.0%	0.0%
Germany	7.7%	16.6%	3.4%	1.8%	0.0%	1.0%
France	1.4%	3.1%	0.2%	0.4%	0.0%	0.3%
Italy	1.1%	2.7%	0.0%	0.2%	0.0%	0.0%
USA	1.6%	3.3%	0.6%	0.7%	0.0%	0.0%
Other[1]	14.6%	22.7%	12.2%	9.2%	0.0%	11.7%

Source: MET, 2013

The competitiveness of Namibia as a tourist destinations stems largely from it climate resource and natural resource assets. From tourism exit surveys, it is also clear that nature/landscape touring and game viewing are the predominant foreign visitor activities, both among tourists generally and among holiday and leisure seekers in particular (Figure 5.16). The Etosha National Park is the most visited National Park, with 22% of all tourists travelling there, and 53% of all holiday tourists.

[1] Note that the "Other" Country of Residence group is relatively small (only 3% of all respondents). Most (69%) of these were from Angola, of which 54% were in transit, 39% were shopping, and 7% were travelling for religious purposes.



Tourist Exit Survey, 2013)

Figure 6.16. Activities undertaken by holiday and leisure tourists

6.1.6.2. Tourism exposure index

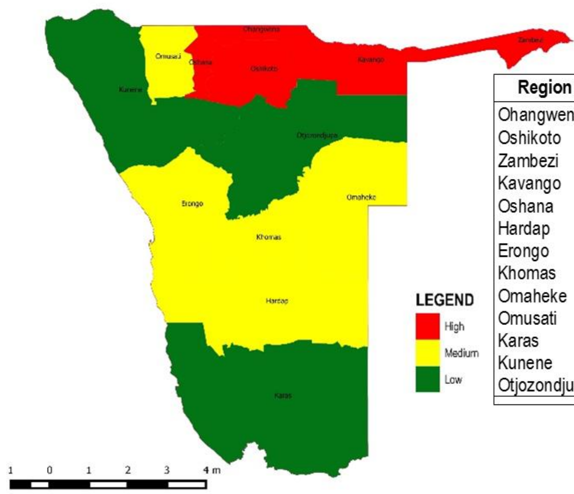
Exposure, is conceptualized here, as the degree or magnitude to which the multisystem (tourism sector and the human system in Namibia) is exposed to the following climate change related stimuli: droughts, floods and extreme temperature. For estimation of the tourism vulnerability index, exposure was further contextualized into current and future exposure. The following are the indicators that were used for current exposure:

The frequency of drought events for the period 1949 to 2009 in each of the 13 regions of Namibia. The rationale for selecting this indicator is that drought negatively affects tourism through its indirect impacts on the natural resource capital of tourism such as wildlife. The hypothesized assumption is that the higher the frequency of drought in a region the greater the vulnerability.

The frequency of flood events for the period 1949 to 2009 in each of the 13 regions of Namibia. Floods negatively affects tourism through its indirect impacts on infrastructure, accessibility, biodiversity and wildlife. The hypothesized assumption is that the higher the frequency of floods in a region the greater the vulnerability.

The suitability of the climate resource, in each of the 13 regions of Namibia, for outdoor tourism activities – as measure by the TCI for the period 1901 to 2009. The suitability and attractiveness of a geographical area for outdoor tourism activities largely depends on the climate resource. The lower the index the higher the vulnerability. Therefore the inverse of the index was used so that it is in the same direction as other indicators.

The Current Exposure sub-index was created by summing up the indicators under the Current Exposure category (Table 5.16). Using the estimated sub-index, the regions were then ranked in descending order – where the highest ranked region has a tourism sector that is highly exposed to climate stressor (Figure 6.17). For the purpose of presenting the results clearly, the estimated sub-index was further recoded into three categories: High Exposure (rank 1 to 5); Medium Exposure (rank 6 to 9); and Low Exposure (rank 10 to 13). Figure 6.17 shows the tourism sectors in the Ohangwena, Oshikoto, Zambezi, Kavango and Oshana region are the most at risk to current climate stress. The least exposed to climate stress are the tourism sectors in the Karas, Kunene and Otjozondjupa regions.



Region	Score	Rank	Category
Ohangwena	1.118	1	High
Oshikoto	1.077	2	High
Zambezi	0.813	3	High
Kavango	0.805	4	High
Oshana	0.788	5	High
Hardap	0.780	6	Medium
Erongo	0.777	7	Medium
Khomas	0.772	8	Medium
Omaheke	0.772	8	Medium
Omusati	0.772	8	Medium
Karas	0.747	11	Low
Kunene	0.730	12	Low
Otjozondjupa	0.713	13	Low

Figure 6.17. Current exposure to climate related stressors of the tourism sector across Namibia

(The red, yellow and green colours indicates high, medium and low exposure regions, respectively)

For future exposure, the following indicators were used:

The aridity index (AI) for the period 2035 to 2065. AI is a numerical indicator of the degree of dryness of the climate at a given location. This indicator was used as a proxy for drought frequency for the mid-century period. Aridity negatively affects tourism through its indirect impacts on natural resource of the sector such as the scenic beauty of landscapes. The lower the index the higher the vulnerability. Therefore the inverse of this index was used so that it is in the same direction as other indicators.

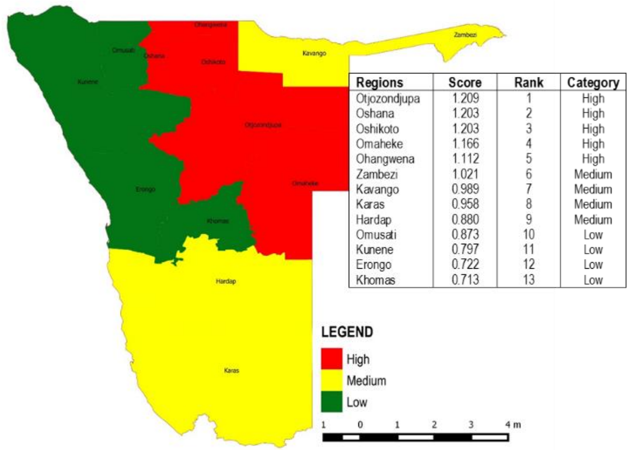
The projected median change in the annual frequency of very hot days (maximum temperature exceeding 350C) over Namibia for period 2035 – 2065 relative to 1961 – 2000 period. Extreme temperatures negatively affects tourism through its indirect impacts on the health of tourists and biodiversity. The higher the frequency, the greater the vulnerability.

The percentage of tourism properties and associated infrastructure are likely to be directly affected by the sea level rise in 2030. Sea level rise will negatively affect the tourism through its indirect impacts on infrastructure and accessibility in coastal areas. The higher the percentage of tourism properties and infrastructure likely to be affected by sea level rise, the greater the vulnerability.

Tourism Climate Index (TCI) for the period 2035 to 2065 is used as a proxy for the suitability of the climate resource of an area for outdoor tourism activities. Changes in the suitability of the climate resource of a destination, affects the destination's attractiveness for outdoor tourism activities. The lower the index the higher the vulnerability. Therefore the inverse of the index is used so that it is in the same direction as other indicators

The Future Exposure sub-index was created by summing up all the indicators in the Future Exposure category. The created sub-index was ranked and classified using the same procedure as described above. Figure 6.18

shows that the top five regions whose regional tourism sectors will have high exposure to future climate stressor are Otjozondjupa, Oshana, Oshikoto, Omaheke and Ohangwena. The least exposed are the tourism sectors in the Hardap, Omusati, Kunene, Erongo and Khomas regions.



Regions	Score	Rank	Category
Otjozondjupa	1.209	1	High
Oshana	1.203	2	High
Oshikoto	1.203	3	High
Omaheke	1.166	4	High
Ohangwena	1.112	5	High
Zambezi	1.021	6	Medium
Kavango	0.989	7	Medium
Karas	0.958	8	Medium
Hardap	0.880	9	Medium
Omusati	0.873	10	Low
Kunene	0.797	11	Low
Erongo	0.722	12	Low
Khomas	0.713	13	Low

Figure 6.18. Future exposure to climate related stressors of the tourism sector across Namibia

(The red, yellow and green colours indicates high, medium and low exposure regions, respectively)

6.1.6.3. Drivers of sensitivity

The climate change impacts that affect tourism destinations, their competitiveness and sustainability can be classified into four broad categories, i.e. direct climate impacts, indirect environmental impacts, impacts of mitigation policies on tourist mobility and indirect societal change impacts.

Climate is a principal resource for tourism, and it codetermines the suitability of locations for a wide range of tourist activities. Climate is also a principal driver of global seasonality in tourism demand, and has an important influence on operating costs, such as heating-cooling, food and water supply and insurance costs, *inter alia*. According to Hamilton (et al., 2005), a decline in international tourist in the mid-century is projected for Namibia.

Increases in the frequency or magnitude of certain weather and climate extremes (e.g. heat waves, droughts, floods, tropical cyclones) are likely as a result of projected climate change. In Namibia there are currently three significant tourist attractions sites that are located at the coast – thus: Sandwich Harbour, the wrecks of the Skeleton Coast and Walvis Bay lagoon with its Ramsar site. Even under the IPCC's best case scenario of an 85% reduction in emissions, a sea level increase of 0.4m to 1.4m points to the erosion of these coastal landmarks to the point where they cease to be effective attractions, or cease to exist altogether (Sea Level Rise Report, 2010). Table 5.15 provides an overview of key climate hazards and their impacts on the tourism sector.

National or international mitigation policies – that is policies that seek to reduce GHG emissions – may have an impact on tourist flows (Simpson et al., 2008a; Gössling et al., 2008b). Namibia is among the long-haul destinations that might be affected by the mitigation policies – which would consequently adversely impact the country's tourism economy (Second National Communication, 2008).

Climate change is thought to pose a risk to future economic growth and to the political stability of some nations. Any such reduction of global GDP due to climate change would reduce the discretionary wealth available to consumers for tourism and have negative implications for anticipated future growth in tourism. Since there is high dependence on international tourism, Namibia is sensitive to global economic growth and its effects on disposable income in source countries.

Namibia's National Circumstances Report (2008) concluded that climate change will mostly impact the country's tourism sector indirectly through changes in water and vegetation, as well as through wider-scale socioeconomic change – for example, fuel prices and patterns of demand for specific activities or destinations. Other indirect impacts may include changes in landscape (including the climate) – the "capital" of tourism, which might lead potential tourists to perceive Namibia as less attractive and consequently to seek new destinations elsewhere.

Table 6.13. Main impacts of climate change and their implications for tourism

Impacts	Implications for Tourism
Warmer temperatures	Altered seasonality, heat stress for tourists, cooling costs, changes in: plant wildlife - insect populations and distribution range, infectious disease ranges
Increasing frequency and intensity of extreme storms	Risk for tourism facilities, increased insurance costs/loss of insurability, business interruption costs
Reduced precipitation and increased evaporation in some regions	Water shortages, competition over water between tourism and other sectors, desertification, increased wildfires threatening infrastructure and affecting demand
Increased frequency of heavy precipitation in some regions	Flooding damage to historic architectural and cultural assets, damage to tourism infrastructure, altered seasonality (beaches, biodiversity, river flow)
Sea level rise	Coastal erosion, loss of beach area, higher costs to protect and maintain waterfronts and sea defences
Changes in terrestrial and marine biodiversity	Loss of natural attractions and species from destinations, higher risk of diseases in tropical-subtropical countries
More frequent and larger forest fires	Loss of natural attractions, increase of flooding risk, damage to tourism infrastructure
Soil changes (such as moisture levels, erosion and acidity)	Loss of archaeological assets and other natural resources, with impacts on destination attractions.

Source: (WTO-UNEP-WMO, 2008)

One of the most popular and commonly used metric indicator is the Tourism Climatic Index (TCI) developed by Mieczkowski (1985). The TCI is favoured as an index because it is one of the most comprehensive metrics, integrating all three facets of climate considered relevant for tourism. The climatic factors identified as having the most impact on tourism are temperature, sunshine, radiation, precipitation, wind, humidity and fog (Stern, 2006; Hamilton and Lau, 2004). The TCI was calculated for Namibia. The assessment methodology that is used starts by estimating the TCI for the baseline period (1901 – 2009), and compares this baseline TCI to the mid-century (2045 – 2065) TCI. The differences between the baseline TCI and the mid-century TCI is the attributed to the impact of climate change on the climate resource.

The results clearly indicates that, for the baseline period, Namibia's climate resource is generally ranked Very Good and Good on the TCI mapping category. This means that the country's climate resource is currently very suitable for outdoor tourism activities such as game viewing, sightseeing and trekking. Figure 6.19 shows that the TCI scores across Namibia fall within the two ordinal ranks of Very Good and Good and Acceptable, with the majority of the country having a climate resource acceptable for outdoor tourism activities. This means that the suitability of Namibia's climate resource will decline in the mid-century for outdoor recreation and tourism activities when moving from the coast in-land – in the eastern direction. The second major conclusion is that, given that there is no change (i.e. between the baseline and mid-century periods) in the TCI category for climate resource around the coastal areas of Namibia. It can be stated with medium confidence that Namibian climate resource around the coastal areas are more resilient to climate change compared to the climate resource of in-land areas. The third major conclusion is that it can be stated with medium confidence that by the mid-century the administrative regions of Erongo, Kunene, Omusati, part Khomas and Karas will have a competitive advantage, in terms of suitability of their climate resource for outdoor tourism activities, compared to the administrative regions of Hardap, Kavango Ohangwena, Otjozondjupa, Omaheke, Oshana, Oshikoto and Zambezi.

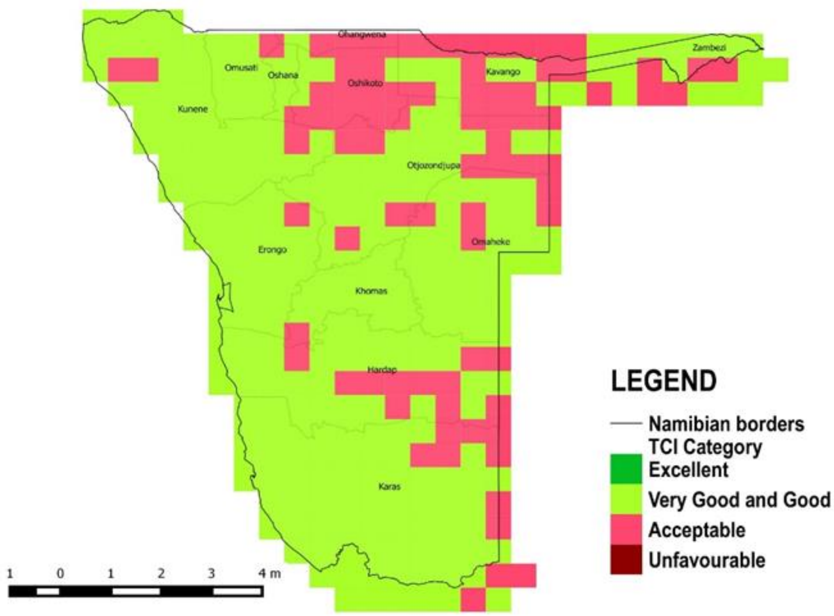


Figure 6.19. Suitability of Namibia's climate resource for outdoor tourism activities in the baseline period

(based on annual TCI scores)

Using the TCI score map for the mid-century (Figure 6.20), the impact of climate change on the climate resource for community conservancies across Namibia can be assessed. The impact of climate change on the conservancies' climate resources will indirectly reduce the attractiveness of the conservancies as tourist destinations. Therefore, by overlaying the spatial map for community conservancies with that of the estimated TCI score map for the mid-century – it can be inferred with medium confidence that by the mid-century about 75% of community conservancies in Namibia will experience a decline in the suitability of their climate resource for outdoor tourism activities (Figure 6.21). This decline in the suitability of the climate resource might be translated into a decline in the number of visitors to these conservancies – and this will ultimately affect the rural livelihoods that demand on tourism.

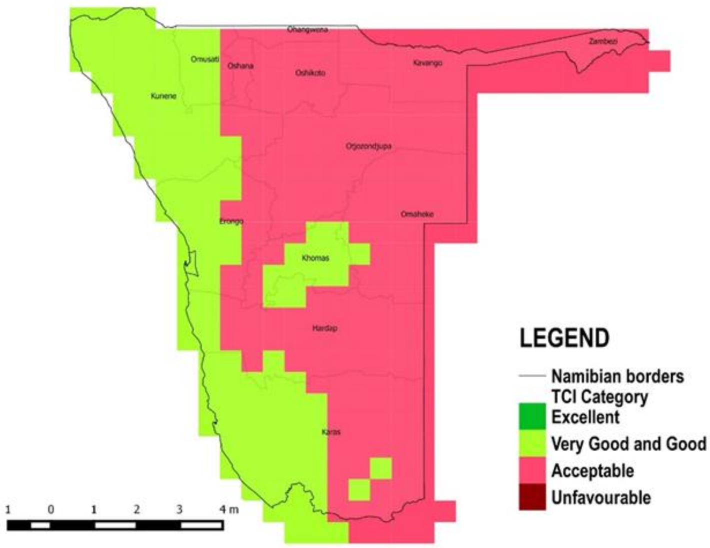


Figure 6.20. Suitability of Namibia's climate resource for outdoor tourism activities in the mid-century

(based on annual TCI scores)

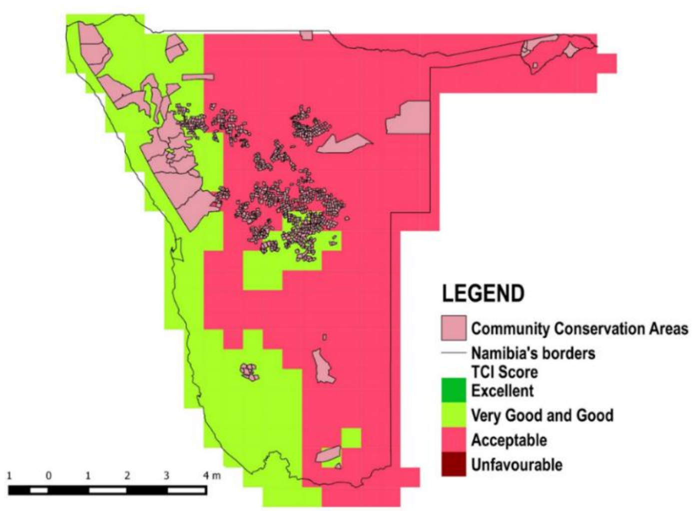


Figure 6.21. The suitability Community Conservancies' climate resource for outdoor tourism activities in the mid-century period

Sensitivity is the degree to which a given system is affected by climatic stressors. For this study, the system was conceptualized as an integrated multisystem consisting of a geographical area, human system and economic system – i.e., tourism sector. The following indicators were used (see also Table 5.16):

The proportion, expressed in percentage terms, of the number of jobs in the tourism sector to total employment disaggregated by regions. Employment in the tourism sector is sensitive to the impacts of climate change on the sector. The higher the proportion the greater the sensitivity, and hence the greater the vulnerability.

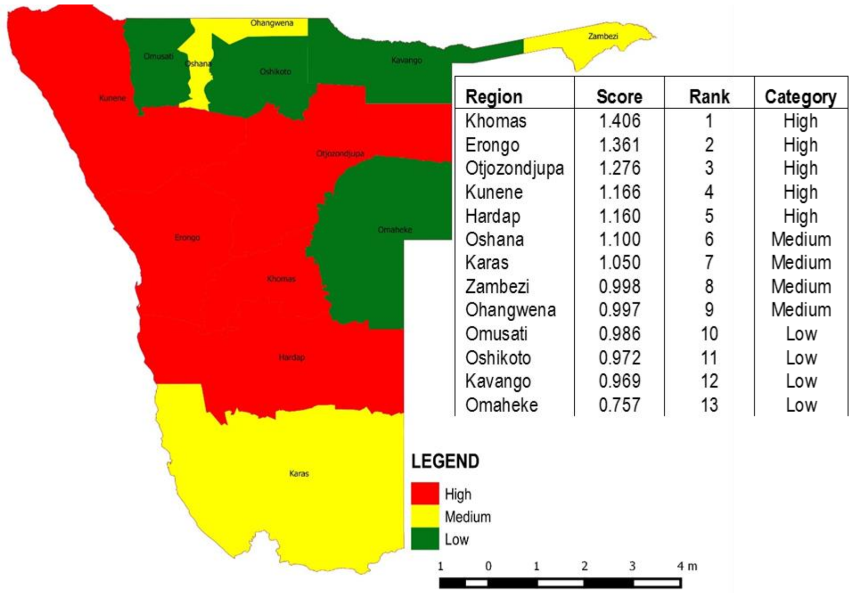
The proportion, expressed in percentage terms, of the number of unskilled labour force (i.e., labour force whose education attainment is less than grade 10) to the total labour force in the tourism sector. Climate change impacts on the tourism sector is likely to lead to job losses. In most cases, the unskilled labour segment of the total employment is the most affected. The higher the proportion the greater the sensitivity, and hence the greater the vulnerability.

The proportion, expressed in percentage terms, of the households whose main source of income is tourism, to the total number of households. Households whose livelihood depends on the tourism sector are sensitivity to the impacts of climate change on the sector. The higher the proportion the greater the sensitivity, and hence the greater the vulnerability.

The proportion of lodges in the region expressed as a percentage of the total number of lodges in the country. This indicator is used as a proxy for tourism economic activities. A high number of lodges in a region implies that tourism is an important sector in the economy of the region. Hence by extension, the region's economy is sensitivity to climate change impacts on the tourism sector. The higher the proportion the greater the sensitivity, and hence the greater the vulnerability.

The proportion of international tourists that visit the region. It is projected that climate change will reduce the number of incoming tourists. Therefore tourist destinations in Namibia are likely to be the hardest affected. The higher the proportion the greater the sensitivity, and hence the greater the vulnerability.

The sensitivity sub-index shows that the tourism sectors in the Khomas, Erongo, Otjozondjupa, Kunene and Hardap regions are highly sensitive to climate change stressors compared to the other regions (Figure 6.22). These regions are highly sensitive because of their close linkages to the tourism sector in terms of number of jobs, livelihood supported and number of lodges, *inter alia*. The least sensitive are the tourism sectors in the Omusati, Oshikoto, Kavango and Omaheke.



Region	Score	Rank	Category
Khomas	1.406	1	High
Erongo	1.361	2	High
Otjozondjupa	1.276	3	High
Kunene	1.166	4	High
Hardap	1.160	5	High
Oshana	1.100	6	Medium
Karas	1.050	7	Medium
Zambezi	0.998	8	Medium
Ohangwena	0.997	9	Medium
Omusati	0.986	10	Low
Oshikoto	0.972	11	Low
Kavango	0.969	12	Low
Omaheke	0.757	13	Low

Figure 6.22. Sensitivity to climate change impacts of the tourism sector across Namibia

(The red, yellow and green colours indicates high, medium and low sensitivity regions, respectively)

6.1.6.4. Adaptive capacity

Adaptive capacity is defined as the ability of a system [human or natural] to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. The following are the adaptive capacity indicators that were used (see also Table 5.16):

Poverty incidence. The proportion of the population identified as poor. Given a poverty line of N$377.96, the poverty incidence is the proportion of the population whose monthly consumption is less than N$377.96. Poverty reduces the adaptive capacity of an individual, household and the community. The higher the poverty incidence the lower the adaptive capacity, and hence the greater the vulnerability.

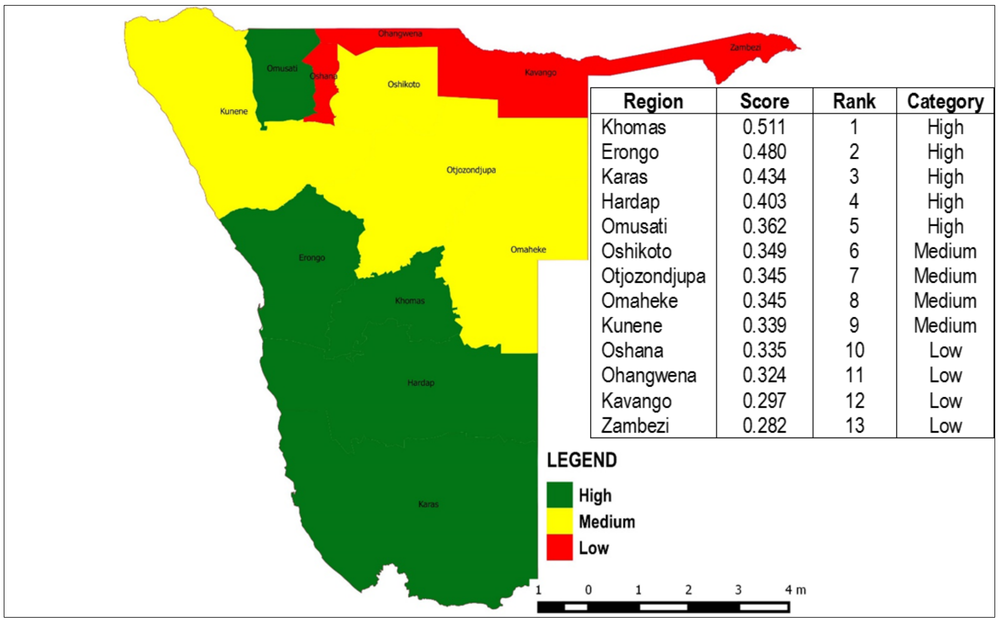
The proportion of tourism households with a single source of income. Household with diversified sources of livelihoods have a high adaptive capacity. The higher the proportion of households with a single source of income lower the adaptive capacity, and hence the higher the vulnerability.

The proportion of the population that cannot read and write. Research shows that literate people have high adaptive capacity than illiterate people. The higher the proportion of illiterate population the lower the adaptive capacity, and hence the higher the vulnerability.

Deprived Access Index. This index was estimated as the proportion, expressed in percentage terms, of the population with deprived access to a radio, television set and/or cell phone. Research shows access to communication assets such as cell phone, radio and television sets increases the adaptive capacity. For this study, only the access proxy is used, as it is difficult to determine the use of climate-related information among the population. The higher the proportion of deprivation the lower the adaptive capacity, and hence the higher the vulnerability.

Human Development Index (HDI). HDI was used as a proxy to show comparative development across the regions. Research shows that the higher the HDI the higher the adaptive capacity of the society. The higher the HDI the higher the adaptive capacity, and hence the lower the vulnerability. Therefore the inverse of the HDI index is used in the estimation of tourism vulnerability.

The Adaptive Capacity sub-index indicates that Khomas, Erongo, Karas, Hardap and Omusati have tourism sectors that have high adaptive capacity to climate change (Figure 6.23). Tourism sectors in the Oshana, Ohangwena, Kavango and Zambezi have low adaptive capacity. Regional tourism sectors with low adaptive capacity are likely to be largely affected by climate change impacts, while those with high adaptive capacity are likely to be more resilient to climate change impacts.



Region	Score	Rank	Category
Khomas	0.511	1	High
Erongo	0.480	2	High
Karas	0.434	3	High
Hardap	0.403	4	High
Omusati	0.362	5	High
Oshikoto	0.349	6	Medium
Otjozondjupa	0.345	7	Medium
Omaheke	0.345	8	Medium
Kunene	0.339	9	Medium
Oshana	0.335	10	Low
Ohangwena	0.324	11	Low
Kavango	0.297	12	Low
Zambezi	0.282	13	Low

Figure 6.23. Adaptive capacity to climate change impacts of the tourism sector across Namibia

(The red, yellow and green colours indicates high, medium and low sensitivity regions, respectively)

6.1.6.5. Vulnerability and indicators

Table 6.14. Summary of tourism indicators, rationale and data source

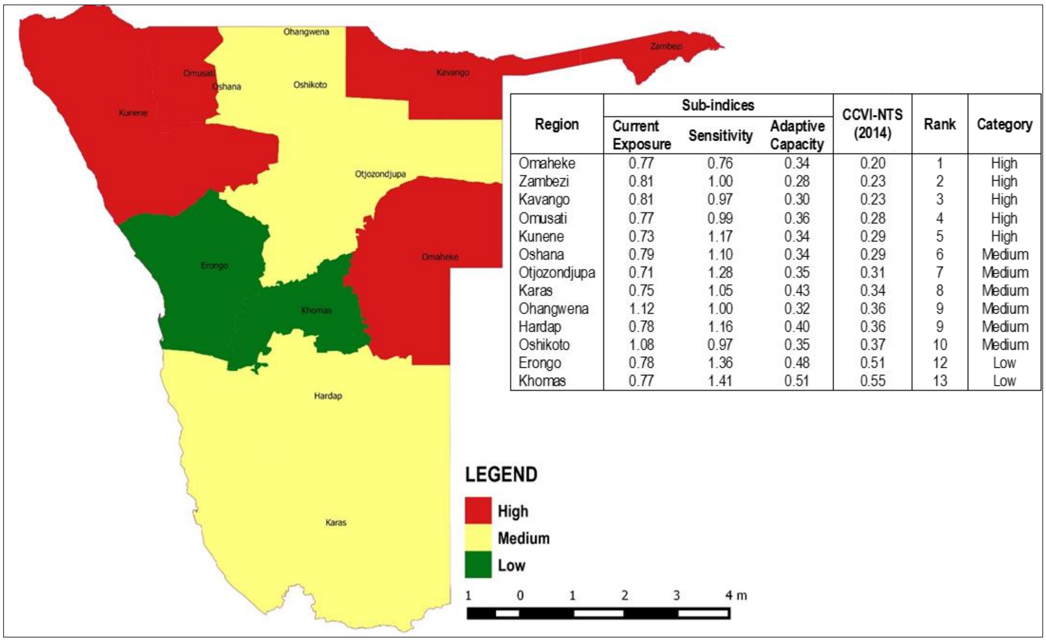
Category	Indicator	Rationale for selection	Description of Indicator	Hypothesised functional relationship between Indicator & vulnerability	Data source
Exposure (current)	Drought	Drought negatively affects tourism through its indirect impacts on the natural resource capital of tourism such as wildlife.	The frequency of drought event for the period 1949 to 2009 in each of the 13 regions of Namibia	The higher the frequency the greater the vulnerability	Gilau et al. (2011)
	Floods	Flood negatively affects tourism through its indirect impacts on infrastructure and accessibility.	The frequency of flood event for the period 1949 to 2009 in each of the 13 regions of Namibia	The higher the frequency the greater the vulnerability	Gilau et al. (2011)
	Tourism Climate Index (TCI) for the period 1901 to 2009	Changes in the suitability of the climate resource of a destination, affects the destination's attractiveness for outdoor tourism activities.	The suitability of the climate resource of an area for outdoor tourism activities	The lower the index the higher the vulnerability. Therefore the inverse of the index is so that it is in the same direction as other indicators	Generated by this study – Chapter 4
Exposure (Future)	Aridity Index	Aridity negatively affects tourism through its indirect impacts on natural resource of the sector such as the scenic beauty of landscapes.	The aridity index (AI) is a numerical indicator of the degree of dryness of the climate at a given location.	The lower the index the higher the vulnerability. Therefore the inverse of the index is so that it is in the same direction as other indicators	Climate Wizard – World Bank, CIAT
	Extreme temperature	Extreme temperatures negatively affects tourism through its indirect impacts on the health of tourists and biodiversity.	The projected median change in the annual frequency of very hot days (maximum temperature exceeding 35^{0}C) over Namibia for period 2035 – 2065 relative to 1961 – 2000 period	The higher the frequency, the greater the vulnerability	Climate risk and Vulnerability: A handbook for Southern Africa – Davis (2011)
	Sea level rise	Sea level rise will negatively affect the tourism through its indirect impacts on infrastructure and accessibility in coastal areas.	The percentage of properties that will be directly impacted by the sea level rise in 2030	The higher the percentage of sea level rise, the greater the vulnerability	Coastal impact study of sea level rise in Namibia – MET/UNDP (2009)
	Tourism Climate Index (TCI) for period 2035 to 2065	Changes in the suitability of the climate resource of a destination, affects the destination's attractiveness for outdoor tourism activities.	The suitability of the climate resource of an area for outdoor tourism activities	The lower the index the higher the vulnerability. Therefore the inverse of the index is so that it is in the same direction as other indicators	Generated by this study
Sensitivity	Employment in the tourism sector	Employment in the tourism sector is sensitivity to the impacts of climate change on the sector.	It is the proportion, expressed in percentage terms, of the number of jobs in the tourism sector to total employment.	The higher the proportion the greater the sensitivity, and hence the greater the vulnerability	Estimated from the National Labour Force Survey 2012 – Namibia Statistics Agency

Category	Indicator	Rationale for selection	Description of Indicator	Hypothesised functional relationship between Indicator & vulnerability	Data source
	Number of unskilled labour in the tourism sector	Climate change impacts on the tourism sector is likely to lead to job losses. In most cases, the unskilled labour segment of the total employment is the most affected	It is the proportion, expressed in percentage terms, of the number of unskilled labour force (i.e., labour force whose education attainment is less than grade 10) to the total labour force in the tourism sector	The higher the proportion the greater the sensitivity, and hence the greater the vulnerability	Estimated from the National Labour Force Survey 2012 – Namibia Statistics Agency
	Livelihoods supported by the tourism sector	Households whose livelihood depends on the tourism sector are sensitivity to the impacts of climate change on the sector.	It is the ratio, expressed in percentage terms, of the households whose main source of income is tourism, to the total number of households	The higher the proportion the greater the sensitivity, and hence the greater the vulnerability	Estimated from the National Household Income and Expenditure Survey (NHIES) 2009/2010 – Namibia Statistics Agency
	Number of lodges	This indicator is used as a proxy for tourism economic activities. A high number of lodges in a region implies that tourism is an important sector in the economy of the region. Hence by extension, the region's economy is sensitivity to climate change impacts on the tourism sector.	It is the proportion of lodges in the region expressed as a percentage of the total number of lodges in the country	The higher the proportion the greater the sensitivity, and hence the greater the vulnerability	Estimated from reports by Namibia Statistics Agency and the Namibia Tourism Board
	Number of international tourists visiting the region	It is projected that climate change will reduce the number of incoming tourists. Therefore tourist destinations in Namibia are likely to be the hardest affected	It is the proportion of international tourists that visit the region	The higher the proportion the greater the sensitivity, and hence the greater the vulnerability	Estimated from the Tourist Exit Survey Report – MET (2012).
Adaptive Capacity	Poverty Incidence	Poverty reduces the adaptive capacity of an individual, household and the community.	Poverty incidence is the proportion of the population identified as poor. Given a poverty line of N$377.96, the poverty incidence is the proportion of the population whose monthly consumption is less than N$377.96	The higher the poverty incidence the lower the adaptive capacity, and hence the greater the vulnerability	Data extracted from the Poverty Dynamics Report in Namibia – Namibia Statistics Agency (2012)
	Households with a single source of livelihood	Household with diversified sources of livelihoods have a high adaptive capacity	It is the proportion of households with a single source of income.	The higher the proportion of households with a single source of income lower the adaptive capacity, and hence the higher the vulnerability	Estimated from the National Household Income and Expenditure Survey (NHIES) 2009/2010 – Namibia Statistics Agency
	Illiteracy	Research shows that literate people have high adaptive capacity than illiterate people	It is the proportion of the population that cannot read and write	The higher the proportion of illiterate population the lower the adaptive capacity, and hence the higher the vulnerability	Estimated from the National Household Income and Expenditure Survey (NHIES) 2009/2010 – Namibia Statistics Agency
	Deprived Access Index	Research shows access to communication assets such as cell	It is proportion, expressed in percentage terms, of the population with deprived	The higher the proportion of deprivation the lower the adaptive	Estimated from the National Household Income and Expenditure

Category	Indicator	Rationale for selection	Description of Indicator	Hypothesised functional relationship between Indicator & vulnerability	Data source
		phone, radio and television sets increases the adaptive capacity. For this study, the only the access proxy is used, as it is difficult to determine the use of climate-related information among the population.	access to a radio, television set and/or cell phone.	capacity, and hence the higher the vulnerability	Survey (NHIES) 2009/2010 Data sets – NSA (2010)
	Human Development Index (HDI)	Research shows that the higher the HDI the higher the adaptive capacity of the society	It shows the comparative development among the regions	The higher the HDI the higher the adaptive capacity, and hence the lower the vulnerability. Therefore the inverse of the HDI index is used in the estimation of tourism vulnerability	Extracted from the Poverty Dynamics report in Namibia – NSA (2012).

Current assessment of spatial vulnerability hotspots for the Namibian tourism sector were identified using the estimated CCVI-NTS for the current time, combining exposure (in section 5.1), and sensitivity and adaptive capacity. The current vulnerability hotspots for the tourism sector in Namibia were identified to be the Omaheke, Zambezi, Kavango, Omusati and Kunene regions (Figure 6.24). These regions' tourism sectors have high current exposure, high sensitivity and low adaptive capacity to climate stressor relative to the other regions. Therefore it can be concluded that the tourism sector is relatively highly vulnerable in the five regions mentioned above, compared to other regions in Namibia.

The tourism sector in the Oshana, Otjozondjupa, Karas, Ohangwena, Hardap and Oshikoto regions have medium vulnerability to climate change related stressors (Figure 6.24). These regions have medium vulnerability on the account that they have high adaptive capacity relative to the regions with high vulnerability. The regions with low vulnerability to climate change related stressors are the Khomas and Erongo regions (see Figure 6.24). The low vulnerability in the Khomas and Erongo regions can be attributed to the regions' high adaptive capacity relative to the other regions.



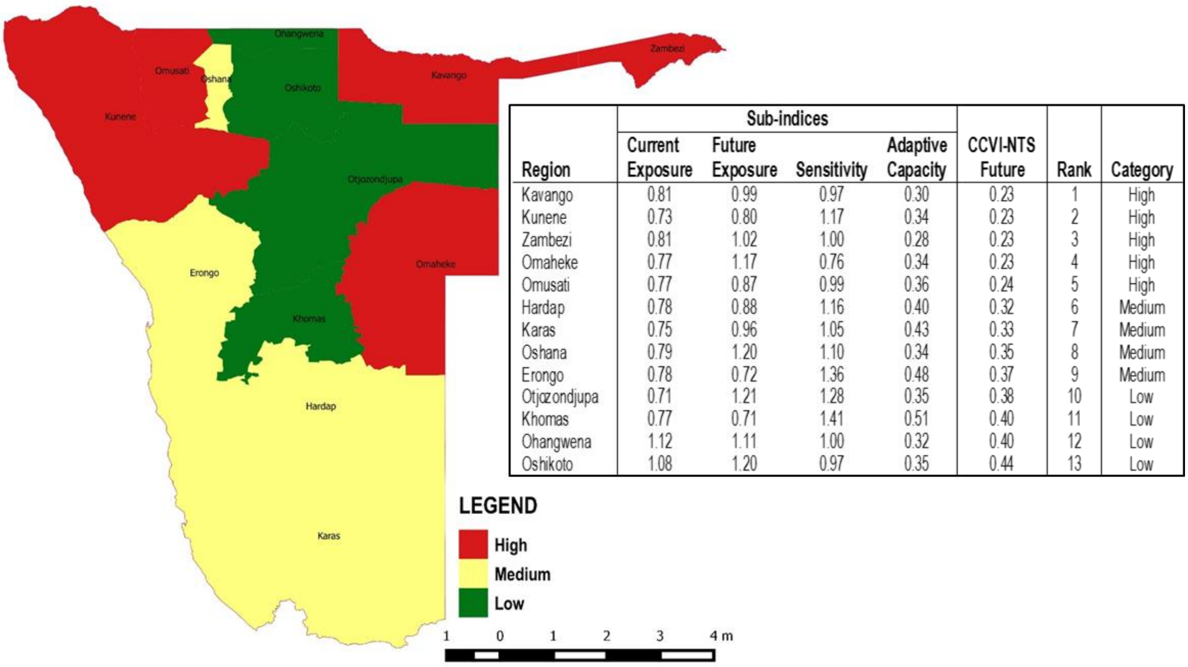
Region	Sub-indices			CCVI-NTS (2014)	Rank	Category
	Current Exposure	Sensitivity	Adaptive Capacity			
Omaheke	0.77	0.76	0.34	0.20	1	High
Zambezi	0.81	1.00	0.28	0.23	2	High
Kavango	0.81	0.97	0.30	0.23	3	High
Omusati	0.77	0.99	0.36	0.28	4	High
Kunene	0.73	1.17	0.34	0.29	5	High
Oshana	0.79	1.10	0.34	0.29	6	Medium
Otjozondjupa	0.71	1.28	0.35	0.31	7	Medium
Karas	0.75	1.05	0.43	0.34	8	Medium
Ohangwena	1.12	1.00	0.32	0.36	9	Medium
Hardap	0.78	1.16	0.40	0.36	9	Medium
Oshikoto	1.08	0.97	0.35	0.37	10	Medium
Erongo	0.78	1.36	0.48	0.51	12	Low
Khomas	0.77	1.41	0.51	0.55	13	Low

Figure 6.24. Current climate change vulnerability hotspots for the tourism sector across Namibia

(The red, yellow and green colours indicates high, medium and low sensitivity regions, respectively)

Since the Erongo and Khomas regions are the top most destinations for both international and domestic tourism, and that these regions also have low vulnerability to climate change impacts – it can be concluded that the tourism sector in Namibia is to some extent resilient to climate change impacts. The second conclusion is that in the medium term the results can be used to allocate tourism adaptation investments in regions, with priority given to regions with high vulnerability.

Future vulnerability was also estimated using climate projections for 2045-2065 (an ensemble of 9 Global Climate Models), assuming that sensitivity and adaptive capacity do not change. On the basis of the estimated CCVI-NTS, the future vulnerability hot spots for the tourism sector in Namibia were identified to be the same five regions as currently, namely Kavango, Kunene, Zambezi, Omaheke and Omusati regions. However, it is expected that climate change will exacerbate the vulnerability degree of these regions (Figure 6.25 and Table 6.17). The degree of vulnerability of the tourism sector is expected to increase in the regions of Erongo (29% increases), Hardap (40% increase), Karas (13% increase), Kavango (100% increase), Khomas (17% increase) and Kunene (86% increase) from the current period to the mid-century period (see the last 2 columns in Table 6.16). The largest vulnerability intensifications are projected in the Kavango and Kunene regions, primarily because of relative low adaptive capacity in the regions. The observed decrease in vulnerability in the Omaheke region can be attributed to the low sensitivity of the region's socioeconomic system to climate change impacts on the tourism sector.



Region	Sub-indices				CCVI-NTS	Rank	Category
	Current Exposure	Future Exposure	Sensitivity	Adaptive Capacity	Future		
Kavango	0.81	0.99	0.97	0.30	0.23	1	High
Kunene	0.73	0.80	1.17	0.34	0.23	2	High
Zambezi	0.81	1.02	1.00	0.28	0.23	3	High
Omaheke	0.77	1.17	0.76	0.34	0.23	4	High
Omusati	0.77	0.87	0.99	0.36	0.24	5	High
Hardap	0.78	0.88	1.16	0.40	0.32	6	Medium
Karas	0.75	0.96	1.05	0.43	0.33	7	Medium
Oshana	0.79	1.20	1.10	0.34	0.35	8	Medium
Erongo	0.78	0.72	1.36	0.48	0.37	9	Medium
Otjozondjupa	0.71	1.21	1.28	0.35	0.38	10	Low
Khomas	0.77	0.71	1.41	0.51	0.40	11	Low
Ohangwena	1.12	1.11	1.00	0.32	0.40	12	Low
Oshikoto	1.08	1.20	0.97	0.35	0.44	13	Low

Figure 6.25. Future climate change vulnerability hotspots for the tourism sector in Namibia

(The red, yellow and green colours indicates high, medium and low sensitivity regions, respectively)

Table 6.15. The temporal changes in the Degree of Vulnerability in the tourism sector across Namibia

Regions	Degree of Vulnerability (1= High Vulnerability)		Direction of Change	
	Ranking for the Current Period	Ranking for the Future Period		
Erongo	12	9	Increases	29%
Hardap	9	6	Increases	40%
Karas	8	7	Increases	13%
Kavango	3	1	Increases	100%
Khomas	13	11	Increases	17%
Kunene	5	2	Increases	86%
Ohangwena	9	12	Decreases	-29%
Omaheke	1	4	Decreases	-120%
Omusati	4	5	Decreases	-22%
Oshana	6	8	Decreases	-29%
Oshikoto	10	13	Decreases	-26%
Otjozondjupa	7	10	Decreases	-35%
Zambezi	2	3	Decreases	-40%

6.1.7. Water

6.1.7.1. Overview of the current status of the sector

Water is recognized as a key national asset (MAWF, 2010). The main consumers of water are shown in Table 6.16. This chapter does not address the water demand of the livestock and tourism sectors, which are dealt with in other chapters of the report.

Table 6.16. Main consumers of water in Namibia, with expected trends in use

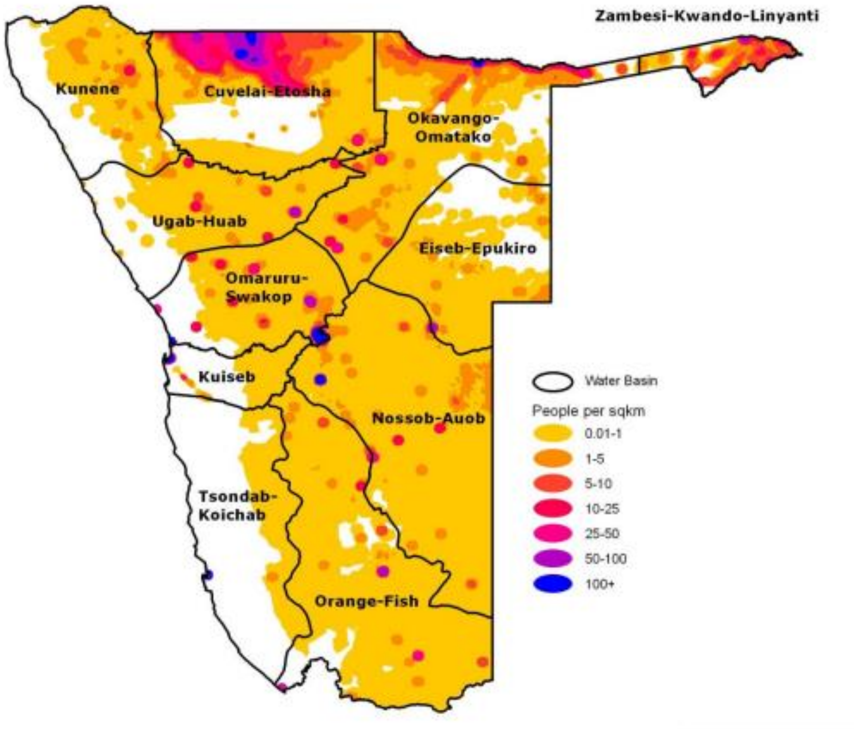
Sector	Present (2008) use and future trend	Comment
Irrigation farming	Presently uses 40% of all Namibia's consumption. This is expected to rise to 65% by 2030, due to expansion of Green Schemes mainly along the Orange and Okavango Rivers.	Efficiency of water use, and pollution, will become important issues.
Livestock farming	The water demand of this sector is expected to stay relatively constant, as the number of livestock is limited by the carrying capacity.	Addressed in the Agriculture chapter.
Urban sector	Both domestic and industrial + manufacturing consumption included in this category. Presently uses about 20%, but the demand will almost double by 2030, due to the high rate of urbanization, rising income levels, and industrial development	This sector will require major capital investment to ensure future access to water and sanitation. Pollution is a significant threat to the available resources.
Rural domestic water sector	This sector is relatively small and is not expected to increase substantially, as the increasing numbers will be absorbed by urban growth.	Although this is a relatively small proportion of the total consumption, this sector is highly vulnerable to climate change due to the reliance on rain-fed agriculture.
Mining sector	A significant consumer but Areva, the owner of Trekkopje Mine, has developed a desalination facility at Wlotzkasbaken. Desalinated water is purchased from this plant by NamWater for distribution and on-selling to all other mines excluding Trekkopje. As a result, their demand does not add to the pressure on the country's fresh water resources. Overall, this sector's water demand will still rise as other new mines develop.	Mining can pose serious pollution threats to water resources.
Tourism sector	A major growth sector.	Addressed in the tourism chapter

Source: MAWF, 2010

Namibia has no perennial rivers in the interior, as perennial rivers occur only on the northern and southern borders. For the supply of water, the country relies on dams on the ephemeral river systems and groundwater. These are supplemented to a limited extent by unconventional sources such as reclaimed water in the central area and desalination at the coast.

Natural water sources are therefore totally reliant on rainfall to feed ephemeral rivers and recharge aquifers. In this arid climate, only 2% of the rainfall ends up as surface runoff, and 1% becomes available to recharge groundwater (Heyns et al*.,* 1998). The balance of 97% of the rainfall is lost through evaporation (83%), and used by plants in transpiration (14%).

In accordance with the Water Resources Management Act of 2013, the approach to the management of water is based on river basins, with resources and demand managed within the basins (= catchments) of the main rivers. The basins delineated as 'management units' are shown in Figure 6.26.



Source: MAWF 2010

Figure 6.26. Population density per basin

Four main basins encompass most of the country's population and growth centres; these are the Cuvelai-Etosha, Omaruru – Swakop, Kuiseb and the Okavango- Omatako basins, described below.

Cuvelai-Etosha Basin

Very little potable water occurs naturally in the Cuvelai-Etosha Basin. Surface runoff is unreliable and the flat nature of the terrain presents no opportunities for major surface water impoundments. Groundwater over the greater part of the central basin contains prohibitive levels of salinity, which makes it unsuitable for human and livestock consumption. Suitable groundwater does occur in the east and south-eastern areas of the basin. Recent groundwater studies have indicated, however, that fresh groundwater may occur at greater depths, below the saline water. Currently most of the water used in this basin is imported from the Kunene River in Angola and distributed by canal and pipelines throughout the basin.

Politically, the abstraction of water from the Kunene and the associated water transfer infrastructure is located in Angola, making it potentially outside the control of Namibian authorities (MAWF, 2013).

Omaruru-Swakop Basin

Urban demand and uranium mines are by far the biggest consumers in the Omaruru-Swakop basin, with the towns of Windhoek, Swakopmund, Okahandja and Omaruru all located in this basin. The city of Windhoek has the largest concentration of population in Namibia and is also the major industrial and financial centre of the country. As such, it accounts for 83% of the water demand in the central areas, and relies mainly on three dams for its water supply: the Von Bach and Swakoppoort Dams on the Swakop River, and the Omatako Dam in the Okavango-Omatako Basin (MAWF, 2010).

Swakopmund derives its water from the Omdel aquifer, recharged from the Omdel Dam, and groundwater from the Rooibank and Swartbank aquifers in the Kuiseb river basin. Desalination of seawater has been introduced for new uranium mines being developed in the central Namib Desert.

Kuiseb Basin

No major plans currently exist to harness the potential of the surface water runoff of the Kuiseb Basin. The only dam in the basin is the Friedenau Dam, which supplies the recently re-opened Matchless Mine. The major resource of the basin is the alluvial aquifers that lie in the lower Kuiseb (Dorop, Rooibank and Swartbank). Water abstracted from these reserves is used to supply Walvis Bay and the Central Namib Area (MAWF, 2010). The establishment of desalination plant(s) north of Swakopmund will relieve some of the demand on the lower Kuiseb aquifers.

Omatako-Okavango Basin

The major water resources of the Okavango-Omatako basin are the Okavango River and the Grootfontein Karst aquifer. There are currently no major water supply issues in the basin; however, large areas of the basin rely on groundwater that occurs in secondary fractured rock aquifers. The basin is earmarked to transfer both surface and groundwater to the central areas of Namibia in future via the Eastern National Water Carrier.

Total water demand

Table 6.17 shows the expected water demand 15 years into the future, in 2030. Not surprisingly, the water demand for all the basins will increase. The table shows that most of the basins are actually meeting their demand, even as far as the year 2030, except for the Omaruru-Swakop (i.e. the Windhoek-Okahandja area), and the Tsondab-Koichab Basin (i.e. Lüderitz).

Table 6.17. Summary of water resources and current (2008) and future (2030) demands in Namibia's river basins

BASIN	WATER RESOURCE POTENTIAL Mm^3/a			DEMAND Mm^3/a		SURPLUS/(DEFICIT) Mm^3/a		INSTALLED INFRASTRUCTURE CAPACITY (Mm^3/a)	
	SURFACE	GROUND	TOTAL	2008	2030	2008	2030	SURFACE	GROUND
Cuvelai-Etosha	180.0[1]	24.0	204.0	63.7	85.6	140.3	118.4	74.0	13.0
Eiseb-Epukiro	0	20.0	20.0	8.6	11.2	11.4	8.8	0	5.8
Kuiseb	9,8	8.0	16.8	8.4	12.6	8.4	4.2	1.0	13,9
Kunene	31,5	26.2	57.7	10.0	11.2	47.7	46.5	0	7,9
Nossob-Auob	8.0	32.5	40.5	31.1	34.9	9.4	5.6	6.2	2,8
Okavango-Omatako	250.0[2]	29.6	279.6	58.1	215.1	221.5	64.5	36.7	2,2
Omaruru-Swakop	41.0	29.5	70.5	50.6	74.9	19.9	-4.4	27.5	18,1
Orange-Fish	379,9[3]	160.0	539.9	74.8	119.6	465.1	420.3	91.3	3,8
Tsondab-Koichab	0	1.8	1.8	3.9	5.1	-2.0	-3.3	0	5,8
Ugab-Huab	7,5	19.8	27.3	14.7	22.0	12.6	5.3	0	16,6
Zambezi-Kwando-Linyanti	4 000.0[4]	10.0	4 010.0	10.3	179.6	3 999.7	3 830.4	4.75	5,6
TOTAL				334.1	771.7				

Source: MAWF, 2010

Climate change is likely to limit the availability of water for the various sectors in these basins.

6.1.7.2. Drivers of sensitivity

Sensitivity of rural livelihoods, especially for the poor

More than half of the Namibian population live in rural areas and depend heavily on subsistence, rain-fed agriculture. While all of these households engage in a variety of farming activities, most families also rely on cash incomes derived from off-farm earnings such as pensions and employment of members of the extended family (Mendelsohn, 2006).

The northern regions (especially Zambezi, Kavango East and West, Ohangwena and Omusati) also have the highest figures for lack of access to safe water and adequate sanitation. The lower rainfall predicted for these regions will make them sensitive to access to safe water, as many rural residents rely on naturally occurring water sources.

Persistent droughts will result in falling groundwater tables and reduced surface water flows. This can lead to wells drying up, extending distances that rural people must walk to collect water, and increasing water source pollution. The poor will be affected the most.

Women-headed households, and households with no people of productive age (i.e. they comprise only children and the elderly), make up a large component of poor and severely poor households. Such households are more predominant in Namibia's northern regions (CBS, 2011) (Figure 6.27).

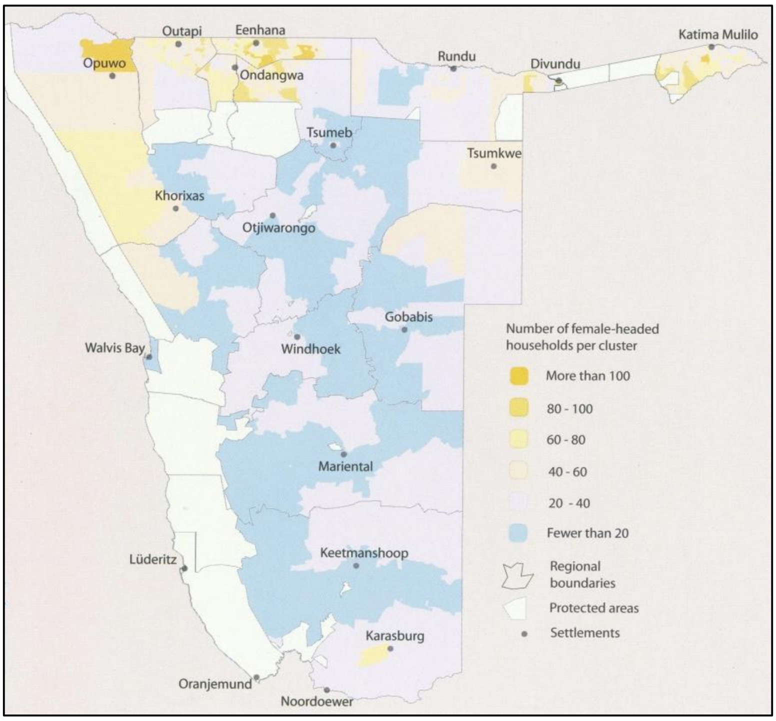


Figure 6.27. Relative distribution of female-headed households in Namibia

Sensitivity of irrigation schemes

The main irrigation projects in the country are located along the perennial rivers (mainly the Okavango, Kunene and Orange Rivers), and at inland dams on ephemeral rivers (such as Naute and Hardap Dams in the Fish River Basin, and the future Neckartal Dam being constructed also on the Fish River). Groundwater from the Stampriet Aquifer supplies the irrigation farms at Stampriet.

Irrigation demand currently (2008) stands at 135 Mm^3/a, and is expected to more than treble by the year 2030, to 497 Mm^3/a (MAWF, 2010). If developed to this extent, irrigation will use 65% of Namibia's total water demand by 2030.

The expected expansion of irrigation farming will be directly impacted by climate change. For example, reduced runoff of the Kunene, Okavango and Zambezi Rivers will lead to reduced availability of water (De Wit and Stankiewicz, 2006). The anticipated growth in irrigated area, and increased food production, is likely to be curtailed by climate change.

Sensitivity of urban people and industries

43% of Namibia's population lives in towns and cities (NSA, 2013). Urban areas, especially Windhoek, are expanding due to high rates of rural-to-urban migration (e.g. Windhoek population increased by 130%

from 1991 to 2011). Industries in these urban areas are also increasing. Such expansions require additional water, while the existing resources are increasingly under threat. Climate change will put even more pressure on the water resources in urban areas.

The predicted temperature increase and droughts will result in water scarcity, which in turn may trigger increases in the cost of water (especially piped water) and sanitation provision. This will be mostly felt by poorer sections of the population, such as those living in informal settlements.

Sensitivity to more extreme flood events

The damages to infrastructure and loss of livelihoods caused by the extreme flooding events of three consecutive years since 2008 in the northern regions exposed the vulnerability and unpreparedness for climate change impacts (SNC, 2011). Such extreme climate events cause major disruptions to the economy. For example, the 2003/4 drought cost the Namibian Government N$275 million in provision of emergency relief alone (MAWF, 2010).

Further indirect effects of climate change on domestic water supply and sanitation situation include the impacts of energy interruptions caused by floods, increasing the unreliability of piped water and sewerage services. In times of floods, unimproved water sources (e.g. rivers and wells) are vulnerable to contamination. Additionally, poor sanitary conditions (e.g. from 'bush toilet' and livestock dung) can contaminate clean water sources. National census statistics (NSA, 2013) show that 74% of rural households, and 22% of urban, have no toilet facilities.

Sensitivity of wetlands and reduced performance of ecosystem services

Wetlands and their associated fauna and flora are currently identified as Namibia's most threatened ecosystems (Barnard, 1998). Most wetlands are under-protected and highly vulnerable to increasing pollution, over-abstraction and clearing of vegetation (Barnard et al. 1998). For example, two impoundments in the central area of Namibia, Goreangab and Swakkoppoort Dams, are already so badly eutrophied, that the water is sometimes unusable or very difficult and expensive to treat. Elevated temperatures caused by climate change will further contribute to this situation, since growth of phytoplankton and zooplankton is enhanced by warmer conditions

The added stress of climate change is likely to further exacerbate the ability of Namibia's wetlands to provide valuable ecological services such as water retention, purification and flood attenuation (Dirkx et al., 2008). In addition, the mouths of the Kunene and Orange rivers (both awarded Ramsar site status) are likely to suffer severe ecological impacts as a result of reduced flow regimes and over-abstraction in future decades.

6.1.7.3. Adaptive capacity

Namibia has considerable expertise for coping with variability in rainfall, because the climate already has this characteristic. But events in the past five years, namely the flooding of Oshakati and Mariental in 2012, and the 'drought' of 2014 (in reality only a year with slightly lower-than-average rainfall after a decade of higher-than-average rains) bring attention to the fact that extreme climate events still cause widespread damage and provoke emergency responses. Namibia's preparedness for climate change is still at a low level.

However, MAWF itself recognises there are considerable challenges facing the water sector (MAWF, 2010). The following points apply to the physical infrastructure:

- Upgrading of existing and construction of new infrastructure to meet growing demands. Funds need to be provided to keep pace with demands.
- Maintaining existing infrastructure. Maintenance has fallen behind what is required for the efficient operation of water supply schemes. Funding and capacity building are the main concerns.

Government has fully committed to implementing Integrated Water Resources Management (IWRM) (MAWF, 2010), which includes the principles of preparing and adapting to the realities of climate change. However, at the same time, it is recognized that human capacity to fully implement IWRM is lacking in Namibia.

The irrigation sector is Namibia's largest water consumer, and the amount of water required for the anticipated expansion of irrigation farming is more than three times what is presently used. This sector therefore presents the greatest opportunity for improved water use efficiency and water demand management (MAWF, 2010).

Government introduced a bold policy for improving drought preparedness, the National Drought Policy and Strategy, in 1997. Unfortunately, it is poorly implemented and indirectly encourages reliance of farmers on drought relief, so that there is little incentive for drought preparedness.

The problems of poor governance and weak capacity, identified above, are compounded by poverty, where people lack the means to respond to a worsening situation (Midgley et al., 2011).

6.1.7.4. Vulnerability and indicators

Even without the threat of climate change, Namibia already faces water scarcity in some of its river basins when the potential of the water resources are considered. Namibia is therefore considered to be highly vulnerable to climate change (DRFN 2008).

The three areas of Namibia that are most water-stressed are the central area, the Walvis Bay – Swakopmund coastal area, and the Cuvelai area with its high density of rural people in north-central Namibia. All three of these areas have very limited, local water resources, but they are 'rescued' from absolute water shortage by the complex water supply schemes that have been put in place over the years. Yet they remain highly vulnerable to climate change due to the water demand rising to levels where the sources for further augmentation might also be inadequate, due to population growth and climate change.

These main areas of vulnerability reinforce the need for Namibia to embrace water demand management more fully. Table 6.18 summarises and ranks the vulnerability indicators.

Table 6.18. Water sector indicators

Exposure in particular areas	Sensitivity	Adaptive capacity	Vulnerability to climate change
North-central regions Reduced rainfall in catchments of northern perennial rivers Reduced rainfall in north-central regions	High dependence on Kunene River water for domestic needs, and on the Angolan component of the water transfer infrastructure. Relatively high levels of poverty and high dependence on rain-fed agriculture Low level of access to safe water and sanitation	Water demand management capacity is low. Poverty diminishes the capacity to respond to climate events, or to find alternative livelihoods	Very high

Exposure in particular areas	Sensitivity	Adaptive capacity	Vulnerability to climate change
	Significant level of dependence on wells for water supplies		
North-central regions Increased frequency and intensity of flooding	Exacerbates existing low level of access to safe water and sanitation Increases costs of water supply	Poverty diminishes the capacity to respond to climate events	High
Central area of Namibia Water scarcity from more frequent and more intense droughts	Rising domestic and industrial demand for water from population and economic growth. Complex infrastructure for supplying the demand is in place, but shortfalls are still predicted. Pollution threatens the capacity of the system.	Technical capacity relatively high, but there are concerns about maintaining and expanding the system. Capacity to prevent pollution is poor. Augmentation options (e.g. from Okavango River) might themselves have limited capacity due to climate change and increased demands in Angola.	High to Very High
West and East Kavango Regions Reduced rainfall in catchments of northern perennial rivers	High dependence on Okavango flows for irrigation	There is potential to reduce water demand by more efficient irrigation methods, but implementation is lacking	High
Central Namib coastal hub Water scarcity from increasing population, exacerbated by droughts	Rising domestic and industrial demand for water from population, mining and economic growth.	Technical capacity to desalinate relatively high, but energy demand and cost might be limiting.	High

6.1.8. Vulnerable groups

Certain socio-economic and demographic groups exhibit particular vulnerability in the face of climate change. These include women and female heads of household, children and the elderly, the chronically sick, and indigenous people.

In the north 57% of the households are female headed, due to migrant labour (Figure 6.27). In the rural areas women are the primary providers of food and crops for the household and are disproportionally affected by environmental degradation. Access to housing is inadequate and urban service delivery such as water, electricity, sewage and waste disposal represent severe problems. Women in rural Namibia compared to their male counterparts are reported to have limited technical skills required to acquire employment or generate income. Additionally, they have limited access to capital, productive land, knowledge and services. These factors decrease resilience and adaptive capacities of men and women differently (Angula and Menjolo, 2014).

Children, the elderly and chronically sick also typically exhibit high levels of vulnerability. This arises from their physiological sensitivity, for example the fact that children are most sensitive to cholera and diarrhoea exposure; and the compromised immune system of people living with HIV/AIDS can increase their sensitivity to other diseases, such as tuberculosis and heat stress. They also typically have low adaptive capacity through high levels of dependence on others for their survival, including their food security, mobility, and access to information.

Indigenous people have been historically disadvantaged in Namibia. Despite improvements since independence in 1990, certain indigenous groups, including the San, Ovahimba, Ovazemba, Ovatue, and Himba (Ovatjimba) have not seen the promises and benefits brought by independence fulfilled for them. They are poorly included in decision-making and often have insecurity of land tenure (Anaya, 2012). The San and Himba groups, in particular, tend to lag in educational attainment relative to other groups, which also increases their vulnerability by impeding adaptive capacity. Their access to healthcare is also impeded based on ability to pay, which further reduces their adaptive capacity and increases vulnerability.

Experiences from the Small Grants Program Namibia shows that characteristics such as wealth, gender, ethnicity, religion, class, caste, or profession can act as social barriers for some to adapt successfully or acquire the required adaptive capacities.

6.2. Adaptation in key sectors

Across all sectors, adaptation needs to be considered at the institutional level within the sector itself, as well as at the individual level in response to the various vulnerabilities (e.g. agriculture, health, tourism and water). As well as sector-specific adaptations that exist or are proposed, there are a number of prerequisites for adaptation that exist within Namibia, regardless of the sector. These include raising public awareness of climate change and behavioural adaptation measures, improving data collection to link observed phenomena with climate drivers and thus better be able to determine and monitor changes in vulnerability (e.g. surveillance systems), improved access to information (to inform timely and adaptive decision-making processes) and implementing effective early warning systems (such as the Famine Early Warning System, which worked effectively during the 2013 drought).

Enabling such adaptations will require the removal of existing barriers to adaptation, which exist at institutional level and affect governance structures and individual behaviour. At institutional level, these include lack of technical knowledge (on vulnerability and adaptation options), poor cross-sectoral communication and liaison across horizontal and vertical governance structures. At individual level, recognition is increasing that understanding psychological factors such as mind-sets and risk perceptions is crucial for supporting adaptation. Cognitive barriers to adaptation include alternative explanations of extreme events and weather such as religion (God's will), the ancestors, and witchcraft, or seeing these changes as out of people's own control. Climate uncertainty, high levels of variability, lack of access to appropriate real-time and future climate information, and poor predictive capacity at a local scale are commonly cited barriers to adaptation from the individual to national level.

6.2.1. Agriculture

6.2.1.1. Adaptation measures implemented since the Second National Communication

Agriculture is a key component of the Namibian economy, and agricultural growth is a key component of national plans and policies. Through the Vision 2030, National Development Plan 4 and the Country Strategy Paper 2014-2018, Namibia continues to pursue a policy framework that promotes import substitution. If the country is to produce most of the currently imported crop and livestock commodities locally, there is a need for adaptation based on commercializing agriculture through technological, policy and institutional capacity building framework. The technological priorities as reported in the SNC remains fostering yearlong food production through irrigation and water harvesting, conservation agriculture, diversification, use of improved indigenous crop germ plasm, use of well adapted indigenous livestock breeds, increased seed and fertilizer (incorporating organic fertilizers) availability, shared water resource management, early warning systems, drought mitigation measures, restoration of rangelands and improved livestock management policies and strategies. In dealing with drought, deforestation, soil and rangeland degradation, adaptation efforts have been decentralized to the natural resources end user level. Individual farmers both on commercial and communal farm holdings are encourage and the later mentored on tactical farm decisions that timely responds to seasonal variations in climate change stressors. Namibia wishes to be a knowledge based economy by 2030 and hence effective adaptation requires advocacy and communication channels that work to change mind set about climate change and the need for surplus farming.

Since the submission of the SNC, resolutions and recommendation in the SNC report have been sustained. More national work has taken place especially in the policy domain. A number of policies have been developed and operationalized, including the Policy for the Eradication of Trans-boundary Animal Diseases in the Northern Communal Areas (NCA), the National Rangeland Management Policy and Strategy (NRMPS), 2012, and the National Policy on Climate Change, 2011. These policies recognize the importance of prudent sustainable management of natural resources and make provision on how best to fund vulnerability and adaptation measures.

In addition to specific policy, implementation of various adaptation initiatives has taken place since the SNC. Through the Namibian Organic Association a series of conferences on sustainable, ecological crop and horticulture production for Namibian producers, supported by the Namibian Agronomic Board (NAB) in collaboration with the Ministry of Agriculture, Water and Forestry have been held (Mpofu and Petrus 2015). The main objectives have been to take stock of the existing activities under the Green Scheme Programmes run by the Ministry of Agriculture, Water and Forestry.

As well as “green schemes”, crop-based agriculture such as pearl millet, maize, sorghum, dryland rice are also receiving attention through provision of timely inputs, breeding programs, extension, and farmer training and mentoring. Adaptation measures being put in place in Namibia, especially smallholder agricultural development programs, have a goal of first satisfying household food security and nutrition, and expanding productivity to enable sales of surplus harvest for cash and improved standards of living in the country. This is done through training, mentoring and establishing crop and livestock production demonstrations plots.

To encourage adaptation among the livestock sector, a number of feasibility studies have been undertaken for improved marketing; and also improved export opportunities. The potential of boosting livestock trade by creating marketing channels and infrastructure in the Zambezi (formerly Caprivi) region can be easily achieved if the Katima and Kopano quarantine camps are refurbished through a $7 million Namibia dollar grant from the Millennium Challenge Account-Namibia (MCA-N). The region is prone to outbreaks of foot-and-mouth disease hence control measures are vital to adapt to any outbreaks. The control measures include animal movement control, vaccination and quarantine. Quarantine of cattle is a crucial part of the formal marketing of cattle in the Zambezi Region. Following the launch in 2014 of a booklet on Community Based Rangeland and Livestock Management (CBRLM), communal farmers have shown keen interest in embracing adaptive practices by implementing timely bush thinning, preventing rangeland degradation through correct stocking and restoring rangelands through reforestation, gully reclamation and fodder grass planting.

6.2.1.2. Proposed adaptation measures

Additional adaptation policies, plans (projects), priorities, climate smart agriculture approaches, and agricultural management options are available for effective resilience to climate change impacts. These proposed adaptations relate to improved soil management and land management, and post-harvest production. Since the National Agricultural Policy of Namibia (NAP) 1995 is currently under review there is scope to include adaptive measures like the growing of drought tolerant crops and using locally adapted hybrid seed. The adaptive practice of spreading risk of vulnerability by planting a mix of traditional and hybrid seed varieties have largely been supported by indigenous knowledge systems and the extension service. This also involves overlapping the growing periods through a time combination of early and late planting.

Studies have consistently indicated that soil erosion is part of the processes through which rangeland degradation is happening in Namibia. As such preventive measures through anti-soil erosion programs should be out-scaled emphasizing the participation of natural resources end users apart from government efforts through the Ministry of Agriculture, Water and forestry and the Ministry of Environment and Tourism. At the same time, soil fertility and fertilizers management has been at the centre of preserving and boosting soil fecundity in Namibia. This should be accentuated through adaptive measures that uses simple but well proven technologies like the use of organic fertilizers (kraal manure.

Land management for livestock systems included the need for fodder flow systems and bush thinning. Fodder flow systems through fodder conservation for all year feeding of livestock is a technique more popular on commercial farms and communal farmers need to adopt this so as to improve their adaptive capacity to seasonal livestock feed supply fluctuations. Animals need adequate nutrition everyday so fodder banks are critical to adapt to intermittent shortages. Bush thinning is a panacea for bush encroachment. Bush encroachment has become a major challenge especially on freehold farms in northern Otjozondjupa where rainfall is higher compared to the south. Bush encroachment causes reduced grass biomass.

Having food loss in the maize and pearl millet subsectors need attention through adapting to post harvest technologies that minimizes wastage caused by pest damage or spoilage. Specialised grain storage containers that can store grains for up to three years should be popularised and used extensively.

6.2.2. Health

6.2.2.1. Adaptation measures implemented since the Second National Communication

The US Centre for Disease Control (CDC) framework ‘Building Resilience Against Climate Effects’ (BRACE) builds on health vulnerability assessment in order to evaluate and monitor public health interventions that could be incorporated in national health adaptation policy. A number of adaptation initiatives have come into existence, or been strengthened, since the SNC. These include disaster risk management and preparedness, proactive management in forced migration situations, improved cholera outbreak and malaria control, and commitments to improved nutrition.

A post-disaster needs assessment carried out after the 2009 floods in northern Namibia acknowledged the need for long-term and sustainable disaster risk reduction, and recognized the fact that the country is likely to experience increased incidence of extreme weather events as a result of climate change (GRN, 2009). Recommendations from this report include:

- Strengthening the capacity of health professionals in Epidemic Preparedness and Response
- Recruitment and training of community health workers to provide emergency first aid
- Improvements in disease surveillance
- Increased nutrition surveillance
- Better staff training on prevention and treatment of malnutrition
- Improved security of water supply at health facilities
- Strengthening transport and communication between health facilities

- Provision of solar power at health facilities vulnerable to disruption of power supply

Some of these recommendations have subsequently been addressed through national health policy. Efforts have been made to improve disease surveillance, however the reporting process still requires standardization across regions and better communication between regional and national staff.

In 2012 Namibia's Disaster Risk Management Act (no. 10 of 2012) was passed. It aims to provide a holistic framework for disaster risk management, focusing on prevention, preparedness, response and recovery.

Disease response programs have also supported adaptation to climate change. In Namibia there is a designated Cholera Outbreak Response Team, led by the director of Primary Health Care, Deputy Director of Epidemiology and Deputy Director of the Family Health Division. In addition to MoHSS personnel, this team also includes representatives from the Centre for Disease Control and Prevention (CDC), WHO, UNICEF and the Namibian Red Cross Society. The key to managing cholera outbreaks is timely reporting and immediate response, including the establishment of Cholera Treatment Centres (CTCs) and the provision of safe water, proper sanitation and health education (including personal hygiene and food handling practices) for the affected community (WHO, 2014a.) The preferred goal would be, of course, to prevent the outbreak occurring in the first place.

Current policy for the control of malaria in Namibia is embodied in National Malaria Strategic Plan 2010-2016 (MoHSS, 2010). The aim of this policy is to move from a disease control program to an eradication program by 2016, with the goal of achieving total eradication of indigenous transmission of the disease by 2020. It is implemented through the National Vector-Born Disease Control Program (NVDCP). In addition to improving reporting procedures a new initiative known as 'reactive case detection' has been adopted in high-prevalence areas. This involves the careful investigation of all new malaria cases to try to determine the source of the infection and whether or not others have been affected within that neighbourhood or household.

To address the problem of malnutrition, the National Alliance for Improved Nutrition (NAFIN) in 2010. This is a multi-sector, multi-stakeholder platform for nutrition involving participation of ten line ministries, including the Ministry of Finance and the National Planning Commission (SUN 2011.) It includes programs implemented by MoHSS to increase vitamin A supplementation amongst children. Other programs include deworming, iron/folic acid supplementation, zinc treatment for diarrhoea and treatment of severe and acute malnutrition (SUN, 2011). It is vital that these programs succeed in order to reduce the vulnerability of the Namibian population to the effects of climate change.

6.2.2.2. Proposed adaptation measures

The implementation and/or expansion of a number of adaptation measures would help to address the identified vulnerability of the health sector to climate change. These include:

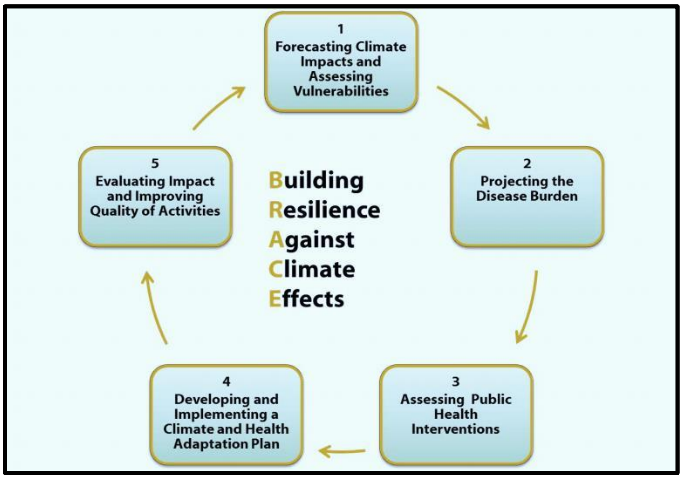
- Undertaking scenario development and pro-active planning to address both fast-onset and slow-onset climate-induced events;
- Strengthening the policies required to effectively address both slow-onset and catastrophic events;
- Improved data collection and surveillance to prepare for climate-induced changes;
- 'Climate-proofing' the public health system to deal with adverse health repercussions and outcomes from climate-related changes; and
- Ensuring that water and sanitation systems are strengthened.

Effectively adapting to climate change also requires availability of information to monitor the evolution of health impacts of climate change. In 2012 MoHSS published a policy document for the development of a national Public Health Laboratory system. The policy recognized the importance of such a system for the delivery of healthcare services and also for the provision of data on which to base policy decisions, including those regarding the allocation of resources and identification and support of national health priorities. It also acknowledged the importance of laboratory governance, coordination and collaboration structures and adherence to a set of clearly defined national standards (MoHSS, 2012b). The establishment of such a system is essential for monitoring and responding to disease outbreaks that may occur as a result of climate change. It will also help map the geographical spread of endemic diseases secondary to climate change and allow the formulation of a nationally coordinated response.

As outlined in section 1.2.2, the public health system is currently facing a number of challenges, and it is likely that these will increase over time and that climate change will add to this pressure. Limited resources must be used efficiently to address both current and future demands. It is important that policy makers remain cognisant of the context in which healthcare will be delivered in the future and of the pressures that the Namibian population will face as a result of climate change. Climate proofing the health sector requires a combination of awareness raising (both among staff and the general population through public awareness campaigns), improved disease surveillance, standardisation of data protocols between regions, communication with other government departments (e.g. the meteorological agency) to link with climate variables, and the establishment of an early warning system (together with improved channels of communication for the distribution of this information). Ensuring healthcare infrastructure is adapted to the anticipated climate conditions is also important: which may mean better ventilation and/or air conditioning in hospitals in the hottest parts of the country, and expanded laboratory capacity for public-health activities, such as the management of disease outbreaks such as malaria and cholera.

While attention is paid to the requirement for proper sanitation and clean water supplies within the CCCM capacity building program, as detailed in section 1.4.2.1, it is essential that these problems also be addressed in non-crisis situations in order to increase resilience in times of climate extremes, such as drought or flooding. When groundwater becomes freely available it becomes the preferred water-source for many people who have limited means to pay for a municipal water supply. As climate change increases inter-annual variability in Namibia, with short periods of heavy rainfall increasing in many regions it is likely that this behaviour will also increase. Public health education and increased availability of water purification systems will contribute significantly to reducing risk of disease outbreaks in these circumstances; as will improved sanitation.

To address the identified adaptation needs, the health sector could follow a 5 step process for assessing and monitoring health vulnerability to climate change. This has been developed by the US Centre for Disease Prevention (CDC) and is known as the Building Resilience Against Climate Effects (BRACE) framework (Figure 6.28). Steps one, two and three are recommended here, and could usefully inform the development of an action plan (step four).



Source: CDC, 2014

Figure 6.28. Building Resilience against Climate Effects (BRACE) framework

6.2.3. Tourism

6.2.3.1. Adaptation measures implemented since the Second National Communication

The SNC proposed three broad climate change adaptation strategies (SNC, 2011). The first broad strategy was that Namibia should respond to climate change challenges by taking advantage of the growing demand for sustainable tourism; the second highlighted the opportunity to promote wildlife land use systems to achieve better value from land (under tourism) than would be achieved from agriculture; and the third was to improve the National Conservancy Information System to include other valuable information or indicators (i.e., such as water resources, ecosystems and biodiversity, *inter alia*), which could be used for effective monitoring of climate change adaptation strategies in the tourism sector (SNC, 2011). The study, *Climate Change Vulnerability and Adaptation Assessment for Namibia's Biodiversity and Protected Area System*, undertaken by Turpie et al. (2010), comprehensively proposed climate change adaptation strategies relevant to the tourism sector. The climate change adaptation strategies proposed in the study range from those that address climate change impacts on biodiversity and ecosystems to socioeconomic impacts of climate change such as loss of livelihoods and income (Table 6.19).

Table 6.19. Summary of adaptation strategies relevant to the tourism sector

Affected system	Climate Change Impact	• Adaptation Strategies
Biodiversity and Ecosystems	Shifts in distribution and migration routes; shrinking ranges of endemic species; and loss of ecosystem services	• Promote the shift from a landscape approach to conservation, including shifts and expansions in protected areas, increasing connectivity through encouragement of conservancies and co-management and removing fences, and fostering cross border cooperation for biodiversity management. • Ex situ conservation – seed/gene banks
	Bush encroachment, loss of open habitats	• Promote charcoal production, compressed fuel blocks, harvesting wood for power production • Grazing/browsing and fire management practices
Natural resources	Shortage of natural resources due to reduced supply and increased demand	• Support efforts to manage natural resources • Product diversification
	Shortages of water (due to decreased supply and increased demand) leading to conflicts, reduced water quality etc.	• Improve water supply: o Artificial recharge of underground aquifers (limited viability) o Desalination (coast) o Water Basin management

Affected system	Climate Change Impact	• Adaptation Strategies
		○ Inter-basin transfers ○ Appropriate water harvesting systems (e.g. jojo tanks, dew harvesting) • Reduce demand and use: ○ Water demand management ○ More economically efficient water allocation ○ Water saving technologies ○ Drought resistant crops ○ Indigenous species for farming
Climate	Unpredictability	• Improve meteorological and climatic forecasts as early warning system and fire warning system • Adoption of adaptive management strategies • Adopt a mix of long and short term strategies
Socioeconomic	Reduced productivity leads to increased poverty putting pressure on natural resources	• Diversify livelihoods • Build capacity and skills to adapt
	Competition for land (competing with conservation needs) and pressure to hand protected areas over to farmers	• Enable community involvement in tourism in parks, integrate parks into local economies

Source: Turpie et al. (2010)

The Millennium Challenge Corporation (MCC) Namibia Program has built capacity for adaptation at local level. The Millennium Challenge Account (MCA) Compact was developed using an extensive consultative process. As stated in the MCA Namibia Compact, the Government of the Republic of Namibia (GRN) held consultations in all 13 regions of the country and began national level consultations in mid-2006. The overarching goal of the Millennium Challenge Account (MCA) Compact was the reduction of poverty in the Republic of Namibia through economic growth.

The MCC funding supported the improvement in management and infrastructure of Etosha National Park (ENP); enhancing the marketing of Namibia tourism; and developing the capacity of communal conservancies to attract investments in ecotourism and capture a greater share of the revenue generated by tourism in Namibia.

Although these activities were formulated and implemented under climate change, they still form what is known as passive adaptation to climate change. Through the project activities, the climate change adaptive capacity of not only communities, targeted by the Tourism Project, but also the Namibia tourism sector as whole was enhanced. However, it is uncertain to what extent these strategies will be capable of dealing with climate change in the future beyond donor assistance.

6.2.3.2. Proposed adaptation measures

With respect to additional adaptation measures, a review of literature shows that there are a number of gaps in terms of policy and growth strategy for the tourism sector. For instance, the National Policy on Tourism for Namibia does to adequate address the climate change, which fundamentally poses a threat to the growth of the sector. Therefore there is need to harmonise and streamline the National Policy on Tourism and the National Climate Change Policy. Harmonization of the two policies will ensure that tourism growth strategies are climate change proofed – which is key to the sustainable development of the sector.

The impacts of climate change on Namibia's climate resource, illustrated in Chapter 4 of this document, could potentially result in the reduction in the number of international tourists, visiting the country. Therefore there is need to growth both the domestic and regional demand for Namibia tourism products so as to counter the effects of the expected reduction in international tourists.

The promotion of CBNRM program through the establishment of conservancy, should be accompanied by technologies that not only increase land productivity, but also technologies that reduce human-wildlife conflict. Without carefully balancing these two aspects, there is a possibility that CBNRM through conservancies might be a maladaptation strategy because experience shows that wildlife and other natural resources conservation objectives are difficult to achieve if they threaten livelihoods, at the community levels.

Other adaptation gaps identified for tourist destinations include: the integration of climate factors into conservation and tourism management plans of protected areas; establishment of monitoring survey programmes to assess ecosystem changes, their relation with tourism activities, and take necessary protection measures; opening up new 'micro destinations' and attractions within and adjacent to an already popular national park or heritage site; carry out re-design or redefinition of protected areas, for example creation of migratory corridors; and adjust tourism programmes accordingly; and improve visitors and congestion management to prevent overuse of sites and physical impacts of visitation.

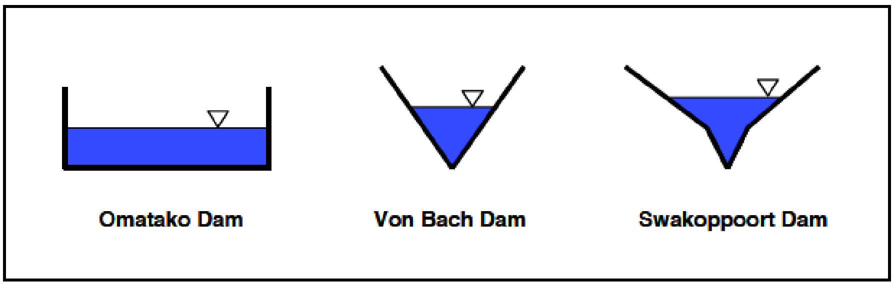
6.2.4. Water

6.2.4.1. Adaptation measures implemented since the Second National Communication

Due to its dry climate and unpredictable rainfall, challenges in the water sector need to be addressed through efficient water resources management. This must include technical, institutional, financial and social aspects. Namibia's Second National Communication (MET, 2011) proposed that adaptation to climate change in the water sector should focus particularly on measures to reduce evaporation and to enhance the efficiency of the utilization of water resources. Five main adaptation measures were proposed:

- Conjunctive use of surface and groundwater resources;
- Improving water demand management;
- Controlling the use of groundwater;
- Improving the policy and legal framework for water management; and
- Expanding stakeholder engagement.

The conjunctive use of surface and groundwater resources is adaptation method is aimed at minimising evaporation losses. This is well established in the strategies presently employed, by enhancing recharge into aquifers and pumping water into aquifers for underground storage.



(MAWF, 2010)

Figure 6.29. Cross section of the three dams which supply water to Windhoek

As the Omatako Dam is a large shallow impoundment with the highest exposure to evaporation, the water that is impounded in it is transferred as soon as possible after the rainy season to the Von Bach Dam. In this way the quantity of water that would have evaporated from the larger surface area in the Omatako Dam is reduced. Water from the Swakoppoort Dam is transferred for the same reason. In this way it is possible to increase the safe yield of the three individual dams (MAWF, 2010).

Windhoek is one of the few places in the world where domestic waste water is treated to a level good enough for re-use as potable water. In addition, Windhoek's water reclamation plant produces treated effluent that is used for irrigating public gardens, sports fields etc., and this is also practiced at a few other small towns (e.g. Okahandja, Swakopmund).

Improvement of water demand management (WDM) practices is an adaptation method aimed at addressing the effectiveness of water management in local authorities. Demand management covers measures to reduce the demand, such as by creating public awareness, installing water saving devices, maximising water re-use, and introducing legislation and a water pricing policy (Heyns et al. 1998).

Since Namibia depends so heavily on its groundwater resources, there is a need to control and closely monitor the use of groundwater. This is the first step in management of this resource, but in itself does not ensure sustainable use, nor necessarily improve adaptation to climate change. Monitoring of groundwater levels, groundwater quality and permits for abstraction, is carried out, with the view to sustainable utilization of the aquifers according to an aquifer management plan (IGRAC, 2013).

Namibia follows the principles of Integrated Water Resources Management (IWRM) (MAWF, 2010) and has recently promulgated a Water Resources Management Act (Act No. 11 of 2013), with the purpose of providing for the management, protection, development, use and conservation of water resources, and to provide for the regulation and monitoring of water services. The regulations have however not been finalized, which hampers the implementation of the Act.

Within the IWRM concept, a river basin is considered as the key entity at which management of natural resources can be discussed and negotiated between stakeholders (SNC, 2011). This entails the decentralisation of management functions to basin management committees that include the communities, local authorities and economic sectors relying on that basin's water resources. So far, 19 Basin Management Committees have been established.

After three consecutive years of flooding in the north-central areas, a series of earth dykes have been planned around Oshakati town in an effort to keep the flood water of the 'Efundja' at bay. The topography of the land, which is a natural floodplain, makes it extremely difficult to remove flood waters from the town once inundated, as there are no lower lying areas to divert water to. Particularly vulnerable are the waste water treatment ponds which are overtopped by flood waters, causing breaches of the earth walls and spillage of sewerage water into the flooded areas.

Work has started on construction of approximately 15 km of dykes to divert water around the town of Oshakati. The Okatana River system that passes through the town, is being deepened and lined, and inflow into the system will be controlled via sluices in the dyke system to keep the water level within the town from flooding buildings and infrastructure (Knight Piesold Consulting Engineers).

It has been reported that a major new groundwater source, the Ohangwena II Aquifer had been discovered. The capacity of this resource still needs to be quantified, but if preliminary indications are correct, the resource might contribute largely to the adaptive capacity of the water supply sector in the Cuvelai Basin. This source should be prioritized for full assessment and possible development as an alternative to connect the Cuvelai to the Okavango system, which could increasingly come under stress of reduced rainfall in Angola and Zambia.

Rainwater harvesting is done on a very limited scale, for instance at some farms and schools where water from the roofs of buildings is held in tanks for drinking and cooking. This small-scale measure is locally helpful but does not ease the overall situation because of the small quantities involved.

6.2.4.2. Proposed adaptation measures

The possibility to harvest water from fog along the Namib Desert coast has been investigated, but apart from a few localized applications, the yields are inadequate for large-scale use.

On-conventional resources, such as water reclamation, artificial recharge of aquifers and desalination of both saline inland resources and seawater are the adaptive strategies that will require urgent implementation. Optimization of existing resources through Water Demand Management, Conjunctive use of resources and further water reuse for non-potable demand, has to be institutionalized and made mandatory for all demand centres.

The predicted higher intensity rainfall events, will have a positive effect on runoff into dams on ephemeral rivers, which could relieve some stress on existing supply strategies, but high intensity runoff will at the same time reduce concentration times with reduced infiltration to groundwater aquifers and lower recharge of soil moisture needed for fodder growth. This might place additional stress on farming conditions and stock watering from ground water.

The predicted shifting and later onset of the rainy season, will lead to a shorter productive growth season which could impact not only rangeland farming, but could have an effect on both irrigation and dry land cultivation of food crops, both for subsistence and commercial farming. This could lead to a need for diversifying food crops to adapt to the shorter season.

The main adaptive measures recommended would therefore be:

- Finalise the promulgate the Regulations for the Water Resources Management Act;
- Place emphasis on unconventional water resources;
- Institutionalise the reuse of water in all demand centres, both potable and non-potable applications;
- Institutionalise water Demand Management and incentivise all demand centres to implement;
- Ensure that ephemeral surface impoundments can cope with high intensity runoff predicted;
- Protect all surface and groundwater resources from pollution through regulating discharges;
- Reduce the evaporation from surface impoundments through innovative measures such as water banking and conjunctive use;
- Prioritise the development of the Ohangwena II aquifer to supply the Cuvelai;
- Prioritise the implementation of augmentation to the Central Areas of Namibia;
- Prioritise seawater desalination to augment supply to the Central Namib area and new Uranium Mines;
- Use water to promote high value addition industries only;
- Use water only for irrigation of high value crops;
- Put emphasis on importing virtual water through fresh produce rather than to cultivate crops in areas where water use is extremely inefficient through high temperatures and evaporation; and
- Institutionalise efficient irrigation practices.

6.2.5. Conclusion

This chapter has provided an assessment of the status of vulnerability and adaptation in four key sectors in Namibia: agriculture, health, tourism and water. Using the IPCC formula of vulnerability as an outcome relating to exposure, sensitivity and adaptive capacity, the particular nature of vulnerability in each sector has been highlighted. Each sector took a slightly different approach reflecting data availability. In agriculture a qualitative approach identified high vulnerability in terms of negative impacts on water supply, rangeland management, staple food and cash crop production, and marketing. In health a quantitative approach identified vulnerability to climate-related disease incidence by region, finding that Kunene, Kavango, Omaheke, Ohangwena and Oshikoto have the highest current levels of vulnerability. If population increase to 2041 is taken into account, then the four former regions remain the most vulnerable, but Oshikoto is displaced by Omusati. In tourism a quantitative was also applied, highlighting the vulnerability of Namibia's predominant international nature-based tourism. The most vulnerable current regions, and from 2045-65 (using future projected climate conditions) are Omaheke, Zambezi, Kavango, Omusati and Kunene. In water the highest vulnerability is in the northern regions (Oshana, Omusati, Ohangwena, Oshikoto, and West and East Kavango), due to the high demands for the rural population and for irrigation.

Namibia has made progress towards adaptation in each of these sectors since the SNC, and the creation of the National Climate Change Policy and Climate Change Strategy and Action Plan establish the appropriate infrastructure for adaptation. Additional adaptation measures for each sector have been highlighted, addressing the identified nature of the vulnerability in combination with the current gaps in adaptation activities.

A number of principles to support effective adaptation have been identified. The first principle is: adaptation should be conceptualized in the context of the country's development agenda. The impacts of climate change could negatively affect a country's sustainable development in diverse ways, and thus integration into the National Development Plans is essential to create the mandate for all sectors to take climate risks into account. The second principle is to build on current adaptive experience to cope with future climate change. Namibia is accustomed to climate variability and identifying response strategies that will be robust, even in a context of higher variability, is important to enable adaptation. This links to the third principle, which is to recognise that adaptation occurs at different levels in particular, at the local level. Adaptation can be undertaken strategically at the national level, for instance through the National Climate Change Policy, but implementation takes place at local level. The fourth principle is to recognise that adaptation is an ongoing process. Most adaptation frameworks recognize that adaptation will be an iterative process of implementing and evaluating strategies as climate conditions continue to evolve over the course of this century – for this reason there is a tendency to now consider adaptive pathways. Following these adaptation principles will ensure reduced risk of adverse effects of climate change in Namibia.

7. Other information considered relevant to the achievement of the convention

7.1. Transfer of Technologies

The transfer of, and access to, environmentally sound technologies and know-how, the development and enhancement of endogenous capacities, technologies and know-how, and measures relating to enhancing the enabling environment for development and transfer of technologies are critical to the achievement of both adaptation and mitigation to achieve the objective of the Convention. Hence, Namibia pays particular attention to this issue and provided for it in the CCSAP under the item *"Promote and support development of technologies for mitigation and adaptation"*.

Namibia has yet to complete a full extensive study on its technology needs and transfer. This exercise is being done piecemeal within the national communications framework and this is delaying both the exhaustive assessments on technology needs and transfer for adaptation to and mitigation of climate change, and the associated cross-cutting issues. This is impeding on the development of adaptation and mitigation plans to inform the stakeholders, especially the private sector for partnering and funding implementation. A list of the most urgent needs related to technology, soft and hard, assessment and transfer for mitigation is given below:

- In-depth Technology Needs Assessments for mitigation;
- Renewable Energy technology transfer;
- Natural gas to electricity (Kudu project);
- Wind power harnessing and electricity generation;
- Photovoltaics for generating electricity for the grid;
- Off grid electricity generation for rural electrification;
- Photovoltaic pumps;
- Latest technologies for rail and road transport;
- Solid and liquid waste treatment systems; and
- Waste to electricity.

With regards to adaptation, there is also the need for a multitude of technologies for the various economic sectors. The ones necessitating most urgent action to safeguard livelihood and welfare of the poorer most vulnerable segment of the population are agriculture and water resources.

The prioritized technologies for agriculture are irrigation and water harvesting, conservation agriculture, crop diversification, use of improved indigenous crop germ plasm, use of well adapted indigenous livestock breeds, increased seed and fertilizer (incorporating organic fertilizers) availability, shared water resource management, early warning systems, drought mitigation measures, restoration of rangelands and improved livestock management policies and strategies.

Adaptation in the water resources sector will include water recycling for reuse, water use efficiency, water harvesting and desalination amongst others.

7.2. Research and systematic observation

Though the scientific evidence indicates that climate has changed significantly over and above that caused by natural variability due to man-made (anthropogenic) interference in the climate system, (IPCC, 2014) climate change and its impacts are still not well understood by major components of the population of developing countries. There exists the need to undertake research to quantify the potential impacts at the local, national and regional levels to enable the proper development of practical solutions for adaptation and mitigation. The strategy aims at the following:

- Collect data and model climate change and national, regional & local levels;
- Monitor ecosystem and biodiversity changes and their impacts;
- Conduct climate-proof research;
- Undertake research on sea level rise;
- Establish a centre for research and training on climate change;
- Conduct inventories on traditional / indigenous knowledge and coping practices;
- Undertake studies on the cost of adaptation and mitigation; and
- Study macroeconomic and sectoral impacts of climate change.

7.3. Education, Training and Public awareness

Education, training and public awareness are primordial for effectively addressing climate change adaptation and mitigation. Climate change is of such importance nowadays that the population have to be properly educated on its cause and effects to enable them to address these at their respective levels. Thus, education has to be formal and informal. Presently, climate change is only part of the tertiary curriculum as modules of some disciplines. Namibia intends to gradually include climate change as a component of the primary and secondary curricula and extend it in the tertiary curriculum to remedy to the present shortcoming. Concurrently, climate change will be introduced in the vocational training programmes and informal education will be resorted to with the support of NGOs and CSOs.

Public awareness programmes implemented up to now have been insufficient to meet the present climate change treat as a result of lack of resources. It is planned to enhance public awareness programmes to maximize outreach, the final objective being to cover all segments of the population countrywide. This is deemed essential as the public needs to have access to the latest information to buy them in the process and enable them to successfully participate in actions to be implemented. The strategy on this aspect will target the following actions:

- Awareness raising and public education on climate change;
- Promote and facilitate development of public awareness materials on climate change;
- Facilitate access of climate change information to the public; and
- Promote public participation in addressing climate change and development of adequate responses.

7.4. Capacity Building

Namibia's successful implementation of the Convention demands for substantial capacity building. Technical capacity building concerns mainly mitigation and adaptation technologies earmarked in the respective chapters for the measures that are most prominent and prioritized in this communication and other reports submitted to-date. Capacity building also concerns overarching issues. As a developing country, Namibia needs robust institutional structures to take on and implement programmes and activities on climate change. Building human and institutional capacity to address climate change will be a fundamental component of the Namibian strategy on climate change. Capacity building for climate change will thus include further development and strengthening of personal skills, expertise and of relevant institutions and organizations on adaptation, mitigation and reporting. Capacity building will involve a wide group of stakeholders, including the government, NGOs, research institutions, local communities and international organizations.

Some of the actions identified are:

- Strengthen human resource capacity building for climate change;

- Mainstream climate change in national, local and sector policies, development plans & program;
- Strengthen institutional capacity for climate change management;
- Mainstream climate change in the media;
- Develop and implement educational program on climate change and its impacts;
- Promote and facilitate development of educational materials on climate change;
- Facilitate and support training of scientific, technical and managerial personnel in climate change;
- Develop disaster risk reduction capacity building plans and programmes for climate change; and
- Establish Climate Change Resource Centre and Climate Change database.

7.5. Information and networking

It is recognized that climate change is a global problem and that it requires the cooperation of all to tackle this issue successfully. Namibia is a Party to the Multilateral Environmental Agreements and various other Protocols and Agencies with the aim to preserving the environment within a sustainable development programme. This is also the aim of the Convention. In line with this objective, the action plan has identified the following actions.

- Strengthen and enhance international collaboration, linkages and networking among stakeholders involved in environment and climate change related issues;
- Participate in regional and international cooperation programs and activities on climate change; and
- Promote international North-South and South-South collaborative research that will facilitate generation of climate change adaptation and mitigation evidence-based information; and
- Facilitate achievement of UN environment international obligations under various Conventions especially UNFCCC and Treaties.

8. Other information considered relevant to the achievement of the convention

8.1. Reporting

Preparation of the INC and SNC was on an *ad-hoc* basis and did not require a permanent set-up that would have proven too onerous for the country being given the scarcity of resources. Thus, reporting on the different thematic areas was outsourced and the CCU of MET catered for the whole process. The enhancement of the reporting requirements demands for higher standards and a permanent framework to enable the sustainable production of these reports while guaranteeing their quality. In addition, there is a need to develop and establish permanent systems for monitoring, reporting and verifying mitigation actions (MRV) and other activities related to the Convention.

During the exercise of strengthening of the existing institutional arrangements, numerous and very daunting challenges cropped up. The most urgent ones were:

- Insufficient capacity of the coordinating body as well as lack of institutional and technical skills within the different thematic areas of the NC;
- To maintain a motivated permanent coordinating body and/or personnel;
- Staff scarcity / unavailability in collaborating institutions due to their already overloaded schedules and staff turn-over; and
- Lack of incentives and adequate funds to develop and maintain the system in place.

The national experts in the various departments will need capacity building for implementation, follow-up, quality control and reporting. New recruits to perform independent validation and verification will have to be trained. Unless technical assistance is provided, the country will have to look for alternatives, such as outsourcing resource persons to provide for these capacity building needs.

Financial resources are also lacking to develop and implement the framework for sustainable reporting and the MRV system. Already, government budget is strained due to the numerous national priorities and it may prove difficult to allocate enough funds to cover all these expenses. It is hoped that funds will be made available through the multilateral organizations like the Global Environment Facility to support activities, including the very urgent capacity building needs, to enable Namibia develop, establish and implement this framework.

8.2. GHG inventory

Namibia, as a developing country, has its constraints and gaps that need to be addressed to produce better quality reports for reporting to the Convention. The following problems were encountered during the preparation of the national inventory of GHG emissions:

- Information required for the inventory had to be obtained from various sources as no centralized archiving system has been developed for GHG inventory preparation;
- Almost all of the AD were not in the required format for feeding in the software to make the emission estimates;
- End-use consumption data for all the sectors and categories were not always readily available;
- Reliable biomass data such as timber, fuelwood, wood waste and charcoal consumed or produced were not readily available and were estimated;

- Inconsistencies were found when data were collected from different sources;
- Solid waste characterization data, amount generated and wastewater generated are not regularly measured and had to be derived;
- EFs have to be derived to better represent national circumstances and improve estimates;
- National experts need more training on the GHG estimation software to become fully conversant with them.

8.3. Mitigation and Adaptation

Implementation of mitigation and adaptation measures and actions is a major challenge for the country in view of the multiple constraints and gaps that exist in various areas, namely at the institutional, organizational and individual levels. There is a need to create the enabling environment in the country. Needs also exist for improving the technological assessment and transfer for mitigation and the technical capacity of national experts. Further assessments still have to be undertaken to identify more prominent measures and actions as well the prioritize those with the highest potential for successful implementation.

Barriers will have to be removed to speed up the process of implementation of mitigation and adaptation, and the preparation of project proposals for funding.

The appropriate funding amounts and timing are important features to take into consideration when these measures and actions, especially the implementation aspect, are aligned with the country's development strategy and agenda. Implementation is even more difficult as a result of the significant amounts of sustained funding required to develop and implement mitigation and adaptation projects. Up to now, Namibia has not tapped much funding to support its mitigation strategy. There is need for these shortcomings to be corrected by the international community through further consolidation of the Green Climate Fund for the latter to fully fulfil its role. It is also expected that new instruments will be developed to assist Non Annex I Parties to play their role in implementing the Convention urgently because of their higher exposure and vulnerability to the impacts of climate change. A list of actions requiring funding have been provided in the BUR1. An estimate of funds needed has also been provided in the INDC for the most urgent actions for both mitigation and adaptation to the 2030 time horizon.

8.4. Financial Needs

For the country to meet its reporting obligations and implement the Convention requires substantial funding. The appropriate funding amounts and timing are important features to take into consideration when these actions, especially the implementation aspect, are aligned with the country's development strategy and agenda. Namibia as a developing country with its challenges to feed its population and provide the minimum requirements to it is not able to allocate the funding requirements to meet the climate change agenda. Avenues concerning funding have been identified in the NCCP and further detailed in the CCSAP.

The NCCP highlighted that government consider and explore a range of multi- and bilateral funding options including grants, concessional and non-concessional loans, as well as market-based instruments. The NCCP also emphasises the importance of evidence-based strategies and action plans, and observes that "Climate change research needs to be properly coordinated, and its benefits optimised to meet the needs of decision-makers in Namibia".

The CCSAP on the other hand identified the need to maximise government financing instruments at the national and local levels; leverage private sector investment; and access scaled-up, new and additional (external) financial resources. The need also exists to develop assessment tools to inform decision-making, and to establish partnerships among national and local government agencies, business, professional and other private groups, community based organisations, academic and scientific organisations and civil society organisations in order to realise its objectives. Policy and incentive mechanisms have to be introduced to facilitate and leverage private sector investment in climate change, and it is expected that Public Private Partnerships will contribute both monetary and human resource capacity to implement the required actions.

Implementation is even more difficult as a result of the significant amounts of funding required to develop and implement mitigation and adaptation projects. Up to now, Namibia has not tapped much funding to support its mitigation strategy. There is need for these shortcomings to be corrected and a list of urgent actions requiring funding is provided in the INDC up to the 2030 time horizon for mitigation and adaptation, including technology transfer for these actions.

Reporting has become more stringent and has to be supported by sufficient background studies to reflect the status of the country and its efforts in implementing activities to meet the objectives of the Convention. While it is recognized that the international community is providing support through the implementing agencies of the GEF, the amounts are insufficient and there are often problems in the timing for the release of the funds that prevents the country to meet the frequency of submission of the national reports.

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