Republic of Namibia
Ministry of Environment and Tourism

Namibia Second National Communication to the United Nations Framework Convention on Climate Change

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Foreword

The Honourable Minister of Environment and Tourism, Netumbo Nandi-Ndaitwah, MP

On behalf of the Government of the Republic of Namibia, it is an honour and privilege to present Namibia's Second National Communication to the Conference of the Parties to the United Nations Framework Convention on Climate Change.

Namibia is one of the driest countries in Southern Africa with a mean annual rainfall that ranges from 25 mm in the southwest and west, to 700 mm north and northeast. Namibia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1995 and became obligated to submitting national communications as per requirement of the UNFCCC. The Initial National Communication (INC) of Namibia was presented to the UNFCCC in 2002. The INC reported that the Namibian economy is natural resource based and is extremely sensitive to climate change effects. The Second National Communication (SNC) is a follow up to the Initial National Communication (INC). The SNC built on and continued the work under the convention.

Since the submission of the Initial Communication, much has happened. Namibia has completed its National Climate Change Policy (NCCP). The policy provides legal basis for resource mobilisation to address climate change adaptation and mitigation. The NCCP promotes the enhancement of synergies amongst sectors. Every sector is requested to prepare and implement a sector strategy to address the impacts of climate change The country has also restructured the National Committee on Climate Change (NCCC), established a National Designated Authority (DNA) office for Clean Development Mechanism (CDM) projects, carried out a Climate Change Vulnerability and Adaptation Assessment for the country's Biodiversity and Protected Areas.

Namibia has conducted and completed an Investment and Financial Flows (I&FF) assessment to address Climate change. The main goal is to describe and quantify the implications of national policy options to address climate change in the country's energy and land use, land use change and forest (LULUCF) sectors. These two sectors have been identified as Namibia's key sectors for enhanced mitigation and adaptation activities.

Namibia's SNC also recognises that climate change is a crosscutting issue which affects all sectors of our economy. Namibia's current primary focus is to build and secure appropriate long-term sustainable resources for adaptation to the effects of climate change. Namibia will predominantly focus on low carbon development and sustainable energy, explore and utilise available global mitigation techniques for the country's economic benefits through CDM projects. Namibia regards itself as a full and active partner of the global village efforts to promote a low carbon economy.

Namibia's SNC has been prepared taking into account of the country's reliance on natural resources for the country's economic activities. The promotion of environmental and ecological sustainability became one of the key national strategies in the present communication. The SNC document has pointed out that the arid and fragile environment places a limit on economic development of our country. Therefore, there is a need to safeguard our biodiversity because it is both a fundamental basis for livelihood generation and a national asset of significant value that underpins an important nature-based tourism industry.

The preparation of Namibia's SNC has drawn relevant stakeholders such as central government, academic and research institutions, and non-governmental organisations. Their involvement has greatly contributed to the comprehensive information contained in this document.

Netumbo Nandi-Ndaitwah, MP
MINISTER

Acknowledgements

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Report	Institution	Date	Authors
Review and Update of National Circumstances	Desert Research Foundation of Namibia (DRFN)	21 Sept 2009	D. von Oertzen, V. Kinyaga, H. Krugmann, and E. Dirkx
Namibia's Greenhouse Gas Inventory for Year 2000	Consulting Services Africa	March 2008	C. Hartz and C. Smith
Namibia Energy Review for the UNFCCC	Asca Investment (Pty) Ltd; Neema Consultanct cc; Tinda ESI Consultants cc	20 July 2007	J. Capôco, E. Hoveka and M. Heita
Climate Change Vulnerability and Adaptation Assessment Namibia	DRFN and the Climate Systems Analysis Group (CSAG), University of Cape Town	March 2008	E. Dirkx, C. Hager, M. Tadross, S. Bethune and B. Curtis
Research on Farming Systems Change to Enable Adaptation to Climate Change	University of Namibia	July 2008	U. Kuvare, T. Maharero and G. Kamupingene
Sea-level rise in Namibia's coastal towns and wetlands: projected impacts and recommended adaptation strategies	Consulting Services Africa; LaquaR Consultancy; Lithon Project Consultants	25 August 2009	G. Bundrit, D. Nel, L. Fairhurst and A. Cartwright
Climate Change Strategy and Action Plan (proposed)	Versacon Consulting, Windhoek	October 2009	J.K. Mfune, O.C. Ruppel, N.E. Willemse and A.W. Mosimane
National Policy on Climate Change for Namibia	Ministry of Environment and Tourism, Namibia	2011	Ministry of Environment and Tourism, Namibia

In addition, the following study was also used:

The economic impact of climate change in Namibia: How climate change will affect the contribution of Namibia's natural resources to its economy, November 2008. H. Reid, L. Sahlén, J. MacGregor and J. Stage. *International Institute for Environment and Development (IIED), Environmental Economics Programme, Discussion Paper 07-02*.

Participants of Workshops

Members of the Namibian Climate Change Committee are thanked for their support and comments during the review process.

Others within the MET or other Ministries

Photographic contributions

Executive Summary

INTRODUCTION

The Republic of Namibia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1995, and thus became legally obligated to adopt and implement policies and measures to mitigate the effects of climate change and to adapt to such changes. This Second National Communication (SNC) to the UNFCCC follows and builds on the Initial National Communication (INC) submitted in 2002, and has been prepared in fulfillment of Namibia's obligations to the UNFCCC under Articles 4 and 12. The Communication follows the UNFCCC guidelines and includes information on Namibia's Greenhouse Gas Inventory for the year 2000, as well as measures to mitigate emissions and adapt to climate change in key sectors. The project was coordinated by the Ministry of Environment and Tourism (MET), through its Directorate of Environmental Affairs (DEA) and on behalf of the National Climate Change Committee (NCCC). The Global Environment Facility (GEF), through the United Nations Development Programme (UNDP), provided funding.

NATIONAL CIRCUMSTANCES

Geography, climate and natural resources

Namibia is situated on the Atlantic coast of southern Africa, with a climate strongly influenced by the cold Benguela Current and the Tropic of Capricorn. The altitude range in Namibia is from sea level to 2606 m. Much of the interior basin has a mean altitude of 1000 m. Nearly half of the country's surface is exposed bedrock, while young surficial deposits of the Kalahari and Namib deserts cover the remainder. The varied geological formations contain a substantial mineral resource, including diamondiferous deposits, coal and gas.

Namibia is one of the driest countries south of the Sahara. The mean annual rainfall ranges from just above 700 mm in the northeast to less than 25 mm in the southwest and west of the country. Most rain falls in the summer months (November to April) in the form of thunderstorms and showers, except in the southwest where winter rains account for at least half of the annual total. Temperatures are moderately cool along the coast, while the interior is moderately warm. Average annual maximum temperatures in the hottest months are usually above 30°C over most of the country, excluding the coastal belt where it is much cooler, and the arid south where mean temperatures rise to as high as 36°C.

Water is scarce, rainfall erratic, and droughts are frequent. Lack of water is the key limitation to Namibia's development. High solar radiation, low humidity and high temperatures lead to very high evaporation and evapotranspiration rates. Surface water sources such as dams are subjected to high evaporation rates. Only about 1% of rainfall replenishes the groundwater aquifers that many Namibians depend on, and 2% runs off into surface water resources. The perennial rivers lie on the borders, with the Orange River in the south and the Kunene, Kavango, Kwando-Linyanti-Chobe and Zambezi Rivers in the north. The use of water from perennial rivers is subject to negotiations with other riparian states. Rivers, springs, pans and wetlands within the territory of Namibia are generally ephemeral. In the north central area, temporary water bodies called oshanas form after rainfall. Current unconventional sources include recycling of water in industrial processes, the reuse of water for industrial and irrigation purposes, the reclamation of domestic sewage effluent to potable water quality standards, artificial recharge of groundwater resources and desalination.

Namibia is globally known for her remarkable variety of species, habitats and ecosystems. Worldwide it is one of the few dry land countries with internationally recognised biodiversity "hotspots". Marine and bird biodiversity are also high. In addition to the three Ramsar sites (Orange River mouth, Sandwich Harbour, Walvis Bay) there are eight Important Bird Areas (IBAs) including three coastal islands. Namibia's biodiversity is both a fundamental basis for livelihood generation and a national asset of significant value which underpins an important nature-based tourism industry.

The main vegetation zones are desert (46%), savanna (37%), and dry woodlands and forests (17%). Less than 2% is arable land. Protected areas cover 13.8% of the land surface. Land tenure takes three forms: freehold private land (43%) used for commercial farming and wildlife management, communal land (37%) used for subsistence farming, and municipal/town/other State land (1%). There are 63 registered Communal Conservancies on communal lands.

Economic sectors

Agriculture is severely constrained by lack of water and poor soils. Agricultural contribution to GDP is in the range 4.5-7%, but the sector supports over 70% of the population. Extensive livestock ranching dominates, and includes cattle, small stock, and game. This sub-sector contributes just under 90% of agricultural GDP. The majority of Namibians depend on rainfed subsistence agriculture, farming pearl millet, sorghum and maize. Rainfed crop production is limited to higher rainfall areas in the north and north-east. Maize and wheat are grown under irrigation on some commercial farms. Irrigated agriculture is concentrated in fertile areas with high annual rainfall or abundant surface of groundwater resources, and includes a variety of horticultural crops. Increased irrigation is planned (the Green Scheme). Irrigated lands are at risk of soil salinisation under inadequate management practices.

While **forestry**'s contribution to GDP is relatively low compared to other renewable resource sectors, it plays an important role in community development. Commercial forest products include fuel wood, poles, sawn timber and non timber forest products. 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.

Namibia has one of the most productive **fishing** grounds in the world, based on the cold Benguela Current and associated nutrient upwelling. The off-shore commercial fishery, based on demersal (bottom dwelling) hake and other deep-sea species, represents the largest component of the fishing industry. The commercial fishing and fish processing sectors significantly contribute to the economy in terms of employment, export earnings, and contribution to GDP. Significant research and management resources, coupled with a robust policy framework, and participation in the multilateral Benguela Current Commission (BCC), have contributed towards establishing a sustainable fishery and rebuilding fish stocks. Freshwater aquaculture is promoted to increase food security in rural areas, while mariculture exploits the lucrative markets of Asia.

There are four significant **coastal towns**, including Walvis Bay. This town is located between 1 and 3 m above sea level, in a small semi-sheltered bay surrounded by an erodible coastline. Walvis Bay is an important deep water port providing trade access to landlocked countries such as Botswana.

Namibia's unique landscapes and biodiversity support a rapidly developing **tourism sector**, second only to mining in terms of contribution to GDP, and an important foreign exchange earner. It provides an important direct and indirect source of employment and income generation, particularly in rural areas where most tourism activities occur. Tourism is largely nature- and wildlife-centred. However, tourism itself impacts on the environment and its services, e.g. by relying heavily on scarce water resources in arid areas. Land use for tourism in parts of Namibia, outside protected areas, has high economic potential compared to livestock and agriculture. The declaration of community conservancies tries to reconcile the basic needs of subsistence farmers with the conservation of nature. Through the national community-based natural resource management (CBNRM) programme, rural communities in communal areas are empowered to manage their natural resource base sustainably, invest in wildlife and benefit from the resulting tourism opportunities, in particular via hunting concessions.

Mining, particularly diamond mining, is the backbone of the Namibian economy in terms of economic output and exports. Other resources mined include uranium, zinc, copper, semi-precious stones, and fluoride. Oil and gas resources have been found and gas is now being exploited at the off-shore Kudu Gas Field in southern Namibia. Mining still plays a vital role in stimulating infrastructure growth. Small-scale mining could contribute significantly to employment creation and poverty reduction. Small-scale mining is expected to grow in relative terms and additionally holds the possibility of "mining tourism," where operating mines provide tourism experiences. Also, the agreement to allocate 16 % of diamond production for local cutting and polishing contributes to domestic value addition.

Manufacturing is currently the third largest contributor to national GDP. The manufacturing sector largely depends on the processing of agricultural (grain and meat processing) products, food and beverages, and fishery products. Mining output is processed to a lesser extent in the country, and includes diamond and gemstone cutting and polishing. Other operations include a lead smelter, a zinc refinery, a large textile plant, a leather tannery, and charcoal production. Namibia's Industrial Policy aims to increase manufacturing activities to reduce dependency on the primary sector and add value to raw materials.

Energy is generated locally using hydropower, and coal- and diesel-burning power stations. Total generation capacity is 384 MW per annum. In the rural areas, energy needs are met with diesel generators, solar panels, firewood, candles and paraffin. Energy demand is growing by about 3% per year. The local supply does not meet the demand. The shortfall (up to 70%) is made up with electricity imported mainly from South Africa. The diminishing overcapacity in South Africa is posing a risk to Namibia's energy security. To increase generating capacity at a national scale, natural gas and more hydropower will be used, including the new 800MW Kudu Power Station, a combined cycle project using natural gas from the Kudu Gas Field. Planned new hydropower plants include Epupa/Baynes on the Kunene River (400 MW), and Orange River Small Hydro Schemes. Smaller wind and solar generation projects are also envisaged, as well as bio-energy from Jatropha and invasive bush.

Namibia's **transport** infrastructure is well developed, and includes an extensive road network, railway, two major ports, one international airport and a network of smaller airports and landing strips. The Trans-Caprivi and Trans-Kalahari Highways connect Walvis Bay to neighbouring countries in the north and north-east, and the east, respectively. Passenger transport is mainly by minibuses and sedans; for business people and tourists, air travel is preferred. Vehicle sales and vehicle fuel demand closely follow economic growth in Namibia, particularly commercial vehicles fuelled by diesel. Transport fuel consumption constituted over 70% of Namibia's total energy demand in 2006. This is due to the economy's reliance on large volumes of imports that come into the country on land. All petroleum products are imported from refineries in South Africa.

Other important sectors, in terms of contribution to GDP, include Government services (the main single contributor to GDP), wholesale and retail trade, real estate and business services, the construction business and financial intermediation.

The Namibian **economy** slowed down in 2008 following stronger growth in mid-decade, due to the global economic crisis. Growth was recorded in the secondary (driven by electricity and construction) and tertiary industries, but the primary industries have declined. In the primary sector, the agriculture (livestock) and forestry sectors are growing moderately, but fishing and onboard fish processing has declined strongly, mainly attributed to lower catches for demersal and mid-water species. This had knock-on effects for onshore fish processing. The mining and quarrying sector recorded a decline in real value added in 2008, reflecting the global financial crises affecting the demand for minerals.

The global economic and financial crises have impacted on Namibia's economic performance and short term economic outlook. Since the small economy of Namibia is highly trade dependent, response measures adopted by major trade partners will affect Namibian exports such as meat, fish, fruits and diamonds. Rising oil prices and the electricity crisis in Southern Africa are a matter of great concern, because these will affect Namibia's capacity to achieve its development goals, objectives and economic targets. Nevertheless, the Government of Namibia is stimulating growth through fast-tracking of several economic sectors. Simultaneously, sustainable Official Development Assistance (ODA), as well as stable and sustainable aid flows are expected within the context of south-south cooperation from the emerging nations such as China and India, who are also increasingly absorbing Namibian exports. Together, these factors should cushion some of the negative impacts of the volatile global economy on the Namibian economy.

On the domestic front, policies aimed at steady and sustained growth are pursued to fight the triple threats of unemployment, poverty and inequality. Targeted sectoral initiatives, particularly development of rural infrastructure, will be fast-tracked. The Green Scheme, land reform and resettlement and Small Medium Enterprises promotions will be accelerated. The telecommunications network will be improved, and policies and strategies will be introduced to ensure a reliable and interruption-free power supply.

Population and health

Namibia's **population** in 2001 was approximately 1 830 330. The country has a relatively young population, with two-thirds living in the rural areas. Population densities vary substantially between regions, with two-thirds of the population living in the four northern regions, and less than one-tenth living in the country's south. Women head approximately 41% of households. Although the fertility rate in Namibia has decreased, the average size of a household is still fairly large at 4.9 persons. The population is expected to grow substantially, by 66%, from 2001 until 2031. Namibia is still mainly rural, but the rate of urbanisation is expected to increase. The percentage of the population 15 years and over who are literate stood at 85% in 2005 following strong improvements. The average percentage unemployment rate was 33.8% for the period 1996 to 2005. Although only 31% of Namibians work formally or semi-formally in agriculture, over 60% of the working population practice some form of agriculture for a livelihood. On average, farm workers spend 70% of their income on food, confirming their high levels of poverty. The GINI index is 74.3, which makes Namibia one of the most unequal societies in the world.

Namibia's provision of **health** services is shared between the public and the private sector, the latter focused 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 public health problems. Fortunately, the annual malaria-related mortality rate has decreased steadily since 2004, as has the incidence of malaria, thanks to malaria control and management programmes. 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 stabilised. 7% of all people living with HIV/AIDS are under the age of 15, and 60% are women. Orphans and other vulnerable children constitute 28% of all children. Of the children who have lost one or both parents, approximately 50% were estimated due to HIV/AIDS. The very high incidence of tuberculosis in Namibia is fuelled by the HIV/AIDS pandemic, which has reduced life expectancy from 62 years in 1991 to 49 years. It is likely that HIV/AIDS has had a negative effect on total GDP growth, with links to poverty and food insecurity. Agricultural labour reductions and loss of productivity in the conservation and health care professions are already being felt. Overall, HIV/AIDS threatens human capacity in the country, with implications for mitigation and adaptation efforts.

NATIONAL GREENHOUSE GAS INVENTORY

The Namibian Greenhouse Gas Inventory for Year 2000 is the second inventory to be prepared for Namibia, following the first one in 1994 which was used for the INC. It is a comprehensive review of the anthropogenic (human caused) sources and sinks for greenhouse gases (GHGs) in Namibia. It is important to note that the inventory does not account for GHG emissions occurring 1) in other countries resulting from electricity imported to Namibia, 2) in Namibia, international open space or other countries resulting from international airplane flights to or from Namibia, or 3) in other countries resulting from the manufacture of consumer goods in other countries that are imported to Namibia. The inventory is broken down into the six sectors which have been prescribed by the IPCC's Revised 1996 Guidelines for National Greenhouse Gas Inventories. Overall, it is shown that Namibia is a net sink for GHGs.

The results for CO_2-equivalent emissions and removals clearly indicate that the agriculture and energy sectors are most important with respect to emissions, and the land-use change and forestry sector (LUCF) is most important with respect to removals. The uncertainty of data for the agriculture, energy and LUCF sectors would appear to be greatest for the LUCF sector. While there is excellent supporting data available for the agriculture and energy sector emission calculations, the supporting data for the LUCF sector removal calculation is less definite. The large removal value is based on a rough estimate of the annual increase in mass of invader bush biomass. It has been estimated that approximately 26 million hectares of land are affected by the bush encroachment problem. A rough estimate of the annual amount of biomass growth for such a large area is clearly subject to some uncertainty. As mentioned in the 2005 report, Review of Greenhouse Gas Emission Factors in Namibia, more scientific data supported by new field tests and remote sensing is needed to reduce the uncertainty underlying the CO_2 removal calculations for bush encroachment.

The largest differences in emissions and removals between the Year 1994 and Year 2000 inventories occur in the agriculture and LUCF sectors. The primary reason for the change (increase) in the agriculture sector GHG emission is that improved emission factors were utilised to calculate emissions from farm animals in the Year 2000 inventory. The improved emission factors are generally higher than those utilised in the 1994 inventory. The primary reason for the change (increase) in LUCF GHG removal is that new data was available regarding the extent of the bush encroachment problem and the annual increase in biomass resulting from the growth of invader bush.

A few detailed recommendations have been formulated that both would improve future GHG inventories, and would provide cross-cutting benefits related to carbon credit applications, promotion of renewable energy, and finding solutions to the bush encroachment problem. The following are the recommendations:

Recommendation 1: Establish a greenhouse gas data collection unit within a Government body such as the National Planning Commission Central Bureau of Statistics or the Ministry of Environment and Tourism – Department of Environmental Affairs.

Recommendation 2: Conduct scientific studies that will significantly improve our understanding of the impact of invader bush encroachment on Namibia's greenhouse gas profile.

Recommendation 3: Clarify the details of pre-anthropogenic baseline ecological conditions in Namibia.

Recommendation 4: A review similar to the 2005 Review of Emission Factors for Namibia should be performed on the 2000 Inventory.

IMPACTS, VULNERABILITY AND ADAPTATION

For the purposes of the impacts and vulnerability assessment, emphasis was placed on the socio-economic contexts of rural areas, in particular the Karas (south) and Caprivi (north) regions. Particular attention was paid to the water and agriculture sectors, the coastal zone, tourism (and specifically the importance of Community-Based Natural Resource Management [CBNRM]), and human health (focusing on malaria and HIV/AIDS). Notwithstanding the challenges associated with modeling the future climate of arid/semi-arid regions, where natural climate variability exceeds the climate change signal over the next few decades, vulnerability was assessed against broad statements of change.

Climate change in Namibia

It is predicted with a high degree of certainty that Namibia will become hotter throughout the year, with a predicted increase in temperatures of between 1°C and 3.5°C in summer and 1°C to 4°C in winter in the period 2046 - 2065. Maximum temperatures have been getting hotter over the past 40 years, as observed in the frequency of days exceeding 35°C. Equally, the frequencies of days with temperatures below 5°C have been getting less, suggesting an overall warming.

Detecting trends in rainfall is typically more difficult, especially in highly variable arid climates such as Namibia. Considerable spatial heterogeneity in the trends has been observed, but it appears as if the northern and central regions of Namibia are experiencing a later onset and earlier cessation of rains, resulting in shorter seasons in most vicinities. There has been a statistically significant decrease in the number of consecutive wet days in various locations, and increases in measures of rainfall intensity could be observed. As far as predictions for the future are concerned, it is not obvious whether Namibian rainfall will be reduced, although intensity is likely to be increased. The most consistent changes are for an increase in late summer rainfall over major parts of the country, and a decrease in winter rainfall in the south and west of the country. Increases in rainfall are most obvious during the January to April period, especially in the central and north-eastern regions. It is important to underscore that variability, and stronger variability at that, is likely to remain the key aspect of Namibia's climate in the future.

Socio-economics and climate change

Vulnerability is informed by climatic changes, but also depends on the capacity to respond adequately to those changes. Household income, income diversification, availability of labour, the health status of household members, and access to productive assets and resources are factors that determine vulnerability. In combination with environmental conditions and the impact of the HIV/AIDS pandemic, these factors negatively impact on agricultural production and food security. Ultimately they contribute to limited adaptive capacity. External factors such as the existence of formal and informal social support networks, the availability and quality of health services, and prices of farm inputs and outputs further influence the capacity to cope with and recover from climate shocks.

The vulnerability to climate change differs between regions in Namibia and between various socio-economic groups. In particular, the impact of poverty and HIV/AIDS may reverse relatively favourable environmental conditions in the northern regions. In general, it is a matter of concern that the capacity for social organization and support in communities in various regions of the country appears to be dwindling. This will limit adaptive capacity.

Water resources

Namibia has reached or exceeded its carrying capacity with regard to water in many areas of the county. The agricultural sector uses about 75% of all water use, and the Green Scheme is likely to add another 80% above current irrigation abstraction. The projected temperature increases will result in evaporation and evapotranspiration increases in the range of 5-15%, further reducing water resource availability and dam yields. It is predicted that, even without the additional stresses of climate change on the water resources, demand will have surpassed the installed abstraction capacity by 2015.

A reduction of 10-20% in rainfall by 2045-2065 over the Angolan catchments of the Zambezi, Kavango, Cuvelai and Kunene rivers is expected to lead to a reduction in runoff and drainage in these river systems by +/- 25%. The impacts of project climate changes on run-off, peak flows, and sustainable dam yields for the Fish river basin were modelled. The interpretation of the results is limited due to uncertainties in the models, particularly the climate models. Within these limitations, there are signs that runoff may increase in the far South of the country, whereas this is less clear for the central-southern area of Hardap.

Wetlands are likely to provide reduced ecosystem services such as water retention, flood attenuation and water purification, negatively affecting rural livelihoods and tourism. The mouths of the Kunene and Orange rivers are likely to be affected, with possibly serious implications for their qualifications as Ramsar sites. Floodplains in the Caprivi and oshanas (ephemeral rivers and pans formed in the shallow depressions of the Cuvelai system in the north) remain particularly vulnerable, as smaller areas will be inundated, and because they may dry out more rapidly due to increased evaporation. The Okavango delta may be strongly affected in similar ways, as a result of which it may potentially shift to a seasonal river.

Due to uncertainties with regard to the relationships between rainfall and runoff in arid environments such as Namibia, only preliminary deductions can be made around the implications for groundwater recharge. Literature suggests that groundwater recharge may suffer a reduction of 30-70% across Namibia; a potential exception could be found in the recharge of alluvial aquifers that have their origins in central areas of Namibia, where more late summer convective rainfall can be expected by the middle of the 21st century (a trend that can moreover already be observed).

Agriculture

The agricultural sector is critical to the subsistence base of a large section of Namibia's society. The dualism of the sector, with its marked differences in access to credit, markets and inputs, accentuates the socio-economic vulnerabilities of rural dwellers in Namibia. While the impact of climate change will be felt across all farming communities, being rich or poor, communal or commercial, poor people living in marginalised areas will be most severely affected. A complex interaction of socio-economic stressors in subsistence farming households exists (poor health, inequitable access to land, gender inequality, population growth, and increasing competition for shared resources), and climate change induced impacts will only add to this situation.

Crop models for potential yields and planting windows for the mid-21st century for Namibia's main staple grains, maize and pearl millet, for Rundu and Grootfontein, yielded largely inconclusive results owing to model uncertainties. The potential for crop production in the Grootfontein area may increase. The success of the flagship Green Scheme (GS), which aims to encourage agricultural and rural economic development within suitable irrigation areas, will be highly dependent on the provision of water resources (particularly the Kavango river). Under climate change, with a projected decrease in rainfall of 10%, proposed GS sites may experience reductions in perennial drainage of 30-60%. This may affect the viability of the scheme with implications for national economic development and food security.

Impacts of climate change on the livestock sector will depend on grazing availability, quality, and bush encroachment; livestock production and reproduction responses; water availability and demand; and disease and parasite impact. Significant changes in vegetation structure and function are projected, with the dominant vegetation type Grassy Savanna losing its spatial dominance to Desert and Arid Shrubland vegetation types, and increases in bush encroachment in the north-eastern regions. Reductions in vegetation cover and reduced Net Primary Productivity (NPP) have negative implications for grazing. Maximum temperature thresholds for conception in cattle will be breached for some popular breeds. Increased water demand will reduce grazing distances and exacerbate degradation around watering points. Warming and changing rainfall distributions could lead to changes in the spatial or temporal distributions of climate-sensitive diseases/vectors/pathogens.

Coastal zone and fisheries

Namibia, with its long coastline and important fisheries sector, is vulnerable to the impacts of sea level rise. Under a short-term (2030) sea level rise scenario, damages are likely to be limited, except for early damages to, and disruption of the economically important Walvis Bay port infrastructure and activities. With the protective Pelican Point sandspit still in place in 2030, enhanced coastal erosion from a sea level rise of +20cm will lead to a likely coastal set-back estimated at almost 100m. With the sandspit destroyed, sea level rise of +2m on an annual basis, and of +3m from extreme sea levels with a return period of 100 years, would inundate much of the town. The other three major coastal towns would only suffer relatively minor damage to fixed infrastructure and property, compared to the serious impacts on Walvis Bay. Over the longer term, under the scenario of polar ice melt, low lying coastal areas will be permanently inundated, leading to the wholesale disruption of infrastructure and services along the coast.

Sea level rise and associated storm surges will bring about biogeophysical impacts such as coastal erosion; flooding, inundation and displacement of wetlands and lowlands; landslides; salt water intrusion into freshwater aquifers and estuaries; and reduced protection from extreme storm and flood events. Coastal populations have a high dependence on aquifers, this constitutes a key vulnerability. Raised water tables could allow an encroachment of polluted water into wastewater treatment facilities, increasing the probability of sewage overflow, with the associated human and ecological health hazards.

The ability of coastal ecosystems to provide services such as provision of food, tourism/recreation, flood attenuation, and replenishment of groundwater, could be impaired. Slowly increasing salinity levels of estuaries and aquifers, and changes to habitats and primary production, would be detrimental to spawning and nursery grounds for many fish species, thus impacting on the shore birds which feed on them. The ability of the Namibian coast to continue supporting large numbers of migratory and shore bird numbers could be jeopardised. Breeding sites on coastal islands would be at particular risk of flooding from sea level rise. In the longer term, the effects of sea level rise on primary production in coastal systems may largely be dependent upon variations in the nutrient concentrations caused by changes in ocean current patterns and upwelling regimes associated with the Benguela system.

CBNRM and tourism

Climate change could affect the growing nature-based tourism industry in Namibia directly by impacting on the tourism resource base, through changes in habitats, landscape characteristics and vegetation cover, biodiversity loss, decreasing water availability, increased frequency and severity of climate hazards, coastal erosion, and increased incidence of vector borne diseases (like malaria). Projected declines in vegetation cover and significant change in vegetation structure and function, would impact on tourism. Beneficiaries of the CBNRM programme in conservancies and forest reserves, who are developing sustainable livelihoods based on resource management and tourism, stand to be severely affected by any such changes. On the other hand, shifts in land use systems away from livestock production systems based on exotic species, toward indigenous biodiversity production systems, may reduce impacts, and possibly even benefit the tourism potential.

The indirect impacts of climate change on the future of the tourism sector are likely to be of greater relevance. Significant shifts are occurring in international consumer awareness and attitudes, with increasing concerns regarding the carbon footprint of long-haul air travel to distant tourism destinations. This is resulting in greater consumer reluctance to engage in such travel for tourism purposes and greater willingness-to-pay for tourism products and services that are environmentally friendly and have a smaller carbon footprint.

Health

Human health will be impacted through a complex set of interactions, both in the shorter- and longer-term, with many direct as well as indirect impacts. Climate change, and particularly the effect of increased variability, will add additional pressures to the social environment and a health care system that is already burdened by challenges such as HIV/AIDS, tuberculosis, malaria and malnutrition (especially in rural areas). In populations with reduced immune responses, additional stresses brought about by climate change could lead to an increased risk of diseases, including co-infection with TB. The HIV/AIDS epidemic, in combination with poverty and a reduced capacity of institutions to respond, has already reduced the resilience of rural households. Also, HIV/AIDS has not yet been adequately mainstreamed in emergency management practices, with recent floods having caused substantial disruptions in the delivery of HIV/AIDS-related health services. Women, orphans and other vulnerable children, the chronically ill, and those infected with HIV/AIDS are more vulnerable to the impacts of climate change.

Climate change could affect health through the direct impacts of increasing temperatures, with newborns, the old and infirm, and those with pre-existing medical conditions particularly vulnerable. Rural Namibians with poorer access to medical services are considered relatively more vulnerable. Increasing contamination of open water sources driven by floods and droughts and a diminishing resource, and exacerbated by increasing pressure from humans and animals, may increase the risk of diarrhoea, cholera, fever and related water borne illnesses. Rising temperatures and more intense rainfall events are conducive to increased breeding of the malaria-carrying mosquito, and rising transmission rates. Currently non-endemic areas bordering endemic zones could experience higher risk of malaria, with sporadic occurrences over time increasing the range of endemic areas. Currently malaria-free areas, including some major population centres, could become exposed in future.

Reductions in crop yields and increasing populations could reduce the availability of food in rural Namibia, thus increasing malnutrition and contributing to weakened human disease defenses, and increasing mortality, particularly in children. The provision of sufficient safe, reliable and affordable water, and good sanitation and drainage, all essential for human health, will become increasingly challenging. Water scarcity is likely to lead to an increase in conflict within and between communities, and in migration and its associated impacts on increasing the spread of diseases, especially in peri-urban and urban areas. This will challenge urban health, water and sanitation services.

The economy

An economic analysis of the potential impacts of climate change on the Namibian economy (GDP and income distribution), based on six scenarios of changes in the agriculture and fisheries sectors (being strongly climate-sensitive), was conducted. Under a best-case scenario, agricultural impacts would be partly offset by improved water distribution, there would be no impact on fisheries and the overall GDP would fall by only about 1%. Under a worst-case scenario, large-scale shifts in climate zones would reduce agricultural and fishing outputs, and the overall GDP would fall by almost 6% over 20 years. However, this estimate constitutes only a fraction of possible climate change impacts because it considers only two economic sectors that are directly affected. Furthermore, climate change impacts will hit the poor hardest, with employment opportunities constrained and a substantial decline in wages, especially for unskilled labour. Even under the best-case scenarios, subsistence farming will fall sharply. In the worst-case scenario for agriculture, labour intensive livestock farming is hit hard, and while high-value irrigated crop production could thrive, employment creation in this area would be minimal. Thus, even under the best-case scenario, a quarter of the population will need to find new livelihoods. Displaced rural populations are likely to move to cities, which could cause incomes for unskilled labour to fall by 12 to 24% in order to absorb the new workers. Income distribution in Namibia is already one of the most uneven in the world and this inequality is likely to increase, with significant implications for future social cohesion, if no counteracting policies are put in place.

Adaptation

This report highlights the importance of addressing climate change from a developmental perspective, cutting across policies and warranting early action. Namibia's ability to adapt to climate change will be informed by its aridity, environmental sensitivity, population growth trends and high densities in northern areas and internal migration, high dependence on natural resources (particularly agricultural land), widespread poverty amongst some sections of the population, decline in effective traditional land management systems, and lack of access to credit and savings.

However, people may not adapt sufficiently to climate change for a variety of reasons. Climate may be perceived to pose little risk relative to other hazards and stressors and therefore given low priority, as shown in the Namibian Poverty Profiles. A Namibia specific study identified the following barriers to adaptation to climate change:

- Insufficient awareness (information limited to specialists and access to research by stakeholders)
- Political and institutional barriers (implementation of policies, low public participation)
- Socio-cultural barriers (technology stigmatation and techno-focus, as well as a different local priority than national ones at times)
- Financial barriers (types and conditionality of funds, insufficient pricing of resources, and lack of access to private funding)

Namibia aims to address its increasing ***water*** scarcity through both supply- and demand-side interventions within a framework of Integrated Water Resources Management (IWRM). Since climate variability is and will remain the greatest threat, adaptation responses should draw on experiences in innovative mechanisms to address water scarcity and expand implementation of such approaches countrywide and at all times. The focus should be on measures to reduce evaporation and to improve water resource use efficiency. Specific measures will include the conjunctive use of surface and groundwater resources, including sub-surface water banking. Monitoring and control of groundwater use will be stepped up. Demand management is required in municipalities, industries, mines, and in the agricultural sector. For local authorities this may go a long way to delay major water infrastructure investments. The Basin Management Approach may assist in raising awareness of the vulnerability to climate change amongst communities, but more resources and capacity building are required to gain experience with the approach. The development of the policy and legal framework around IWRM must be sped up.

For ***agriculture***, adaptive responses are structured along technological, policy and institutional imperatives. Technological priorities include irrigation and water harvesting, conservation agriculture, diversification, use of improved crops (especially those developed from indigenous germplasm), use of indigenous livestock breeds, increased seed and fertilizer availability, shared water resource management, early warning systems, drought mitigation measures, livestock management strategies, and crop modeling skills development. Adaptation at the farm-level focuses on tactical decisions farmers make in response to seasonal variations in climatic, economic, and other factors, and influenced by a number of socioeconomic factors including access to information and supportive institutions. For effective adaptation at this level, perceptions of current and future climate are important, and improved communication and information dissemination should be established to guide behavioural adaptation. There is a great need for improving social organisation and local adaptive capacity, to counteract dwindling social support and increasing conflict in communities. It is important that research is linked to existing local knowledge of climate related hazards and involves local communities in exploring adaptation decision making.

In view of the uncertainties surrounding ***sea level rise***, adaptation responses that retain options, and promote continued monitoring and flexibility are most valuable. From a financial perspective, sea-level rise adaptation options in Namibia can be divided into (1) no regrets options – desirable, low cost, high benefit options should be pursued even if climate change was not a threat, (2) sea-level rise specific responses that save more money than they cost and (3) sea-level rise specific options that are necessary (to save human life or heritage value) but are costly. From a methodological perspective, adaptation options can be divided into (1) infrastructure and hard engineering responses (such as sea-walls, dolosses and raising the level of harbours; desalination plants), (2) soft and biological responses such as the retention of wetlands and riparian vegetation in estuaries, beach and sandspit replenishment, the planting of dune vegetation to ensure dune buffers are retained and the cultivating of kelp beds that dissipate wave energy, and (3) socio-institutional responses such as enforced coastal buffer zones, early warning, insurance market and planned relocations. Selecting and applying these options will be most effective within the Integrated Coastal Zone Management (ICZM) approach, which takes cognisance of Namibia's existing development priorities and programmes, the economic, social, recreational and cultural objectives of the coastal zone, and the limits set by the carrying capacity of the coast. ICZM must also be undertaken in collaboration with neighbouring countries, through the Benguela Current Commission (BCC).

Adaptation in the ***tourism*** sector will focus on sustainable tourism, underpinned by Namibia's negligible carbon footprint and its excellent reputation for nature conservation, and in particular pro-poor nature conservation (CBNRM). Namibia will actively seek to market the country as a "carbon-neutral", "fair trade", "pro-environment" and "pro-poor" tourism destination. Conservancies, by diversifying land use and associated rural income sources and livelihoods, provide benefits which improve the capacity of rural ecosystems, rural land use systems, and rural livelihood systems to adapt to the effects of climate change. This makes rural people benefiting from CBNRM less vulnerable and increases their adaptive capacity. Wildlife is generally better adapted than livestock to the current ecological and climatic conditions in arid Namibia, and can be expected to be more resilient and adaptable to future conditions. The Conservancy programme's monitoring activities and developing database, collated and stored in a national conservancy information system (CONINFO) provides a valuable information base which can be used towards effective climate change monitoring and adaptation for both the natural resource base and the tourism-related activities which it supports.

An integrated ***health*** system-wide response and capacity building on all fronts is required to adequately respond and cope with the health-related impacts of climate change. Adaptation to climate change within other sectors, notably water resources, agriculture and food security, and disaster management can offset many of the negative repercussions within the health sector. First, immediate year-to-year health imperatives driven by slow-onset linear changes in weather patterns (and thus disease) will require well-planned public health responses. For example, the encroachment of malaria into new areas can be met by improvement and intensification of current efforts. Second, different response measures are required for abrupt and/or fast-onset changes, which can give rise to large-scale epidemic outbreaks. These include large-scale social upheaval, and secondary effects of extreme climatic events, which are more likely to be effectively dealt with under the umbrella of a nationally coordinated emergency response.

To complement and strengthen existing policies and programmes e.g. for malaria and HIV/AIDS, Namibia needs to enhance and further mainstream climate-related awareness, improve access to timely and relevant information, undertake scenario development and pro-active planning and policy development to address both fast-onset and slow-onset climate-induced events, develop health-centred adaptation strategies, climate-proof the public health system, and strengthen water and sanitation systems.

In terms of managing the impacts of drought and floods the capacity for ***disaster risk preparedness***, rather than disaster response, should be strengthened. Spatial planning that takes ecosystem requirements into consideration has the potential to markedly reduce flood related costs. In order to address the disaster-related risks suffered by the majority of the rural population, pro-poor disaster insurance schemes should be developed.

MITIGATION

This chapter deals with measures planned to mitigate climate change through a reduction in GHG emissions. Even though Namibia's contribution to global GHG emissions is negligible and it is shown to be a net sink of carbon dioxide, the country is nevertheless committed to reducing its GHG emissions where this is financially and environmentally feasible.

Namibia imports between 50% and 70% of its electricity from South Africa, and has a very low population number and population density and small industrial and agricultural sectors. Taking a sectoral approach, the most significant variables in the emissions equation are the energy sector, the agricultural sector and the land use change and forestry sector. Between 1994 (previous GHG inventory) and 2000 (current GHG inventory), energy and agriculture showed a growth in emissions of 15.5% and 81.5%, respectively. Land use change and forestry showed an increase of 84.7%. Within these sectors, transport, cattle farming and extensive bush encroachment are the greatest contributors to the GHG balance. Taking the above into account, especially the observations made regarding transportation and land use and forestry, the mitigation measures outlined below are in line with the nation's emissions profile.

1. Assessment of the costs and benefits of fuel switching for motor vehicles in Namibia

Liquid petroleum fuels for transport fuel consumption constituted over 70% of Namibia's total energy demand in 2006. All petroleum products are imported from South Africa, and demand has been increasing by an average of 4.4% per year between 1999 and 2006. This rate of increase is expected to continue due to the strong link between transport fuels (especially diesel) and economic growth in Namibia. The most viable alternative fuel is Liquefied Petroleum Gas (LPG), which can be supplied by the Namibian Kudu Gas Field.

The Namibian vehicle population is dominated by passenger sedan vehicles and light commercial vehicles (light load vehicles), which together constitute 88% of the national registered vehicle population numbering 233,640 vehicles. The study estimates that the total number of vehicles that can potentially be converted to use LPG is about 69,000 light commercial vehicles (light load vehicles) and 101,800 passenger sedan vehicles. This would constitute a saving in the foreign exchange required to import the fuel of about N$ 278 million. In terms of GHG emissions, this would reduce the carbon dioxide emissions from transport by 20%, amounting to about 140,000 tonnes of carbon dioxide per year.

There is potential for development of other alternative vehicle fuels such as biodiesel and ethanol that could be produced in Namibia. The study ranked the options for reducing GHG emissions from transport in the short and medium to long term, and made a number of recommendations relating to technical issues, as well as policy and institutional constraints in the promotion of fuel switching and improved vehicle fuel use efficiency. These activities have potential to access investment through the Clean Development Mechanism (CDM). However a major constraint is the capacity for preparing projects for CDM. It is a recommendation of this study that Designated National Authority for CDM be established. This would enable Namibia to access resources through the Nairobi

Framework to build the required capacity to participate in CDM.

2. Assessment of feasible and economic investment in cleaner energy in Namibia.

Since the submission of the INC in 2002, the renewable energy market in Namibia has witnessed dramatic progress with regard to the delivery of commercially, institutionally and technically sustainable solar energy services to the household, institutional, commercial and agricultural sectors. The key investment challenges in renewable energy are in the area of solar home systems, solar water heaters, photovoltaic pumps, solar cookers and the Kudu Gas Project (using natural gas from the Kudu Gas Field 170 km off-shore from Oranjemund). This project uses combined cycle gas turbine (CCGT) technology. Overall, mitigation projects qualifying to clean energy in Namibia are: solar, wind, natural gas for cars, biogas, biomass, geothermal, wave/tidal, afforestation and agroforestry projects, improved stoves and charcoal kilns. A strong rationale exists for public support, investors and sponsors in the exploitation of clean energy, based on the many economic, environmental, health, job creation, enterprise competitiveness and security benefits which these technologies offer. There is growing international support for clean energy development, from which Namibia as a developing country and Non-Annex 1 Party could benefit.

The local financial market is driven by the Barrier Removal to Namibia Renewable Energy Programme (NAMREP) whose mission is to increase affordable access to sustainable energy through the further development of a market for renewable energy technologies (RETs). This will be achieved through the removal of technical, financial, social, institutional, capacity, public awareness and social acceptability barriers. NAMREP developed an effective loan financing scheme in 2004 named “Solar Revolving Fund”, administered by Konga Investment (Pty) Ltd. However, one of the most significant barriers to widespread implementation of proven RETs is the lack of reliable and commercially available financing for end-users, developers, contractors, manufacturers and vendors. The problem is not a lack of available funds in general, but the lack of available funds through the local financial institutions. Recommendations are made for measures which would strengthen the local capital market for the financing of such projects, and for building capacity around CDM projects.

3. Assessment of the potential for building local entrepreneurship in Namibia in respond to Clean Development Mechanisms and research in most suitable solar technology options.

The basic conditions required for the sustainable development of the renewable energy sector in Namibia is the development of technical capacity to promote renewable energy and the raising of public awareness. The Government of Namibia, through the Ministry of Mines and Energy (MME), is designing policies condusive to the development of small renewable energy enterprises and fostering new RETs entrepreneurship in Namibia. In the area of technical capacity building, NAMREP has to date trained about 140 RETs technicians, government officials and NGOs throughout the country. This has also helped to decentralise renewable energy SMEs by making renewable energy technical skills available countrywide. This has resulted in 30 technicians setting up SMEs spread across all 13 regions of the country, thus extending renewable energy services. In addition to NAMREP, a further development was the establishment of the Renewable Energy and Energy Efficiency Institute (REEEI) in 2006 under the Polytechnic of Namibia.

Namibia has not had success with efforts to develop CDM projects, mainly due due to lack of technical capacity and political understanding and will. Most successful CDM projects in emerging economy countries have complementary technical assistance components to help ensure achievement of programme objectives. Technical assistance support can include marketing, training, information dissemination, market development and consumer outreach. Capacity building and local capacity support are needed to strengthen the skill sets within Namibia (NAMREP, REEEI and individuals) in a number of areas to facilitate successful CDM projects.

The chapter outlines a number of needs around developing solar technology, technical capacity in dealing with renewable energy issues, and developing local entrepreneurs. Mitigating these barriers will require policy based tools, regulatory interventions, financial structuring, institutional support, market-based mechanisms and awareness and capacity building. As the sector faces considerable financing needs which cannot all be mobilised from public sources, overcoming these constraints is a major challenge for Namibian policymakers, and the way in which these constraints are overcome will to a large extent determine the country’s ability to achieve a more sustainable energy mix and make a contribution to climate change mitigation.

4. Assessment of the economic costs and benefits of improving lighting and energy efficiency/demand side management in public and other buildings.

The costs of saving energy through the particularly large, untapped demand-side energy efficiency potential in Namibia is cheaper than the cost of adding new supply capacities. It is as much an energy resource as an option in the marketplace today, including conventional fuels. As Namibia faces a 3% growth in energy demand per year, energy efficiency has the potential to be an integral part of future energy supply strategies. Improved energy efficiency in government buildings, the fishing and mining industry, agriculture sector, transport sector and residential properties could lead to lower energy use overall. Improving energy efficiency through reduced distribution losses, achievable through engineering and provision of adequate resources, are an important offset to CO_2 emissions, particularly in view of coal-based Paratus Plant and the heavy fuel oil based Van Eck Plant.

A number of countries worldwide have extensive experience in the effective promotion and utilisation of energy efficiency measures, realising dramatic benefits for their economies in terms of energy savings, carbon saving, jobs and investment. As a way forward, Namibia should learn from these experiences. This requires putting in place a favourable regulatory framework bolstered by long-term national policies which aim to minimize primary demand, improve the energy efficiency of facilities and equipment, and rationalise energy use.

5. Review of the forestry sector activities and their impact on Namibia`s green gas balance.

In reviewing the forestry sector activities and their potential impact on Namibia’s GHG balance, it was found that Namibian forestry is, and will continue to be a carbon sink in the foreseeable future. Impacts on the GHG balance in the future are likely to result from the change to community management of most of Namibia’s forest resources and the extent to which this will impact fire management in particular, as well as land clearing for agricultural production, invader bush utilisation, and oil crop production. These planned projects are likely to have little impact on the carbon balance. However, Namibia’s woody biomass stock, as a result of bush encroachment and forest conservation, is a significant carbon sink and will be able to keep the country as a net sink. Current use of invader bush is only 7% of sustainable yield. It should be managed in such a way as to maintain and enhance its sink capacity. This will require constant monitoring to detect and understand any changes in the GHG balance from forestry.

The following actions are recommended:

- The collection of data for assessing carbon stocks in the inventories of community forests, stocks in each managed area destroyed by fire, stocks reduced due to forest clearing for agriculture, and energy used in the course of forest management activities;
- Monitoring of impact of community managed forests on the carbon balance of each stand, as part of community forest inventories;
- Regular reporting of the carbon sink situation in the different forest stands be incorporated into the current forestry reporting framework;
- REDD+ be assessed as a way of conserving the above by providing economic incentives for sound forest management.

OTHER INFORMATION

Integration of climate change into policies and development planning

Currently the Namibian government is in the final stages of developing the National Climate Change Policy (NCCP). The main purpose of this policy is to provide the legal framework and overarching national strategy for the development, implementation, monitoring and evaluation of climate change mitigation and adaptation activities. The policy will promote the enhancement of synergies amongst sectors, policies and stakeholders for effective and efficient climate change mitigation and adaptation. It is thus in line with the key existing policy frameworks, including Vision 2030 and the National Development Plans (currently NDP3).

The government of Namibia's many legal and policy instruments do not adequately incorporate climate change issues, since many were developed before this issue became acknowledged as serious. In particular, most of the sector specific policies reflect this shortcoming, and it is widely agreed that climate change should be considered when these policies come up for revision. While some sector policies may address elements of climate change, there is a need to identify issues of climate change commonality amongst sector policies in order to enhance synergies, facilitate cost effectiveness and avoid duplications of effort. In addition, new policies may need to be developed to address climate change.

Namibia is a member of the Southern African Development Community (SADC) and participates in a number of relevant regional treaties and policies. Despite the lack of a SADC climate change specific policy and strategy, Namibia recognises the need to co-operate at regional level in the development and implementation of climate change adaptation and mitigation interventions. Namibia shares all of its major perennial rivers with its neighbours, and controls none of their major catchments. The SADC Protocol on Shared Watercourses outlines the guidelines for the usage of water from shared watercourses in the SADC countries. This protocol has been one of the main reference points for Namibia's negotiations and agreements with other basin states on the usage of transboundary water resources. Bi-lateral and multi-lateral agreements also exist for conservation areas, Ramsar sites, endangered species, hazardous wastes, and sustainable management of shared marine resources.

Namibia is a signatory to the UNFCCC, the United Nations Convention to Combat Desertification (UNCCD), and the United Nations Convention on Biological Diversity (CBD), as well as the UN Millennium Development Goals. All of these will help to inform the appropriate responses to climate change.

Institutional arrangements

The Cabinet of Namibia is the Government agency with overall responsibility for all decisions around Climate Change Policy. The Parliamentary Standing Committee on Economics, Natural Resources and Public Administration shall advise Cabinet on relevant policy matters. While the Ministry of Environment and Tourism (MET) is responsible for all environmental issues in the country, MET is also the climate change coordinating Ministry through the Climate Change Unit (CCU) established within the MET. The CCU is supported directly by a formalised multi-sectoral National Climate Change Committee (NCCC) for sector-specific and cross-sector implementation and coordination advice and guidance, and oversees the country's obligations to the UNFCCC.

Various Ministries, Organisations and Agencies actively implement climate change related issues. The Climate Change Unit within MET will assist directly with planning, development, implementation and coordination of climate change activities at the local, regional and national levels. The Meteorological Services Division of the Ministry of Works and Transport (MWT) carries out climatic monitoring, research and assessment. This unit will serve as the national Climate Analysis Unit (CAU) that will support the CCU, MET, NCCC and line ministries with pertinent information and data. A broader civil society engagement on climate change known as the Contact Group on Climate Change (CGCC) supplements these structures in terms of public awareness, public debate, and focus on local and thematic issues.

Resource mobilisation

Climate change is a development issue that threatens the achievement of national development goals including Vision 2030, therefore the Government of Namibia shall make budgetary provision per sector based on needs assessments to address aspects of climate change. The Government shall mobilise adequate human and material resources for the effective and efficient implementation of a National Climate Change Policy (NCCP).

The study currently underway (2010) to assess the required investment and financial flows (IFF) to adequately address climate change shall be used as a guideline to plan for resources to become available for climate change activities. Multilateral, bilateral and donor funding avenues will be explored, as well as private sector, insurance, risk management, and market-based instruments. The country will improve access to financing through more efficient procedures and governance. Namibia will also increase capacity at individual and institutional levels for an appropriate response to climate change. Public Private Partnerships will be developed, and the role of the private sector in supporting climate change adaptation and mitigation encouraged. All interventions will be subject to monitoring and evaluation to ensure that they respond to the national, regional and local circumstances.

Climate change could bring economic opportunities to Namibia. These could include urbanization linked to entrance into the formal economy and thus economic growth in the secondary and tertiary sectors, opportunities linked to the CDM, such as productive use of invader bush for biofuels and other clean energy, and the benefits of reforestation and afforestation. CBNRM will provide synergies between climate change adaptation and improved natural resource management with tangible financial benefits for rural communities.

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

Adequate resources, including finances are required in order to undertake climate change adaptation and mitigation. Namibia has a significant need for development of new technologies and transfer of existing appropriate technologies. New and clean energy technologies need to be developed to reduce GHG emissions, while technologies must be developed to address climate change issues related to water shortages for agricultural production, drought resistant crop varieties and livestock breeds and food security. Climate change research must be properly coordinated and the benefits optimised to meet the needs of policy makers in Namibia. Attention must focused on projects that will assist with mitigation of, and adaptation to climate change, and address specific areas of vulnerability. Further, development and demonstration projects are required to show the advantages and acceptability of a variety of technologies.

Specific identified research needs include:

- Strengthen systematic meteorological observation and improve climate and hydrological datasets
- Coordinated data management
- Disaster preparedness and vulnerability mapping
- Agricultural technologies and production systems
- Other monitoring-based research
- Indigenous knowledge and coping strategies
- Carbon sequestration by anthropogenic ecological disturbances
- Fuel switching and fuel use efficiency
- Wind and solar energy
- Economics of climate change impacts, adaptation and mitigation
- Greenhouse gas data collection and analysis

The complex nature of climate change requires well-trained scientific, technical and managerial staff that will not only understand climate change but also be involved in responses to climate change. Namibia will also need institutional structures that are adequately equipped and able to provide facilities and finances to support climate change programmes and activities.

Specifically, the following needs have been identified:

- Capacity building for improved spatial planning, including town and regional planning and engineering, to include ecosystem requirements;
- Capacity building of boundary organizations to facilitate climate change feedback loops between science institutions, policy makers, and land users. This requires capacity to access, interpret, translate and communicate climate change science and concomitant local level indicators.
- Capacity building for academics and professionals to apply and interpret climate models and impact models in sectors that are considered critical for the development of Namibia, with the aim to build a broader understanding of the vulnerability of various sectors to climate variability and change.
- Capacity building for the application of economic principles to quantify/compare the impacts of certain changes and policy interventions to foster fact-based decision-making when allocating very scarce public resources to programmes or interventions.
- Capacity building for the identification, preparation (incl. design) and appraisal of potential CDM projects; many projects elsewhere fail to qualify for CDM status due to design shortcomings;
- Capacity building for local commercial banks as an important source of clean energy loans and debt funds, and project bundling;
- Further theoretical and practical training of RETs technicians, government officials and NGOs throughout the country, to make renewable energy technical skills available countrywide. This to be accompanied by capacity support for the adoption of nation-wide regulatory policy to enforce standards for RETs currently perceived as barriers that prevent the roll-out of renewable energy projects in the country.

Climate change is likely to exert its greatest impact on the natural resources of Namibia, threatening the resource-based livelihoods of the majority of people who live in rural areas. Public awareness raising using accurate up-to-date information is required to empower stakeholders, especially local subsistence and commercial farmers, to participate in adaptive response activities.

The global nature of climate change necessitates exchange and sharing of data, information, expertise and financial capacity at regional and international levels in order to enhance appropriate and effective responses. The National Climate Change Policy makes provision for international cooperation, collaboration and networking to achieve this, including the promotion of international North-South and South-South collaborative research that will facilitate generation of climate change adaptation and mitigation evidence-based information.

Proposed climate change projects

The emerging Namibia climate change strategy, giving rise to the Action Plan, is based on three main responses: adaptation, mitigation and tackling cross-cutting issues through adaptation and mitigation. Cross-cutting issues relate to issues that will be addressed through multi-sectoral and multidisciplinary activities. Each of the three aspects is subdivided into themes.

Details of each theme are provided in the last chapter. The 14 Themes are:

Adaptation:

- Food security and sustainable resource base
- Sustainable water resources
- Human health and well being
- Infrastructure

Mitigation:

- Sustainable energy and low carbon development
- Transport

Cross-cutting issues for adaptation and mitigation

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

Investment and financial flows to address climate change

Namibia is one of 19 countries worldwide participating in a UNDP supported project on assessing Investment and Financial Flows

(I&FF) to address climate change in key sectors of the economy. The assessment aims to provide financial information on the expected costs of mitigation and adaptation to selected key sectors, over an approximately 20-year planning framework. The results will be used to show-case the investment needs for effective adaptation and mitigation sector efforts, both to national and international policy and decision-makers and funders, and to provide a strong planning foundation for future investments.

In terms of **adaptation**, Namibia initially intended to assess I&FF relating to adaptation needs in the Land Use, Land Use Change and Forestry (LULUCF) sector, incorporating agriculture, forestry, fisheries (inland), tourism, wildlife and the underlying ecosystem services. Due to time constraints and practical issues, it was decided to focus the assessment on the two sub sectors (crop and livestock production) within agriculture.

In terms of **mitigation**, Namibia selected to assess the energy sector. The energy sector is central to development opportunities for Namibia in the future. Southern Africa as a whole is challenged by an energy crisis, and it is of great importance for Namibia to position herself in a proactive manner to address future energy needs in the context of mitigation of climate change. It is expected that investment opportunities can be leveraged for the sector through this association.

The studies identified the adaptive and mitigative measures needed to address the impact of climate change, and estimated the financial requirement to implement them. A prescribed methodology was used, based on the guidebook provided by the UNDP. The overall I&FF adaptation assessment period is from 2005 to 2030, informed by the NDP2, NDP3 and Vision 30 timeframes. The conceptual framework for the assessment was developed through working group discussions, and brainstorming ideas from the team and the capacity support experts. Key uncertainties and methodological limitations are outlined in the reports.

Abbreviations and acronyms

AGOA	Africa Growth and Opportunity Act
AMCEN	African Ministerial Conference on the Environment
ARV	anti-retroviral
AR4	Fourth Assessment Report of the IPCC (2007)
AU	African Union
BCC	Benguela Current Commission
BCLME	Benguela Current Large Marine Ecosystem Programme
BIOTA	Biodiversity Monitoring Transect Analysis in Africa Programme
CAU	National Climate Analysis Unit
CBD	United Nations Convention on Biological Diversity
CBNRM	Community Based Natural Resource Management
CBO	Community Based Organisation
CBS	Central Bureau of Statistics
CCGT	Combined Cycle Gas Turbine
CCU	Climate Change Unit
CDM	Clean Development Mechanism
CGCC	Contact Group on Climate Change
CH_4	methane, a greenhouse gas
CITES	Convention on the International Trade in Endangered Species of Wild Flora and Fauna
COD	chemical oxygen demand
CONINFO	national conservancy information system
CO_2	carbon dioxide, the principle anthropogenic greenhouse gas
CSA	Consulting Services Africa
CSAG	Climate Systems Analysis Group, University of Cape Town
DEA	Directorate of Environmental Affairs
DRFN	Desert Research Foundation of Namibia
DSSAT	Decision Support System for Agrotechnology Transfer
DWA	Directorate of Water Affairs
EAF	Ecosystem Approach to Fisheries
ECB	Electricity Control Board
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
FF	Financial flow: an ongoing expenditure on programmatic measures, not related to expansion or installation of new physical assets
FMD	foot-and-mouth disease
Gg	gigagram or 1 kiloton (equals 1x109 grams)
GCM	Global Circulation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	greenhouse gas
GNI	Gross National Income
GS	The Green Scheme
GWh	GigaWatt hour (equals 1x109 watt hour)
ha	hectare (equivalent to 10 000m^2)
HFO	heavy fuel oil
HIV/AIDS	Human Immune Virus/ Acquired Immune Deficiency Syndrome
HPI	Human Poverty Index of the UNDP
ICZM	Integrated Coastal Zone Management
IF	Investment flow: the capital cost of a new physical asset with a life of more than one year, such as the capital cost of a new power plant
IIED	International Institute for Environment and Development
INC	Initial National Communication to the UNFCCC
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
IWRM	Integrated Water Resources Management
JPTC	Permanent Joint Technical Commission on the Kunene River
JPWC	Permanent Joint Water Commission between Namibia and Botswana
km	kilometer
kt	kiloton or one thousand tons (equals 1x109 grams)
kV	kilovolt
LFO	light fuel oil
LLD	Land Levelling Datum
LNG	Compressed Natural Gas
LPG	liquid petroleum gas
LTER	long-term ecological research
LTO	landings and take-offs
m^3	cubic metres
mamsl	metres above mean sea level
Mg	megagram (1x106 g) also known as a metric ton
mm	millimeter
Mm^3	million cubic meters
MAWF	Ministry of Agriculture, Water and Forestry
MDGs	Millennium Development Goals
MET	Ministry of Environment and Tourism
MFMR	Ministry of Fisheries and Marine Resources
MHSS	Ministry of Health and Social Services
MLHPZ	Mid-Latitude High Pressure Zone
MME	Ministry of Mines and Energy
MW	megawatts (equals 1x106 watts or 1x106 J/s)
MWT	Ministry of Works and Transport
N_2O	nitrous oxide, a greenhouse gas
NACOMA	Namibian Coast Conservation and Management Project
Namcor	National Petroleum Corporation of Namibia (Pty) Ltd
NamPower	Namibia Power Corporation Limited
NAMREP	Barrier Removal to Namibia Renewable Energy Programme
NAMROM	Namibian Rainfall / Runoff Model
NAPCOD	Namibian Program to Combat Desertification
NATIS	National Transport Information System
NCCC	National Climate Change Committee
NCCP	National Climate Change Policy
NDP1	National Development Plan 1
NDP2	National Development Plan 2
NDP3	National Development Plan 3
NGO	Non-government organisation
NMS	National Meteorological Service
NMVOCs	Non-methane volatile organic compounds
Non-Annex 1	Countries not listed in Annex 1 at the UNFCCC i.e. developing countries
NPC	National Planning Commission
NPGRC	National Plant Genetic Resources Centre
NPRAP	National Poverty Reduction Action Programme
NTFPs	non-timber forest products
N$	Namibian Dollar
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
OKACOM	Permanent Okavango River Basin Water Commission
OM	Operation and Maintenance: ongoing fixed and variable costs such as salaries and raw materials, brought about by the purchase of physical assets
OVCs	Orphans and vulnerable children
PA	Protected Areas
PET	potential evapotranspiration
PPA	Participatory Poverty Assessment
PV	photo voltaic
PVP	Photovoltaic Pump
RAMSAR site	The Convention on Wetlands of International Importance
RCM	Regional Climate Model
	was signed in the town of Ramsar in Iran in 1971
REDD+	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
REEEI	Renewable Energy and Energy Efficiency Institute
RET	Renewable Energy Technology
SA	Republic of South Africa
SADC	Southern African Development Community
SAM	Southern Annular Mode
SAPP	Southern African Power Pool
SHS	solar home systems
SME	Small Medium Enterprise
SNC	Second National Communication to the UNFCCC
SWH	solar water heaters
t	ton (one metric ton, 1x106 grams)
TAR	Third Assessment Report of the IPCC (2001)
TB	tuberculosis
TJ	terajoules (1x1012 joules), a measure of energy
ULP	Unleaded Petrol
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
US$	United States Dollar
VCF	Veterinary Cordon Fence
WDM	Water Demand Management
WHO	World Health Organisation

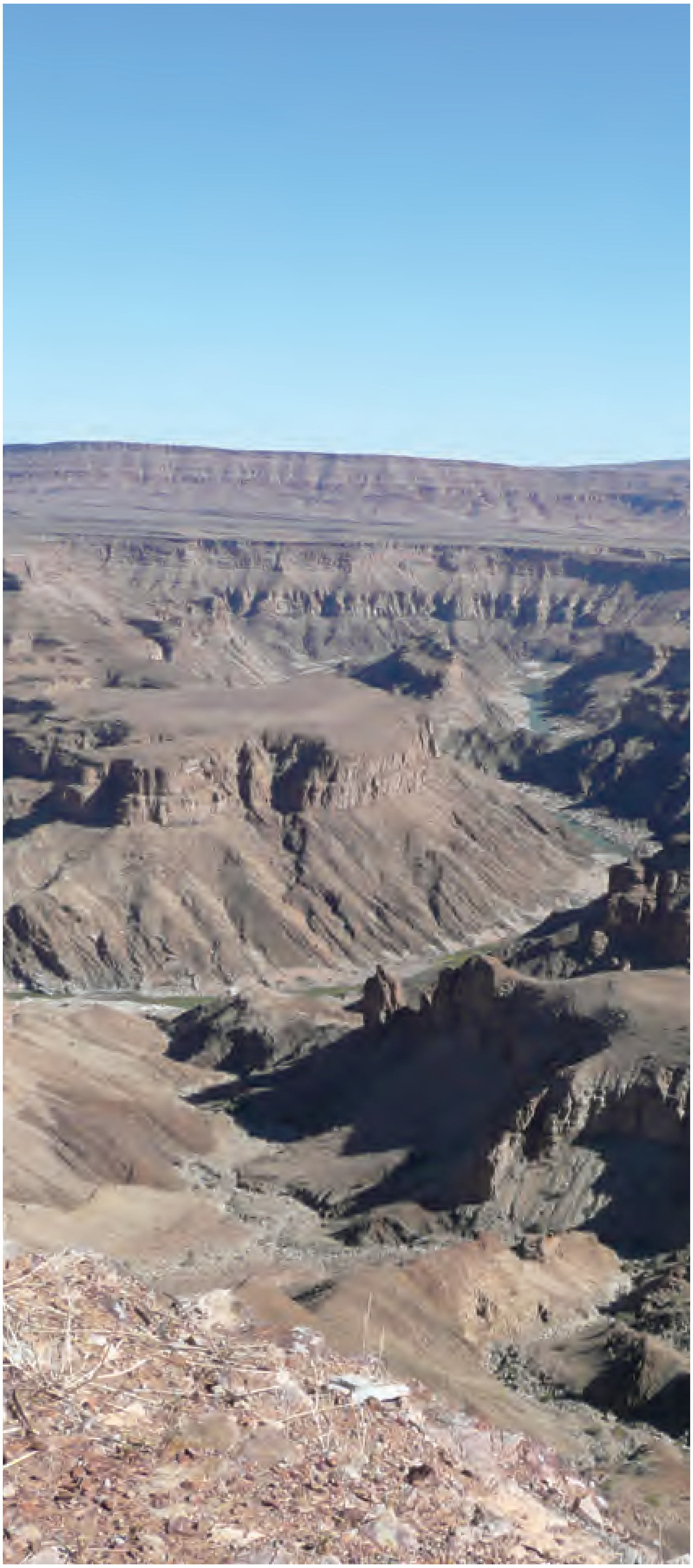
Table of Contents

1. Introduction

Namibia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1995 as a Non-Annex 1 Party, and became legally obligated to adopt and implement policies and measures designed to mitigate the effects of climate change and to adapt to such changes. The Global Environment Facility (GEF) through the United Nations Development Program (UNDP) provided funding for the development of Namibia's Second National Communication (SNC) to the UNFCCC, which is required in order to fulfil the country's obligations under the Convention.

The Namibia National Climate Change Committee (NCCC), through the Ministry of Environment and Tourism (MET) and its Directorate of Environmental Affairs (DEA), is responsible for overseeing the coordination of Climate Change issues in Namibia, and thus the implementation of the SNC project. The SNC project built on and continued the work done under the Initial National Communication (INC) of Namibia, which was presented to the UNFCCC in 2002. In the INC, it was reported that the Namibian economy is natural resource based and is extremely sensitive to climate change effects. The direct effects of climate change on the various economic sectors could potentially be felt in thematic areas such as water, agriculture, fisheries, ecosystems, biodiversity and tourism, coastal zone, health and energy.

However, more in-depth assessments were needed for sectors such as agriculture, water, ecosystem/ biodiversity and tourism, the coastal zone (sea level rise) and human health. The NCCC, through the MET, and with the support of the UNDP therefore called for a series of top-up studies that were needed in preparation of the SNC. Furthermore, the Namibia Greenhouse Gas Inventory was updated for the year 2000 and a Namibia Energy Review commissioned. Finally, Namibia is in the process of finalising its National Climate Change Policy. All these documents were used towards the preparation of this SNC, and thus the SNC reflects the most up-to-date level of scientific knowledge and policy development in Namibia towards the end of the year 2010.



Fish River valley, Namibia
Photo: Adam Masters

2. National Circumstances

This chapter is an update of the Namibia Initial National Communication (INC) to the United Nations Framework Convention on Climate Change (UNFCCC) (Republic of Namibia, 2002), and aims to reflect significant changes in Namibia's national circumstances relevant to climate change. The primary source documents were the Review and Update of National Circumstances (DRFN, 2009), Climate Change Vulnerability and Adaptation Assessment Report Namibia (DRFN, 2008), the Sea Level Rise in Namibia's Coastal Towns and Wetlands: Projected Impacts and Recommended Adaptation Strategies (CSA, LaquaR and Lithon, 2009), and Research on Farming Systems Change to Enable Adaptation to Climate Change (University of Namibia, 2008).

Himba women, Namibia
Photograph by Adam Masters

Namibia is on a developmental trajectory informed by its core policy documents, the Vision 2030, and the current third Medium Term National Development Plan (NDP3). The fundamental objectives are to accelerate economic growth whilst at the same time utilising Namibia's natural resources productively yet sustainably, and in so doing ensure human development and enhanced quality of life for its citizens. Against this backdrop, the following sections summarise the current biophysical, economic and social circumstances which will inform how Namibia is impacted by climate change, will address climate change, and meet its obligations under the Convention.

2.1 GEOGRAPHY & GEOLOGY

Namibia is situated in southwestern Africa, between 17° and 29°S and 11° and 26°E, and covers a land area of 825,418 km^2. It has a 1 500 km long coastline on the south Atlantic Ocean. Its neighbours are Angola, Zambia, Botswana and South Africa. 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 of up to 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 1 000 mamsl. Nearly half of the country's surface is exposed bedrock, while young surficial deposits of the Kalahari and Namib deserts cover the remainder. Namibia is underlain by many geological formations, including mineral-bearing metamorphic complexes, as well as Meso- to Neoproterozoic rocks containing copper, gold, zinc and uranium and Permian rocks of the Karoo sequence with coal deposits. Following the discovery of the offshore Kudu gas field of Cretaceous age, recent hydrocarbon exploration also intersected potential oil-producing rocks. Tertiary to Quartenary diamondiferous deposits are currently exploited along the southwestern coast of the country.

2.2 CLIMATE

Namibia is one of the driest countries south of the Sahara. The climate of Namibia is a consequence of the country's location on the south-western side of the African continent, situated at the interface between different climate systems. The climate is influenced by the country's proximity to the northward flowing Benguela current, which brings 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 (MLHPZ), while the southern part of the country lies at the interface between the MLHPZ 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 movements of the sun.

The cold water from the western shores (Benguela current) is advected 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 MLHPZ brings drier conditions. The movement of the ITCZ towards the south during the Namibian summer results in the rainfall season, normally starting in October 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 south-west 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.

Namibia is semi-arid to hyper-arid with highly erratic rainfall. The mean annual rainfall ranges from just above 700 mm in the northeast to less than 25 mm in the southwest and west of the country (Figure 2.1). The rainfall isohyets generally follow a gradient from the north-east to the south-west. 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, giving rise to orographic rainfall. On the other hand, the coastal zone receives almost no rainfall at all.

Most rain occurs in the summer months from November to April in the form of localized showers and thunderstorms. In the extreme southwest, winter rain and even snow can be expected from June to 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.

Namibia is characterized by high temperatures (Figure 2.2, Table 2.1). 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. Daytime

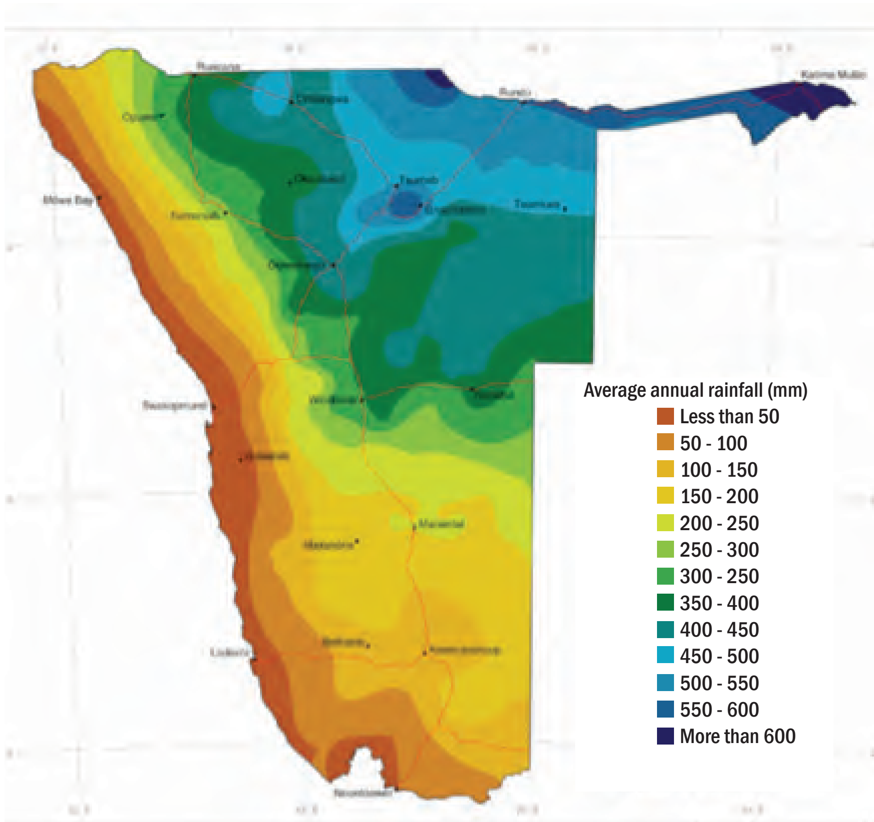


Figure 2.1: Distribution of average annual total rainfall in Namibia. *Source: Mendelsohn et al. (2002)*

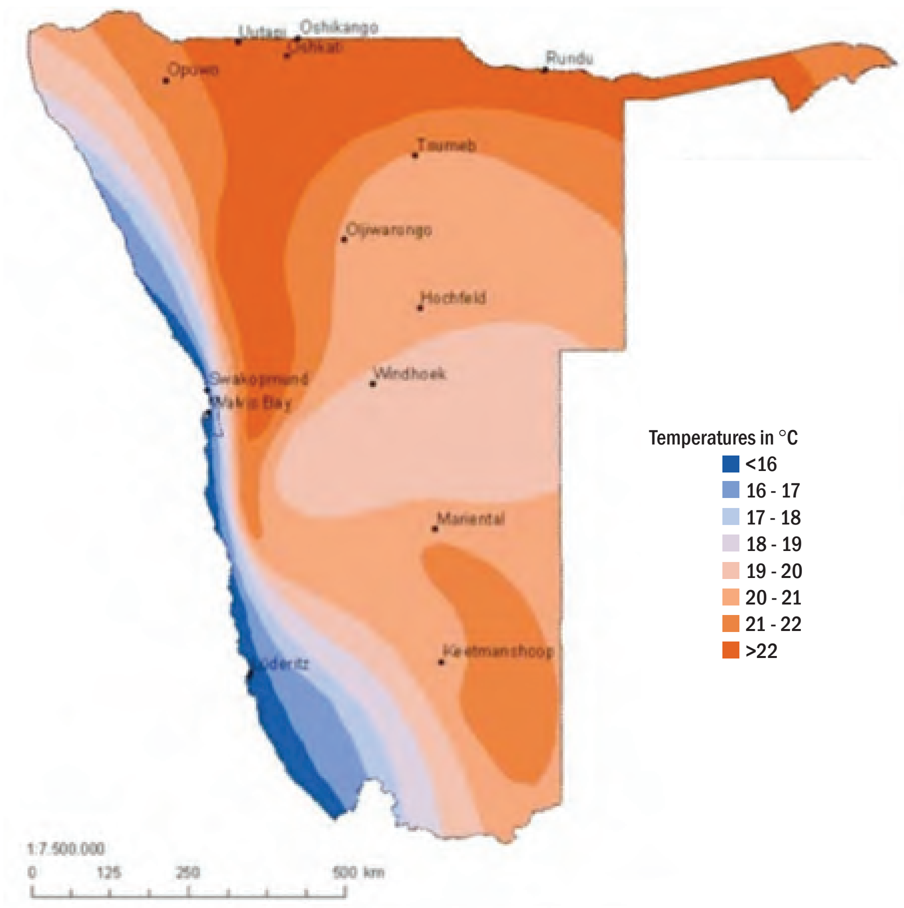


Figure 2.2: Average annual temperature in Namibia. *Source: University of Cologne, Data from Atlas of Namibia (Mendelsohn et al., 2002)*

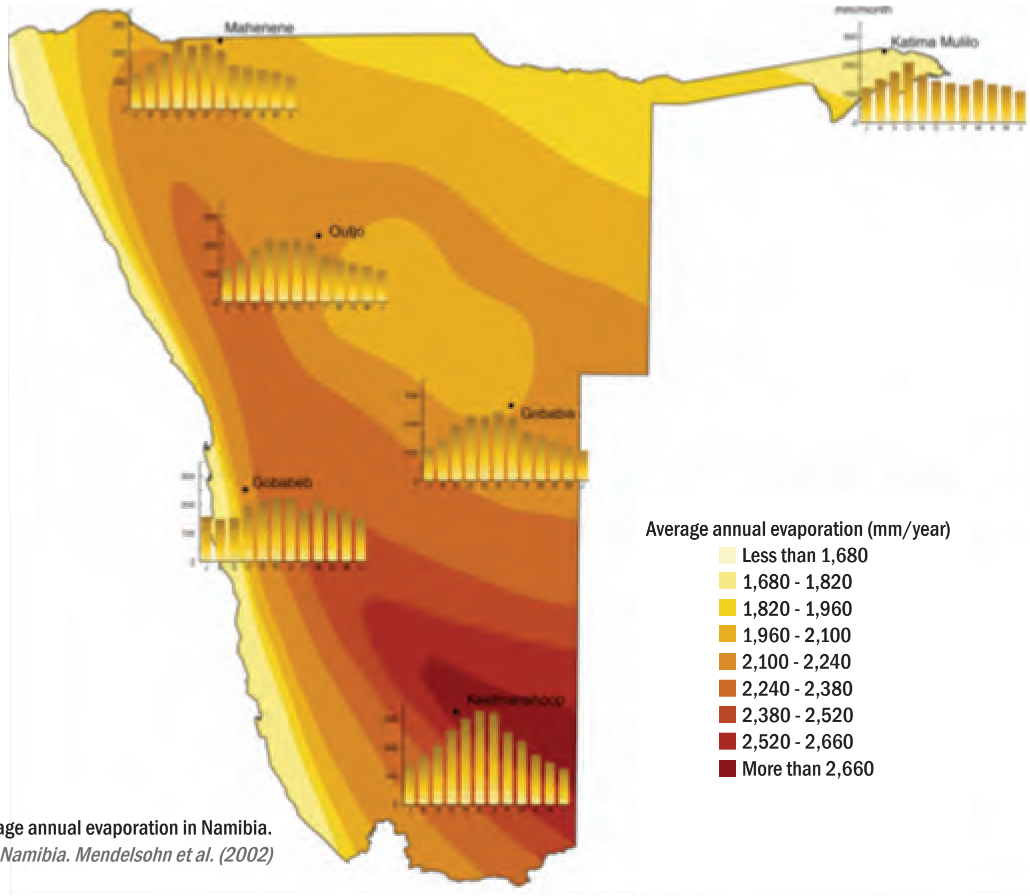


Figure 2.3: Map showing average annual evaporation in Namibia.
Source: Atlas of Namibia. Mendelsohn et al. (2002)

Table 2.1
Mean monthly minimum and maximum temperatures in Namibia

LOCATION		MEAN MONTHLY MAXIMUM TEMPERATURES	MEAN MONTHLY MINIMUM TEMPERATURES
Coastal areas	Throughout the year	16-22°C	10-17°C
Inland areas	Summer	28-37°C	13-20°C
	Winter	20-30°C	2-12.5°C

air temperatures are generally warm to hot due to high insolation, but because of low humidity and outgoing long wave radiation at night, minimum temperatures can drop to below freezing point in winter. In the coastal areas, temperature extremes are rare.

From a hydrological point of view, Namibia is truly an arid, water deficit country. High solar radiation, low humidity and high temperature lead to very high evaporation rates, which vary between 3 800 mm per annum in the south to 2 600 mm per annum in the north (Figure 2.3). 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.

The potential evapotranspiration (PET) from soils and vegetation is at a minimum during June and July, due to the lower air temperatures during the winter months. During the growing season the PET is rather high, with values as high as 200 mm per month in the north and central areas and 250 mm in the south of Namibia. This illustrates the severe climatic constraints on natural vegetation and agriculture.

Winds are southerly, and south-westerly winds dominate both the frequency (30-40%) and strength (6 - >9m/s) along the coast, whereas variable winds of the interior do not present a clear pattern. Wind speeds are generally low in Namibia, only at the coast do mean wind speeds exceed 3m/s, and it is only at isolated climate stations in the inland, e.g. Keetmanshoop, where the mean wind speeds exceed 2m/s. These winds, and the occasional stronger gusts, do not cause any real problems 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. However, the difference is not excessive due to the lower temperatures during the dry season. Both wind and humidity do, however, influence the water requirements of vegetation and crops.

The effect of the sparse and highly variable rainfall, high evaporation rate and virtual absence of permanent surface water, other than in a few dams and perennial streams, make water an extremely scarce resource in Namibia. Drought is a recurring feature of the climate and desertification is a serious national concern.

2.3 BIODIVERSITY

Namibia is globally known for her remarkable variety of species (Table 2.2), habitats and ecosystems. Worldwide it is one of the few dry land countries with internationally recognised biodiversity "hotspots". The most important hotspots are the Sperrgebiet, situated in the Succulent Karoo floral kingdom in southern Namibia,

	No. of species known in Namibia	No. of endemics known in Namibia	Knowledge base in Namibia	Main known threats in Namibia
Fungi	190	None known	Poor	Insufficient information
Lichens	330	Several	Poor	Off-road driving in the desert
Plants	4344	687	266 sp have RDB status	Population increase, demand for plant resources, deforestation, overgrazing, fire, over-harvesting, illegal trade, inadequate protection in PAN
Arachnids	1357	Several	Only 20% of total sp known	Insufficient information. Lack of formal protection in PAN
Myriapods	45	14	Poor	Habitat degradation
Insects	6400	1540	Reasonable	Habitat degradation, lack of sufficient knowledge of impacts
Fish (freshwater)	115	5	Reasonable	Overfishing, habitat destruction, water abstraction, aliens, poor catchment management
Amphibians	50	6	Reasonable	Habitat loss along perennial rivers
Reptiles	260	55	Mostly poorly known; 34 sp in possible threat categories	Habitat alteration, illegal trade
Birds	658	14	Well known; 86 sp in possible threat categories	Habitat degradation, hunting, poisoning
Mammals	250 (incl. marine)	14	Well known, except in small mammal groups; 40 in possible threat categories	Habitat degradation and loss, overgrazing by domestic stock, deforestation, fire, hunting and illegal trade

Table 2.2. Summary of biodiversity of higher order plants and animals.
Source: Ministry of Environment and Tourism. http://www.met.gov.na/Pages/METResourceCentre.aspx

and the rugged Namib Escarpment, which is part of Africa's great western escarpment. Countrywide, 4 344 plant species have been recorded, of which 687 are endemic and occur in the escarpment and southwest winter rainfall area. Namibia is also known for its fungal diversity. Of 190 species recorded for Namibia, two edible species contribute substantially to the diet of Namibians living in regions where they occur (Barnard, 1998). Namibia is fortunate in not having large numbers of problematic invasive species introduced from elsewhere in the world.

Annual rainfall determines the three main vegetation zones: savanna covers 37% of Namibia, dry woodlands and forests 17%, while desert (Namib and Karoo biome) vegetation is distributed over 46% (Barnard, 1998). The recent Atlas of Namibia (Mendelsohn et al., 2002) presents an updated vegetation classification system resting on 101 vegetation types.

Namibian marine biodiversity consists of about 1053 marine species of which 47% are non-fish species from 212 families and 53% fish species from 163 families (Ministry of Fisheries and Marine Resources, pers. comm.). Fish community structure reflects the topography of the Namibian marine environment. Almost 50% of the 516 fish species are bottom dwellers while 36% are deepwater fishes and only 13% are pelagic fishes. The next most documented groups are the high trophic level groups (e.g. cephalopods, seabirds and marine mammals) comprising 15% of species, and benthic invertebrates accounting for 13% of the species composition. Endemicity is relatively low accounting for only 1% of the total number of species.

Namibia's biodiversity is both a fundamental basis for livelihood generation and, a national asset of significant value, and underpins an important nature-based tourism industry. In addition to the tourism value, biodiversity is essential for food security, income generation, health improvements, the provision of ecosystem services and maintaining production systems. Although Namibia generally has a good record in protected areas and biodiversity is largely intact, various pressures constitute a significant threat to biodiversity (Table 2.2). These include habitat destruction and uncontrolled development, forest clearing, overstocking, unsustainable harvesting of wild plants and animals, unequal resource distribution, fencing and fragmentation of protected areas. The impacts of climate change are predicted to increase the threats to biodiversity.

2.4 WATER RESOURCES

Water is the primary limiting factor to development in Namibia. In the late 1990s Namibia adopted the Integrated Water Resources Management (IWRM) approach as a way to safeguard water resources and to allow for stakeholder involvement in water

(LEFT) Image of Welwitschia mirabilis, an ecologically highly specialized endemic plant that grows in isolated communities in the Namib Desert .
Source: CSA, LaquaR and Lithon, 2009

development and management.

Currently, of the water that falls as rainfall in Namibia, 83% evaporates, 1% recharges groundwater, 14% returns to the atmosphere through evapotranspiration, with only 2% remaining for runoff and potential surface water storage (Heyns et al., 1998). 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).

Namibia's surface water resources can be divided broadly into two types, those derived from perennial systems and those derived from ephemeral (seasonal, non-permanent systems) (Figure 2.4). In the latter group are included all the wetland areas and man-made storage dams on or associated with the sporadic flows of ephemeral rivers as well as pans, pools and other wetlands derived from local runoff.

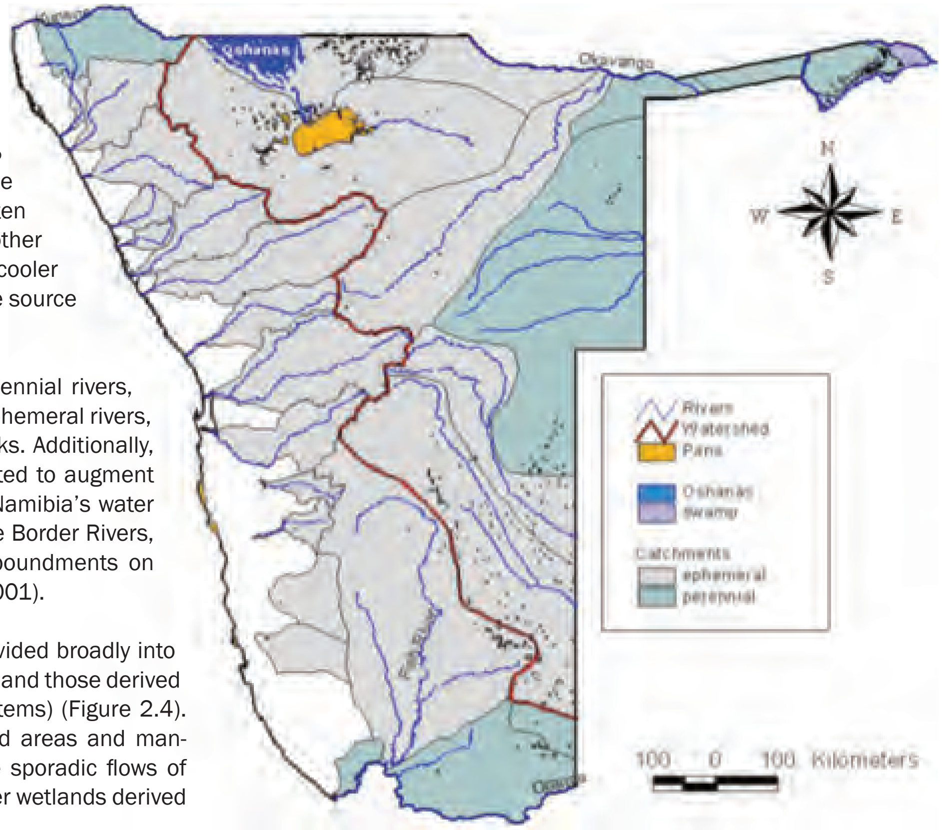


Figure 2.4: Surface water resources in Namibia.
Source: Atlas of Namibia (Mendelsohn et al., 2002)

There are few rivers in Namibia. The perennial rivers lie on the southern and northern borders, with the Orange River in the south and the Kunene, Kavango, Kwando-Linyanti-Chobe and Zambezi Rivers in the north. The use of water from perennial rivers is subject to negotiations with other riparian states.

All the rivers in Namibia's interior (e.g. Swakop, Kuiseb) are ephemeral, flowing only after intensive rains. The potential of ephemeral surface water is limited because they rely directly on variable (often low) rainfall. The water can therefore only be harnessed during the rainy season. To date, Namibia has constructed about ten dams on ephemeral rivers. The total storage capacity of these impoundments is 665 million cubic meters, but the 95% assured safe yield is only 87 cubic meters, which is an indication of the low efficiency of surface water storage facilities in arid environments.

Ephemeral waters include rivers that run for short periods after rain has fallen upstream in the catchments, the pools they leave behind after flow has stopped, and pools formed as a result of rain falling in inward-draining basins. Some near-permanent pools, streams and lakelets are relatively fresh and others are hyper-saline (Day, 1997). The oshanas are ephemeral rivers formed in the shallow depressions of the Cuvelai system which originate in Angola and flow into the Etosha Pan during years of very high rainfall. Oshanas occur in the north-central region (Figure 2.4), which is the most densely populated area of Namibia. Wetlands of international importance include the Etosha Pan and three Ramsar sites (Orange River Mouth, Sandwich Harbour, Walvis Bay).

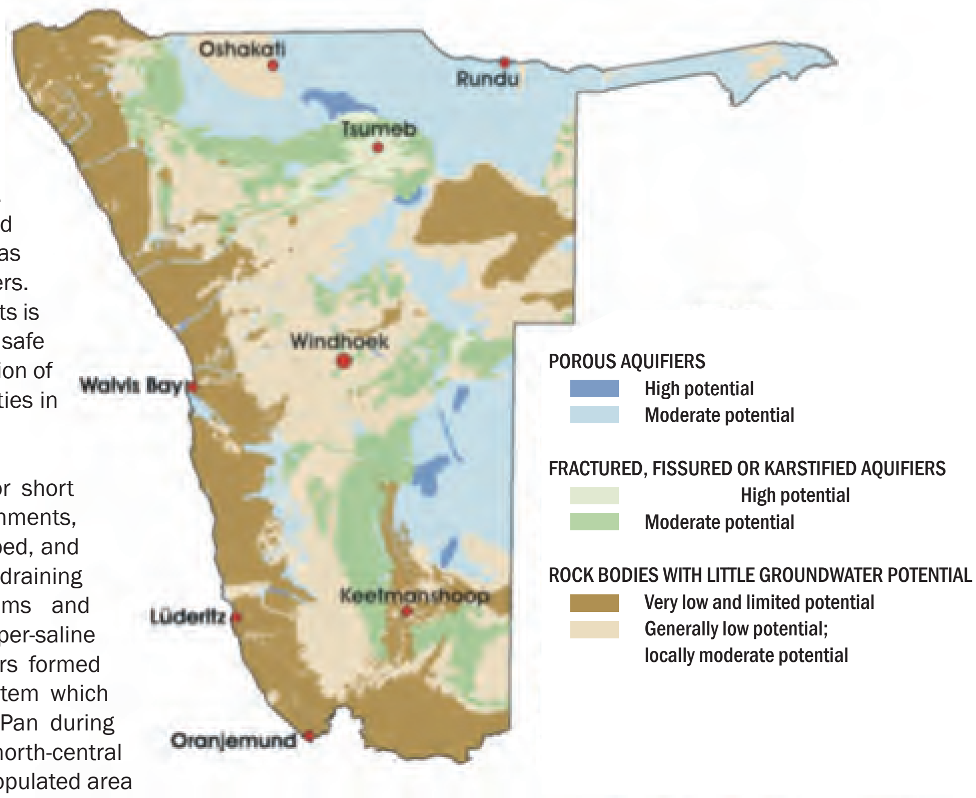


Figure 2.5: Hydrogeological map of Namibia.
Source: Christelis and Struckmeier (2001)

In arid areas, where rainfall is limited and surface runoff is only available during the rainy season, and during droughts, groundwater (Figure 2.5) is a very important water source. Like surface water sources, groundwater can also be regenerated and replenished by rainwater filtering into the ground. The magnitude and sustainable yield of the groundwater sources are therefore determined by the size and extent of the aquifers, the conditions that facilitate the rate of recharge to the aquifers and the potential of the hydro-climate to produce rainfall and runoff. In addition there are also fossil groundwaters that have accumulated over tens of thousands of years in water-bearing aquifers when the climate in the southern African region was much wetter. The number of boreholes in use today are about 50 000 (Christelis and Struckmeier, 2001). It is estimated that the sustainable yield of the useable groundwater sources in the country is at least 300 million cubic meters per annum. However, groundwater is vulnerable to over-abstraction, pollution and contamination.

Current unconventional sources include recycling of water in industrial processes, the reuse of water for industrial and irrigation purposes, the reclamation of domestic sewage effluent to potable water quality standards, artificial recharge of groundwater resources and desalination. The municipality of Windhoek recycles about 36% of the water it consumes, and operates the largest re-cycling plant in the southern hemisphere. A large desalination plant at either of the coastal towns of Swakopmund or Walvis Bay is under consideration.

Based on projections for future water demand (estimated to grow at 2.2% per annum) the country's developed water sources are likely to be fully exploited by 2016. Even if stricter Water Demand Management (WDM) practices are enforced, the central areas of Namibia (in particular the high growth points in the Khomas Region) are expected to experience full use of currently developed sources by 2012.

Figure 2.6 is a population density map of Namibia based on the population figures estimated for the enumeration areas used in the national census of 2001. The map clearly shows which basins support large numbers of people, and which are sparsely populated. The most sparsely populated areas are shown in white.

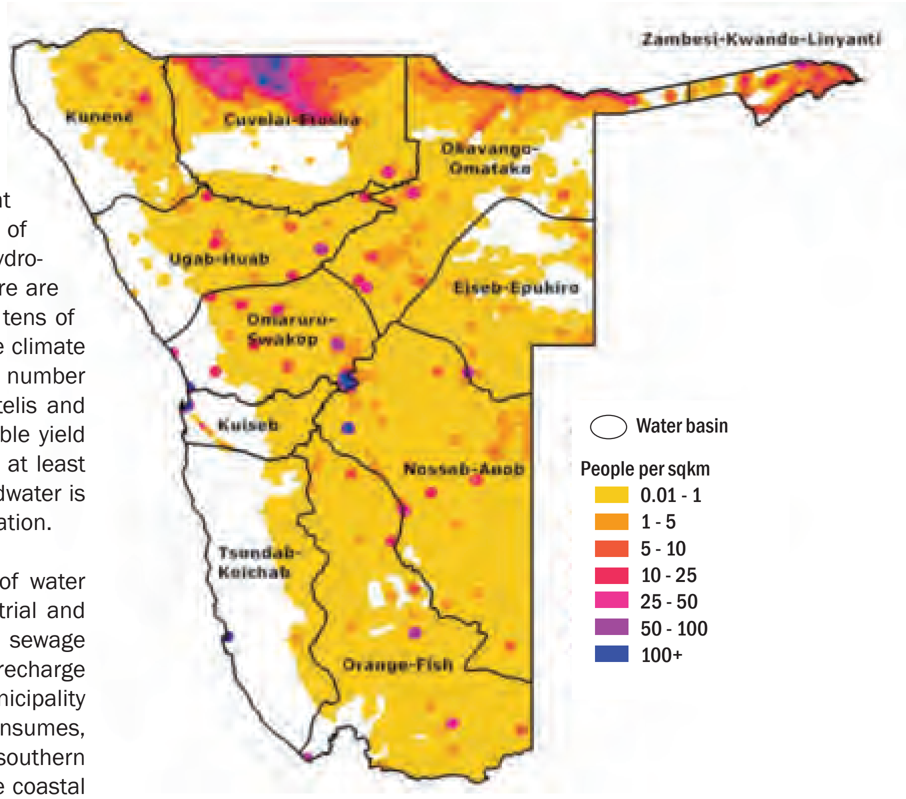


Figure 2.6: Population density map per water basin.
Source: DRFN (2009) based on data from the 2001 national census (NPC, 2003)

Figure 2.7 shows the estimated water demands by sector for 2008 and Figure 2.8 indicates the estimation for 2030. These demands exclude water from unconventional sources. It is estimated that by 2008 the total water demand in Namibia was 327 Mm^3 per annum. By 2030 demand for water will have increased to 765 Mm^3 per annum. The agricultural sector is the major user of water in Namibia. In 2008 irrigation accounted for 41% of the total water demand. It is expected that water demand for irrigation will increase to 65% by 2030. The increase in water demand by 2030 for the mining sector seems insignificant, due to increased demand from mining (particularly uranium) being planned to be met mainly from desalinated water (an unconventional source).

Figure 2.7: Total water demand in Namibia in 2008.
Source: IWRM Plan Joint Venture (2009)

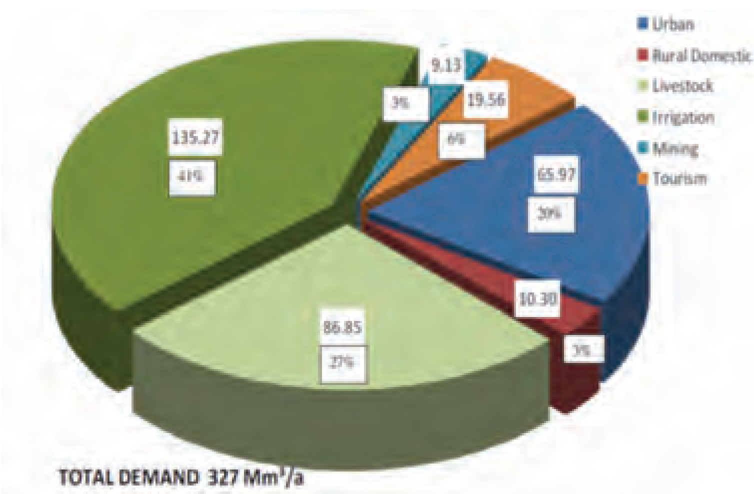
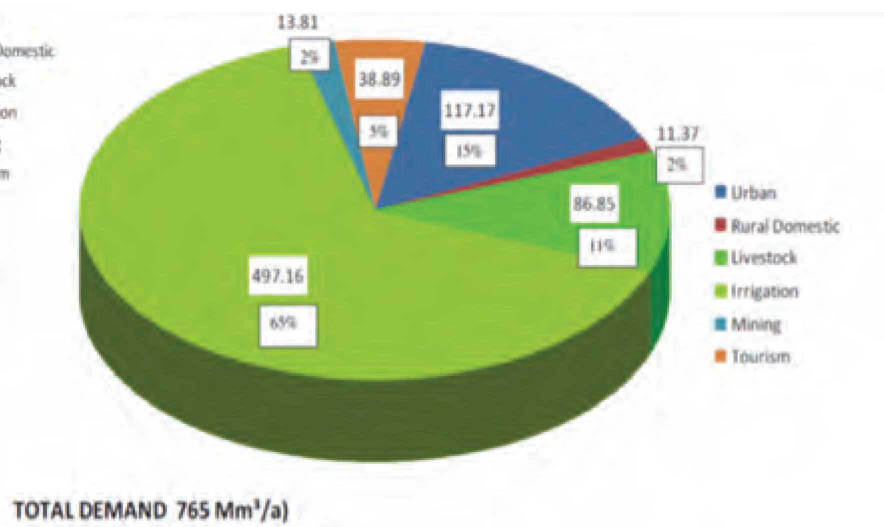


Figure 2.8: Estimated water requirements in 2030.
Source: IWRM Plan Joint Venture (2009)



2.5 LAND USE AND LAND TENURE

With the exclusion of protected areas, land tenure in Namibia takes three forms: freehold private land (43% - mainly in the south and in central Namibia), communal land (37% - mainly in the north central/ north east and east of the country) and municipal, town and other State lands (1%). Namibia's extensive network of Protected Areas (PA) on State Lands covers 13.8% of the country's land surface. The PA network is being expanded through the incorporation of new sites, with a total area of 33,341 km^2. In addition, there are 63 registered Communal Conservancies on communal lands (totalling 123,347 km^2) which is essentially a management unit with legal rights over the use and management of natural resources (see section 2.8). An estimated 15% or 7,600 km^2 of Namibia's freehold land is dedicated to wildlife management.

The main land uses in Namibia include farming (crop, livestock and game, commercial and subsistence on communal land, small and large scale); conservation on proclaimed state protected areas; resource use, management and conservation on registered communal conservancies; areas earmarked for resettlement; urban areas and informal settling; government agriculture farms; tourism and mining.

Long-term investments of any kind require firm property rights. The communal areas of Namibia are currently left somewhat in a void between traditional law and newly-established judiciaries not yet functional nor necessarily accepted. The tenure arrangements do not lend themselves to promote the type of infrastructural investments climate change adaptation would warrant. Current tenure arrangements in Namibia are presented in Figure 2.9.

2.6 AGRICULTURE AND FORESTRY

The agriculture sector secures food for the majority of the population and provides formal and informal jobs. Directly or indirectly, it supports over 70% of the country's population (National Programme for Food Security, 2007). Agricultural contribution to GDP (Table 2.3) grew from 4.5% in 2001 to about 7% in 2005, with growth driven primarily by the commercial sector. However, this fell short of the second National Development Plan's (NDP2) targets, owing to episodes of drought and currency appreciation among other constraints (National Programme for Food Security, 2007). In 2008, the contribution to GDP had fallen to 5.5% (Figure 2.11).

Namibia is a nett importer of most agricultural and fisheries related products. Meat and fish are the exception as they are produced in abundance and are exported to neighbouring countries and internationally. Namibia pursues a policy of import substitution i.e. producing more of the imported agricultural products locally.

The agricultural sector has, broadly, a dual system comprising a well developed, capital intensive and export oriented commercial sub-sector and a subsistence-based communal farming sub-sector, low in technology and external inputs and highly dependent on labour. In 2005, total agricultural output was estimated at

Table 2.3: Contribution of Agriculture and Forestry sectors to GDP.
Source: Republic of Namibia (2007a)

Sector	2001	2003	2005
Agriculture and Forestry	4.5	5.8	7.0
Commercial	2.8	4.3	5.0
Subsistence	1.7	1.5	2.0

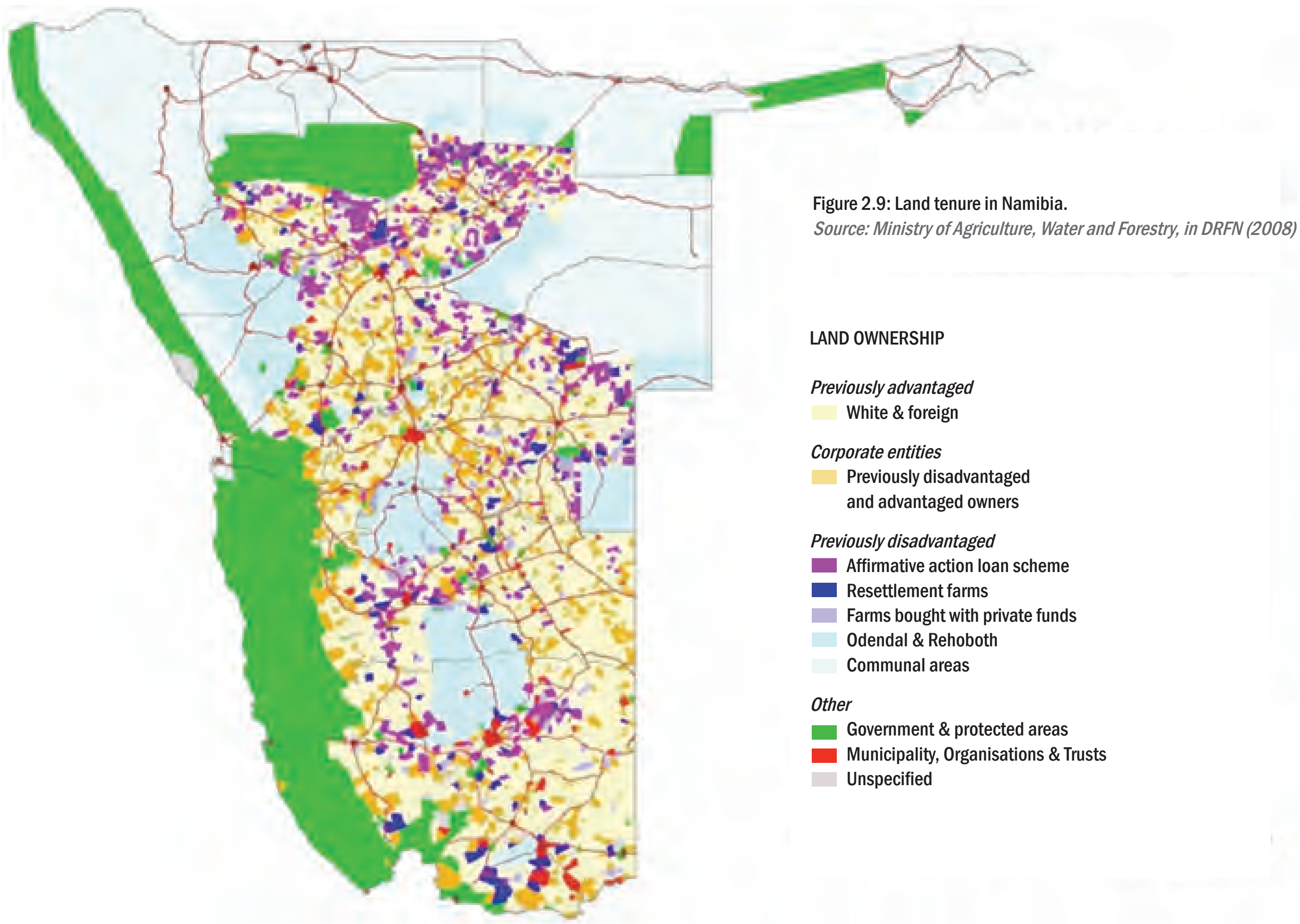


Figure 2.9: Land tenure in Namibia.
Source: Ministry of Agriculture, Water and Forestry, in DRFN (2008)

N$1.13 billion out of which 66.8% and 33.2% was contributed by the commercial and communal sub-sectors, respectively. It is estimated that about 152 000, 20 300 and 16 000 households are directly involved in crop, cattle and small stock production, respectively. Five major farming systems exist in Namibia and these are: smallscale cereals and livestock, small stock production, mixed cattle ranching, intensive agriculture and natural resource production.

Owing to climate, soil types and evapo-transpiration rates, Namibia is better adapted to livestock-based as opposed to crop-based agriculture. Extensive livestock ranching thus dominates, with cattle farming in the northern and central regions and small-stock and ostrich farming in the more arid western, southern and south-western regions. Recently, game farming and mixed wildlife/ livestock production has become a fast-growing industry. The Veterinary Cordon Fence (VCF) exists to prevent the spread of foot-and-mouth disease (FMD) from wildlife to livestock, and to comply with other international sanitary and phyto-sanitary standards for meat exports. The livestock sub-sector contributed 87% to agricultural GDP in 2004 (Republic of Namibia, 2005a). The areas receiving between 250 and 400 mm rainfall allow cattle farming, and consequently mixed livestock farming based on ruminants. In areas with rainfall in excess of 400 mm, cattle farming is predominant but dry-land crop production can be initiated. The main challenges faced by this sector include droughts and floods that affect the output of both livestock and crops.

Crop production activities are limited, mainly due to general dry conditions (lack of water) and poor soils. Low and sometimes poorly distributed rainfall limits rain-fed crop production to only those areas receiving annual rainfall of 400 mm and above (north and north-eastern regions), or about 34% of the country. Rain-fed crops include pearl millet, sorghum and maize. Maize and wheat are grown under irrigation on some commercial farms. Crop production's contribution to the formal agricultural GDP is less than 10%, but it makes an important contribution to food security and livelihoods.

Irrigated agriculture is concentrated in fertile areas with high annual rainfall or abundant water resources from rivers, streams, dams or boreholes. Horticultural production occurs across a wide range of environmental conditions, with distribution restricted primarily by access to water, water quality, soil quality and by topography. Grape production along the Orange River on South Africa's border has grown significantly in recent years. Horticulture supports more than 100 crop types, categorized into 21 commodity groups. Horticultural production systems have good potential for expansion in Namibia and are seen as a source of adaptation to climate change, provided that secure sources of water are available. Increased irrigation is planned (the Green Scheme, see section 5.v.i.i). However, high evaporative demand, when combined with sufficient soil moisture in irrigated areas, can lead to soil salinisation under inadequate management practices.

While forestry's contribution to GDP is relatively low compared to other renewable resource sectors it plays an important role in community development. The value of forest products was estimated at N$10.2 billion in fuel wood, N$2.0 billion in poles, N$634 million in sawn timber and N$5.9 billion in non timber forest products (NTFPs). 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.

2.7 FISHERIES AND THE COASTAL ZONE

Namibia has one of the most productive fishing grounds in the world, with the potential for sustainable yields of up to 1.5 million metric tons. Namibia's fisheries sector is based on the cold Benguela Current. The associated up-welling cells carry nutrients that support fish stocks in Namibian waters. 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.

The commercial fishing and fish processing sectors significantly contribute to the economy in terms of employment, export earnings, and contribution to GDP. Fishing and fish processing onboard contributed 2.9% to GDP in 2008, with fish processing onshore contributing another 1.5% (NPC, 2009). The sector is a substantial export earner, with over 85% of Namibia's fish output destined

for international markets. Significant research and management resources, coupled with a robust policy framework, are directed towards establishing a sustainable fishery (Henrik et al., 2009) and rebuilding fish stocks, with considerable success. Namibia is the first host and a member state of the Benguela Current Commission (BCC) which aims to restore depleted fish stocks, halt ecosystem degradation and apply an ecosystem approach to fisheries (EAF). Nevertheless, the quantity of fish harvested in Namibian waters appears to be reaching a limit and the Government has actively pursued value-addition policies aimed to increase onshore processing of fish products.

Aquaculture has been identified as a key development focus for the next 30 years, but has not performed as expected due to lack financing. Freshwater aquaculture is promoted to increase food security in rural areas while mariculture exploits the lucrative markets of Asia. Mariculture development has been slow because suitable space is a critical limiting factor.

In northern Namibia people fish in the oshanas during the rainy season and in the perennial Okavango, Zambezi and Kwando Rivers. The fish is mainly for own consumption and smallscale local trade. It is national policy not to encourage the commercialisation of inland fisheries, especially in the rivers, but to allow only subsistence fisheries.

The coastline of Namibia is 1 500 km long, and consists of 78% sandy beaches, 16% rocky shores and 4% mixed sand and rock shores. Only 2% of the shore is backed by lagoons. The land that flanks the coastline comprises mobile sand dunes, extensive gravel plains and occasional exposed bed rock surfaces. Strong prevailing south-westerly winds transport sediment towards the shoreline and sand-drift towards the north-east (NACOMA, draft).

The Namibian coast supports a rich diversity of birds. In addition to the three Ramsar sites (Orange River mouth, Sandwich Harbour, Walvis Bay) there are eight Important Bird Areas (IBAs) - Kunene, Cape Cross, Swakop Salt Works, 30 kilometres of beach Swakopmund to Walvis Bay, Mercury Island, Ichaboe Island, Possession Island, Lüderitz lagoon).

There are four significant towns on the coast: Lüderitz, Walvis Bay (the only deep water port), Swakopmund and Henties Bay. The coastline is an important tourism and recreation asset hosting attractions such as angling, sport fishing, seal colonies, bird watching and historical sites. Walvis Bay is located between 1 and 3 m above sea level, in a small semi-sheltered bay surrounded by an erodible coastline. Walvis Bay is an important deep water port providing trade access to landlocked countries such as Botswana.

The mean annual rainfall is 20 mm, and the town relies on coastal aquifers.

2.8 TOURISM

Namibia's unique landscapes and biodiversity support a rapidly developing tourism sector. The number of foreign visitors topped the 1 million mark in 2006, and in that year tourism contributed 14.2% to Namibia's GDP (Table 2.4), second only to mining. Tourism is a substantial contributor to foreign exchange earnings. It provides an important direct and indirect source of employment and income generation, particularly in rural areas where most tourism activities occur.

Most tourists expect a nature- and wildlife-centred experience such as game-viewing, bird-watching, hiking, sport-fishing, marine tours or trophy-hunting, as well as enjoyment of the sparsely populated, spectacular arid scenery and wide-open spaces. These are valuable natural assets which give the country a competitive edge in the global tourism market. Therefore, preserving these

Table 2.4: The contribution of the tourism sector to the Namibian economy. *Source: Namibia Tourism Board (2008)*

	2005	2006	2007P (preliminary)	2008E (estimated)	2017E (forecast)
Total travel & tourism demand (billion N$)	7,883	9,332	10,981	12,752	36,942
Direct effect of travel & tourism industry					
GDP (billion N$) (% of GDP)	1.56 (3.9%)	1.83 (3.9%)	2.1 (4.0%)	2.5 (4.1%)	7.8 (6.5%)
Employment (1000 jobs) (% of national total)	20 (5.1%)	20.6 (5.1%)	22 (5.2%)	22 (5.3%)	28 (6.0%)
Overall effect of travel & tourism economy					
GDP (billion N$) (% of GDP)	5.66 (14.3%)	6..65 (14.2%)	7.8 (15.1%)	9.0 (15.6%)	28.4 (22.4%)
Employment (1000 jobs) (% of national total)	73 (18.7%)	74.9 (18.7%)	77 (18.8%)	79 (18.9%)	103 (20.0%)

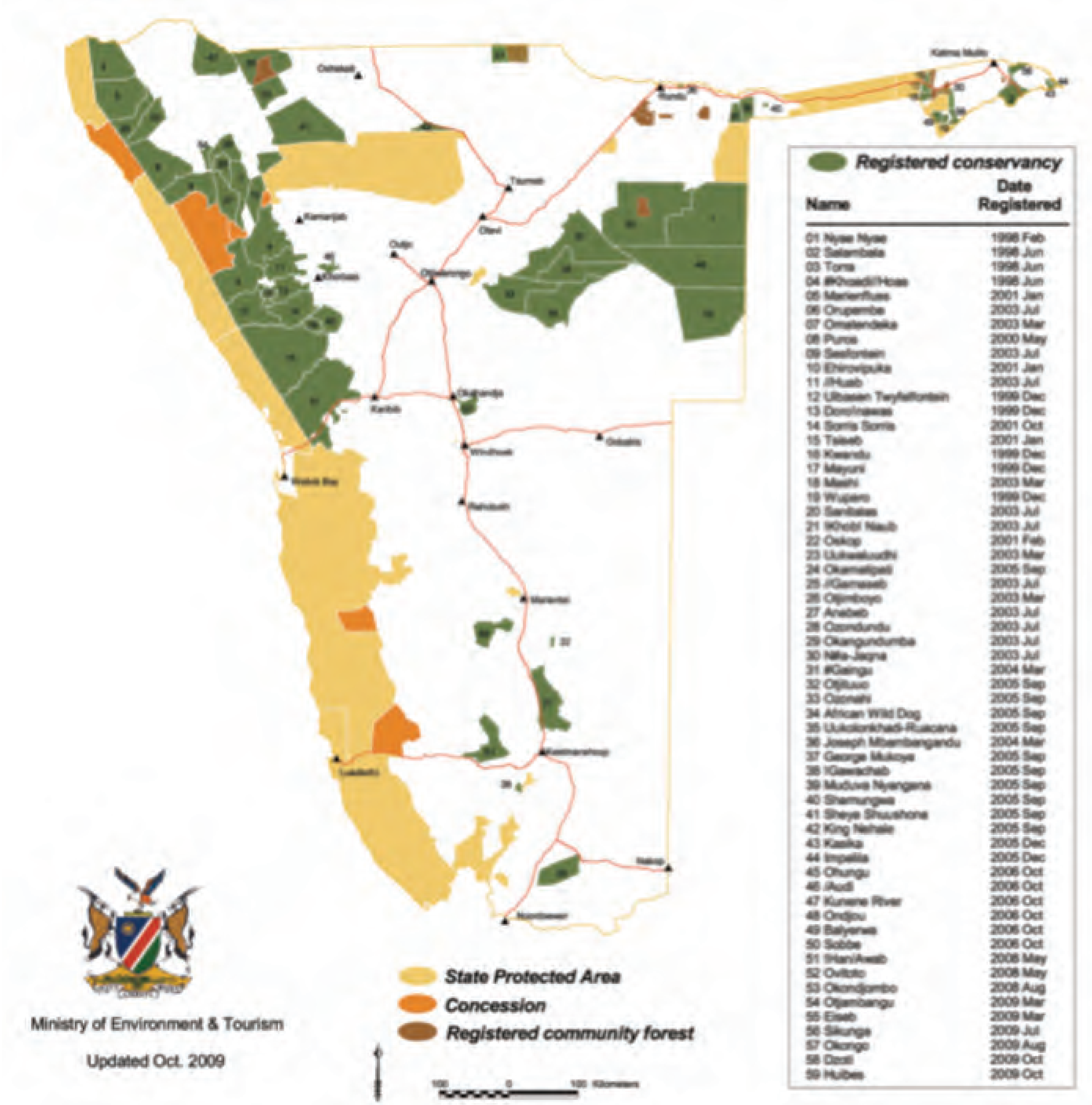


Figure 2.10: Distribution of 59 communal conservancies, community forests, national parks and tourism concessions across Namibia. *Source: NACSO (2009a)*

assets by using them sustainably is fundamental to sustaining the development and growth of the tourism sector. However, tourism itself impacts on the environment and its services, e.g. by relying heavily on scarce water resources in arid areas. The future growth of the industry will require careful long-term planning to avoid rapid tourism growth that goes at the expense of the ecologically sensitive arid environment. Since the most scenic sites are scattered across the vast country, tourism is quite transport-intensive and thus energy demanding, thereby contributing to the country's greenhouse gas emissions.

While Namibia's variety of animals attracts tourists, free roaming animals such as elephants compete with humans, in particular subsistence-farmers, for land and water. It has been shown, however, that land-use for tourism in parts of Namibia, outside protected areas, has high economic potential compared to livestock and agriculture. The declaration of community conservancies tries to reconcile the basic needs of subsistence farmers with the conservation of nature. Through the national community-based natural resources management (CBNRM) program, rural communities in communal areas are empowered to manage their natural resource base sustainably, invest in wildlife and benefit from the resulting tourism opportunities, in particular via hunting concessions.

Various kinds of CBNRM-type programs have been developed in Namibia, dealing with different natural resources like wildlife, forests, water and inland fisheries. Two of these include:

Communal-area conservancies

Subsequent to the promulgation of wildlife-focused CBNRM policy and legislation in 1995/96, conservancies began to be established, increasing rapidly to 50 conservancies by the end of 2007, covering nine out of 13 Regions, 14.4% of Namibia, and

more than one third of the total area under active conservation management (Figure 2.10). Income to registered conservancies plus from other CBNRM activities outside conservancies rose from N$ 600,000 in 1998 to nearly N$ 40 million in 2007. Direct and indirect contributions of CBNRM to the national economy for the same year amounted to approximately N$ 220 million. Most of the growth in overall conservancy income has come from joint venture tourism (N$ 14 million in 2007) and direct wildlife utilization (N$ 12 million) (NACSO, 2008). Figures indicate that the CBNRM programme is economically fully viable. Favourable effects on the wildlife resource have materialised through natural growth and translocations, underpinning the substantial wildlife-and tourism-derived benefits.

Community forests

The concept of decentralised community-based management of natural forests was formally introduced in Namibia in 1996, with the Namibia Forestry Strategic Plan (NFSP, 1996). Active participation of rural communities in forest management is proposed to be achieved by granting the local communities ownership and tenure rights to forest resources. The first 13 community forests were gazetted in 2006 (Figure 2.10), with another 10 applications expected to be gazetted soon, and a further 28 emerging. Guidelines exist for the functioning of community forests, the development of a natural resource inventory, and a Forest Management Plan (including zonation maps), according to each forest's bio-physical, socio-economic and cultural context. The programme is still at a relatively early stage in Namibia and is yet to realise significant income.

2.9 MINING

Mining is the backbone of the Namibian economy in terms of economic output and exports, contributing 15.9% to the national GDP in 2008 (Figure 2.11). Resources explored and mined include diamonds, uranium, zinc, copper, semi-precious stones, and fluoride and as well as oil and gas exploration (the Kudu Gas Field in southern Namibia). Diamond-mining, in particular, contributes to total government revenue in the form of company taxes and through diamond royalties, and accounts for roughly 50% of the total export value. Uranium interest and exploration has boomed in Namibia over the past 5 years with high potential contributions to the national economy. Mining still plays a vital role in stimulating infrastructure growth. The sector supports a variety of community and conservation initiatives, as well as training and skills development programmes.

If not planned and managed appropriately, mining results in a variety of significant adverse impacts which threaten human health/life, biodiversity and ecosystems/ landscapes. With modern environmental management and safety instruments, with mitigation and limiting the geographic extent of negative impacts mining operations in Namibia are improving. Small-scale mining could contribute significantly to employment creation and poverty reduction. Small-scale mining is expected to grow in relative terms and additionally holds the possibility of “mining tourism,” where operating mines provide tourism experiences. Also, the agreement to allocate 16 % of diamond production for local cutting and polishing contributes to domestic value addition.

2.10 MANUFACTURING

Manufacturing is currently the third largest contributor to national GDP (NPC, 2009). The manufacturing sector largely depends on the processing of agricultural (grain and meat processing) products, food and beverages, and fishery products. Mining output is processed to a lesser extent in the country, and includes diamond and gemstone cutting and polishing. A copper smelter is operated at Tsumeb and a zinc refinery has been constructed at the Skorpion Mine. A large textile plant is under construction in Windhoek that will employ up to 5 000 workers and consume considerable amounts of water and electricity. Despite the large number of cattle in the country, a leather industry is emerging slowly with an additional tannery to be opened in the north soon. There is no significant chemical and metal-working industry in the country. Charcoal production has increased over the past years. The felling of mature indigenous plants for charcoal production speeds up the process of bush encroachment by smaller, less valuable shrubs. Exact figures are hard to obtain but estimates of wood used range between 15 000 tons and 50 000 tons per year. Namibia's Industrial Policy aims to increase manufacturing activities to reduce dependency on the primary sector and add value to raw materials.

2.11 ENERGY

The key institutions in Namibia's energy sector include the Ministry of Mines and Energy (policy maker), NamPower (national utility), Namcor (state oil and gas parastatal), and ECB (national electricity regulator).

On the supply side, Namibia currently has three electricity-generating plants: a hydroelectric plant at Ruacana (240 MW capacity) which depends on the rainfall in Angola, the coal-fired Van Eck station at Windhoek (120 MW capacity) which imports coal from South Africa, and the stand-by Paratus station at Walvis Bay (24 MW), which burns diesel (Republic of Namibia, 2007b). This translates to 384 MW per annum in total. In addition, diesel generators and solar panels are used to provide electricity in remote areas and on farms. Subsistence households use firewood to prepare food and candles and paraffin lamps for lighting. Energy demand is growing by about 3% per year.

The local supply does not meet the demand, with maximum demand now standing at 409 MW. To cover the demand that cannot be met by local supply, electricity is imported through a 400 kiloVolt (kV) and a 220 kV power line from the South African utility Eskom, and to a much lesser extent, from the Zambian utility Zesco to supply the Caprivi Strip. South Africa generates electricity primarily from coal-fired power plants. Imports into Namibia account for up to 70% of total electricity (Republic of Namibia, 2007b). The high import rate of electricity from Eskom has been based on historical over-capacity in generation in South Africa, which however is rapidly diminishing, posing a risk to Namibia's energy security.

To increase generating capacity, the feasibility and costs of clean energy projects in Namibia have been investigated. NamPower is developing the 800MW Kudu Power Station near Oranjemund in south-west Namibia. The combined cycle project will use natural gas from the Kudu Gas Field, located170 km off-shore. The plant will be connected to the Namibian and Southern Africa power grids and power from the plant will be purchased under long-term regional Power Purchase Agreements. The first gas production from this project was expected by 2010. The carbon credit potential of the Kudu power station is being investigated by NamPower, which, if approved, would generate additional revenue and could thus assist in making the Kudu Power Project commercially viable and sustainable.

Other potential and current clean energy projects which have been investigated include:

- Epupa/Baynes Hydro Plant or Hydro Kunene Power Scheme (400 MW), on the Kunene River forming part of the northern border with Angola;
- Divundu Mini-Hydro Power Plant on the Kavango River in the vicinity of the Popa Falls (30 MW);
- Orange River Small Hydro Schemes (5 to 35 MW) along the Orange River forming the border with South Africa;
- Lüderitz Wind Park (20–50 MW) wind generation project;
- Coastal Wind Park (98 MW) along the coastline especially in the area of Walvis Bay, Lüderitz and Oranjemund;
- Solar energy projects: there has been an increased use of decentralised solar Photovoltaic (PV) Systems providing basic electricity services in remote areas, including Solar Home Systems (SHS), Solar Water Heaters (SWH), and Photovoltaic Pumps (PVP).
- Bio-energy projects: through the National Bio-Energy Road Map launched in 2006 by the Ministry of Agriculture, Water and Rural Development, it is envisaged that approx. 63,000 ha of Jatropha would be planted in Namibia by 2013, growing to 100,000-500,000 ha by 2030.
- Namibia has over 26 million hectares of invasive bush biomass material which is being harvested and converted into woody briquettes largely for export. Studies are underway into wood gasification.

The ECB is promoting energy-efficiency and demand-side-management as an integral part of future energy supply strategies. Energy efficiency is the fastest, cheapest and cleanest solution for stretching Namibia's energy supply and enhancing energy security in an environmentally sustainable manner. Improved energy efficiency in government buildings, fishing and mining industry, agriculture sector, transport sector and residential properties could lead to lower energy use overall.

2.12 TRANSPORT

Namibia's transport infrastructure is well developed and highly rated. Gravel roads cover almost 59 000 km, tarred roads 5 400 km and railway lines stretch over some 2 600 km. The country has two major ports (Walvis Bay and Lüderitz), one international airport and an impressive network of smaller airports and landing strips. Namibia is positioning itself as the 'gateway to Southern Africa'. The Trans-Caprivi Highway was constructed to connect Namibia's deep-sea port of Walvis Bay to neighbouring countries in the north (Democratic Republic of the Congo, Angola) and north-east (Zambia, Zimbabwe, northern Botswana). The Trans-Kalahari Highway connects Walvis Bay to countries to the east (Botswana and South Africa's industrial heartland in Gauteng). Indeed Botswana is in the process of establishing a dry port in Walvis Bay and these arrangements will lead to an increase in import and export of goods from Botswana and link Walvis Bay to Gauteng, cutting the link between Windhoek and Johannesburg by 400 km. These routes will be used by both rail and heavy goods vehicles, with both modes of transport running predominantly on diesel. Intensive investment in the two Namibian ports – Walvis Bay and Lüderitz – has increased the capacity to handle additional cargo substantially and has improved competitiveness with South African ports such as Cape Town. Thus it is expected that transport activities in the country will increase in the medium term.

Passenger transport is on the increase and mainly carried out by minibuses and sedans. For business people and tourists, air travel has become a more important means of transport to bridge the long distances. In March 2007, Namibia had a total of 233,640 vehicles, augmented by steady growth in vehicles coming in from neighbouring countries. Vehicle sales and vehicle fuel demand closely followed economic growth in Namibia between 1999 and 2006. This is not surprising as transport is affected by activities in all other sectors of the economy and as these grow, so does the need for transport. Nationally the vehicle population is dominated by light passenger vehicles at 46%, followed closely by light load vehicles at 42%. However, the proportion of commercial vehicles has grown significantly between 1997/99 and 2000/04, linked closely to rapid growth in GDP.

Transport fuel consumption constituted over 70% of Namibia's total energy demand in 2006. This is due to the economy's reliance on large volumes of imports that come into the country on land. Transport demand is strongly linked to economic growth. All petroleum products are imported from refineries in South Africa. The planned use of Kudu Gas Field natural gas resources to provide an alternative transport fuel will reduce the economy's vulnerability to imported fuels. The main transport fuels in Namibia are petrol, used in most light passenger and light load vehicles, whilst diesel is used by almost all the heavy load and special vehicles, as well as by the fleet of fishing vessels and locomotives. Between 1994 and 2006, petrol use increased by an average rate of 2.8% per year whilst diesel increased at an average annual rate of 4.7%, almost equal to the GDP growth rate.

2.13 WASTE

Namibia, as a low / medium income country with a considerable poor rural society, a growing wealthy urban middle class, and significant urban drift (6% to towns from 1991 to 2001), is beginning to feel the pressure on its disposal facilities throughout the country. Apart from the Gammans / Otjimuise operations in Windhoek, reliable data is not available for the majority of Namibia's waste water effluent plants. At Windhoek, waste water amounts to about 42m^3 per person per year (refer to section 3.7 for calculations). Similarly, data for solid waste are not available except for Windhoek (Kupferberg landfill site), which show that average per person solid waste disposal in 2000 was about 0.35 kg (section 3.7). When compared with an estimate of the average per capita solid waste disposal in the USA of 0.85 kg/day, the value for Windhoek would appear reasonable.

Other significant sources of waste include fish processing and meatpacking industries, breweries and tanneries, but figures are

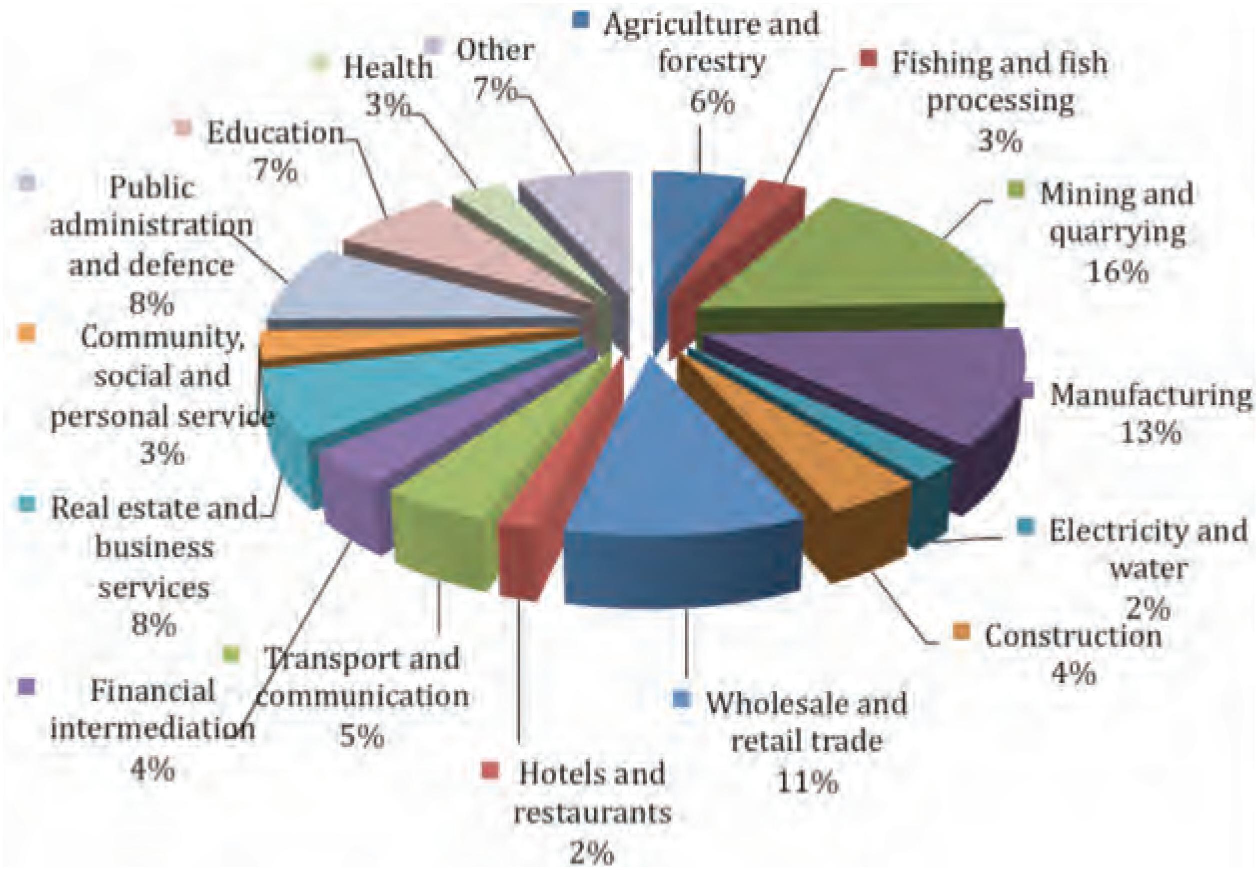


Figure 2.11: GDP composition in 2008 in %.
Source: Central Bureau of Statistics (NPC, 2009)

not available. It should be noted that refuse is regularly burned at dumps located throughout Namibia as a way to reduce volumes. However, not all towns follow this practice, so it would not be practical to estimate the amount of refuse burned annually in Namibia.

2.14 OTHER ECONOMIC SECTORS

Government services (including public administration and defence, education and health) are the main single contributor to GDP at about 18.6% in 2008 (Figure 2.11; NPC, 2009). Government is also the major single employer in the country, while agriculture is the sector that provides most jobs. Other important sectors, in terms of contribution to GDP, are wholesale and retail trade (10.5%), real estate and business services (7.5%), the construction business (4.2%) and financial intermediation (4.0%).

2.15 ECONOMIC OUTLOOK AND DEVELOPMENT

In 2008, the Namibian economy (GDP) recorded a slow growth of 2.9% as compared to 5.5% in 2007 (NPC, 2009). This growth was attributed to the secondary and tertiary industries recording moderate growths of 2.0% and 5.2% in 2008, respectively. However the primary industries declined by 1.6% in 2008 as compared to a decline of 2.8% in 2007.

Gross National Income (GNI) grew by 4.9% in 2008, down from 8.5% in 2007. On a per capita basis, GDP grew by 1.1% in 2008 (3.6% in 2007) which translated into growth of per capita GNI of 3.0% (7.4% in 2007). The ratio of gross savings to GDP has for all the years (2000-2008) been more than the ratio of investment to GDP. In 2008 the ratio of gross saving to GDP stood at 24%, while the ratio of investment to GDP stood at 23%.

In the primary sector, the agriculture and forestry sector registered a growth in real value added of 3.0% in 2008, mostly attributed to the livestock subsector which increased by 6.3%. Farmers preferred restocking their animals rather than to export them on hoof due to favorable weather in the country. However, crop farming and forestry recorded slow growth of 0.1% in 2008 as compared to the 3.5% contraction experienced in 2007. The real value added by fish and fish processing on board sector declined by 12.3% in 2008 following a decline of 19.0% in 2007. This decline is mainly attributed to lower landings recorded in 2008 for demersal and mid-water species. The mining and quarrying sector recorded a decline in real value added of 1.8% in 2008, reflecting the global financial crises affecting the demand for minerals.

In the secondary sector, the real value added by the manufacturing sector declined by 2.6% in 2008, driven by declines in meat processing, fish processing onshore and other manufacturing 8.4, 18.0 and 2.3%, respectively. The decline in meat processing was due to a drop in the number of livestock marketed in 2008. The decline in fish processing onshore was due to increases in input costs and low landings recorded in pelagic, demersal and deepwater fisheries. The decline in other manufacturing was due to high input costs in the manufacturing of basic metals noted in 2008. One the other hand, the growth in the electricity sector (8.0%), and the construction sector (15.6%) yielded an overall positive growth in the secondary sector. The good performance in the construction sector was mainly due to an increase in civil engineering works and related services in the mining and quarrying, transport, storage and communications, and general government sectors.

In the tertiary sector representing business and government services, overall slow growth was experienced in 2008, attributable to inflation that eroded the purchasing power of consumers. Nevertheless, restaurants (14%), transport (10%), financial intermediation (10.1%) (supported by growth of 21.5% in the insurance and pension sub-sector), government (7.9%) and health (11.1%) showed healthy growth in 2008.

The global economic and financial crises have impacted on Namibia's economic performance and short term economic outlook (Angula, 2008). Since the small economy of Namibia is highly trade dependent, response measures adopted by countries such as the USA, the Euro zone and Japan will affect Namibian exports such as meat, fish, fruits and diamonds. Soaring oil prices and the electricity crisis in Southern Africa are a matter of great concern, because these will affect Namibia's capacity to achieve its development goals, objectives and economic targets.

Nevertheless, the Government of Namibia is making concerted efforts and financial commitments towards development by stimulating growth through fast-tracking of several economic sectors. Simultaneously, sustainable Official Development Assistance (ODA) is expected from European Union (EU) donors, as well as stable and sustainable aid flows within the context of south-south cooperation from the emerging nations such as China and India, who are also increasingly absorbing Namibian exports. Together, these factors should cushion some of the negative impacts of the volatile global economy on the Namibian economy (Angula, 2008).

On the domestic front, policies aimed at steady and sustained growth are pursued to fight the triple threats of unemployment, poverty and inequality. To this end, pro-poor, pro-rural and pro-agriculture development policies and strategies are encapsulated in the NDP3, anchored within Vision 2030, and supported by a Development Budget of N$11.0 billion for the three years 2008/2009 to 2010/2011 (Angula, 2008). The Development Budget is the main instrument to implement the Public Sector Investment Program. In this respect, targeted sectoral initiatives will be fast-tracked. These include the building and development of roads, clinics, water supply, schools and skills. The Green Schemes, land reform and resettlement and SME promotions will be accelerated. The telecommunications network will be improved, and policies and strategies will be introduced to ensure a reliable and interruption-free power supply. Finally, safety nets for the vulnerable groups will be improved.

2.16 CULTURE AND HISTORY

Namibia is characterised by a variety of ethnic groups. The Ovambo form the largest group – about 50% of the total population - living mainly in the north-central regions. Other major ethnic groups include the Coloureds, Damara, Herero, Himba, Lozi, Mafwe, Baster, Tswana, Mbukushu, Nama, San, Subiya, and citizens of European descent with Afrikaans, English and/or German as their mother tongue. English is the official language of Namibia.

The early inhabitants were the Nama and San people that lived as hunters and gatherers. Bantu groups started moving into Namibia from East and North East Africa more than 1 500 years ago. The first Europeans reportedly arrived in 1486 as seafarers, but colonisation started only towards the end of the nineteenth century once Africa had been divided between European countries at the Berlin Conference. Namibia was allocated to Germany and became a settler colony in the late 19th century. During the colonial period, the Germans fought against the Herero and Nama people, almost destroying these groups completely. The German colonial period came to an end during World War I. The League of Nations asked Great Britain to govern the country as a 'C-Mandate' on its behalf, but Great Britain handed it over to what was then the South African Union in 1920. After winning the national election in the South African Union in 1948, the National Party also introduced its apartheid ideology to Namibia and created the so-called homelands for the different ethnic, non-white groups. Pressure from the United Nations, among others, through Resolution 435 in 1978 which spelled the way for Namibia's Independence - and from the liberation struggle that started in 1966, eventually led to the Independence of Namibia in 1990. General elections included all political parties and led to the first democratically elected independent government in March 1990.

The new Constitution has been acclaimed for its far-reaching civil rights and democratic spirit. Namibia is a parliamentary democracy with national and regional elections held every five years. The power is separated between three organs: the executive (cabinet), the legislative (parliament) and the judiciary (courts).

2.17 POPULATION

The 2001 Namibia National Population and Housing Census estimated that there are 1 830 330 people in Namibia. The country has a relatively young population, with 43% under 15 years of age and less than 4% over age 65 (NPC, 2003). A total of 65% of the population lived in the rural areas, whereas 35% of the population lived in urban areas. Overall, the population density is low (less than 2 persons per square kilometer), but regional population densities vary substantially, with almost two-thirds of the population living in the four northern regions, and less than one-tenth living in the country's south (NDHS, 2008). In Namibia 59% of households are headed by males and 41% by females (NPC, 2006a). Women head approximately 48 percent of rural households (NPC, 2003).

Although the fertility rate in Namibia has decreased, the average size of a household in Namibia is still fairly large at 4.9 persons (NPC, 2006a). On average rural households are larger than urban households, 5.4 compared to 4.2 persons per household. The dependency ratio (defined as the ratio of the total population to the employed population) in rural Namibia is relatively high: an employed person needs to support close to six other persons on average.

Although the fertility rate will continue to diminish according to the population projections of the Central Bureau of Statistics (CBS), the population of Namibia is expected to grow substantially until 2031 (NPC, 2006b; Table 2.5). A combination of reduced, but still relatively high fertility rates and increased life expectancy would culminate, in part, in significant growth of the Namibian population over the next decades. In fact, by 2031 the population of Namibia is expected to have grown by 66% to a total of 3,031,463 persons, representing an average annual growth rate of approximately 1.7 percent over 30 years (Table 2.5). This projected population figure is based on the medium scenario of the population projections by CBS.

Despite rapid urbanisation, Namibia is still mainly rural, with approximately one in three persons living in urban areas. The rate of urbanisation is expected to increase. However, the projections have not clearly outlined this aspect of demographic change in Namibia, so it is impossible to make sound projections for urbanisation.

The percentage of the population 15 years and over who are

Region	Population 2001	Population 2031	Growth over 30 year period
Caprivi	79,826	105,344	32%
Erongo	107,563	122,290	14%
Hardap	68,246	77,521	14%
Karas	69,321	78,748	14%
Kavango	202.690	472,994	133%
Khomas	250,260	638,993	155%
Kunene	68,735	93,552	36%
Ohangwena	228,383	360,382	58%
Omaheke	68,041	110,771	63%
Omusati	228,841	276,005	21%
Oshana	161,917	213,676	32%
Oshikoto	161,006	239,567	49%
Otjozondjupa	135,385	241,170	78%
Namibia	1,830,331	3,031,463	66%

Table 2.5: Population growth projections by region.
Source: Adapted from NPC (2006b)

literate stood at 85% in 2005 (UNDP, 2007) following strong improvements. The average percentage unemployment rate (% of total labour force) was 33.8% for the period 1996 to 2005 (UNDP, 2007). Of the total people employed in Namibia 31% are employed in the agriculture, 12% in industry and 56% in services. Although only 31% of Namibians work formally or semi-formally in agriculture a lot more are self-employed in agriculture and related industries i.e. over 60% of the population practice some form of agriculture for a livelihood. This situation makes the effects of climate change on agriculture and subsequently on labour obvious.

The vast majority of farm workers both on communal and commercial farms is unskilled and lives under precarious situations. On average farm workers spend 70% of their income on food, confirming their high levels of poverty (LaRRI, 2004). This makes farm workers highly vulnerable to economic shocks associated with loss of agricultural production due to climate change.

Namibia represents a typical dualistic economy where abject poverty exists alongside extremes of wealth. For example, the richest 10% of the households in Namibia has more than 50 % of total income of private households. The GINI index is 74.3 (UNDP, 2007), which makes Namibia one of the most unequal societies in the world. There is a wide disparity in infrastructural development between the impoverished northern parts of the country, where most of the population lives, and the central and southern Regions.

The percentage of the Namibian population below the income poverty line is estimated at 34.9% for the 1U$ a day category and 55.8% for the 2U$ a day category (UNDP, 2007). The human poverty index, which is a composite index measuring deprivations in three basic dimensions, namely; a long and healthy life, knowledge and a decent standard of living, is estimated at between 24.7% (Republic of Namibia, 2004) and 26.5% (UNDP, 2007).

The share of food consumption of total consumption is used as a crude poverty measure. In Namibia, 4% of households fit the definition of "severely poor" (>80% of consumption spent on food) and the proportion of "poor" households is 24% (60-80% spent on food). More people are classified as 'poor' and 'very poor' in rural areas than in urban areas. Climate change is expected to worsen the situation.

2.18 HEALTH

Namibia's health system and service delivery are based on the primary health care approach (MHSS, 2006; PDNA, 2009), and are decentralised. The provision of health services is shared between the public and the private sector, the latter focused on urban areas. Mission health facilities are subsidised by the government. Namibia has four referral hospitals, 34 district hospitals, 37 health centres and 259 clinics under the public sector (PDNA, 2009). Because of the vastness of the country, the sparse distribution of the population, and lack of access to permanent health facilities in some communities, outreach (mobile clinic) services are provided at about 1,150 outreach points across the country.

Infant and child mortality in Namibia is counted among the lowest in sub-Saharan Africa. However, the maternal mortality ratio has increased in the period 2000 to 2007, despite the fact that over 70% of births are delivered in hospitals (NDHS, 2008). General life expectancy has not improved, partly because of the HIV/AIDS epidemic. Household food insecurity is high among vulnerable female-headed households. Malnutrition levels in children under the age of five years are as high as 38% in some of the affected regions. The prevalence of acute malnutrition was 7.5% in 2006-07 (NDHS, 2008).

According to the MHSS Annual Report (MHSS, 2006), the 10 leading causes of inpatient deaths in 2005/05 of all age groups is shown in Figure 2.12.

Malaria is one of the major public health problems, causing 7% of all inpatient deaths (2005-06) amongst under-5 children (NNHA, 2008; MHSS, 2006). Malaria accounted for 26.4% of outpatient cases, 21.6% admissions, and 8.6% of all hospital deaths in 2002 (WHO, 2008). Fortunately, the annual malaria-related mortality rate has decreased steadily since 2004, as has the incidence of malaria, thanks to malaria control and management programmes

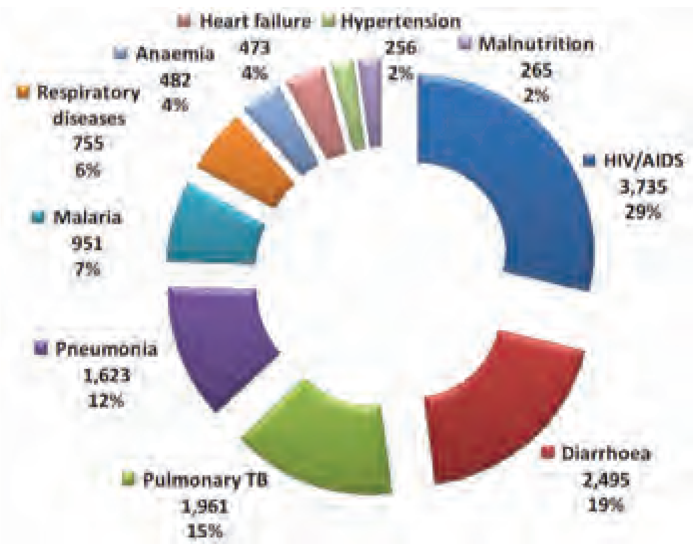


Figure 2.12: Top ten inpatient causes of death for all ages in 2005/06. *Source: MHSS (2006)*

(MHSS, 2006). 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 (Figure 2.13). The Okavango and Caprivi regions experience high temperatures, high rainfall and high humidity, conditions conducive to mosquito breeding and parasite development. In these two regions in particular, the existence of perennial rivers and associated open surface waters renders malaria transmission perennial, while a seasonal transmission peak occurs from the middle to the end of the rainy season. Other parts of the north and northeastern regions have a climate that is suitable for the transmission of malaria for between four and six months per year. In contrast, in north-western and parts of central Namibia, malaria transmission is seasonal and follows the onset of rains – a peak usually occurs between February and May. Here, the occurrence of malaria is seasonally dependent and is therefore unstable. Seasonality, climatic variability and unstable occurrences increase the risk of malaria epidemics.

The first cases of HIV/AIDS in Namibia were identified in 1986 and thereafter the HIV infection spread across the country reaching a peak of 22% amongst pregnant women aged 15-49 in 2002. The rate then diminished to nearly 18% in 2008 (Figure 2.14). This corresponds to an estimated HIV prevalence rate in the total Namibian population aged 15-49 years of 15% (MHSS, 2008b), which is expected to reach 16% by 2012/13, and suggests a stabilising of the epidemic. It is estimated that in 2007/08 approximately 204,000 adults and children were living with HIV/AIDS in Namibia (of which 7% were under the age of 15), and this will rise to about 247,000 in 2013.

New infections are expected to be dominant amongst young people, and in particular young women. The fact that 60% of infected Namibians are women underscores the vulnerability of women to HIV. The pandemic has had major implications for the number of orphans in Namibia. According to the 2006/07 Namibia Demographic and Health Survey (NDHS, 2008), 17% of Namibian children under the age of 18 were classified as orphans and 14% as vulnerable children. The two categories together (OVCs) represented 28% of all children in Namibia. Approximately 97,000 children have lost one or both parents (NPC, 2003), of which approximately 50% were estimated due to HIV/AIDS. The proportion of OVCs is highest in the northern and north-eastern regions (Figure 2.15).

As HIV reduces the immunity of individuals, co-infection with tuberculosis (TB) is a risk for HIV-positive individuals, and the incidence of TB in Namibia is fuelled by the HIV/AIDS pandemic. Namibia ranks second in the world in terms of the incidence of TB.

The HIV/AIDS pandemic has had substantial impacts on demographic factors in Namibia, in particular on mortality and life expectancy, which has been reduced from 62 years in 1991 to 49 years. This trend has caused a reversal of improvements in the health status of the Namibian population, and is likely the principle cause for the negative trends in human development and human poverty indices in Namibia between 1991 and 2001.

It is likely that HIV/AIDS has had a negative effect on total GDP growth, as the pandemic slows down population growth,

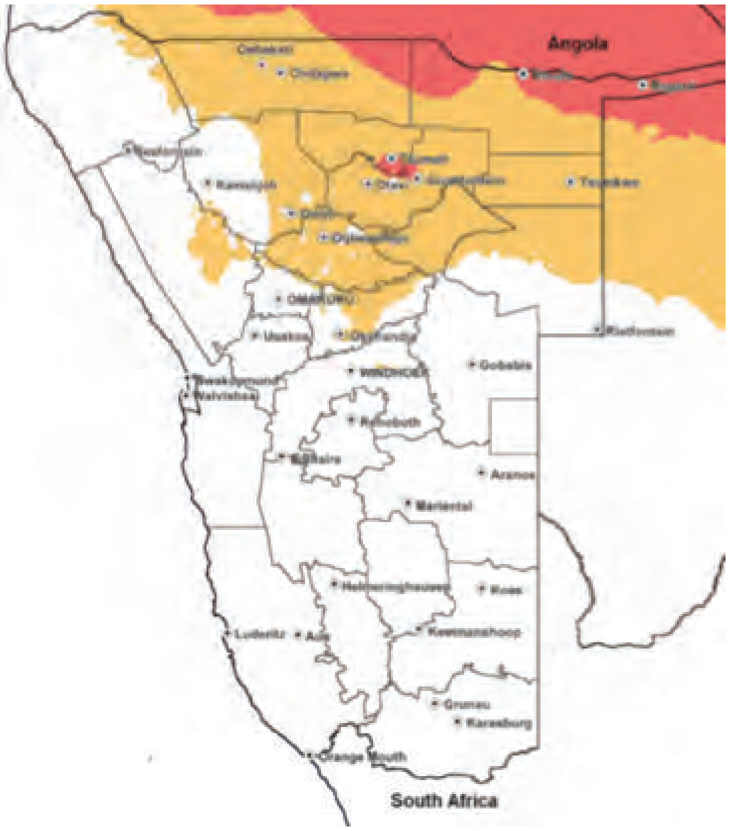


Figure 2.13: Present-day distribution of endemic malaria (red areas) and marginal (orange) areas. *Source: MARA (2009)*

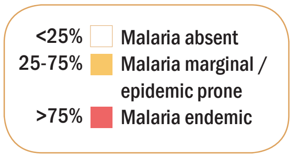


Figure 2.14: HIV prevalence amongst pregnant women aged 15-49, 1992-2008. *Source: MHSS (2008a)*

reduces life expectancy, and is compounded by reductions in productivity, due to morbidity and the shortage of skilled labour. For Namibia the decline in GDP per capita in the medium term was estimated to amount to 5.8%, whilst the decline in the long term would amount to 1.8%. Increasing health expenditure and expenditure for funerals are moreover expected to lead to a decrease of disposable income at household level with roll on effects in terms of economic growth.

There is general consensus that HIV/AIDS has a major impact on food security, agricultural and rural development as substantial amounts of agricultural labour are lost. Estimates of loss of agricultural labour for Southern Africa for the period 1985-2020 range from 20 to 26 percent, where Namibia with 26% scores top of the list of labour loss.

There appears to be some consensus in the environmental sector that AIDS-related morbidity and mortality have an impact on the management of natural resources (Dwasi, 2002; IECN, 2005; NACSO, 2009b). CBNRM support organizations, conservancies and parks report that they are losing personnel, knowledge and skills through HIV/AIDS related sickness and death and that absenteeism and psychological stress affect productivity on the work floor.

It is generally accepted that HIV/AIDS affects the performance of health systems in Sub-Saharan and Southern Africa (Tawfik and Kinoti, 2003; Cohen, 2002; WHO, 2006). This is mediated via the impact of HIV/AIDS on the demand for health care services, on mortality and attrition in the health sector, and on the performance of the health workforce / sector.

Overall, HIV/AIDS threatens human capacity in the country. If these trends continue, it is predicted that HIV/AIDS will exacerbate the predicted climate change impacts as result of lost human capacity for mitigation and adaptation.

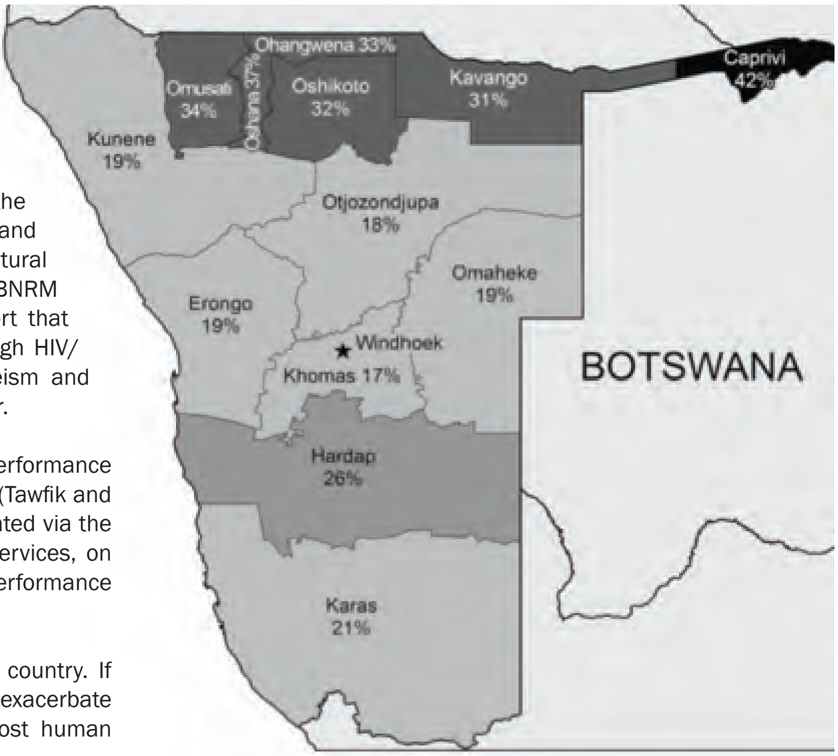


Figure 2.15: Proportion of orphans and vulnerable children (OVC) by region.
Source: NDHS (2008)

3. National greenhouse gas inventory

3.1 INTRODUCTION

The Namibian Greenhouse Gas Inventory for Year 2000 (Hartz and Smith, 2008) is the second inventory to be prepared for Namibia, with the first inventory (1994 Inventory; du Plessis, 1999) reported on in the Initial National Communication (Republic of Namibia, 2002). This inventory has been prepared in accordance with the requirements for non-Annex I PARTIES decision as laid out in UNFCCC decision 17/CP.8 (paragraphs 2, 6 through 24). In particular, estimates have been made for certain emissions for years other than 2000 (Para 7) in order to provide context for the 2000 emissions estimates; revised 1996 guidelines have been employed (para 8); where appropriate and possible country-specific emissions factors have been employed (Para 10); a selected number of key source and sink analyses have been undertaken (paras 12 and 14); both sectoral and reference approaches have been applied for fuel combustion emissions in key sectors (para 18); separate reporting of international aviation bunker fuels are estimated (para 19); and efforts to describe sources of uncertainty have been made, where these are deemed critical (para 24).

3.1.1 DATA COLLECTION INSTITUTIONAL ARRANGEMENTS

Namibia does not currently have a designated institution that is tasked with the collection, storage and analysis of greenhouse emission and removal data (though it is noted that MET - DEA and the National Climate Change Committee (NCCC) provide continuous support and oversight of climate change issues in general). As a result, this work is currently undertaken through a consultancy process only when required, and the data required are not managed centrally on a continuous basis. The process of contacting individuals and organisations during the data collection process is extensive and time consuming. The process could be significantly improved if a government entity such as the National Planning Commission Central Bureau of Statistics or MET – DEA could be capacitated (through staffing, training, and funding) to perform greenhouse gas data collection, management, storage on a continuous basis, and analysis when required. A detailed list of the approximately 50 individuals who were contacted for data supply during the preparation of this inventory is provided in Appendix 1.

The following key documents were critical to the preparation of the 2000 Inventory:

First Greenhouse Gas Inventory: A Report on Sources and Sinks of Greenhouse Gases in Namibia in 1994 (1994 Inventory). A Preliminary Overview was commissioned in 1999 by MET and was one of three reports that served as the foundation for the Initial National Communication (INC) to the United Nations Framework Convention on Climate Change (Republic of Namibia, 2002). The report was referred to on several occasions in the development of approaches to obtain, confirm and present greenhouse gas emissions data. The author (P. du Plessis) was also consulted during the preparation of this report.

Review of Greenhouse Gas Emission Factors in Namibia. The Review of Greenhouse Gas Emission Factors in Namibia, commissioned by MET and published in March 2005, provides a detailed review of the Inventory prepared for year 1994, and makes a number of recommendations about how to reduce uncertainties in future greenhouse gas inventories for Namibia. These recommendations have been followed whenever possible in the preparation of this report.

Revised 1996 Guidelines for National Greenhouse Gas Inventories: Reference Manual (Volumes 1-3). The Revised 1996 Guidelines were consulted frequently, and various default values required for the IPCC data sheets were obtained from the Reference Manual.

Namibia Energy Review for the UNFCCC (Republic of Namibia, 2007b). The report is one of several climate change-related reports that was commissioned by MET during 2007-2008 with funding assistance from UNDP. The report provided useful data regarding biomass consumption and growth.

Bush Encroachment in Namibia (2004). This report was prepared by JN de Klerk for the Ministry of Environment and Tourism and was published in 2004. The report provides important data and information regarding bush encroachment in Namibia.

Petroleum Wholesalers' Database, Managed in South Africa by Caltex. The Caltex head office in South Africa manages a database for all petroleum wholesalers in South Africa. This database includes records of all petroleum products exported to Namibia. These exports (imports to Namibia) have been recorded in a disaggregated and detailed manner, identifying the sector in which the fuel has been utilized.

3.1.2 IMPROVEMENTS AND REVISIONS OF THE 2000 INVENTORY RELATIVE TO THE 1994 INVENTORY

A number of improvements AND REVISIONS have been incorporated into the Year 2000 Inventory. Most improvements are due to the thorough review of the Year 1994 Inventory that was performed in the 2005 report, Review of Greenhouse Gas Emission Factors in Namibia, and the recommendations contained therein. Other improvements are due to the approach taken by the consulting team who prepared the Year 2000 Inventory.

The following is a summary of the improvements made in accordance with the recommendations of Review of Greenhouse Gas Emission Factors in Namibia:

- The specific gravity values for petroleum fuels provided in Appendix C of Review of Greenhouse Gas Emission Factors in Namibia were used instead of IPCC values.
- Tier 2 calculated methane emission factors were utilized for domestic livestock as provided for by the Review of Greenhouse Gas Emission Factors in Namibia.
- Satellite mapping of wild-land fire scars were utilized, together with fuel load values and emission factors provided in the Review of Greenhouse Gas Emission Factors in Namibia to determine the emissions from savanna wild-land fires (wild-land fires refer to managed and un-managed vegetation fires due to human and natural ignitions, and consuming various proportions of above ground biomass mainly in grasslands and savannas).
- Estimated greenhouse gas emissions from wastewater treatment based on available data from the 2001 Population and Housing Census (NPC, 2003) and other population/ sanitation sources, and on the nitrous oxide emission factor provided in Review of Greenhouse Gas Emission Factors in Namibia.

The following is a summary of the improvements made by the consulting team for the Year 2000 Inventory:

- The recorded amount of fuel consumed by the fishing, agricultural and mining subsectors was independently confirmed based on an approach that established a consistent correlation between the output production levels of the sub-sectors and the amount of fuel consumed.
- The amount of paint sold in Namibia was estimated, although this data could not be utilised to calculate greenhouse gas emissions because IPCC has not yet made available to non-Annex I countries excel worksheets, calculation methods or emission factors for the Solvents sector.
- Improved estimate of the amount of carbon dioxide removed from invader bush. New data were available for this Inventory which was not available for the Year 1994 Inventory. The data concerns the estimated annual increase in mass of invader bush. The data were obtained from the 2007 report, Namibia Energy Review for the UNFCCC, which sourced the data from MET-DEA.

3.1.3 SUMMARY OF INVENTORY RESULTS

Table 3.1 shows calculated greenhouse gas emissions and removals, disaggregated by major sector and compared with the 1994 inventory.

Table 3.1: Calculated greenhouse gas emissions for Year 2000 and comparison of results with Year 1994.

[1] CO_2 equivalence factors are 21 for methane and 310 for nitrous oxide

Sector	Year 2000 carbon dioxide (CO_2) emission (Gg)	Year 2000 carbon dioxide (CO_2) removal (Gg)	Year 2000 methane (CH_4) emission (Gg)	Year 2000 nitrous oxide (N_2O) emission (Gg)	Year 2000 carbon dioxide equivalent (CO_2-e) emission / removal (Gg)[1]	Year 1994 carbon dioxide equivalent (CO_2-e) emission / removal (Gg)[1]	Year 2000 nitrogen oxides (NO_2) emission (Gg)	Year 2000 carbon monoxide (CO) emission (Gg)	Year 2000 sulphur oxides (SO_2) emission (Gg)	Year 2000 non-methane volatile organic compounds (NMVOCs) emission (Gg)
Energy	2,018	0	5.7	0.2	2,200	1,905	14	171	11	26
Industrial processes	0	0	0	0	0	5	0	0	0	4
Solvents					not calculated	not calculated				
Agriculture	0	0	310.5	0.7	6,738	3,712	27	1,580	0	0
Land use change and forestry	6	-10,566	0	0	-10,560	-5,716	0	0	0	0
Waste	0	0	5.6	0.2	180	63 (incomplete calculation)	0	0	0	0
Total	2,024	-10,566	322	1	-1,442	-31	41	1,751	11	30

3.2 ENERGY

At the time of the Inventory year 2000, Namibia produced no fossil fuels of its own, nor refined / processed any fuels, thus only fuel consumption data are presented. The energy section utilises two different and independent methods for calculating emissions as specified by the IPCC process: the Reference Approach and the Source Categories Approach. The Reference Approach is the simpler method. The results of the Source Categories Approach, not the Reference Approach, are utilised in the calculation of the official total greenhouse gas emission.

The Reference Approach generally involves: 1) determining the total amounts of liquid and solid fossil fuels consumed by the economy, 2) adjusting those amounts to account for exports, international bunkers, and carbon storage when the fuels are used as raw materials, and 3) using IPCC conversion factors and emission factors to determine the amount (mass) of carbon dioxide emitted.

The Source Categories Approach generally involves determining fuel consumption according different source categories and using the IPCC conversion and emission factors to determine emissions. The following are the designated IPCC source categories: energy industries; manufacturing industries and construction; transport; other sectors (commercial/institutional sector, residential sector, and agriculture, fishing and forestry sector); and other sectors not specified.

3.2.1 REFERENCE APPROACH (TABLE 3.2)

Reference values for liquid fossil fuels, solid fossil fuels and biomass burned were first determined. In accordance with IPCC 1996 Revised Guidelines, carbon dioxide emitted from biomass combustion is reported as a memo item because it is assumed that the emitted carbon dioxide is removed during the re-growth of biomass.

Energy summary	Gg[1]	TJ	CO_2 Gg
Liquid fossil fuel inputs:			
Total use	719	31,312	
Less international use (ship and plane)	-108	-4,607	
Subtotal liquid fossil fuel internal use	611	26,705	1,494
Solid fossil fuel inputs:			
Internal use	23	581	46
Total liquid and solid fossil fuel	634	27,286	1,540
Memo item (not counted as emissions)			
Woody biomass			
National stock	179,816	3,056,872	
Firewood use	716	12,170	1,330
Poles, saw and carvings (stored C)	234	117	
Charcoal production wood	203	3,443	
Annual replacement growth	12,479	212,140	
Net change in bio-stock[2]	11,326	196,410	

Table 3.2: Summary of Namibian energy consumption and emissions.

[1] One Gigagram (Gg) is 1000 metric tons (kt); a Terrajoule (TJ) is a measure of energy content. [2] Net change – Annual Repl. Growth – firewood use – poles, saw and carvings – charcoal production

The total calculated amount of carbon dioxide emission according to the Reference Approach is 1540 Gg.

Table 3.3: Summary of liquid fossil fuel inputs. Average of 1999-2001.

Note: In UNFCCC 1.1 AVGAS added to gasoline, SGs from Review of GHG Emission Factors (Republic of Namibia, 2005b)

Liquid fuel type (l)	1999	2000	2001	Average	Specific gravity	Gg	Heat content (MJ/kg)	Energy content (TJ)
AVGAS	2,777,217	2,075,907	2,066,045	2,306,390	0.788	2	44.80	81
DIESEL	368,858,355	372,420,446	445,823,806	395,700,870	0.839	332	43.33	14,385
FURNACE OILS	19,279,648	22,113,654	17,771,318	19,721,540	0.984	19	40.19	780
ILLUMINATING PARAFFIN	13,399,794	6,558,083	6,954,173	8,970,683	0.788	7	44.75	316
JET	56,937,175	64,222,514	31,288,405	50,816,031	0.788	40	44.59	1,786
LPG	7,500,820	5,042,407	12,901,596	8,481,608	0.650	6	47.31	261
MOGAS	299,045,456	293,615,346	314,279,881	302,313,561	0.723	219	44.80	9,792
POWER KERO	48,000	87,800	512,408	216,069	0.788	0	44.75	8
ASPHALT	4,462,494	3,077,540	11,015,458	6,185,164	1.000	6	40.19	249
Above data from Caltex, Cape Town database, AJ Peens. (Note: UNFCCC assumes 95% of asphalt / bitumen remains as stored carbon								
Lubes								
Grease	237,489	299,744	280,610	272,614	1.000	0.27	40.19	11
Industrial oils	2,477,081	2,720,442	2,931,874	2,709,799	1.000	3	40.19	109
Motor oils	6,883,364	6,928,817	8,353,822	7,388,668	1.000	7	40.19	297
Total lubes	9,597,934	9,949,003	11,566,306	10,371,081		10	40.19	417
Above data from Caltex, Cape Town database, AJ Peens. (Note: UNFCCC assumes 50% of lubes remain unburnt)								
International bunkers (to offshore shipping)								
Diesel	62,138,525	29,240,705	20,109,079	37,162,770	0.839	31	43.33	1,351
Marine fuel oil	43,531,138	2,355,257	3,722,358	16,536,251	0.984	37	40.19	1,470
Sum of energy content Gg/TJ						719		31,312
Above data from Caltex, Cape Town database, AJ Peens.								

3.2.1.1 Liquid fossil fuels (Table 3.3.)

As mentioned above, all of Namibia's liquid fossil fuels are imported. Imported liquid fossil fuels have been equated to consumption. However, a 3-year average (1999, 2000, 2001) was performed to reduce the potential affect of occasional large deliveries and extended storage of fuels. The source data used is from the Petroleum Wholesalers' database which is located in Cape Town and managed by Caltex. Comparison of the Petroleum Wholesalers data with data from the Ministry of Mines and Energy (MME) shows that the data is generally comparable.

Fuels, lubricants and international bunker data are entered as above on the Petroleum Wholesalers' database; jet fuel is entered as international bunker data (not to be included in Namibia's reported emissions) as almost all such fuel is used for cross border flights. Lubricants to international bunkers were apportioned according to the ratio of bunker diesel to total consumption – approximately 10%. The volume of AvGas was added to that of gasoline (MOGAS).

IPCC default values were used throughout, with the exception of specific gravity values which were obtained from Appendix C of the Review of Greenhouse Gas Emission Factors in Namibia. The figure for carbon oxidation was reduced from .99 to .98 due to the average old age of the Namibian fleet (more than 60% older than 12 years according to NATIS data) which results in reduced combustion efficiency. ***The total emission of carbon dioxide from liquid fossil fuels as calculated by the Reference Approach is 1494 Gg.***

3.2.1.2 Solid fossil fuels (Table 3.4)

Primary coal data was obtained from TransNamib as all coal used in this period was imported from South Africa and delivered either by ground transport across Namibia's southern border or by ship to the Walvis Bay port. Major truck operators were unaware of any significant transport of coal by road in recent years. The average of imports is determined as stock levels are typically high in relation to consumption.

The main consumers of coal are NamPower for electricity generation, the Tsumeb smelter which recommenced operations in April 2000, and MeatCo's major abattoirs. The Otjiwarongo cement plant was closed in late 1998 and has subsequently been dismantled. Regarding coal consumption at the Van Eck power station, the manager confirmed that 12% of the coal entering the combustion chamber remains as un-oxidised (residual) carbon. Furthermore, at least another 5% of Van Eck's imported coal is not combusted due to fines losses during handling and uncombusted particles blowing straight up the stacks. The above losses have been taken to account and are likely under-estimated due to the old age of Van Eck.

Tsumeb smelter residual / stored carbon is small with only occasional "wind losses" during converter operation; coke or wood were not used in this period. Coal quality is poor (< 26 MJ/kg). Handling losses are similar to NamPower, for similar reasons. ***The total emission of carbon dioxide from liquid fossil fuels as calculated by the Reference Approach is 46 Gg.***

3.2.1.3 Biomass burned for energy (Tables 3.5, 3.6, 3.7)

In accordance with IPCC 1996 Revised Guidelines, carbon dioxide emission from the burning of biomass is noted as a memo item because it is assumed that the emitted carbon dioxide is removed during the re-growth of biomass. Note that absolute changes in biomass are accounted for under changes in Land Use.

Fuel wood remains a significant source of energy in Namibia and results in localized environmental degradation as its use provides informal income and "cheap" source of fuel. The data below indicates the woody stocks, usage and replacement during 2004. This data was assumed to be valid for year 2000 with no adjustments.

Table 3.4: Coal imports and power generation data. Average of 1999-2001.

Power generation inputs (plus TransNamib coal imports)	1999	2000	2001	Average	Energy input (TJ)
Fuel inputs to NamPower					
Coal (Gg)	6.2	2.9	3.6	4.2	111
MJ/kg	24.9	27.2	27.2	26.1	
LFO (Gg)	0.017	0.023	0.022	0.021	1
MJ/kg	44.0	44.0	44.0	44.0	
HFO (Gg)	0.397	0.019	0.028	0.148	6
MJ/kg	43.4	43.4	43.4	43.4	
Source: NamPower, Researcher Eli Kasai					
Rail movements of coal (Gg):					
TransNamib rail transport (both import ex SA and via W/Bay	27.4	15.9	26.1	23.2	581
Source: TransNamib, Operations Manager, Jack Dempsey / UNFCCC MJ/kg = 25.1					

Table 3.5: Woody mass availability, use and annual replacement

Woodlands:					
Source: Namibia Energy Review for the UNFCCC, 20 July 2007					
Forest woody volume (2004)	Density (m^3/ha)	Volume (million m^3)	Area (calc) (km^2)	Resource mass (Gg)	Gross energy content (TJ)
Total:		257	825,090	179,816	3,056,872
Source: Namibia Energy Review for the UNFCCC, 20 July 2007, DEA				Using 0.7 t/m^3	Using 17 MJ/kg
Harvested product: (2004)					
	Annual replacement (1000 m^3/yr)	Annual harvest (1000 m^3/yr)	Usage gap (1000 m^3/yr)	Annual addition to resource mass (Gg)	Annual addition to energy content (TJ)
Fuel wood	16294	1023	15271	10,690	181,723
Poles	2716	334	2382	1,667	28,341
Saw timber	171	0	171	120	2,038
Totals	19181	1357	17824	12,477	212,102
Source: Namibia Energy Review for the UNFCCC, 20 July 2007, DEA				Using 0.7 t/m^3	Using 17 MJ/kg
Source: Using 0.7 t/m^3 not 0.8 – (still high?) wood densities (dry) – ex FAO web site					

(TOP RIGHT)
Table 3.7: Domestic woody mass use (2004)

Growth and usage	Annual replacement (1000 m^3/yr)	Annual harvest (1000 m^3/yr)	Usage gap	Annual usage (Gg)	Gross energy content (TJ)
Fuel wood	16294	1023	15271	716	12170
Poles	2716	334	2381	234	117
Saw timber	171	0	171	0	0
Totals	19180	1357	17823	950	12287
Source: Namibia energy review for the UNFCCC, 20 July			Using 0.7 t/m^3		Using 50% C
Source: Using 0.7 t/m^3 not 0.8 – (still high?) wood densities (dry) – ex FAO web site					

(BOTTOM RIGHT)
Table 3.6: Charcoal production and related woody mass use

	1999	2000	2001	NCV (MJ/kg)	Energy content (TJ)
Charcoal produced (Gg)	45	45	45	31	1395
Woody mass harvested (Gg)	203	203	203	17	3443
Source: W. Enslin, NCAP, Grootfontein estimates as no central data, all exported (verbal)					
Wood usage @ 4.5 t/t charcoal / NCV 31 MJ/kg as UNFCCC petroleum coke					

Charcoal wood consumption, retail / exports of firewood, and industrial use are noted at the end of this section and in more detail under the sector analysis; their impact is minimal.

The charcoal data shown from the National Charcoal Producers Association (NCPA) are comparable to that reported in Appendix D of Review of Greenhouse Gas Emission Factors in Namibia (2005). No significant industrial consumers remain locally and local domestic consumption remains unknown; wholesalers indicate that much charcoal sold domestically is imported. An assumption has been made that 10% (4.5 kt) of charcoal produced in Namibia is consumed in Namibia.

Firewood exported data will be used as reported in the Review of Greenhouse Gas Emission Factors in Namibia (2005) (56 kt) based on export permit source. Local sales are unavailable due to the informal nature of the business. An assumption has been made that local consumption is approximately 10% of exports (5.6 kt).

Fuel wood is a cause for concern because the amount consumed is large and estimates of the amount consumed show high variability. The sector analysis uses an alternative approach. The data presented here under the Reference Approach is that shown in the Namibia Energy Review for the UNFCCC (Republic of Namibia, 2007b).

3.2.1.4 Methane to energy at Gammans sewage plant

The methane emission from Gammans sewage plant digesters in Windhoek is related to the mass of organic matter. The boiler and fixed engine are currently both out of action and have been sporadically for some years. These systems when operational can generate about a third to half of the plant's power needs. Operational records are missing and it is assumed that all methane is vented (< 0.5 Gg pa), i.e. not consumed as an energy source.

3.2.2 SOURCE CATEGORIES APPROACH (TABLE 3.8)

There are five general designated categories to be considered in the Source Categories Approach: Energy Industries; Manufacturing Industries and Construction; Transport; Other Sectors (commercial/institutional sector, residential sector, and agriculture, fishing and forestry sector); and Other Sectors (not elsewhere specified). The prime source of fuel data for Source Categories Approach is the main consumers (ex. NamPower). However, accurate consumer fuel consumption information was, in several cases, not available or incomplete. For those cases, other relevant data was obtained that, together with educated assumptions and estimates, would lead to fuel consumption estimates. When that alternative approach also was not feasible, the disaggregated data available in the Caltex Petroleum Wholesalers' database was utilised as a last resort. However, the accuracy of the data was then confirmed using an innovative method based on output production figures from the respective categories (excluding the fishing sub-category).

(LEFT) Table 3.8: Summary of emissions (Gg) according to the source categories approach

Category	CO_2	CH_4	N_2O	NOx	CO	NMVOCs	SO_x
Energy industries	239	0	0	0.6	0	0	3.8
Manufacturing industries and construction	99	0	0	0.3	0	0	1.1
Transport	1025	0.2	0	10.7	74.4	13.9	1.4
Other sectors (com./inst/, res., ag., fish.&for.)	558	5.5	0.1	2.6	96.3	12.0	4.6
Other sector (mining)	97	0	0	0	0	0	0
Total	2018	5.7	0.1	14.2	170.7	25.9	10.9

(BELOW) Table 3.9: NamPower fuel consumption data

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Av 99-01 (Gg)	Av 99-01 (TJ)
Coal	7.8	90.3	100.4	16.4	13.6	11.0	16.8	6.2	2.9	3.6	4.2	107
HFO				25.1	581.4	252.9	397.2	19.0	28.2	103.9	50.4	2024
LFO (Diesel)				17.4	33.8	29.6	17.2	23.5	21.7	12.5	19.2	833
Lubes								0.1	0.1	0.1	0.1	2
Total											73.9	2966
Local power (GWh)						630	1019	1216	1426	1232		4649
Source: NamPower (Kasai) and Annual Report 2006												

	Smelting / process	Beer	Meat	Cement	Other / no split	Total (Gg)	Total (TJ)
Coal	5.1	0.0	2.0	0.0		7.1	178
HFO	0.5	3.6	7.1	0.0		11.2	450
LFO (Diesel)	0.8					0.8	35
Lubes					3.3	3.3	133
Bitumen					2.7	2.7	5
Kerosene					1.8	1.8	81
LPG					3.6	3.6	170
Avgas					1.8	1.8	81
Jet					0.0	0.0	0
Gasoline (MOGAS)					7.9	7.9	354
Total:	**6.4**	**3.6**	**9.1**	**0.0**	**21.1**	**40.2**	**1486**

Table 3.10: Fuel consumption data for the manufacturing and construction category. Input in Gg.

3.2.2.1 Energy industries category (Table 3.9)

During year 2000, electricity generation fuel inputs were entirely accounted for by NamPower. Year 2000 was a time of high availability for electricity imports from South Africa; therefore relatively little fossil fuel was burnt at Van Eck compared to other years. In addition to Van Eck, fuel was fuel for electricity generation was consumed at NamPower's Paratus plant in Walvis Bay.

3.2.2.2 Manufacturing industries and construction category (Table 3.10)

The manufacturing sector's contribution to the GDP, excluding fish processing (see later section), remains under 10% with the primary outputs of beer, beef and base metal smelting unchanged. The construction sector contributes 2-3% to GDP.

Fossil fuel inputs are primarily used for manufacturing process heat, although the Tsumeb smelter does consume some carbon during processing. Tsumeb copper production restarted in April 2000 and produced 5.1 Gg of blister copper that year. No wood, charcoal or coke was used. Coal consumption is based on 1.00 Mg of coal per Mg of copper. 5.1 Gg of coal usage was therefore estimated. A basic input of 60 l/hr is required to maintain "hot" services; this equates to 0.5 Gg of residual fuel oil (source: smelter manager, verbal). Rössing Uranium produced 3.2 Gg of product and used 0.8 Gg LFO/diesel for acid plant production.

The cement plant at Otjiwarongo closed down permanently at the end of 1998. The magnitude or disposal of coal stocks that remained is uncertain.

Namibia Breweries (Windhoek and Swakopmund) used 3.6 Gg of residual fuel oil (average of 1999 to 2001 consumption). No coal was used in this period. Local beer production is not taken to account as this will be included in fuel for residential use as a split is not possible from available information. Production in 2000 was 1.0m hl (2007 will be about 1.6m hl). Beer making does involve carbon dioxide release in process but the gas is fully recycled and thus emissions are minimal (Namibia Breweries - verbal).

About 70% of animal slaughter is conducted by MeatCo at their Windhoek and Okahandja plants. MeatCo, Windhoek used 3.6 Gg of residual fuel oil and their Okahandja plant used 2.8 Gg of fossil fuels (est. coal 1.4 Gg; HFO 1.4 Gg). Interestingly, the latter plant is currently reverting to coal bias again due to oil prices. MeatCo (both abattoirs) slaughter 70% of livestock in the country. The total figure for fuel consumed in the meat industry was therefore based on a pro-rata adjustment of the available MeatCo data.

The construction industry is highly diversified and detailed information is unavailable; however it is assumed that a considerable amount of LFO/diesel is consumed, mainly on transport. Fuel for transport is covered in the transport category.

Lubricant data were obtained from the Caltex Petroleum Wholesaler's database (3.3 Gg).

3.2.2.3 Transport category

3.2.2.3.1 Tier 1 Analysis for road and rail transport (Table 3.11)

The transport category is the major consumer of liquid fuels; however, comprehensive fuel data, independent of the Caltex Petroleum Wholesaler's data, is not available. An alternative approach therefore is required to estimate fuel consumed in this category. The alternative approach is based on improved vehicle

Table 3.11: NATIS data expanded to estimated vehicle fuel usage for January 2001.
Source: NATIS (National Transport Information System)

	No of vehicles on books	Estimated km/yr per vehicle	Estimated consumption (l/100 km)	Estimate % diesel driven	Diesel used (Gg)	Gasoline used (Gg)
Motorcycle, tricycle and quadrucycle	2869	3000	6	0	0.0	0.4
Light passenger mv less than 12 persons	69334	15000	10	10	8.7	67.7
Heavy passenger mv 12 or more persons	1942	100000	15	25	6.1	15.8
Light load vehicle GVM 3500 kg or less	67254	20000	12	20	27.1	93.4
Heavy load vehicle >GVM 3500 kg, not to draw	7171	40000	12	95	27.4	1.2
Heavy load vehicle >GVM 3500 kg, equipped to draw	2963	100000	18	100	44.7	0.0
Special vehicle	4067	20000	20	100	13.6	0.0
Total	**155600**				**127.8**	**178.4**

registration data available from the National Transport Information System (NATIS) from the beginning of 2001. Using the NATIS data, a rough estimate of fuel consumption has been made based on rough estimates of typical distances covered in conjunction with estimates of fuel consumption rates per vehicle class. NATIS data indicates a large percentage of the Namibian fleet (68% of passenger and 25% of commercial) was more than 9 years old in 2006 (Republic of Namibia, 2007b). Equivalent data is not available for the period prior to 2001 but it is likely that the situation was similar. As such, fuel efficiency is likely to be compromised.

The NATIS analysis provides only a rough estimate. Some of the problems and uncertainties involved in making this estimate include: the number of vehicles registered may be significantly more than the actual number of vehicles that are used; fuel consumed by foreign owned and registered vehicles (trucks primarily) is not accounted for; fuel consumed by Namibian vehicles (such as long-distance trucks) may actually be purchased in other countries. It is impossible to determine the magnitude of the uncertainties involved with the NATIS analysis. It should be noted, however, that road transport makes up the largest part of the transport category.

Furthermore, the transport category is the largest emitter of all the source categories. As such, the road transport portion of the transport category likely accounts for the greatest source of uncertainty in the Energy Sector and possibly explains why the results of the Reference Approach and Source Categories Approach differ as much as they do. Nonetheless, the NATIS analysis represents the best estimate that could be achieved in the transport category for Source Categories Approach that is independent of the Caltex Petroleum Wholesaler's data that was utilised for the Reference Approach.

TransNamib LFO / diesel consumption for rail movements in the 2000-2001 financial year was 12.9 Gg. A complex analysis approach, such as the one required for road transport, was not required for rail transport given the availability of the TransNamib data.

3.2.2.3.2 Tier 2 Analysis for civil aviation (Tables 3.12, 3.13, 3.14, 3.15)

The Ministry of Works, Transport and Communications (MWTC) Civil Aviation has developed a real time record of all aircraft movements from controlled airports[1]; data entry is entered by the air traffic controllers as movements occur. Over-flights are recorded similarly, but on a different linked system. Reliable electronic records are available from 1 January 2005 to present time; the 139,108 records used in this analysis cover the period to 2 July 2007. Records are not available in a usable form prior 1 January 2005. It is important to note that "over fly" data is becoming available.

This data has enabled the analysis to be reduced to the 13 aircraft types listed while maintaining a high level of confidence. This was achieved by using the product of the distance traveled in Namibian airspace in nautical miles (NM) and the maximum take off weight (in kg) for each type of aircraft. Sorting these various totals indicated that the 13 aircraft types represented a very high proportion of fuel consumed (>99%); this allowed significant reduction of the approximately 270 types of aircraft represented.

Thus the number of landings (and take-offs) and the total distance traveled in Namibia for each of the 13 types allows a Tier 2 calculation to be manageable and fully representative of energy input[2].

The only aircraft using jet fuel with substantial internal flights is the B190, but as the work load (kg x NM [nautical miles]) is so small in comparison to the international jets it is assumed that all jet fuel should be included under international bunkers as a memo item. All avgas is assumed to be for internal flights as the proportion of cross border flights is small – and thus all reports to Namibian emissions. IPCC ignores piston engine inputs as insignificant worldwide, but Namibia flies a considerable number of such flights. Therefore, as Tier 2 emission factors are not available in detail for such engines, the LTO fuel usage is combined with the data shown in the 1996 IPCC Reference Manual Tables 1.47 / 1.52 where ICAO / manufacturer information is not available.

[1] The number of flights travelling between two uncontrolled airstrips is statistically very small and is ignored in this exercise

[2] Motive power efficiencies may skew this relationship marginally but are not considered significant

		2005	2006	2007	Total	LTOs 05-07	NM total
Plane type	**Fuel type**	**kgNMX10-9**	**kgNMX10-9**	**kgNMX10-9**	**kgNMX10-9**	**Number**	**Nautical miles**
A346	Jet	11,606	68,789	17,009	97,404	4,024	2,166,092
B744	Jet	41,511	38,192	9,145	88,847	4,381	2,379,504
A343	Jet	12,329	18,506	10,344	41,179	3,496	1,555,896
B732	Jet	15,265	12,842	1,754	29,860	9,119	2,068,608
C210	Avgas	3,922	6,273	2,613	12,807	55,352	5,770,802
CRJ2	Jet	4,102	3,577	881	8,560	6,845	1,753,523
B190	Jet	3,279	2,746	988	7,012	12,929	2,456,678
A332	Jet	672	1,593	552	2,816	1,038	504,298
B738	Jet	568	676	167	1,412	2,110	313,295
F406	Jet	653	520	78	1,250	6,149	1,290,093
A342	Jet	130	538	542	1,210	581	225,138
C208	Avgas	179	234	84	497	5,074	845,003
C310	Avgas	195	227	44	466	5,275	1,007,839
Totals		**96,415**	**156,719**	**46,208**	**293,323**	**116,373**	**22,336,769**
The units used are a little esoteric! (kgNMX10-9) but are directly proportional to the more familiar kgfm.							

Table 3.12: Summary analysis of take-off data to identify most significant plane types.

Note: 2007 only entails 6 months data.

Source: MWTC, Civil Aviation Directorate (derived)

The only aircraft using jet fuel with substantial internal flights is the B190, but as the work load (kg x NM [nautical miles]) is so small in comparison to the international jets it is assumed that all jet fuel should be included under international bunkers as a memo item. All avgas is assumed to be for internal flights as the proportion of cross border flights is small – and thus all reports to Namibian emissions. IPCC ignores piston engine inputs as insignificant worldwide, but Namibia flies a considerable number of such flights. Therefore, as Tier 2 emission factors are not available in detail for such engines, the LTO fuel usage is combined with the data shown in the 1996 IPCC Reference Manual Tables 1.47 / 1.52 where ICAO / manufacturer information is not available.

	Maximum take off weight – kg (MTOW)	Distance travelled in Namibia (NM)	No of landings	Product MTOW x NM flown
Year	**% of kg lifted**	**% of nautical miles**	**% of landings covered**	**% of work – kgNM**
2005	97.3	76.5	74.6	99.7
2006	97.0	77.0	72.3	99.7
2007	98.4	76.0	75.1	99.9
Source: MWTC, Civil Aviation Directorate – derived from database				

Table 3.13: Energy-related percentages attributed to the 13 most significant types of aircraft. Data shows % of total for annual database total

Table 3.14: Back-projected take off and landing count data for Year 2000.
(Note: Data for 2007 is that to end June, doubled. Data for 2000-2004 based on 2005/7 data deflated at 7%.)

Plane type	2000	2001	2002	2003	2004	2005	2006	2007
A346	690	742	798	858	923	992	1,999	2,070
B744	1,346	1,447	1,556	1,674	1,800	1,935	1,652	1,592
A343	845	908	976	1,050	1,129	1,214	1,437	1,692
B732	2,635	2,833	3,046	3,275	3,522	3,787	3,728	3,208
C210	8,767	9,427	10,137	10,899	11,720	12,602	16,574	22,210
CRJ2	2,031	2,184	2,349	2,526	2,716	2,920	2,467	2,916
B190	3,405	3,662	3,937	4,234	4,552	4,895	5,380	5,308
A332	296	319	343	368	396	426	375	474
B738	591	636	684	735	791	850	855	810
F406	1,900	2,043	2,197	2,362	2,540	2,731	2,486	1,866
A342	104	112	121	130	140	150	212	438
C208	340	366	393	423	455	489	472	478
C310	1,377	1,481	1,593	1,713	1,841	1,980	2,274	2,044
Total LTO	**24,329**	**26,160**	**28,129**	**30,246**	**32,523**	**34,971**	**39,911**	**45,106**

Table 3.15: The 13 aircraft, their engines and LTO data.
Source: ICAO engine test database.

Plane type	No of engines	Engine name	Fuel type	Fuel LTO cycle / engine (Mg)	Plane LTO cycle all engines (Mg)
A346	4	TRENT 556	Jet	0.843	3.372
B744	4	PW4062	Jet	0.887	3.548
A343	4	CFM56-5C2	Jet	0.466	1.864
B732	2	JT8D-9/15	Jet	0.433	0.866
C210	1	TS10-520-R	Avgas	0.011	0.011
CRJ2	2	GE CF34-3B1	Jet	0.164	0.328
B190	2	PT6A-67D	Jet	0.033	0.066
A332	2	CF6-80E	Jet	0.928	1.856
B738	2	CFM56-7B27	Jet	0.456	0.912
F406	2	PT6A-112	Jet	0.026	0.052
A342	4	CFM56-5C2	Jet	0.466	1.864
C208	1	PT6A-114	Avgas	0.026	0.026
C310	2	TS10-520B	Avgas	0.011	0.022

3.2.2.3.3 Summary of fuel inputs in the transport category (Table 3.16)

	Road transport	Rail	Air (domestic)	Other / no split	Total Gg	Total TJ
LFO (Diesel)	127.8	12.9			140.7	6097
Gasoline / AvGas	178.4		1.8	7.9	188.1	8427
Kerosene				*1.2*	1.2	54
LPG				*0.1*	0.1	5
Jet				*0.0*	0.0	0
Lubricants				*1.9*	1.9	38
Total:	**306.2**	**12.9**	**1.8**	**9.2**	**330.1**	**14619**
Data in *italics* sourced from Caltex database						
Jet all reports to international bunkers.					17.4	776

Table 3.16: Summary of transport sector fuel inputs. Input in Gg

	1997	1998	1999	2000	2001
Wood harvested	203	203	203	203	203
Charcoal produced	45	45	45	45	45
Conversion ratio t wood / t charcoal	4.5	4.5	4.5	4.5	4.5
Est. carbon retained in product %	60.0	60.0	60.0	60.0	60.0

Table 3.17: Charcoal production data. Data in Gg.

	Government	Retail and tourism	Charcoal	Other / no split	Total Gg	Total TJ
Wood (dm / Gg)			203.0		203.0	3451
LFO (Diesel)				*19.9*	*19.9*	862
Gasoline / AvGas				*9.9*	*9.9*	444
Furnace oils				*6.3*	*6.3*	253
Kerosene				*0.1*	*0.1*	4
LPG				*0.7*	*0.7*	33
Lubricants				*0.4*	*0.4*	9
Total:	**0.0**	**0.0**	**203.0**	**37.3**	**240.3**	**5056**
Data in *italics* sourced from Caltex database						

Table 3.18: Commercial and institutional inputs. Input in Gg.

	Residential	Total Gg	Total TJ
Wood (dm / Gg)		0.0	0
LFO (Diesel)		*0.0*	0
Gasoline / AvGas		*0.0*	0
Furnace oils		*0.0*	0
Kerosene	*1.3*	*1.3*	58
LPG	*1.1*	*1.1*	52
Lubricants		*0.0*	0
Total:	**2.4**	**2.4**	**110**
Data in *italics* sourced from Caltex database			

Table 3.19: Residential and commercial energy use. Input in Gg.

3.2.2.4 Commercial and institutional sub-category (Tables 3.17, 3.18)

The wholesale/retail and Government sectors represent about 9% and 30% of GDP respectively. Their prime fossil fuel use is for transport, stationary engines and various small boiler and incinerator purposes. The Caltex Petroleum Wholesaler's database is the only dependable source of data for this sub-category, and indicates a use of 19.9 Gg and 9.9 Gg of diesel and gasoline respectively. It is suspected (but not confirmed), however, that this fuel was used mainly for transport, which could partially explain the gap between the NATIS based transport fuel estimate and the Caltex transport fuel data. Nonetheless, this data was utilised for this sub-category, with the addition of the Caltex data for furnace oil (6.3 Gg) and LPG (0.7 Gg) which was used for institutional heating and for which no independent source data is available. Coal has been estimated as a nominal 1 Gg as it is known that various small activities burn coal, but only a minimal amount.

To retain consistency with the Greenhouse Gas Inventory for Year 1994, charcoal production is reported under this sub-category. While carbon dioxide emissions do only require reporting as a memo item, there are other greenhouse gas emissions which have been calculated under this source sub-category. The National Charcoal Producers Association (NCPA) does not keep central production figures but Mr. W. Enslin (Chairman) at Grootfontein and Mr. D. Coetzee (Manager) at Otjiwarongo both confirmed that production has been steady at 45 Gg for many years. They estimate 3.5 to 4.5 dm/t per t/charcoal, and that between 60 - 75% of the wood's carbon ends up in the charcoal, although yields vary according to feedstock. Almost all charcoal produced is exported. Estimates of local retail consumption of charcoal (and firewood) are unavailable as it is an ad hoc and localised business.

3.2.2.5 Residential sub-category (Table 3.19)

Electricity, paraffin and LPG are energy inputs into the more formal residential sector for heating, lighting and appliance use; detailed information to build up source data is not available and relatively small. It was therefore necessary to use Caltex Petroleum Wholesaler's data for Paraffin (1.1 Gg) and LPG (1.3 Gg). Note that fuel wood is included as a memo item – refer to section 3.2.2.7.

3.2.2.6 Fishing, agriculture and forestry sub-categories

3.2.2.6.1 Fishing sub-category (Table 3.20)

The fishing industry was in general reluctant to release fuel data information relating to fleet operations as it was regarded considered commercially sensitive data; contacts also indicated that data for 2000 was not readily available anyway as it is buried away in archives. Thus building up input based on independent inputs from producers for the fishing sub-sector proved impracticable due to a lack of individual producer information.

Nonetheless, an approach to performing a sectoral analysis was developed. The approach is based on historical catch data; comparing the catch data to the historical, disaggregated fuel usage reported in the Petroleum Wholesalers' database; and concluding whether or not a correlation is evident that supports the

Summary data:	1999	2000	2001	2002	2003	2004	2005
Reported catch (in Gg):							
Total fish harvest	580	590	557	625	633	567	552
Source: MFMR web site							
Fossil fuel inputs (in Gg):							
Total:	101	96	107	128	132	121	116
Source: Caltex database							
In TJ (calculated)							
Total:	4,395	4,157	4,653	5,547	5,721	5,242	5,011
Indicator ratios							
TJ energy / Gg catch	7.6	7.0	8.4	8.9	9.0	9.2	9.1
Avg 99-01 TJ / Gg catch		7.7					
Equiv litre diesel / t catch	208	194	230	244	249	254	250

Table 3.20: Fishing sub-category energy use ratios based on catch data and petroleum wholesalers' database.

disaggregated figures presented by the Wholesalers' database.

The analysis shows that there is a correlation between fuel usage and the amount of fish caught. It was also observed that the amount of fuel required per unit weight of catch is increasing over time -- a trend which was confirmed (off-record) by a fishing industry insider. It was determined that 200 litres of fuel per ton of catch was an acceptable number to utilise in the sectoral analysis. The analysis supports the fuel usage figures for the fishing sub-sector presented in the Petroleum Wholesalers' database.

3.2.2.6.2 Agriculture sub-category (Table 3.21)

Agricultural fuel use, as recorded in the agriculture sub-category, is equally obscure. Therefore a similar analysis approach as that used for the fishing sub-category was used for the agriculture sub-category. It is reasonable to assume that the area planted is approximately proportional to agricultural fuel use.

The area planted for controlled crops (maize / wheat) is well documented in the Namibian Agronomic Annual Report; note the data for the period under review used is for the financial year 1999 / 2000. While marketed output of dry land farming is unpredictable due to rain and pricing variability, relating the disaggregated data for Farmers and Agricultural Crop from the Petroleum Wholesalers' database to the planted area indicates that there is a reasonable correlation between fuel usage and planted area, which is approximately 0.1TJ / ha planted. In the end, the analysis supports the fuel usage figures for the agricultural sub-sector presented in the Petroleum Wholesalers' database.

3.2.2.6.3 Forestry sub-category

Energy use in the forestry sub-category is assumed to be totally transport orientated. However, unlike the fishing and agricultural sub-sectors, the amount of fuel consumed for forestry is very small and can thus be ignored.

3.2.2.6.4 Available fuel data for agriculture, forestry and fishing sub-categories (Table 3.22)

The following disaggregated fuel data was available from the Petroleum Wholesalers' database. This data is also incorporated within the general figures presented in the Reference Approach.

Table 3.21: Agricultural sub-category energy use ratios based on planted area and petroleum wholesalers' database.

Summary data:	1999	2000	2001	2002	2003	2004	2005
Grain production data:							
Total area planted (ha)	15,838	10,247	8,869	12,258	14,971	15,543	15,361
Total yield of maize / wheat (Gg)	15	41	30	34	37	67	53
Total raw value marketed (NM$)	9	24	24	29	28	47	42
Source: Namibian Agronomic Board Annual Report 2005/6							
Fossil fuel inputs:							
Liquid fossil fuels (mass) (Gg)	34	35	33	36	33	33	28
Liquid fossil fuels (energy) (TJ)	1,493	1,513	1,440	1,553	1,422	1,431	1,224
Source: Caltex database – Farmers and Agricultural Coop disaggregation							
Indicator ratios:							
TJ / ha planted	0.09	0.15	0.16	0.13	0.09	0.09	0.08
N$ value marketed output / TJ	6,273	15,895	16,365	18,875	19,447	32,947	34,214
TJ / Gg marketed	100	37	49	46	39	21	23
Avg 99-01 TJ / ha planted		0.135					

	Fishing	Agriculture	Forestry	Other / no split	Total Gg	Total TJ
Kerosene	0.0	0.8	0	0	0.8	36
LFO (Diesel)	95.5	31.0	0	0	126.4	5479
Gasoline / AvGas	0.2	3.2	0	0	3.3	149
Furnace oils	5.3	0.0	0	0	5.3	211
LPG	0.0	0.0	0	0	0.0	1
Lubricants	1.7	1.3	0	0	3.0	61
Total:	**102.6**	**35.5**	**0**	**0**	**138.1**	**5936**
Data sourced from Petroleum Wholesalers' database, as managed by Caltex						

Table 3.22: Disaggregated fuel data for the Agriculture, Forestry and Fishing sub-categories as available in the petroleum wholesalers' database. Input in Gg.

3.2.2.7 Fuel wood consumption in the other sectors source category for commercial, institutional, residential, fishing, forestry, and agriculture (Table 3.23)

Fuel wood, despite being a memo item, is a cause for concern both as it is a large number and the various sources show high variability. Thus an alternative approach was sought. The comparison between Botswana and Namibia below is based on independent figures for broadly comparable situations and adjusted appropriately. This data has been backtracked to 2000 based on population. The outcome indicates that the data shown in the Namibia Energy Review For The UNFCCC (Republic of Namibia, 2007b) may overall be on the low side but, for urban and domestic use, is remarkably similar; a positive outcome as informal activity is difficult (and expensive) to measure and thus there is a tendency to underestimate. It is also similar to the "high" figure (635 Gg) reported in Appendix D of the Review of Greenhouse Gas Emission Factors in Namibia (Republic of Namibia, 2005b).

Institutional (schools mainly) use data is unavailable and has been roughly estimated as 100 Gg based on biomass figures below and the increased access to electricity in rural schools.

Rural industries (beer and bread) are used as below.

Thus total estimated fuel wood consumption was 808 Gg.

Poles are used for traditional dwellings and kraals; they are reported as stored carbon. The 2001 Population and Housing Census (NPC, 2003) indicates that there are 143,810 such dwellings in Namibia; 4718 and 139,092 in urban and rural areas respectively. The 1998 estimate of 694 Gg of poles in storage, as reported in Appendix D of the 2005 Review of Emission Factors in Namibia, combines with an annual harvest of poles of 2.38 Gg per year, as reported in the 2007 Namibia Energy Review would indicate an approximate stock of 698 Gg in 2000. This figure is used. Crafts and roots are small contributors, assumed to be exported, and have been ignored.

3.2.2.8 Mining source sub-category (Tables 3.24, 3.25)

Mining is essentially a materials handling exercise with liquid fossil fuels being used for materials transport and electricity being the prime processing energy input. Note that smelting and value added processes are covered under the Industrial sector – where coal and liquid fuels are used additionally. As there are multiple producers with numerous different products, it was decided that an approach similar to that used for the fishing and agricultural sub-categories should be adopted. The approach taken for the mining sub-category involved confirming whether there is a correlation between material moved and the disaggregated fuel use reported in the Petroleum Wholesalers' database. Mining data was derived from the Namibian Chamber of Mines Report.

Table 3.23: Fuel wood estimate based on Botswana / Namibia comparison. Fuelwood usage patterns (1991)

	BOTSWANA				NAMIBIA		
	1991 (%)	**(No.)**	**Household consumption (t/yr)**	**Total consumption (Gg)**	**2000 (No.)**	**Household consumption (t/yr)**	**Total consumption estimate (Gg)**
Rural households	50.9	201789	1.9	375.3	209546	1.9	398
Urban households	18.9	63269	2.2	139.2	136909	2.2	301
Rural industries	1.2			8.8			9
Institutions	29			213.6			100
Total	100			736.9			808
Comparative information:							
	BOTSWANA	**NAMIBIA**					
Populations 1991 census	1335845	1409920					
Surface area	582000	824000	Similar rainfall patterns and vegetation				
Source: Biomass Energy Policy. Selected case studies. Papers 2,3 relating to Botswana –ISBN Pb 1-85649-520-5, Kgathi, Mlotshwa, Sekhwela							
Namibia household data from 2001 Population and Housing Survey.							

Once the different mining processes were categorised into diamonds, concentrate production, and industrial chemicals, the analysis yielded manageable and practical correlations with sufficient consistency to suggest that the disaggregated data in the Petroleum Wholesalers' database is reliable. Thus the disaggregated data for the mining sub-category is regarded as fit for input into the IPCC data sheets without change, apart from using a 3-year average for the period 1999 to 2001.

3.2.3 COMPARISON OF THE RESULTS OF THE REFERENCE APPROACH TO THE RESULTS OF THE SOURCE CATEGORIES APPROACH

As Table 3.26 indicates, the calculated total emissions of carbon dioxide based on the Reference Approach and on the Source Categories Approach differ significantly.

Table 3.26: Reference Approach vs Source Categories Approach

Approach	Total calculated CO_2 emission (Gg)
Reference Approach	1540
Source Categories Approach	2018

The data utilised for both approaches has been reviewed in detail. It has been concluded that there is no other source of available data that could be obtained, and no change to the calculation methods followed and developed that could be reasonably justified, to reduce the difference in results between the two approaches. It has also been concluded, however, that the greatest potential source of uncertainty/difference most likely lies in the Source Categories Approach (in particular the road transport section of the transport category) since it includes a greater number of assumptions and estimates than does the Reference Approach, which is based on a limited number of data sources that are generally regarded as dependable. This is not to say that there are no uncertainties associated with the comprehensiveness and accuracy of the data utilised in the Reference Approach; only that there appears to be greater potential for error in the Source Categories Approach.

The following are a few possible explanations that together could help explain the difference in results between the two approaches:

1) It is likely that there were imports of liquid fuels to Namibia from neighbouring countries which were performed unofficially and not recorded in the Caltex Wholesaler's database. This source of uncertainty has greater relevance for the Reference Approach.

Table 3.24: Correlation of materials handled with fossil fuel consumption

	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total product, diamonds ('1000 carats)	1,418	1,440	1,712	1,552	1,410	2,825	2, 936	3,866	3,720
Total product, concentrates (Gg)	275	157	92	126	201	172	236	217	158
Total product, chemicals (Gg)	531	533	528	682	731	776	835	907	782
Material moved ratio (carats) (t/carat)	20	20	20	20	20	20	20	20	20
Material moved ratio (carats) (t/t concs)	8	8	8	8	8	8	8	8	8
Material moved ratio (carats) (t/t chemical)	2	2	2	2	2	2	2	2	2
Total material moved (total) (Gg)	31,626	31,115	36,030	33,423	31,262	59,440	62,303	80,865	77,231
Total mining fossil fuel input (Gg)	26	25	17	31	55	58	49	53	62
Total mining fossil fuel input (TJ)	1,108	1,093	758	1,327	2,386	2,510	2,107	2,289	2,680
Energy / material moved	0.035	0.035	0.021	0.040	0.076	0.042	0.034	0.026	0.035
Energy / material moved (kWh/t)	10	10	6	11	21	12	9	8	10

Table 3.25: Disaggregated fuel data for the mining sub-category as available in the Petroleum Wholesalers' database. Input in Gg.

	Mining	Total (Gg)	Total (TJ)
Wood (dm / Gg)	0.0	0.0	0
LFO (Diesel)	24.2	24.2	1048
Gasoline / AvGas	2.2	2.2	99
Furnace oils	1.1	1.1	45
Kerosene	2.3	2.3	101
LPG	0.0	0.0	1
Bitumen	2.8	2.8	6
Lubricants	1.7	1.7	35
Total:	**34.3**	**34.3**	**1334**
Data sourced from Petroleum Wholesalers' database, as managed by Caltex			

2) The number of vehicles registered by NATIS is probably greater than the actual number of vehicles that are active in Namibia. There is no assumption that can be reasonably justified, however, that would ensure a more accurate estimate of the number of active vehicles in Namibia. The other assumptions and rough estimates made in the NATIS analysis are also subject to significant uncertainty. Nonetheless the innovative NATIS analysis that was developed for this inventory should be retained since it allows the liquid fuels used for transport sector (highly significant) to be quantified independently of the Caltex Wholesaler's database, upon which the Reference Approach is based. It is recommended that the NATIS analysis be further investigated for possible improvements that could be made in future inventories.

3) The amount of fuel obtained by Namibian vehicles (in particular international commercial trucks) in other countries is not recorded anywhere and would be very difficult to estimate reasonably.

3.3 INDUSTRIAL PROCESSES

The Industrial Processes category covers those industrial processes that transform materials, chemically or physically. It does not include inputs for process heat, as this is shown under the Energy Sector section. The IPCC broadly classifies this sector into seven industrial processes, of which three are most relevant to Namibia: Mineral Products (for road paving with asphalt); Metal Production (for copper smelting); and Other Production (for food and drink production).

Namibia's industrial sector remains small and little changed over the years; its total GDP contribution remains just over 10% with on-shore fish and meat processing representing 0.7% and 1.6% of this total. Beer and cool-drink production make up the majority of the balance.

Cement production at Otjiwarongo ceased in 1998.

The Tsumeb smelting facility was re-commissioned in mid-2000 under new ownership – their production of 5.8 Gg blister copper would have resulted in the release of approximately 6 Gg sulphur (30%Cu in concentrate, 30%S in concentrate).

Fish meal production is fairly constant over the years at about 18 Gg / annum – using approximately 3 Gg of fuel oil / annum – all as process heat (Etosha and United fishing companies only).

Vegetable oil products – very small and negligible.

Grains (wheat and maize data only) are consumed either as bread (wheat based) or as mealie porridge (mainly maize). Using wheat data available from the Namibian Agronomic Board, the data in Table 3.27 is used for input (80% of milled grain reports as flour – source: Bokomo).

Beer production in year 2000 was 1 million hl (about 1.6 million hl in 2006). All carbon dioxide is captured and recycled. Locally produced brew is assumed to also be 1 million hl.

Road paving: the stored mass of bitumen from the Energy Sector section is used as input for NMVOC calculation.

Table 3.27: Flour and bread production

	1998/9	1990/2000	2000/1
Marketed production (t)	2,896	3,429	6,119
Wheat imports (t)	61,392	47,485	49,317
Flour ex imports / production (t)	51,430	40,731	44,349
Wheaten flour imports (t)	6,569	5,906	5,563
Wheaten flour exports (t)	8,839	4,664	5,230
Total flour consumed locally (t)	38,874	33,827	35,812
Flour kg / kg bread	0.61	0.61	0.61
Bread output (Gg)	63.6	55.4	58.6

3.4 SOLVENTS AND OTHER PRODUCT USE

Solvents and related compounds are a significant source of emissions of non-methane volatile organic compounds (NMVOCs) (IPCC, 1997). The Solvents and Other Product Use category includes chemical cleaning substances used in dry cleaning, printing, metal degreasing, and a variety of industrial applications as well as household use. Also included in this category are paints, lacquers, thinners and related materials used in coatings in a variety of industrial, commercial and household applications. Greenhouse gas emissions for the Solvents and Other Product Use category could not be calculated because the calculation instructions and excel worksheets that were available for the other categories were not available for this category. Nonetheless, the items under this category were investigated and rough estimated data for paint were obtained.

Paint: it is estimated that 6,000,000 litres/annum (about 6 Gg/annum) of paint is sold in Namibia. With only 3 major manufacturers, it is understandable that the product breakdown and the imported component are commercially sensitive. However, it was suggested by a supplier that the cheaper varieties are made locally and probably represent 60% of the volume sold.

Autobody finishing is an unknown quantity.

Industrial cleansing is an unknown quantity.

Nitrous oxide emissions from medical waste are unknown, but could be investigated in future inventories.

Note that data for paint imports and cleaning solvents may become available from 2006 as the Customs and Excise ASYCUDA system becomes available for analysis.

3.5 AGRICULTURE

The Revised 1996 IPCC Guidelines indicate that agricultural greenhouse gas emission sources to be considered for the 2000 Inventory are unchanged from the 1994 Inventory. Methane remains the most significant emission, and as Namibia cultivates only a miniscule amount of rice in flooded fields, the areas of significance remain:

- Domestic livestock: Enteric fermentation and manure management
- Burning of savannas

- Field burning of agricultural residues
- Agricultural soils

The nature of Namibian agriculture in year 2000 changed little since the 1994 Inventory report - extensive ranching and dry-land cropping with differing methods and productivity between the commercial and subsistence growers. One small feedlot for cattle is in operation. Dairy operations supplied about half the nation's needs: all fresh milk was produced locally while all ultra high temperature (UHT) products were imported (UHT locally produced from 2007).

3.5.1 DOMESTIC LIVESTOCK (TABLES 3.28, 3.29, 3.30)

Records of domestic livestock are well maintained by the Meat Board. The numbers of livestock are steadily rising apart from ostrich where profitability has decreased from 2003 onwards. Methane emissions are significant especially when the environmental impact of methane is 21 times that of carbon dioxide. The emission factors for enteric digestion, the bodyweights, and the food and protein consumption input were obtained from the Review of Greenhouse Gas Emission Factors in Namibia, calculated according to the Tier 2 method (IPCC 1997 – Table 5) requirements, and are summarised below.

The emissions of the dairy herd of 2190 head (year 2000) makes minimal impact, and as 90% of milk production comes from Namibian Dairies whose average yield is 25 litres/head/day, the Western European emission factor of 100 was used (Review of Greenhouse Gas Emission Factors in Namibia recommends a figure of 77.9 for beef cattle). Other dairy farmers have lower yields, but as their output is so low their different circumstances and thus emissions are ignored.

The discussion of the anthropogenic decline in game numbers over the past 150 years, and thus the "saving" of methane emissions remains in question, and thus game emissions (ex. game farms) have not been taken into account. Note that although game count data is not available for year 2000, the rapid expansion of both communal and commercial conservancies with their reporting requirements will result in numbers becoming available.

It is important to note that the 2005 Review of Greenhouse Gas Emission Factors in Namibia concluded that emissions from manure are negligible in Namibia and indicated that the calculations for such emissions could be eliminated from the 2000 Inventory, even though those worksheets were completed in the 1994 Inventory. Emissions from manure were therefore not calculated in this inventory.

3.5.2 WILD-LAND FIRES (MAINLY SAVANNAS) (TABLE 3.31, 3.32, 3.33)

Satellite mapping of fire scars has improved analysis of wild-land fires, although the data for year 2000 are incomplete. Use of 2001 – 2003 data iterated by use of the available Kavango / Caprivi data enabled a reasonable estimate of the burn area for year 2000.

The tables below show data from two different sources for comparison purposes. The first is based upon Table 8 of the Review of Greenhouse Gas Emission Factors in Namibia which was based on MODIS analysis, the Mendelsohn vegetation categorisation, and gave a practical indication of fuel loading and consumption. This report simplified the 29 "Mendelsohn zones" to the 14 Giess zones. While this is based upon "overlap" estimates which result in some area discrepancies, it is fortunate that the discrepancies occur in areas that suffer little or no wild-land fire impacts. The data available were for the year 2003. Small, insignificant discrepancies were identified in some of the data obtained.

The comparative data was obtained from maps published by the National Remote Sensing Centre for years 2001 through 2003 (LandSat). Tabulated data was included in these maps indicating burn by region (year 2003 only indicated a total).

Table 3.28: Livestock inventory, Namibia totals

	1996	1997	1998	1999	2000	2001	2002	2003
Cattle	1,989,947	2,055,416	2,192,359	2,278,569	2,504,948	2,508,570	2,329,553	2,336,094
Sheep	2,198,436	2,429,328	2,086,434	2,160,651	2,446,146	2,369,809	2,764,253	2,955,454
Goats	1,786,150	1,821,009	1,710,190	1,689,770	1,849,569	1,769,055	2,110,092	2,086,812
Camels	49	38	50	40	N/A	N/A	88	124
Horses	56,988	57,099	53,325	49,777	61,885	52,502	47,305	119,828
Donkeys	169,678	166,296	162,973	164,496	167,548	169,314	134,305	119,828
Pigs	18,923	16,884	14,706	18,731	23,148	21,854	47,805	46,932
Poultry	458.158	522,618	403,937	450,513	476,331	502,356	883,950	894,027
Ostriches	38,891	46,725	52,393	33,116	47,823	59,309	62,976	18,930
Source: MeatCo data sheets								

Table 3.29: Major livestock distribution – commercial / communal

	1996	1997	1998	1999	2000	2001	2002	2003
Distribution:								
Cattle % in communal areas	62.7	61.5	62.4	63.6	66.2	63.6	63.0	59.4
Sheep % in communal areas	14.5	13.0	17.2	13.6	14.7	11.2	9.6	9.6
Goats (%) in communal areas	69.5	70.0	71.9	72.7	73.4	66.2	69.0	71.5
Slaughter data:								
% offtake from NCA						1.2	2.2	1.7

	Mean body mass (kg)	Namibian herd size	Protein in diet (%)	Emission factor (g CH_4 / yr / head)	Total emission (Gg CH_4 / yr)
Dairy cattle	400	3,190	12	100,000	0
Cattle	330	2,504,948	9	77,931	195
Sheep	60	2,446,146	9	12,990	32
Goats	60	1,849,569	9	8,713	16
Horses/donkeys	350	229,433	4	30,244	7
Pigs	130	23,148	13	3,417	0
Total					250.4

Table 3.30: Methane emissions for 2000

Region	Area (km^2)	% firescar												
		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Caprivi	31,532	37	35	23	35	22	28	35	31	23	16	20	29	24
Kavango	46,718	26	36	38	40	31	47	21	26	23	32	26	50	22

Table 3.31: Fireburn data for Caprivi / Kavango 1989-2001. *Source: Verlinden NPC / Le Roux MET*

Region	Area of region (km^2)	Fireburn 2001 (km^2)	Fireburn 2002 (km^2)	Fireburn 2003 (km^2)
Caprivi	14,528	9.556	7,147	
Erongo	63,579	957	0	
Hardap	109,651	440	0	
Karas	161,215	0	0	
Kavango	48,463	8,681	21,000	
Khomas	37,007	2,370	142	
Kunene	115,293	6,367	39	
Ohangwena	10,703	0	77	
Omaheke	84,612	5,294	2,390	
Omusati	26,573	3,556	395	
Oshana	8,653	601	0	
Oshikoto	38,653	1,470	113	
Otjozondjupa	105,185	9,494	5,145	
Totals	**824,115**	**48,786**	**36,448**	**31,369**
Data from NPC database – regional area data, population				

Table 3.32: Fireburn data for Year 2001-2003 . *Source: NRSC maps 2001 through 2003 (2003, no disaggregation)*

Giess code	Giess vegetation category	Area (sq km)	Burn area (sq km)	% burn area of total	Fuel consumed
1	North Namib	20,893	0	0	0
2	Saline desert with dwarf savanna	9,956	199	2	68
3	Forest savanna & woodlands	161,550	29,706	18	16,850
4	Camel thorn savanna	60,945	390	1	146
5	Mixed tree & shrub savanna	68,361	0	0	0
6	Central Namib	32,096	5	0	0
7	Southern Namib	47,304	2	0	0
8	Desert succulent and steppe	20,265	2	0	1
9	Semi desert & savanna transition	78,804	521	1	159
10	Mopanie	112,748	3,172	3	1,406
11	Mountain savanna & Karstveld	14,366	274	2	214
12	Thorn bush savanna	42,495	17	0	10
13	Highland savanna	23,801	126	1	55
14	Dwarf shrub savanna	131,995	47	0	7
	Totals	**825,579**	**34,460**	**4**	**18,916**

Table 3.33: Fireburn data for Year 2003. *Source: Review of Greenhouse Gas Emission Factors in Namibia*

Table 3.33 indicates the extent of wild-land fires over a 13 year period for the Kavango / Caprivi regions, where wild-land fire is most significant in Namibia, and is thus used to provide a proxy for the fire regime in other regions. It is evident that year 2000 was a year of above-average incidence of wild-land fires, perhaps as a result of late rains and a high fuel load. Overall, indications are that 30,000 to 50,000 km^2 are burned annually in wild-land fires, which equates to about 3.5% to 6.0% of Namibia's total land area. The estimate of 3.5-6.0% is relatively low compared to the Mendelsohn estimate of 6-13% in the Review of Greenhouse Gas Emission Factors in Namibia.

As wild-land fire fuel consumption depends on many variables – humidity, rainfall, wind, temperature, last burn, fuel load and numerous other degrees of freedom -- the accuracy of emission calculations remains uncertain. Data collection on wild-land fires has waned, and data after year 2003 appears to be lacking. The lack of tabulated data for management purposes is of considerable concern.

With respect to whether wild-land fire regimes are anthropogenic or not, almost all those consulted in the course of data collection were of the opinion that fires in communal areas are ignited by people, are generally un-managed and are allowed to burn without intervention. Wild-land fires are described by the Directorate of Forestry (on their maps) as follows:

"Fires in Namibia are a mixture of uncontrolled fires, controlled fires, prescribed fires and naturally occurring fires. Naturally occurring fires happen in the late dry season and are a result of lightning. Prescribed fires occur in April - May, while the other man-made fires mainly occur between July and October. The majority of fires are still uncontrolled and started by people".

Fires in commercial areas appear to be controlled or extinguished for economic reasons. Thus, as a matter of policy, wild-land fire is considered as anthropogenic but the carbon dioxide emitted is not counted towards recorded national emissions as it is assumed that vegetation re-growth compensates the emissions (carbon-neutral).

It is also pertinent to note the Verlinden (NPC, Lux Cooperation) has firescar figures of 48,570 and 52,453 km^2 for years 2001 and 2002 respectively, from his work based on LandSat images.

The figure used for biomass consumed in wild-land fires in year 2000 is 24,000 Gg (25% above 2003), as 2000 was a high fire year. As recommended in Review of Greenhouse Gas Emission Factors in Namibia, emissions from manure and the burning of agricultural residue are entered as zero.

3.6 LAND USE CHANGE AND FORESTRY (Table 3.34)

Vegetation growth captures carbon dioxide and increases the rate of transpiration; vegetation clearing has the reverse effect. The following general types of anthropogenic impacts on land-use and forestry are considered:

- Deforestation, primarily in northern areas but also around expanding urban areas
- Clearance for commercial agricultural purposes
- Bush encroachment resulting to a large extent from commercial ranching practices subsequent to colonisation in the early 1900's.

In terms of the IPCC worksheets, the Land Use Change and Forestry sector is comprised of the following sub-sectors:

- Changes in Forest and Other Woody Biomass
- Forest and Grassland Conversion – CO_2 from Biomass
- Non-CO_2 Trace Gases Released by On-site Burning of Biomass
- Abandonment of Managed Lands, Soil Carbon, Organic Soils and Liming

As indicated in the IPCC data sheets, the impact of bush encroachment is highly significant for Namibia's greenhouse gas emissions profile; the bush encroached area serves as a huge, anthropogenic CO_2 sink. New information regarding the extent and nature of bush encroachment was published subsequent to the preparation of the 1994 Inventory, and can now be utilised for this 2000 Inventory. The most notable contribution to the study of bush encroachment is a report by JN de Klerk which was published in 2004 and entitled Bush Encroachment in Namibia. The report highlights earlier work performed by Bessie Bester which indicates that bush encroachment occurs over an area of approximately 26 million hectares; this is significantly larger than the estimated 10 million hectares upon which calculations in the 1994 Inventory were based. The issue of woody mass growth is discussed at length in the Review of Greenhouse Gas Emission Factors in Namibia, which emphasises the need for extensive field studies to be performed.

While new field studies have yet to be performed, an estimate of the average growth rate of invader bush was calculated in the 2000 Inventory using data presented in Namibia Energy Review for the UNFCCC (Republic of Namibia, 2007b) which was sourced from MET-DEA. The Namibia Energy Review report provides data on the growth of woody biomass for each region during year 2004. After reviewing the regions where bush encroachment is most predominant, data

Table 3.34: Total woody mass and woody biomass growth in Namibia by region.
Source: Namibia Energy Review for the UNFCCC (Republic of Namibia, 2007b)

Summary of Namibia's woody stock data:							
Land category	Area (km^2)						
Desert	131000						
Savanna	532000						
Woodlands	161000						
Total:	824000						
Forest woody volume (2004) and growth estimate for bush encroached area							
Region	Density (m^3/ha)	Volume (million m3)	Area (calc) (km^2)	Resource mass (Tg)	Contained C (Tg)	Growth / yr (million m^3)	Growth / yr (Tg)
Caprivi	21.37	30.92	14467	21.64	10.82		1.62
Erongo	0.10	0.64	63590	0.45	0.22		0.03
Hardap	0.10	1.10	109660	0.77	0.38		0.06
Karas	0.05	0.81	161080	0.56	0.28		0.04
Kavango	18.00	87.27	48483	61.09	30.54		4.56
Khomas	0.25	0.92	36860	0.65	0.32		0.05
Kunene	0.20	2.30	115155	1.61	0.81		0.12
Ohangwena	20.00	21.39	10694	14.97	7.49		1.12
Omaheke	2.00	16.89	84440	11.82	5.91		0.88
Omusati	3.22	8.54	26517	5.98	2.99		0.45
Oshana	0.90	0.78	8682	0.55	0.27		0.04
Oshikoto	11.44	44.24	38669	30.97	15.48		2.31
Otjozondjupa	3.90	41.08	105334	28.76	14.38		2.15
Total:	3.12	256.86	823631	179.80	89.90	19.18	13.4
				Using 0.7t/m^3	Using 50% C	Ex report total	Using 0.7t/m^3
Harvested product (2004)							
	Annual replacement (mill m^3/yr)	Annual harvest (mill m^3/yr)	Usage gap (mill m^3/yr)	Annual addition to resource mass (Tg)	Annual addition to C sink (Tg)		
Fuel wood	16.29	1.02	15.27	10.69	5.34		
Poles	2.72	0.3344	2.38	1.67	0.83		
Saw timber	0.1713	0	0.1713	0.12	0.06		
Totals:	19.18	1.36	17.82	12.48	6.24		
Using 0.7 t/m^3 not 0.8 t/m^3 – wood densities (dry) – from FAO web site							

from four regions (Omusati, Oshikoto, Otjozondjupa and Omaheke) was utilised to calculate an estimate of the average growth rate for woody biomass in the bush encroachment area. Data provided in Namibia Energy Review for the UNFCCC is summarised in Table 3.34.

In addition to providing data related to bush encroachment, the Namibia Energy Review for the UNFCCC provides useful data regarding traditional fuel wood and wood poles which was back adjusted to year 2000 and input into the IPCC data sheets. Data regarding charcoal production was obtained from the National Charcoal Producers Association and input into the IPCC data sheets.

Data regarding the total area/annum of conversion of forested land were obtained from the 1994 Inventory, which was still valid during year 2000. Other data required for the IPCC data sheets, such as estimated amount of biomass/ha, was obtained from the Namibia Energy Review for the UNFCCC. On- and off-site burning of woody biomass from cleared forested areas was assumed to be negligible. Note the low density of woody biomass (2 tons/ha) that was recently estimated for such areas in Namibia Energy Review for the UNFCCC. Both the amount of non-CO_2 trace gases released by on-site burning of biomass and carbon dioxide emissions resulting from abandonment of managed lands, soil carbon, organic soils and liming were estimated to be negligible.

3.7 WASTE (TABLES 3.35, 3.36, 3.37, 3.38)

The most important greenhouse gas produced in the Waste category is methane. The Waste category considers three main types of waste: 1) solid wastes disposed of through landfilling, recycling, incineration, or waste-to-energy; 2) treatment of liquid wastes, and; 3) waste incineration.

As societies develop their industry and economy so does their production of waste materials; the major products to be handled are 1) waste water (industrial and domestic) and 2) solid waste of variable nature, some with the potential to be recycled economically. Both may include materials that may constitute a health hazard (toxic or biological). Namibia, as a low / medium income country with a considerably poor rural society, a growing wealthy urban middle class, and significant urban drift (6% to towns from 1991 to 2001), is beginning to feel the pressure on its disposal facilities throughout the country.

Reliable flow and COD (Chemical Oxygen Demand) data are not available for the majority of Namibia's waste water effluent plants; however, the Windhoek Gammans / Otjimuise operations, which handle the majority of Windhoek's sewage do have good data. The plants handle approximately 27,000 m^3 of waste water per day (10 million m^3 per year). This represents approximately 75% of the NamWater input, and is equivalent to 42 m^3 per person per year. Plant managers also indicate that COD recovery is approximately 95% for Gammans / Otjimuise and 87% for the Ujams pond system (which treats mainly industrial waste). Furthermore, the Gammans / Otjimuise operations recover more than 95% of the TKN (Total Kjeldal Nitrogen).

The IPCC data sheets utilise the above data for the Windhoek population, and IPCC default values and the recommendations of the Review of Greenhouse Gas Emission Factors for the remainder of the urban areas.

Information regarding the percentage make-up of typical contents in solid waste and the typical amounts\ per capita was difficult to identify. However, some data on the content of waste based on a 2004 study is shown on the following page. The contractor for the Kupferberg landfill site (Windhoek) provided recent, but very limited data; this would indicate that about 40Gg of waste is produced per annum in Windhoek (present rates). Discounting this back (-5% per annum) to 2000 and using the Windhoek population at that time indicates that a town dweller would dispose on average 0.35 kg of solid waste per day. When compared with an estimate of the average per capita solid waste disposal in the USA of 0.85 kg/day (Source: Mexico Emissions Inventory Program Manuals, Volume V - Area Source Inventory Development, Final, March 31, 1997), the value for Windhoek would appear reasonable. 0.35 kg/day was therefore used.

It should be noted that refuse is regularly burned at dumps located throughout Namibia as a way to reduce volumes. However, not all towns follow this practice, so it would not be practical to estimate the amount of refuse burned annually in Namibia.

Table 3.35: Sewage treatment types and urban populations. (Note: data from 2001 Population and Housing Census – Table 1.2.3)

Region	Town	Sewage type(s)	Population 2000
Caprivi	Katima Mulilo	Ponds	22,134
Erongo	Walvis Bay	Activated sludge plant	43,611
Erongo	Swakopmund	Activated sludge plant	23,808
Erongo	Omaruru	Ponds	4761
Erongo	Arandis	Ponds	3974
Erongo	Karibib	Ponds	3726
Erongo	Henties Bay	Ponds	3285
Erongo	Usakos	Ponds	2926
Hardap	Rehoboth	Ponds	21,308
Hardap	Mariental	Ponds	9836
Karas	Keetmanshoop	Ponds	15,778
Karas	Lüderitz	Ponds	13,295
Karas	Oranjemund	Ponds	4451
Karas	Karasburg	Ponds	4075
Kavango	Rundu	Ponds	36,964
Khomas	Windhoek	Anaerobic digesters, activated sludge and bio-filters, industrial waste ponds	233,529
Kunene	Outjo	Ponds	6013
Kunene	Khorixas	Ponds	5890
Kunene	Opuwo	Ponds	5101
Ohangwena	Eenhana	Ponds	2814
Omaheke	Gobabis	Ponds	13,856
Omusati	Outapi	Ponds	2640
Oshana	Oshakati	Ponds	28,255
Oshana	Ondangwa	Ponds	10,900
Oshana	Ongwediva	Ponds	10,742
Oshikoto	Tsumeb	Biofiltration plant	14,929
Otjozondjupa	Otjiwarongo	Ponds	19,614
Otjozondjupa	Grootfontein	Ponds	14,249
Otjozondjupa	Okahandja	Ponds, activated sludge plant	14,039
Otjozondjupa	Otavi	Ponds	3813
Otjozondjupa	Okakarara	Ponds	3296
Total:			**606,612**

Region	Water (m^3)	Water (m^3/head)	Toilet, flush (% of households)	Toilet, bush (% of households)	Garbage collected (% of households)	Number of households	Population	Numbers living in main urban areas	% living in main urban areas
Caprivi	2,622,191	33	13.3	83.4	31.5	16839	78785	22134	28.1
Erongo	8,742,045	85	80.3	11.5	87.7	27496	103180	86091	83.4
Hardap	3,160,883	48	49.6	34.0	58.3	15039	66028	31144	47.2
Karas	3,707,581	58	57.8	26.0	76.8	15481	64039	37599	58.7
Kavango	3,331,759	17	7.3	81.3	30.6	30467	198963	36964	18.6
Khomas	13,130,931	54	75.3	20.2	87.9	58580	243585	233529	95.9
Kunene	2,317,043	35	26.2	65.5	45.6	12489	66385	17004	25.6
Ohangwena	360,097	2	3.2	88.8	45.4	35958	226416	2814	1.2
Omaheke	1,092,173	16	32.9	62.2	34.5	12590	66779	13856	20.7
Omusati	781,319	3	3.3	83.0	42.4	38202	226337	2640	1.2
Oshana	3,478,191	22	19.2	49.2	53.3	29557	158181	49897	31.5
Oshikoto	488,767	3	15.9	70.2	43.1	28419	158352	14929	9.4
Otjozondjupa	3,924,677	34	47.8	42.7	64.6	25338	116205	55011	47.3
Total:	**47,137,656**	**27**	**34.4**	**54.2**	**42.4**	**346455**	**1773235**	**603612**	**34.0**
Urban			72.5	17.4	76.6	136909	578812		
Rural			9.5	78.3	20.1	209546	1194423		
Namibia			34.4	54.2	42.4	346455	1773235		

Table 3.36: Water, toilet and garbage data by region. Note: Water data from NamWater – some urban areas have own systems (i.e. Tsumeb / Grootfontein) – thus not included. Population, garbage, toilet and urban distribution all from 2001 Population and Housing Census. Collected garbage is sum of regular, irregular collection plus roadside dumping (usually skip collection)

Analysis of general waste	% weight	% volume	kg/day/town dwellers	Gg / yr
Metal	4	6	10498	3.8
Glass	14	7	36742	13.4
Ceramics	0	0	0	0.0
Non-biodegradable	18	13	47239	17.2
Plastic (containers)	4	14	10498	3.8
Plastic (soft)	7	14	18371	6.7
UV degradable	11	28	28868	10.5
Organic food products	15	7	39366	14.4
Garden refuse	32	16	83981	30.7
Wood / timber	1	1	2624	1.0
Biodegradable organics	48	24	125971	46.0
Paper (plain)	9	14	23620	8.6
Paper (carton)	6	15	15746	5.7
Biodegradable paper	15	29	39366	14.4
Total:	**92**	**94**	**241445**	**88.1**
Total based on 0.4 kg/day/urban dweller then material distribution back calculated				

Table 3.37: Typical contents of solid waste in Windhoek.
Source: Nature of General Waste graphic – Kupferberg, study of October – November 2004 (from Windhoek City Engineers).

Table 3.38: Recent monthly amounts of solid waste in Windhoek.
Source: EnviroFill contractors data from City Engineer.

Analysis of Kupferberg inputs	Apr-07 (m^3)	May-07 (m^3)	Jun-07 (m^3)	% by volume
General waste	5064	4958	5562	91
Garden waste	1	1	1	0
Builders rubble	76	5	11	1
Hazardous waste	459	452	490	8
Total:	**5600**	**5416**	**6064**	**100**
Mass estimates				**% by weight**
General waste @ 0.5 t/m^3	2532	2479	2781	46
Garden waste @ 0.3 t/m^3	0.3	0.3	0.3	0
Builders rubble @ 2.0 t/m^3	152	10	22	1
Hazardous waste @ 2.0 t/m^3	918	904	980	16
Total:	**3602**	**3393**	**3783**	**100**

3.8 RECOMMENDATIONS

A few detailed recommendations have been formulated that both would improve future greenhouse gas inventories, and would provide cross-cutting benefits related to carbon credit applications, promotion of renewable energy, and finding solutions to the bush encroachment problem. Some of the recommendations are supported by previous recommendations made in the Year 1994 Inventory and in the 2005 Review of Greenhouse Gas Emission Factors in Namibia. The following are the recommendations:

3.8.1 RECOMMENDATION 1

Establish a greenhouse gas data collection unit within a Government body such as the National Planning Commission (NPC) Central Bureau of Statistics or the Ministry of Environment and Tourism – Department of Environmental Affairs (MET-DEA).

The process of contacting individuals and organisations during the data collection process is extensive and time consuming. The data to be collected is more than five years old and typically stored away in archive files. Furthermore, there is limited disaggregated data available since key stakeholder institutions are not encouraged and monitored by any Government body to improve and communicate their record keeping of greenhouse gas data. The situation could be significantly improved if a government body was delegated with the responsibility of collecting relevant data and communicating with key stakeholder institutions on a continuous basis. In addition to being necessary for Namibia's greenhouse gas inventories, reliable and comprehensive greenhouse gas data will be critically important for the future preparation of carbon credit funding applications for projects and programmes that could prove highly beneficial for Namibia. It is important that the mission of the future greenhouse gas data collection unit include both of these objectives: improved greenhouse gas inventories, and optimal technical support of carbon credit applications.

DEA and the National Climate Change Committee (NCCC) should take the lead in identifying the ideal institutional body to host the greenhouse gas data collection unit. DEA and NCCC should then discuss the need for the data collection unit with the leaders of the potential host institution, propose the number of staff required and the annual budget required.

3.8.2 RECOMMENDATION 2

Conduct scientific studies that will significantly improve our understanding of the impact of invader bush encroachment on Namibia's greenhouse gas profile.

Bush encroachment is the single most significant factor in determining Namibia's greenhouse gas profile, yet the available data regarding the total area, mass density, and growth rate, is based largely on rough estimates performed by local experts. The vast potential of invader bush as a commercial resource for the electricity, liquid fuel, and cooking fuel sectors also warrants the funding of comprehensive scientific studies. Furthermore, the disastrous consequences that bush encroachment has had on the agriculture sector have prompted numerous stakeholders to call for wide-scale elimination of invader bush. It is important that future studies establish a better understanding and consensus of the pros and cons of large-scale bush harvesting and the underlying sustainability criteria. Similar to Recommendation 1, it is important that the funding and implementation of this recommendation be focused on more than just supporting the better greenhouse gas inventories in the future. There are other important economic and environmental objectives and benefits to be achieved simultaneously.

DEA and NCCC should work with experts within MET and MAWF to determine the type of studies (remote sensing, field tests) that should be performed to obtain data required for improved greenhouse gas inventories and environmental management. DEA, NCCC and the newly established Designated National Authority should meet with leaders of MAWF and MME, and other informed stakeholders, to identify and obtain consensus about the cross-cutting objectives of invader bush study and the funding required for such a study.

3.8.3 RECOMMENDATION 3

Clarify the details of pre-anthropogenic baseline ecological conditions in Namibia.

A number of questions were raised at the stakeholder workshop regarding what are the baseline ecological conditions that define anthropogenic influence. Some examples of the questions raised include:

- To what extent can game numbers be increased on Namibian game farms before the impact is considered an anthropogenic factor to be quantified and recorded in the greenhouse gas inventory?
- What is the defining year and corresponding vegetative conditions after which the growth of invader bush is considered an anthropogenic influence?
- Have termite populations increased as a result of anthropogenic factors?

It is recommended that the baseline ecological conditions that define the starting point of anthropogenic influences be better defined, and that selected issues such as the one related to termites be given more review and evaluation. This will help to ensure that the fundamental environmental principles that underlie Namibia's greenhouse gas inventory process are better understood by Namibia's environmental stakeholders and that there is consensus around those principles.

DEA and NCCC should approach UNDP, GEF or UNFCCC to provide funding for a short study that would address the issues raised above.

3.8.4 RECOMMENDATION 4

A review similar to the 2005 Review of Emission Factors for Namibia should be performed on the 2000 Inventory.

The 1994 Inventory received a thorough review in the 2005 Review of Emission Factors for Namibia; and this 2000 Inventory requires a similar, independent in-depth review. The review should in particular focus on how Source Categories Approach in the Energy Sector could be improved and become more independent of the Caltex Wholesaler's database upon which the Reference Approach is largely based. The review could also resolve potentially conflicting recommendations made in the 2005 Review and by the independent UNDP reviewer for this inventory regarding the need and significance of calculating emissions for manure in the Agriculture Sector.

DEA and NCCC should approach UNDP, GEF or UNFCCC to provide funding for such a review.

4. Steps taken or envisaged to implement the Convention

The previous chapter presented Namibia's greenhouse gas emissions, showing that they make an insignificant contribution to global emissions. Hence, in view of Namibia's vulnerability to the impacts of climate change and resultant threats to national development (Chapter 5), the country shall primarily focus on climate change adaptation measures (Chapter 5) while necessary attention will be given to mitigation measures (Chapter 6). Efforts to integrate climate change into national policies and development planning, and resource mobilisation for policy implementation are presented in Chapter 7. These chapters inform the steps taken or envisaged to implement the Convention, given Namibia's common but differentiated responsibilities and circumstances.

5. Impacts, vulnerability and adaptation measures

Etosha Pan, Namibia. Photograph by Stewart Aston

This chapter presents the potential impacts of projected climate change in Namibia, the vulnerability of its people, economic sectors and the natural resource base, and adaptation responses. The following reports were used as primary sources of information: Climate Change Vulnerability and Adaptation Assessment (DRFN, 2008), Research on Farming Systems Change to Enable Adaptation to Climate Change (University of Namibia, 2008), Sea Level Rise in Namibia's Coastal Towns and Wetlands: Projected Impacts and Recommended Adaptation Strategies (CSA, LaquaR and Lithon, 2009), and the Draft National Policy on Climate Change for Namibia (Republic of Namibia, 2010a).

The Vulnerability and Adaptation Assessment (DRFN, 2008) was constrained by the lack of knowledge about exactly what to adapt to. Much of the available information is regional and only allows for broad statements of change, i.e. it is of limited use for national or sub-national studies. The high level of uncertainty introduced by Namibia's natural variability only exacerbates the shortcomings of global and regional climate models. In addition to climate modelling, the combined effects of rainfall and temperature called for the use of crop modelling (for two specific regions) and rainfall run-off modelling (for the Fish River Basin). Unfortunately, the lack of long-term continuous data posed a serious constraint to all modelling since it necessitated vast interpolation of results which do not lend themselves to accurately project future changes.

5.1 SELECTION OF REGIONS AND SITES FOR MODELLING

In addition to presenting the climate change impacts and vulnerabilities for Namibia in general, the Vulnerability and Adaptation Assessment (DRFN, 2008) focused specific attention on the Caprivi and Karas regions, which represent two extremes in Namibia in terms of geographical location, as well as environmental and socio-economic conditions (Figure 5.1).

The analysis of historic trends in climate change and climate modelling were undertaken for the whole of Namibia. During the modelling process specific attention was, however, paid to three locations (Kazangula, Grootfontein and Keetmanshoop). Thus, predictions for temperature and rainfall could be analysed in more detail for a station in the Caprivi, a station in Karas and a third station in the middle of these two.

The crop modelling was focused on potential yields and planting windows for the middle of the 21st century for Namibia's main staple grains, maize and pearl millet. Rundu and Grootfontein (Figure 5.1) were selected as the best proxies for the major communal and commercial crop production sites, respectively, for which long term weather records were available. Unfortunately the paucity of meteorological records prohibited crop modelling for locations that are closer to the North-Central regions where cultivation of millet is carried out by a significant proportion of the population.

The rainfall-runoff modelling was undertaken for two locations in the Fish River Basin in southern Namibia: Mariental and Keetmanshoop (Figure 5.1). The selection of these two towns was justified as they are located in the proximity of two major dams that supply the population in southern Namibia of water: the Naute dam in the Karas region and the Hardap dam in the Hardap region. Moreover, long term weather records could be obtained from the Meteorological Service of Namibia for these locations. Lack of input data prevented the undertaking of rainfall-runoff modelling for the rivers and floodplains in northern Namibia, i.e. the Caprivi.

5.2 CLIMATE CHANGE IN NAMIBIA

5.2.1 INTRODUCTION

The following section (from DRFN, 2008) provides background information on the changes in historical climate observed over Namibia and the changes projected to occur towards the middle of the century, through anthropogenic climate change. As such it draws on observed data, reviewed literature and the 4th Assessment Report of the Intergovernmental Panel on Climate Change (AR4) (IPCC, 2007).

The issue of uncertainty is important, and four sources of uncertainty currently limit the regional and national climate projections: extremely high natural climate variability and a lack

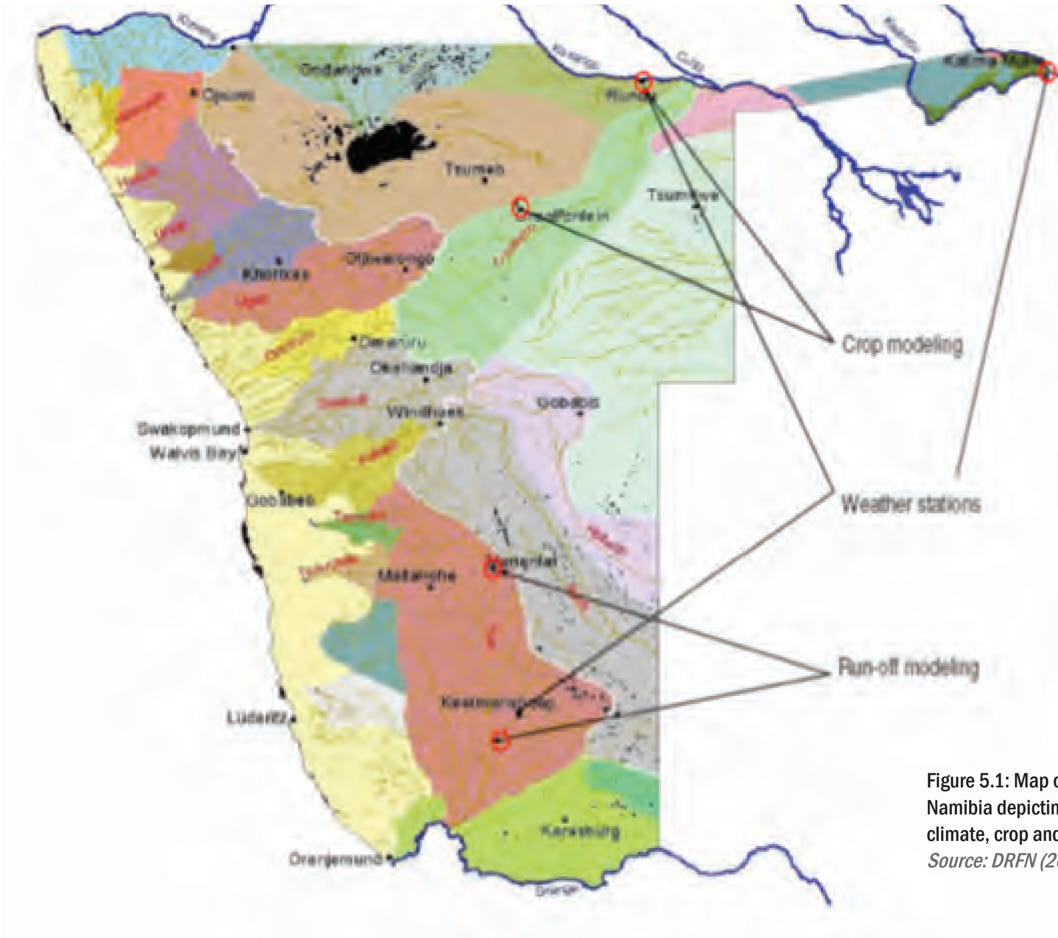


Figure 5.1: Map of river basins in Namibia depicting sites selected for climate, crop and runoff modelling. *Source: DRFN (2008)*

of data in time and space, uncertainty around future emissions of greenhouse gases, uncertainty in the science and limited understanding of regional climate system dynamics, and uncertainty introduced by GCM downscaling tools. Overall, the result is limited confidence in the magnitude of the projected change, although the pattern of change can be interpreted with greater certainty.

5.2.2. RECENT HISTORICAL TRENDS IN TEMPERATURE AND RAINFALL

There have been noticeable changes in climate means and extremes and rainfall seasonality in the observed historic climate trends in Namibia since 1960. Temperatures have followed the global trend - even exceeding the global mean temperature increase. Figure 5.2 indicates monthly surface air temperature observed over southern (Figure 5.2a) and northern (Figure 5.2b) Namibia. In both cases there is a clear trend for warmer temperature in the latter half of the 20th century, which is generally 1-1.2°C warmer than at the beginning of the century, with greater increases in the north.

Besides these general trends in temperature an analysis of seven stations with more than 25 years of recent data indicates that there have been consistent increases in daily maximum temperatures, with both positive and negative changes in daily minimum temperatures (Table 5.1). Most notable have been the increases in the maximum values of daily maximum temperature i.e. the hottest temperatures have been getting hotter. The frequency of days with maximum temperatures above 25°C and 35°C has increased significantly (at four and three weather stations, respectively), with decreases in the frequency of days with minimum temperatures

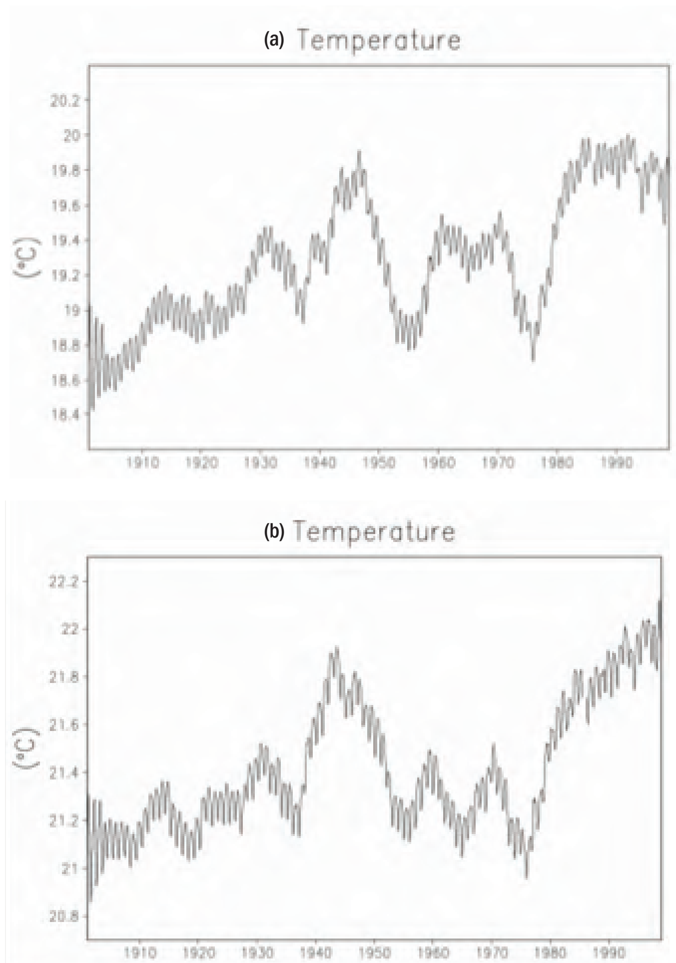


Figure 5.2: Surface monthly air temperature (°C) measurements 1901-2000: a) southern Namibia (16-20°E, 28-24°S); b) northern Namibia (16-20°E, 22-18°S). *Source: Climate Research Unit (Mitchell et al., 2004)*

Station name	Latitude	Longitude	Period	Max T_{max}	Min T_{max}	Max T_{min}	Min T_{min}
Lüderitz	-26.6333	15.1000	1960-2000	0.075	0.006	-0.013	0.032
Keetmanshoop	-26.5333	18.1167	1970-2006	0.025	0.016	0.065	-0.042
Windhoek	-22.5667	17.1000	1960-2006	0.046	0.007	0.020	0.010
Hosea Kutako Int. Airport	-22.4833	17.4667	1980-2006	0.005	0.024	0.024	-0.099
Sitrusdal	-21.4167	15.9333	1976-2003	0.041	0.115	-0.053	-0.154
Grootfontein	-19.9333	16.3833	1980-2006	0.085	0.175	0.136	0.055
Okaukuejo	-19.1833	15.9167	1975-2004	0.030	0.025	0.027	0.013

Table 5.1: Trends (°C yr^{-1}) in annual maximum/minimim of daily maximum temperatures (Max T_{max} / Min T_{max}) and the annual maximum/minimum of daily minimum temperatures (Max T_{min} / Min T_{min}). Trends significant at the 90% significance level noted in bold. *Source: DRFN (2008)*

below 5°C at four stations.

Detecting trends in rainfall is typically more difficult than detecting trends in temperature, especially in highly variable arid climates such as Namibia. This is largely because a single extreme rainfall event can contribute a significant proportion of the annual rainfall in some regions. Figure 5.3 shows how rainfall has varied (as an average over 4 years) between 1901 and 2000 over southern (Figure 5.3a) and northern (Figure 5.3b) Namibia. There are no obvious trends during the 100-year period. However, there have been statistically significant increases in the length of the dry season, and decreases in the number of consecutive wet days. Additionally, rainfall intensity has increased significantly at Windhoek.

Whilst there is considerable spatial heterogeneity in the trends, the far northern and central regions of Namibia show a trend since 1960 towards a later onset of rainfall (Figure 5.4a) and an earlier cessation of rains (Figure 5.4b). Together these trends result in a tendency for shorter rainfall seasons in later years in the north (Figure 5.4c). This tendency for a shorter rainfall season is consistent with the trends for a longer dry season noted above. The observed changes in temperature extremes, the length of the dry season and rainfall intensity not only underscore that the climate in Namibia is tending to become drier, but also that climate variability is as significant a phenomenon as the long-term climate trends.

Whilst there have been few studies of trends in the atmospheric circulation over Namibia, Hewitson et al. (2006) note a trend for an increase in the daily frequency of higher pressures over the continent during the December – February period between 1979 and 2001. Such changes in atmospheric circulation are consistent with changes noted in the Southern Annular Mode (SAM), which is the dominant mode of circulation variability in the southern hemisphere (Marshall et al., 2004; Solomon et al., 2007).

Since 1979 the SAM has tended towards a positive polarity, a consequence of lower pressures over the Antarctic and higher pressures further north between 40 and 50°S. This change is consistent with those expected due to increases in greenhouse gases (Arblaster and Meehl, 2006) and is therefore likely to continue in the future. A local manifestation of this change may be the long-term increase noted in southerly winds, which induce upwelling (cold surface water) off the Namibian coast.

5.2.3 CLIMATE CHANGE AND SEA LEVEL RISE PROJECTIONS

5.2.3.1 Data and methods applied in climate projections

The Climate Change Vulnerability and Adaptation Assessment

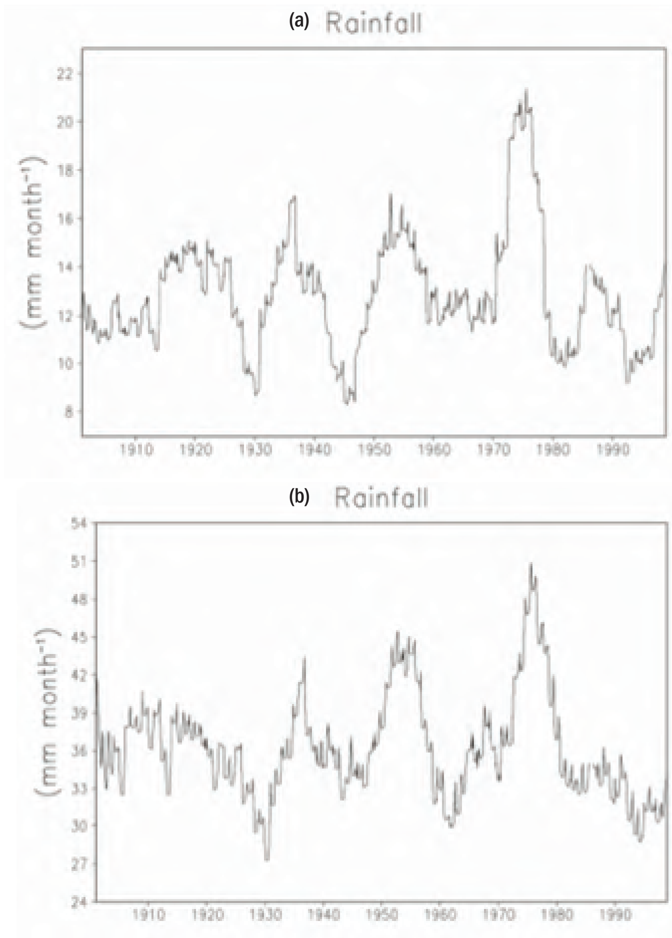


Figure 5.3: Monthly mean rainfall (mm $month^{-1}$) measurements 1901-2000: a) southern Namibia (16-20°E, 28-24°S); b) northern Namibia (16-20°E, 22-18°S).
Source: Climate Research Unit (Mitchell et al., 2004)

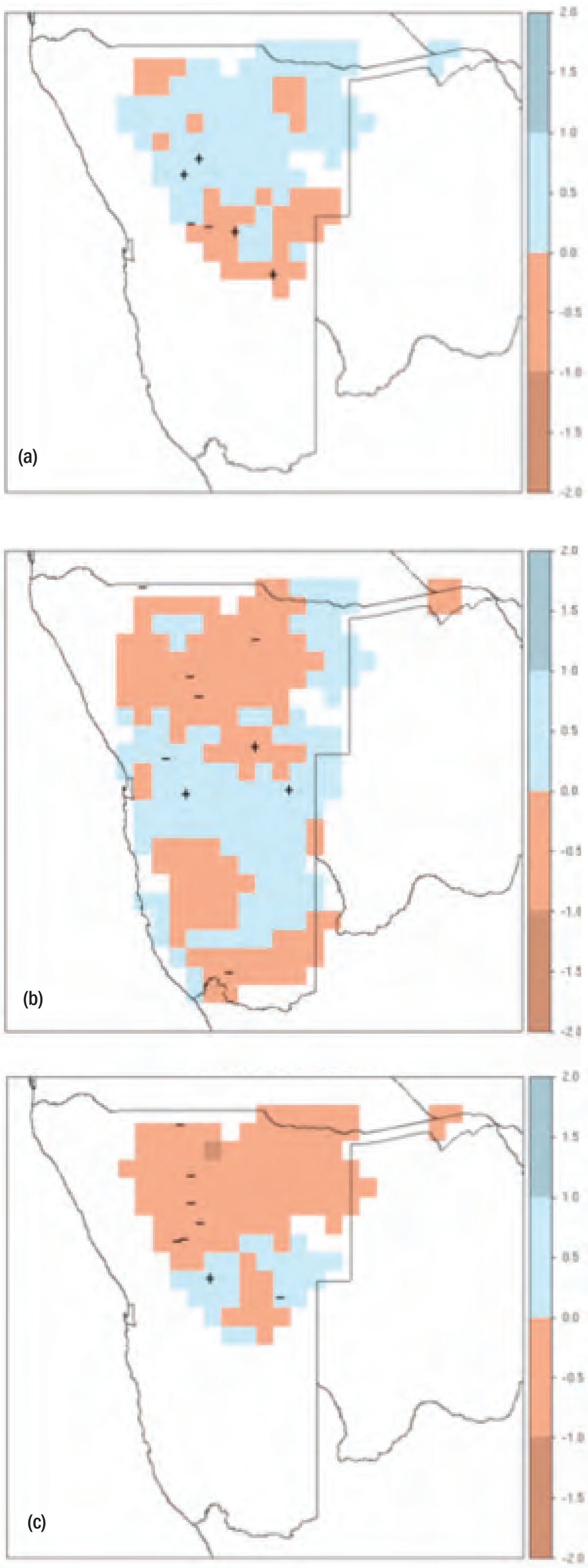


Figure 5.4:
Trends in a) start (25 mm in 10 days not followed by a dry spell of 10 days or longer), b) end (3 consecutive 10 day periods of less than 20mm) and c) duration (end – start) of the rainfall season since 1960 (days year^{-1}). Station trends are kriged (143 stations) and statistically significant positive/negative trends are indicated by "+"/"-".
Source: DRFN (2008)

(DRFN, 2008) used Global Circulation Models (GCMs) to formulate projections of changes in temperature and wind for the period 2046 to 2065. These were based on 13 GCMs used in the IPCC AR4 (IPCC, 2007) and taken from the World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project phase 3 (CMIP3) multi-model dataset.

On the other hand, downscaled climate change (rainfall) projections were developed using two broadly different techniques. Firstly, empirical downscaling of six different GCMs was used (Hewitson and Crane, 2006). Three of these were used in the IPCC Third Assessment Report (TAR; IPCC, 2001), namely HadCM3, CSIRO MK II, and ECHAM 4.5; and three were used in the AR4 (IPCC, 2007), namely GFDL, MIROC, and MRI CGCM.

Secondly, dynamical downscaling was performed using two Regional Climate Models (RCMs), namely the Mesoscale Model 5 (MM5) (Grell et al., 1994) and PRECIS (Mitchell et al., 2004), both forced within a single GCM (HadAM3P) (Mitchell et al., 2004; Tadross et al., 2005). Each RCM simulates a hydrological cycle of different intensity; PRECIS rains more often and with a lower than observed intensity, whereas MM5 rains less often and with a higher than observed intensity.

It should be noted that the assessment used several downscaled GCMs to make rainfall projections, which resulted in a range of future climate scenarios. This is important as no single model is considered absolutely superior to all others, and all downscaled GCMs in use for southern Africa have a variety of predictive weaknesses. Also, a similar family of GCMs was used for temperature and wind projections. Using this approach, climate trends rather than precise climate predictions become apparent.

All future scenarios are for the period 2046-2065 and are taken from the IPCC A2 SRES scenario, which assumes (conservatively) that society will continue to use fossil fuels at a moderate growth rate. The precipitation data was linearly scaled to this period from downscaled projections for the period 2081-2100. The choice for the period 2046-2065 (rather than 2081-2100) is based on the need to combine good practice in climate research with the need to take a time horizon that is not too far beyond Vision 2030.

5.2.3.2 Future rainfall

Figure 5.5 indicates the median of projected changes in total monthly rainfall change from the six statistically downscaled GCM rainfall estimates. Regions where three models (50%) indicate wetting and three models drying are left blank, as are regions which increase less than 10mm per month (the increase in potential evapotranspiration). The following discussion concentrates on the sign of the change (positive or negative), which likely shows greater consistency between models than the magnitude of change.

The most consistent changes are for an increase in late summer rainfall over major parts of the country, and a decrease in winter rainfall in the south and west of the country. Increases in rainfall are most obvious during the January to April period, especially in the central and north-eastern regions. The signals for the Cuvelai area are, however, not conclusive. Decreases in the southwest are suggested for most months, except February and March but they are particularly widespread during the core winter months.

These projected changes are consistent with the process-based understanding of how climate change will manifest itself over Southern Africa i.e.

- That winter storms will retreat southward, reducing winter rainfall to the southern and especially the southwestern parts

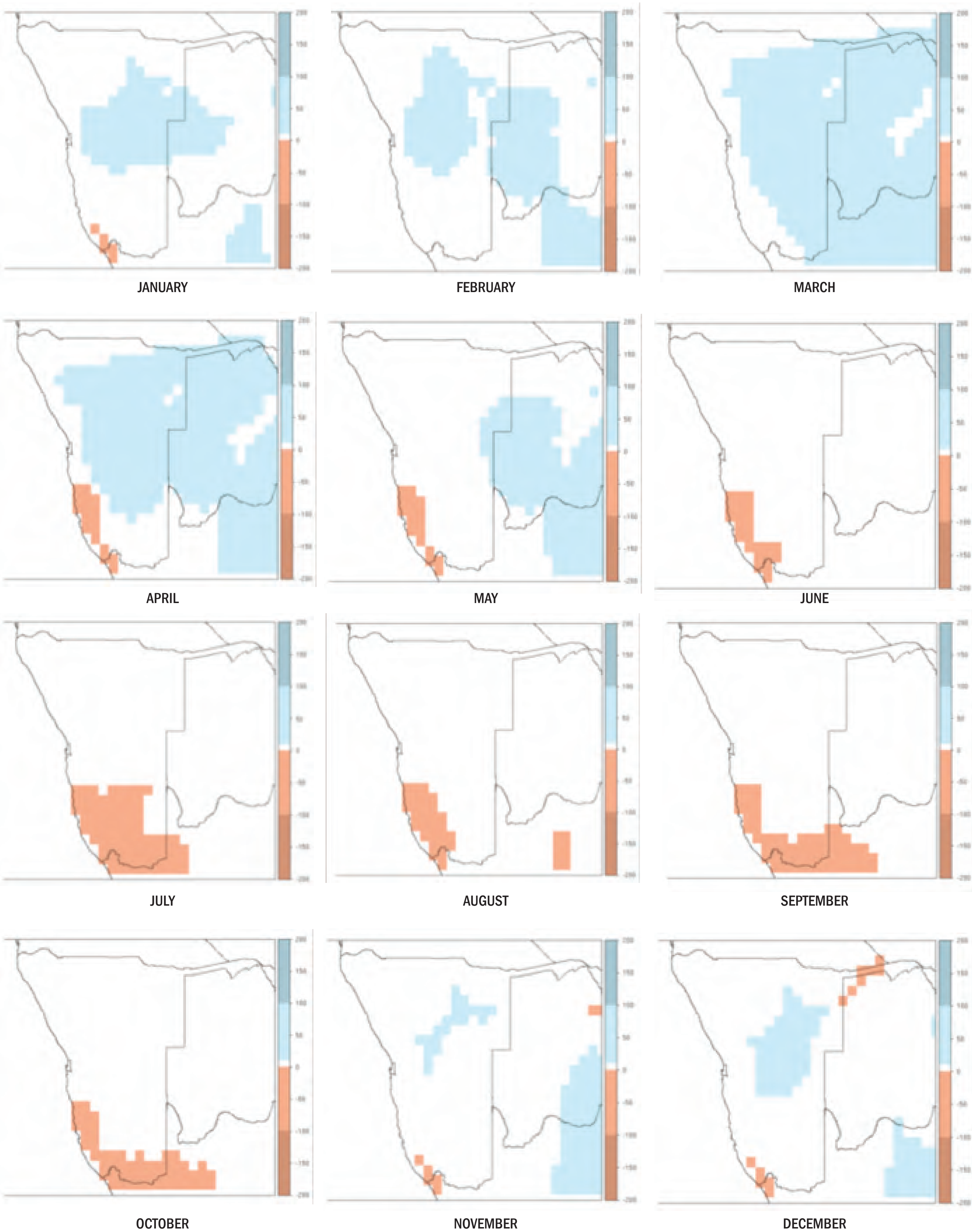


Figure 5.5: Median change in total monthly rainfall (mm month^{-1}) from the 6 statistically downscaled GCM rainfall projections. Regions where 3 models indicate drying/wetting, as well as experiencing increases of less than 10mm month^{-1} (less than increases in potential evapotranspiration) are left blank. *Source: DRFN (2008)*

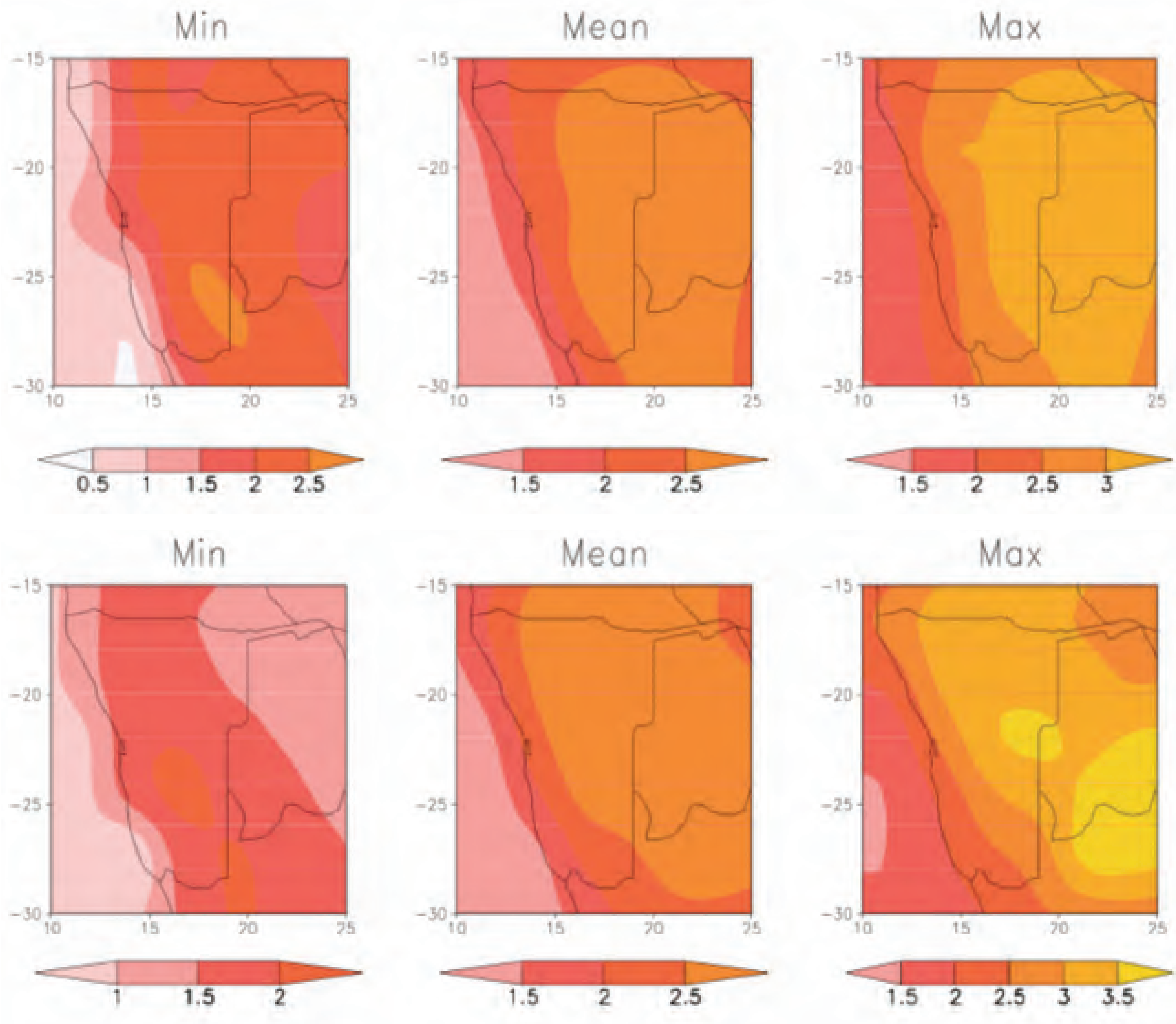


Figure 5.6: Minimum (left), mean (middle) and maximum (right) projected change in (TOP) January-March and (BOTTOM) July-September mean surface air temperature (°C) from 13 GCMs. *Source: DRFN (2008)*

of the country;

- Increases in thermal heating, coupled with increases in atmospheric moisture, especially during mid to late summer, will increase convective rainfall over much of the country.

5.2.3.3 Future temperature

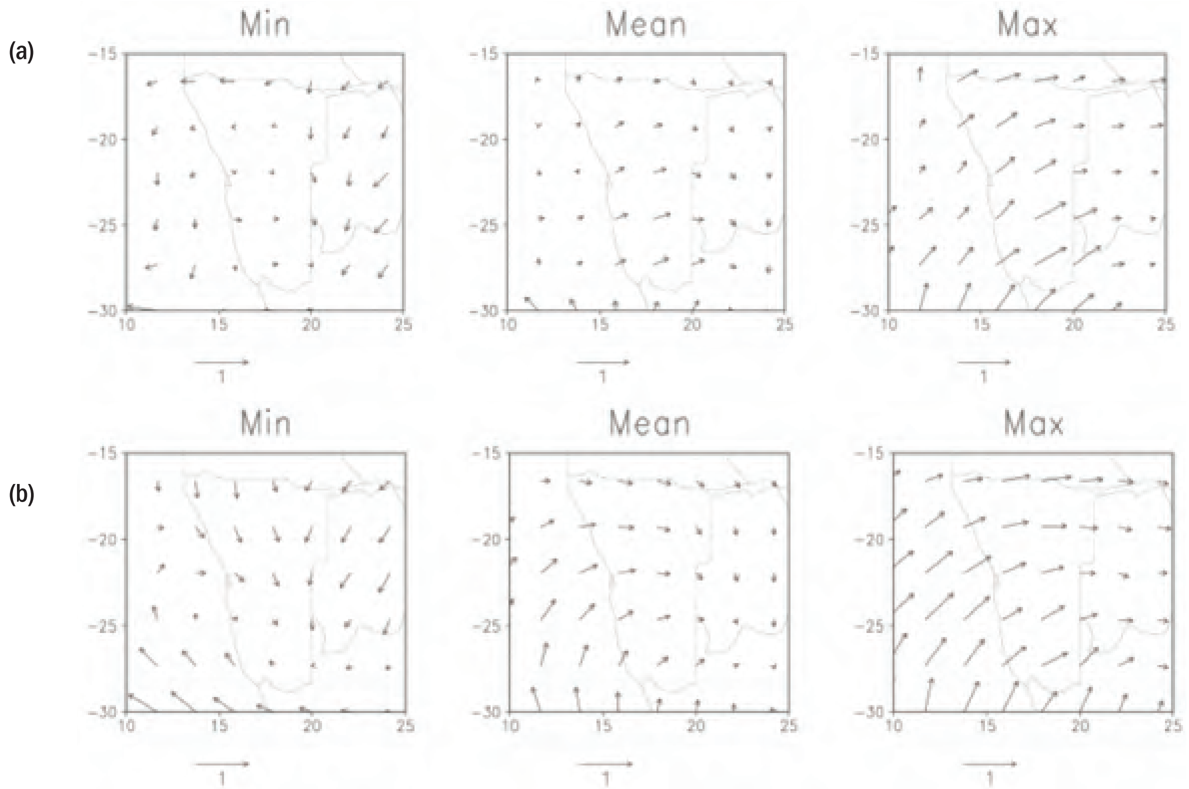
Figure 5.6 indicates the minimum, mean and maximum expected change in surface temperature for the 2046-2065 period for both the summer (Figure 5.6 top) and winter (Figure 5.6 bottom) periods. Changes are a minimum towards the coast and increase further inland during all seasons, with minimum expected increases during summer of 1°C -2°C and maximum changes of 2°C -3.5°C. Maximum projected increases in temperature are slightly higher during winter (2.5°C -4°C) whereas the minimum projected increases are similar to those during summer.

It should be noted that downscaling using Regional Climate Models may reduce these estimates of temperature change by a few 10ths of a degree (Tadross et al., 2005) partly because they better resolve complex topography.

5.2.3.4 Future wind

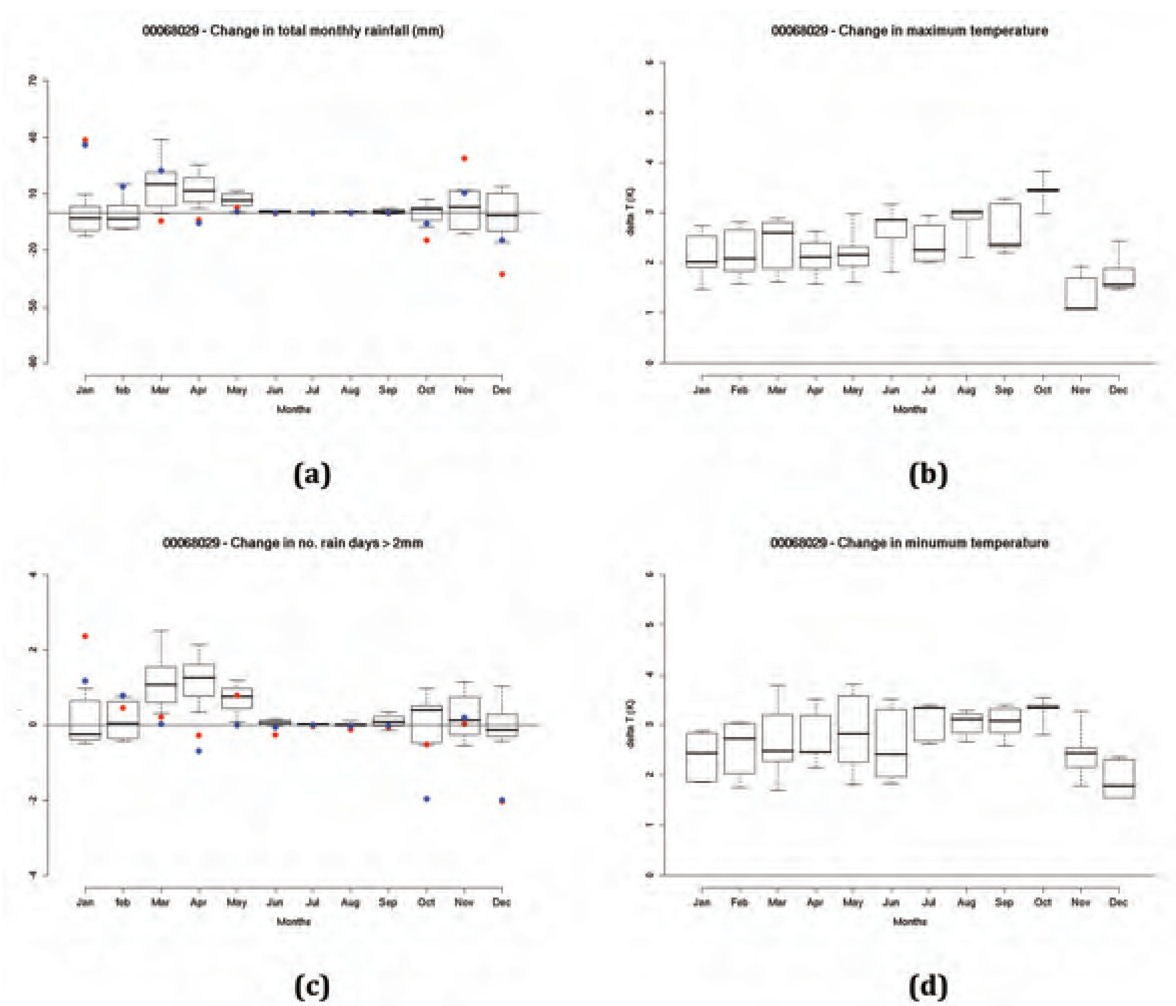
Figure 5.7 presents the minimum, mean and maximum expected changes in surface wind for the 2046-2065 period from the 13 AR4 GCMs. During summer (Figure 5.7a) minimum changes are mostly around zero whereas maximum changes are for onshore flow from the southwest, which are highest (approximately 0.8 ms^{-1}) towards the south. The mean changes are of a similar pattern (though lower magnitude) to the maximum changes and are consistent with increased convective activity and an associated low-pressure trough over the continent during summer.

Both mean and maximum wind changes during winter indicate a similar (though stronger – approximately 1 ms^{-1}) pattern of change to that during summer (Figure 5.7b). However, the minimum projected change also indicates increases in winds from the southeast over the ocean towards the south. Indeed both the maximum and mean projected changes also indicate increases in the southerly component of wind over the ocean. These projected changes are consistent with a retreat of mid latitude storms (which normally bring northwesterly winds) towards the south and an increase in the south Atlantic high-pressure system which drives winds from the south.



(ABOVE) Figure 5.7: Minimum (left), mean (middle) and maximum (right) projected change in (a) January-March and (b) July-September mean surface wind from 13 GCMs. *Source: DRFN (2008)*

(BELOW) Figure 5.8: Station 68029 (Kazungula). Empirically downscaled mean change (for the 2070-2090 period) for 6 GCMs (boxplots) and 2 RCMs (Blue/Red dots); a) total monthly rainfall (mm), c) monthly number of rain days >2mm. RCM-scaled temperature change (K) (for 5 GCMs); b) maximum temperature, d) minimum temperature. *Source: DRFN (2008)*



5.2.3.5 Future change at selected stations

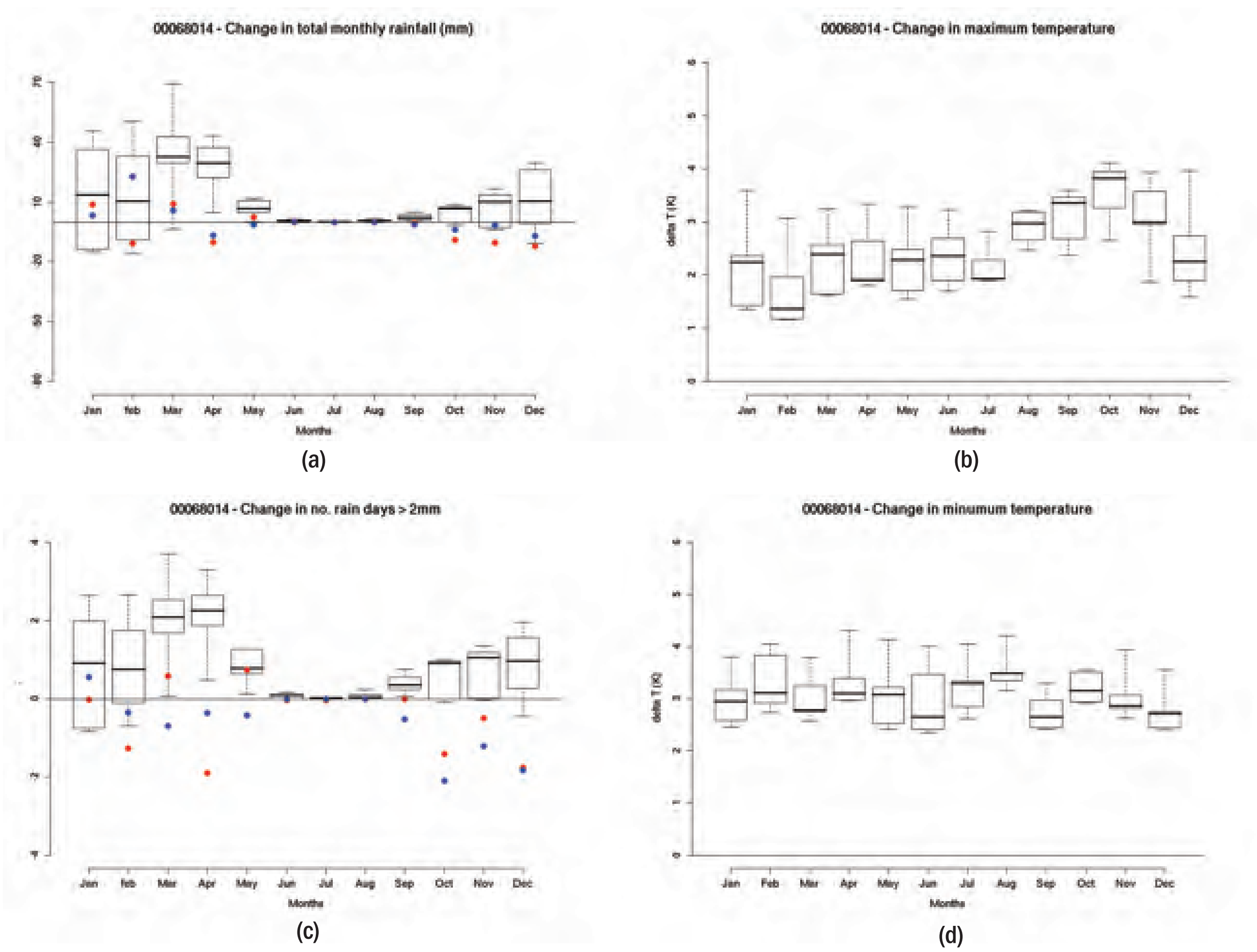
To better illustrate the future projected changes in rainfall and temperature we have selected 3 stations (00068029 to represent Caprivi; 00068014 to represent the Otjozondjupa region; 00068312 to represent the Karas region) at which there are available a range of projected future data (for the 2046-2065 period), namely: empirical downscaling of rainfall from 6 GCMs; dynamical downscaling of 1 GCM using 2 RCMs; and the original GCM data itself. The following discussion concentrates on the sign of the change (+ve/-ve), recognising that the greatest uncertainties lie in projecting the magnitude of change (IPCC, 2001).

In Figure 5.8 (Kazangula), boxplots represent the range of projections from the downscalings of multiple GCMs; rainfall from the empirical downscaling and temperature from the RCM-scaled GCM temperature. The blue/red dots in the rainfall figures indicate the rainfall changes from the RCMs. Total monthly rainfall changes from the empirical downscaling suggest a late summer wetting during March-May but at other times of the year are suggesting a range of both positive and negative (undetermined) changes. The RCMs suggest a very weak drying during March-May. Similar results are seen for monthly raindays, with the consistent message of late summer wetting at this station. Both maximum and minimum temperatures are projected to rise in all months, with minimum temperatures on average rising more than maximum temperatures and maximum increases of 3-4 °C in October. The sharp drop in temperature increases between October and November are likely in part due to the increase in rainfall in the RCM during this transition, highlighting that these temperature projections are at least partly dependent on the RCMs hydrological cycle and ability to simulate rainfall changes; they should therefore only be taken as an approximate guide to future change.

Figure 5.9 presents similar data to Figure 5.8 but for station 00068014 (Grootfontein). Increases in total monthly rainfall are seen in the empirical downscaling projections in both the early and late summer months (higher increases than those projected for Kazungula), though again the RCMs would seem to disagree on the sign of the change during the early summer period. Changes in the number of raindays again reflect those for total monthly rainfall, and similar ranges of temperature change are suggested as for Kazungula. It is noticeable that the high increases in maximum temperature during early summer coincide with a reduction in the number of raindays in the RCMs, suggesting that these may be tied to both reduced latent cooling and increased incident shortwave radiation in the RCM. Again we are cautious about over-interpreting these high temperature changes as they are likely influenced by potential biases in the RCM.

Figure 5.10 (Keetmanshoop) indicates changes that are not dissimilar to those noted for the other stations, except that empirically downscaled rainfall changes are smaller in magnitude, especially during early summer (mostly negligible). Temperature changes are similar to the other stations, though maximum temperatures increase less in May – again likely due to changes in the RCM affecting the surface energy balance. The empirical rainfall downscalings therefore indicate some consistent changes across all three locations (increases in late summer rainfall,

Figure 5.9: Station 68014 (Grootfontein). Empirically downscaled mean change (for the 2070-2090 period) for 6 GCMs (boxplots) and 2 RCMs (Blue/Red dots); a) total monthly rainfall (mm), c) monthly number of rain days >2mm. RCM-scaled temperature change (K) (for 5 GCMs); b) maximum temperature, d) minimum temperature.
Source: DRFN (2008)



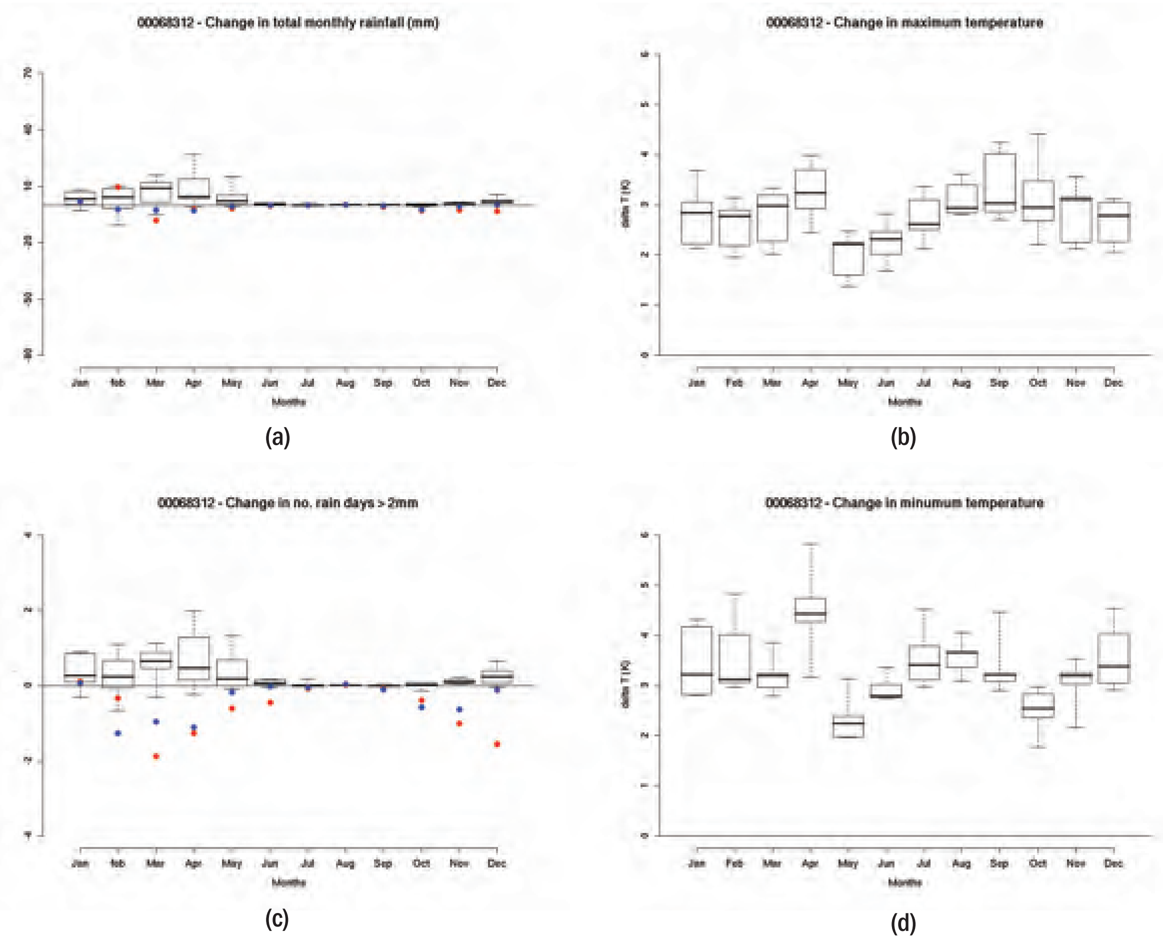


Figure 5.10: Station 68312 (Keetmanshoop). Empirically downscaled mean change (for the 2070-2090 period) for 6 GCMs (boxplots) and 2 RCMs (Blue/Red dots); a) total monthly rainfall (mm), c) monthly number of rain days >2mm. RCM-scaled temperature change (K) (for 5 GCMs); b) maximum temperature, d) minimum temperature. *Source: DRFN (2008)*

of greater magnitude towards the north and east) whilst some changes are more consistent at particular locations (e.g. increases during early summer at Grootfontein). However, the RCM rainfall for the same downscaled GCM is sometimes in disagreement; this mostly occurs during early summer, suggesting that there may be some processes not fully represented in either the empirical downscaling or the GCM driving fields at this time of year. These processes may be linked to land surface – atmosphere feedbacks, which are currently topics of active research. Temperature changes are more consistently predicted and are positive everywhere for both minimum and maximum temperatures. The range of projected changes is wide, though those changes presented here are dependent on the PRECIS RCM from which they are all derived. In the future empirically downscaled temperature projections will become available though it is important to understand that the sign of the change (i.e. positive) will not be different, only perhaps the magnitude; the changes shown here are consistent with those seen in the latest report of the IPCC (Christensen et al., 2007).

5.2.3.6 Comparison of the observed trends with the projected changes

The projected changes for the middle of the 21st century that have been demonstrated here are linked to physical changes in the regional climate system, which offers a way to reconcile observed trends and future projected change where they disagree. Consistently projected future change is a consequence of the following physical changes:

- Increases in temperature which promote convective activity associated with a predominance of low pressure systems and related wind patterns, especially during mid to late summer
- Increases in humidity, which increases the amount of moisture available for rainfall once it is triggered.
- Retreat of the mid-latitude storm systems and increases in the continental high pressure system during winter (and potentially autumn and spring)

However, these changes in the physical system will interact and couple in a non-linear manner and individually manifest themselves at different periods in the future. The regional expression of change is therefore dependent on which mechanisms, which may compete with each other (e.g. increases in rainfall may offset decreases in rain days), are dominant at any particular time. So, notwithstanding the average trends reflected in the projections discussed in this chapter, referring to the observed historic climate trends that substantiate the natural climate variability in Namibia, the latter serves to underscore that variability is likely to remain a key aspect of the Namibia's climate in the future. More information may, however, need to be collected about extreme weather events and more modelling is required to determine and understand the inter-annual variability of the climate in Namibia in the future.

It should also be remembered that unlike the temperature signal due to climate change, which is expected to be currently observable, the rainfall signal (as estimated from low variability GCM data – hence likely a conservative estimate) is not expected to be strongly observable for several decades (70-90 years) (Christensen et al., 2007). As such, allowing for uncertainty in the changes simulated with CO_2 forced climate change, the projected changes are not at odds with changes noted in the observational record, though statements of attribution are not easily made.

In particular the projections of increased late summer rainfall, whilst currently inconsistent with the observed trend for an earlier end to the season, are more consistent across models, suggest that this aspect will contribute to future change. Furthermore, there are suggestions of increases in rainfall intensity in the observed record, which is consistent with increases in humidity and convection and can be expected to become more apparent in the future.

5.2.3.7 Sea level rise

A baseline study was conducted (CSA, LaquaR and Lithon, 2009) using current mean sea levels and the result from the simultaneous occurrence of an extreme tide and an extreme storm, an event with a nominal return period of 100 years - the "Present Day Worst Case Scenario". Using rounded values derived from sea level and wave observations at Walvis Bay and Lüderitz, the maximum sea levels that can currently be expected along the coast of Namibia are:

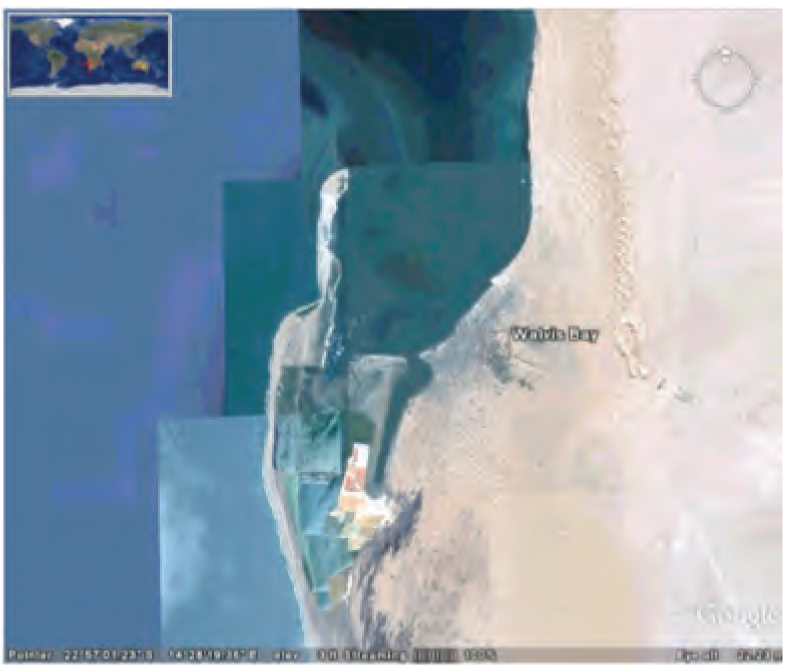
LLD+1.5m in sheltered environments
LLD+4m in exposed environments, and
LLD+6m in very exposed environments,
where LLD refers to Land Levelling Datum, which corresponds to Mean Sea Level.

Coastal erosion of 30m can be expected under these conditions. The sea levels expected in northern Namibia will be somewhat reduced, because of the less extreme wave climate in exposed and very exposed environments.

Thereafter, three scenarios for future sea level rise were explored:

First, the "Sea Level Scenario at 2030" assumes the climate change driven acceleration in sea level rise which is expected to add 20cm to base levels in the near future (2030). Given the comparatively small rise in the sea level over this period, the levels to be used and the details of the inundation to be expected are the same as in the "Present Day Worst Case Scenario". However, expected frequencies differ. The frequency with which the sea levels for exposed and very exposed environments are reached will depend upon the frequency expected for severe storms. It is possible that, with climate change, severe storms will become more frequent, and so the critical levels may well be reached more often in the future. On the other hand, the critical sea level of LLD+1.5m in sheltered coastal environments will definitely be reached more frequently. By 2030, these levels are likely to be reached every year.

Figure 5.11: Google Earth view of Walvis Bay indicating the Pelican Point sandspit. *Source: CSA, LaquaR & Lithon (2009)*



Second, in the longer term, up to 2100, the onset of polar ice melt (Greenland and West Antarctica ice sheets) will lead to sea level rise of several metres along the coast of Namibia ("Polar Ice Melt Scenario"). There is much uncertainty about the extent and the timing of the melting of the polar ice sheets and their eventual contribution to sea level rise and coastal inundation. Consequently, this Scenario is fundamentally different from the others in that the focus is on Mean Sea Level and the changes to be expected from the ice melt alone (no tides or storms), so as to provide an everyday scenario for these circumstances. It will map the location of the new coastline. The important information will be the order in which different land areas are overwhelmed by sea level rise.

Third, the "Sea Level Impact Scenario for Walvis Bay" follows the "Sea Level Scenario at 2030", but with a particular focus on Walvis Bay which has been identified as highly vulnerable. Walvis Bay is low lying with much of the town at an elevation of less than 2m above mean sea level. The town is protected from the open sea by the 10km long sandspit terminating in Pelican Point (Figure 5.11). Walvis Bay is the principal harbour of Namibia, through which most of its trade passes, and is the third largest urban centre in the country.

There are two possible future situations for Walvis Bay: The first is the scenario that the protective Pelican Point Sandspit remains in place and the town and harbour of Walvis Bay remains a sheltered environment; under this scenario, Walvis Bay will experience a sea level of LLD + 1.5m on an annual basis. Sea level rise will raise the water table in the wetlands inside the bay, and result in the increased possibility of erosion of the water-logged areas. This can be illustrated through changes in the coastline following sea level rise of 100cm (Figure 5.12)

Figure 5.12: Walvis Bay after simulated 1m sea level rise, with flooding in the Kuiseb estuary. From www.flood.firetree.net in CSA, LaquaR & Lithon (2009)

The second scenario is that the Pelican Point Sandspit is breached and Walvis Bay is exposed to the full impact of storms from the sea, and could no longer be considered to be a sheltered environment. The town and harbour would be located on an open coast, exposed to greatly enhanced wave activity. With no additional protection, the town and harbour of Walvis Bay would be subject to sea levels of LLD+2m on an annual basis, and of LLD+3m from extreme sea levels with a return period of 100 years.

5.3 THE SOCIOECONOMIC CONTEXT

Vulnerability to climate change not only depends on change in frequency or duration of climatic conditions, but also on the capacity to respond adequately to those changes. Socio-economic factors, such as household income, income diversification, availability of labour and the health status of household members, influence the vulnerability of livelihoods, as well as the adaptive capacity of individuals, households and communities. These socio-economic factors may ameliorate or exacerbate current environmental conditions, and may similarly inform the vulnerability of livelihoods to climatic change and climatic variability.

The following sections present an overview of various aspects of human development, including income and poverty, education, health and access to resources and services, with a specific focus on the Caprivi, Hardap and Karas regions, since these were the focal areas for the Vulnerability and Adaptation Assessment (DRFN, 2008). They represent the diversity of Namibian conditions.

5.3.1 GEOGRAPHICAL CHARACTERISTICS AND LIVELIHOOD SYSTEMS

The Caprivi region in north-eastern Namibia and the Karas and Hardap regions in the south-west embody the environmental and economic contrasts Namibia's rural areas offer. The natural environment of the Caprivi region is characterised by relatively fertile soils and savanna vegetation. Wetlands are an important feature in the landscape of Caprivi, as the region is bordered and dissected by the Zambezi and Kwando-Linyanti rivers which run throughout the year. Every so many years the confluence of waters from the respective rivers results in flooding of low-lying plains in the eastern part of the region. The region is further characterized by productive aquifers across the region and receives in excess of 550 mm precipitation annually (see Figure 2.1), with rather low variability and relatively low evaporation levels (see Figure 2.3).

These natural conditions imply that the regional livelihood system is based on subsistence oriented maize cultivation, which is combined with a small number of goats and cattle for domestic purposes, supporting approximately 12,000 farming households (Mendelsohn, 2006). The cereals are usually cultivated in communal land on small plots that surround people's homes, whilst livestock is largely grazed on open access common pastures and woodlands. In fact, the region has an excess carrying capacity for livestock, although the population density is a multiple of that in the vast Karas region (5.5 versus 0.4 persons/km², respectively; NPC, 2003). Thus, cattle densities in the area around the flood plain in the Caprivi are higher than 10 head/km², whilst they hardly reach to 1 head/km² in Karas (Mendelsohn, 2006).

Livelihoods in the eastern part of the region further depend on the interchange of the seasonal flow of water from the Zambezi, Kwando and Lyanti rivers, which causes flooding of the flood plain. These wetlands have a natural capacity to absorb large amounts of water and allow for 'regression farming' of maize and seasonal fishing. They further provide substantial opportunities for tourism, as it attracts birds and wildlife that migrate between Botswana, Zambia and Namibia. Livelihoods used to be flexibly organized around this seasonal movement of water, as cattle and people used to be moved temporarily to higher elevations when the water levels in the floodplain became high. Nowadays, the region is considered vulnerable to flooding of the wetlands, as high stream flow of the Zambezi puts infrastructure that has been established in the flood plain at risk and makes economic life and access to schools, clinics and government services more difficult in times of 'flooding'.

Vulnerability to climate change is likely to be determined by changes in rainfall intensity (later onset, possibly heavier rains) over the Kavango and Zambezi catchments in Angola and Zambia, decrease in total precipitation, run-off and perennial drainage and further informed by the loss of traditional coping mechanisms and other socio-economic trends discussed later in this chapter.

Natural conditions and livelihood systems in the southern regions of Namibia are very different from the Caprivi. Annual precipitation varies between 0 and 160 mm per annum in Karas and ranges from less than 50 mm in the west to 250 mm in other parts of the Hardap region (Figure 2.1). Rainfall in both regions is characterised by high seasonal variation, and fog days per annum play an important role in the coastal ecosystem. The west-draining Orange River catchment which forms the southern border of the Karas region carries little water and groundwater is very scarce in both regions. Whilst vegetation is generally dominated by shrubs as in most semi-deserts, there are only very small pockets of medium soil fertility in the southern regions, with the rest of the soils too poor to be suitable for cropping. Rural production is therefore dominated by raising small stock such as goats and sheep (Mendelsohn, 2006).

In the Karas and Hardap regions title deed land dominates (Figure 2.9). More than 214,000 km² or 77% of farm land in these regions is being farmed by approximately 2,000 land owners on freehold farms ranging in size from 7,000 to 15,000 hectares. Another 61,000 km² (23% of farm land) belongs to open access communal land in the so-called Bondelswarts, Hoachanas and Warmbad reserves and the former Namaland in Hardap and Karas, which is farmed by approximately 6,300 households. The rangelands carrying capacity is, at best, a third of Caprivi's and as livestock production is the major livelihood source for the majority of rural people in the region, rangelands are perpetually overstocked, especially around water points (Mendelsohn, 2006). In addition to cattle farming, large scale irrigated farming (grapes, dates etc.) occurs along the Orange River, whilst scenic beauty in catchments of the Fish and Orange rivers has lead to an increase in tourism activity over the past few decades.

Vulnerability to climate change in the Karas and Hardap regions is expected to be determined by the impact of trends in drying on the western side of the sub-continent, which will likely result in more frequent droughts, higher variability of already very limited rainfall, generally longer dry spell duration and an expected decrease in run-off and perennial drainage –also affecting the Orange River. The question is therefore how the population will adapt to the even drier future conditions.

5.3.2 DEMOGRAPHY AND POPULATION GROWTH

In 2001, the population of Caprivi comprised 79,826 persons (NPC, 2003). Nearly 70,000 persons were living in the Karas (69,329) and Hardap regions (68,249). Whilst in the Caprivi and Hardap regions the majority of the population in 2001 was predominantly rural (67% and 72%, respectively), only 46% of the population of Karas was classified as rural; more than half of the population of this region lives in medium sized towns such as Keetmanshoop, Aussenkehr, Rosh Pinah and Lüderitz (NPC, 2003).

When comparing the life expectancy between the Caprivi and Karas region two near extremes in Namibian demographics are visible, mostly due to the Caprivi region having the highest HIV/AIDS infection rate in the country. Life expectancy is, however, expected to improve towards 2031 across the board, although it is likely to remain lower in the Caprivi region than in the other regions. Fertility rates in the three regions are lower than the national average, however more strongly so in the Karas region. By 2031 fertility rates are expected to have dropped substantially in all three regions.

The projected increase in population until 2031 (see Table 2.45) may exacerbate the climate vulnerability of livelihoods and ecosystems, particularly in the more densely populated communal areas in the north-central regions and the Kavango and Caprivi regions. In 2001 the six northern regions altogether accounted for 58% of the Namibian population. Expected growth rates towards 2031 range from 21% to 58% for the north-central regions and Caprivi, whilst the population of Kavango will more than double. This implies increased pressure on ecosystems in regions where there is already evidence of land degradation, related to a combination of relatively high population and stock densities and limited implementation of sustainable land management practices. On the other hand, the populations in the dry southern regions (Hardap and Karas) will only increase by 13.5% between 2001 to 2031, representing an annual growth rate of less than 0.5 percent (Table 2.45).

Although little information is available about internal migration, Namibia is experiencing relatively high out-migration rates particularly from the south and north-east. The rate of urbanisation is expected to increase, as land degradation and constrained access to productive resources will force people to seek opportunities to make a living elsewhere. This will reduce the impact of population growth in rural areas but bring immense challenges for the few Namibian urban centers. Demand for serviced land and water supply and sanitation services is likely to increase in urban centres and this has implications for the institutional capacity that is required to provide adequate services. At the same time it is not guaranteed that the vulnerability of the migrating population is reduced, unless more employment opportunities are created.

5.3.3 FACTORS DETERMINING VULNERABILITY

Namibia's vulnerability and adaptation assessment indicates that poor and rural populations of Namibia are the most vulnerable to climate change because rural populations are extremely reliant on natural resources. In a marginal environment such as Namibia's, farming and other land-based livelihoods are heavily dependent on the climate, and predicted higher temperatures, along with more variability in the rainfall, suggest severe strains on rural existence both in the north and the south of the country. However, there are considerable regional differences. In the Caprivi region relatively more people depend on the natural environment for a livelihood than in the south (Figure 5.13), and the impact of poverty and HIV/AIDS may reverse relatively favourable environmental conditions. Moreover, there are additional risks for those who are living in the flood plain (Caprivi), especially since communities seem to lose traditional adaptation strategies with the establishment of government infrastructure in the flood plain.

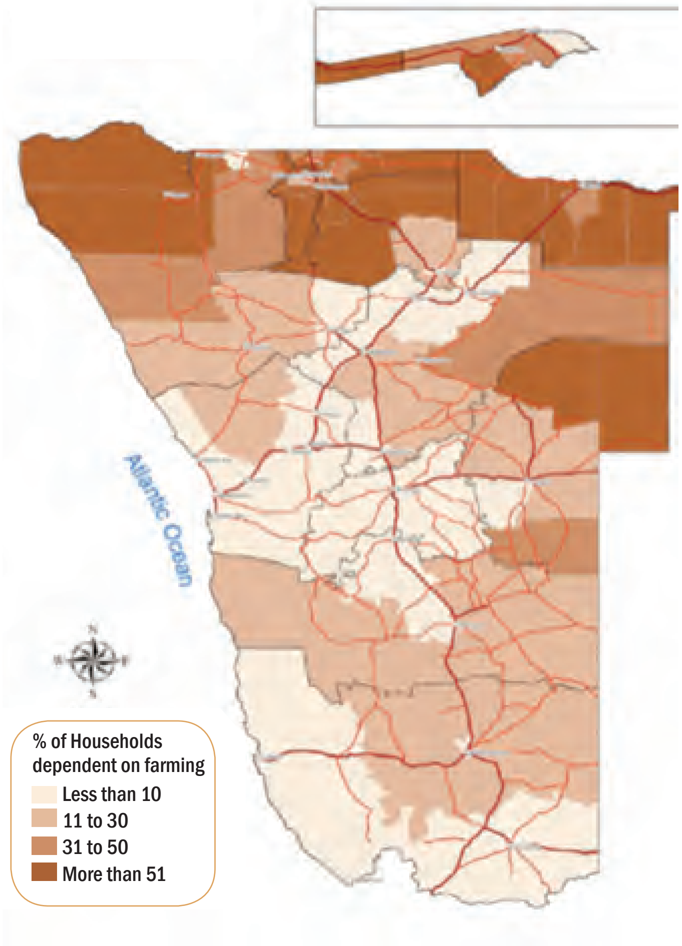


Figure 5.13: Households dependent on farming as main source of income.
Source: University of Namibia (2008)

Poverty, lack of income and lack of employment opportunities greatly exacerbate the vulnerability of households, because these factors substantially constrain access to productive resources, with negative consequences in terms of food security for those concerned. It also hampers the capacity of households and communities to recover from recurrent shocks. It should be acknowledged however, that this vulnerability to climate change differs for various socio-economic groups in Namibia. Access to capital, land, labor and other factors of production as well as the possibility to pursue off-farm employment and other diversification strategies are very different for various groups in society e.g. commercial farmers, emerging farmers, and elder people in the rural areas, female headed households or full-time vs. part time farmers. Their respective buffering capacity to deal with climatic shocks differs markedly. There are also regional differences. Communities in the e.g. the Karas and Hardap regions seem to be somewhat less vulnerable than those in the Caprivi, as more people have access employment, which is reflected in the per capita income and the lower incidence of poverty of the respective regions.

In any discussion on vulnerability the impact of HIV/AIDS cannot be neglected. Although the impact of the pandemic is felt in households across the country, the situation in the certain regions (i.e. Hardap and Karas) is relatively more favourable as compared to e.g. the Caprivi region, where the loss of people in the productive ages due to the pandemic has substantially decreased life expectancy and increased the number of dependents and orphans that households have to support (see Figures 2.15). This puts a strain on rural production and productivity, as well as on financial resources, people and support networks and thus exacerbates the vulnerability of the population, in some regions more strongly than in others. The latter also seems to be reflected in the Human Poverty Index (HPI) for the country and Caprivi in particular (UNDP, 2007).

Given the constrained access to productive resources amongst, the level of poverty and the impact of HIV/AIDS on society, it is a further matter of concern that the capacity for social organization and support in communities in various regions of the country appears to be dwindling. According to the Participatory Poverty Assessments (PPA), community based organisations are often non-existent in rural areas or not very strong. Accounts of lack of cooperation, jealousy, lack of information sharing and miscommunication between factions in communities and between communities, their elected representatives and service providers during the PPA were numerous. Therefore questions need to be raised about the capacity (and interest) of communities and service providers to address vulnerability under prevailing climatic conditions, let alone to deal with the added stress of climate change.

In relation to matters of capacity, it is furthermore indicative that in many regions of the country the youth are considered a vulnerable group, due to the high drop-out and failure rates in the education system. The national pass rates for the Grade 10 certificate underscore that considerable efforts need to be undertaken to realise a knowledge-based economy. As there are substantial regional differences in educational attainment, one's origin seems to affect future opportunities to obtain employment or to move out of subsistence oriented livelihoods. As educational attainment affects the general level of skills and knowledge in communities, the above further suggests that the organizational and adaptive capacity are likely to be constrained in the longer term in various parts of the country.

High rainfall dependency and prevailing natural vulnerability should have led to an inherent greater resilience and preparedness for climate related shocks. The various issues presented in this chapter however underline that the vulnerability and adaptive capacity in Namibia are exacerbated by a number of factors, such as population growth, lack of access to productive resources, poverty and HIV/AIDS, lack of social cooperation/cohesion and the limited educational attainment. In general, given current population densities, population growth projections and land degradation currently experienced in north-central regions, these regions will remain particularly vulnerable to climate variability and change. The interplay of various socio-economic and environmental factors is however regionally specific. This means that the certain regions have become more vulnerable than others, even though the local environmental conditions appear more favourable at first sight. The Caprivi region – as compared to Karas and Hardap- seems to provide an example of this. High levels of poverty (43%) and a high HIV-prevalence rate have exacerbated vulnerabilities in the region. At the same time, as in many other regions, a limited degree of social organization, limited feedback between communities and service providers, low levels of educational attainment and limited perspectives for the youth further hamper the adaptive capacity in the region.

It is common among rural communities and households that women play a vital role in securing food and income through participation in food collection activities, cropping and livestock farming. In Caprivi female-headed households are relatively more important than compared to the Karas and Hardap regions. In times where gender inequity plays a role in access to productive resources and income, this adds another dimension to vulnerability amongst small-scale farmers in the Caprivi region. Whilst –at national level- more than half of the male headed households in Namibia (53%) can rely on salaries and wages as their main source of income, this only applies to 36.6% of female-headed households in Namibia. In comparison with male headed households, relatively more female headed households depend primarily on subsistence farming as their main source of income (25.5% and 33.7% respectively) (NPC, 2006a). The PPA in various regions of Namibia revealed that having access to a salaried job has positive implications in terms of access to productive farming resources for rural households, as a proportion of cash income can be invested in productive means.

5.4 WETLANDS AND WATER RESOURCES

5.4.1 IMPACT AND VULNERABILITY OF WETLANDS AND WATER RESOURCES

Namibia is a water scarce country where potential evaporation exceeds precipitation, and where the impact of human activities on water resources is significant (DRFN, 2008). Even without human influence, climate variability and climate change will bring about added stress to Namibia's water resources and wetlands. The projected temperature increases of between 1 and 4°C will lead to increases in evaporation and evapotranspiration in the range of 5-15% (Table 5.2). This will result in even less water being available for recharge and surface storage e.g. for urban areas and farm dams. Increased evaporation will decrease the length of inundation of seasonally flooded wetlands, and may lead to increased salt content of pans and pools. Increased temperatures will also lead to increased transpiration from plants, which will result in more groundwater and surface water being used by plants. The overall effect of this will be reduced size and productivity of many wetlands. Ephemeral rivers are dependent on sporadic floods not only for groundwater recharge but for recruitment of young trees before their roots reach the groundwater. Decreasing frequencies of floods threaten to disrupt this, resulting in less recruitment of riverine vegetation.

Changes in rainfall patterns over Namibia, Zambia and Angola will affect runoff and drainage in perennial rivers in northern Namibia (Table 5.3). A reduction of 10-20% in rainfall by 2045-2065 over the catchments of the Zambezi, Kavango, Cuvelai and Kunene rivers is expected to lead to a reduction in annual runoff and perennial drainage in these river systems by +/- 25% (De Wit and Stankiewicz, 2006). This would reduce the area of flood plains inundated each year in northern Namibia. Smaller and shallower flood plains would dry out earlier, which could disrupt agricultural systems in northern Namibia, presently depending on surface water.

The wetlands least likely to be adversely affected are those perennial river systems in the north-east that are dependent on higher rainfall outside of Namibia and whose flow is not restricted by impoundments. Those most likely to be affected are the Kunene River, the Cuvelai system, the westward flowing ephemeral rivers and numerous seeps and springs. A decrease of 20-30% in the Kunene, if coupled with increased extraction of water to meet increasing water demands in central northern Namibia could have a negative effect on this river system. The mouth of the Kunene River may be affected, with possibly serious implications for its qualifications as a Ramsar site.

The Cuvelai wetlands (the oshanas) are recharged partly by local rainfall and partly by run-off from rainfall in Angola. With both decreasing run-off and rainfall there could be serious impacts on these wetlands. Smaller areas will be inundated, and increased summer temperatures would lead to increased evaporation and possible increased salt content in the oshanas. The Okavango delta downstream of Namibia in Botswana may be strongly affected in similar ways, as a result of which it may potentially shift to a seasonal river, with disastrous consequences for the ecology of the delta and its associated lucrative tourism.

Overall, these impacts lead to reduced productivity of floodplains and floodplain lakes, amongst others characterised by disrupted breeding/growth cycles of invertebrates, fish and flora, as well as reduced ecosystem services such as water retention, flood attenuation and water purification. On the positive side, with reductions in drainage of major river systems, one may expect a reduction in flood damages.

Reduced ecosystem services may negatively affect rural livelihoods and tourism. For example, Etosha Pan could also be seriously affected, since it is dependent on really big flood events to fill with water from the Cuvelai system. Decreases in rainfall and runoff and increases in evaporation will have a marked effect on the pan and its associated wildlife. The effect of climate change could be compounded by increased abstraction of groundwater from surrounding aquifers, thus impacting seeps and waterholes. The combined effect of predicted climate change and increased abstraction would in turn have a large impact on tourism to the area.

The vulnerability of water resources in the interior and the south (Table 5.4) is determined by both changes in total annual rainfall and summer rainfall, and by changes in winter rainfall, which is projected to decrease in the winter rainfall area of the south-west. This is expected to have a detrimental effect on the terrestrial ecosystems, but will not affect the only large wetland there, namely the Orange River Mouth, since this is fed from runoff from further east. There are, however, many much smaller ephemeral desert pools that rely entirely on what little rain there is, to come alive intermittently. The very special desert adapted aquatic invertebrates supported by these pools are little studied and may well prove important in terms of biodiversity. Any reduction in the already very low rainfall of often less than 20mm will have serious consequences to the animals dependent on the little freshwater available.

The Orange River Basin is one of the driest in southern Africa (Beekman et al., 2005), with high water stress indicator values, due to overabstraction of water (Eales et al 1996). A decrease in rainfall upstream in South Africa, as predicted by De Wit and Stankiewicz (2006), could affect the amount of water released from the numerous impoundments upstream, with serious effects downstream along Namibia's southern border, especially at the already stressed RAMSAR site at the mouth.

Table 5.2: Overview of climate change vulnerabilities for Namibia's water resources: temperature, evaporation, rainfall and perennial drainage. *Source: DRFN (2008)*

Climatic issue	Model agreement	Direction of change	Primary impact	Secondary impacts
Temperature increase	Yes	► Warming: (increases of between 1°C and 3.5°C in summer, and 1°C to 4°C in winter) ► Hottest days become more frequent (observations across weather stations in Namibia)	Increased evaporation and evapotranspiration (increase of 5% - 15%)	Flood plains, oshanas and pans dry out sooner. Shorter life cycles for fauna and flora, causing reduced productivity of wetlands
				Increase in salt content of pans and pools
				Increased water usage by people, animals and plants
				Higher crop water demands reduces dryland cropping potential
				Less water available for runoff
				Lower water table in ephemeral rivers with negative impacts on water levels in springs, wells and waterholes. Affects riparian vegetation, animals and people.
Rainfall / perennial drainage	Models do not always agree: ► Information from GCMs for Southern Africa not always in line with downscaled modelling for Namibia ► Rainfall modelling for Namibia is merely conclusive for central and north-eastern regions	Observed historic trends depict: ► Increase in the duration of the dry season ► Shortening of the rainy season ► Decrease in the number of consecutive wet days Projections for the future vary: ► Global models predominantly suggest drying in Namibia as over Southern Africa (10-20% less rainfall); Downscaled models predict: ► An increase in late summer rainfall over central and north-eastern regions for mid-century ► Drying trend in the south-west	For the north: ► Reduction in runoff and drainage of perennial rivers by +/- 25% (2045-2065)	General impacts: ► Smaller area of flood plains inundated, drying out sooner ► Disruption of seasonal breeding cycles of invertebrates, fish and flora ► Reduced productivity of flood plains and floodplain lakes

Climatic issue: Rainfall / perennial drainage			
Model agreement	**Direction of change**	**Primary impact**	**Secondary impacts**
Models do not always agree: ► Information from GCMs for Southern Africa not always in line with downscaled modelling for Namibia ► Rainfall modelling for Namibia is merely conclusive for central and north-eastern regions	Observed historic trends depict: ► Increase in the duration of the dry season ► Shortening of the rainy season ► Decrease in the number of consecutive wet days Projections for the future vary: ► Global models predominantly suggest drying in Namibia as over Southern Africa (10-20% less rainfall); Downscaled models predict: ► An increase in late summer rainfall over central and north-eastern regions for mid-century ► Drying trend in the south-west	25% reduction in drainage	**Kunene:** ► Reduced flow, increased salinity and closing of the mouth, with negative influence on fauna and flora and the potential as a Ramsar site ► Added stressor: increasing human demand for water for Angola and the interbasin supply in the central north
		25% reduction in drainage	**Cuvelai:** ► Reduction of productivity of oshanas, affecting livelihoods ► Reduction of flood related damages ► Increased salinity of water
		25% reduction in drainage	**Etosha:** ► Less frequent efundja recharge of Etosha Pan
		25% reduction in drainage	**Caprivi:** ► Reduction of water retention in marshes ► Duration of river flow and extent of flooding may be reduced ► Lake Liambezi likely to be dry for longer periods ► Reduced productivity of flood plain, affecting rural livelihoods ► Low flow of Zambezi could affect flooding in Chobe, with negative impacts on tourism ► Ecosystem services (water purification, flood attenuation) seriously affected ► Negative impact on lifecycle of killifish in rainwater pools
		25% reduction in drainage	**Okavango Delta:** ► Potential shift to a seasonal river

Table 5.3: Overview of climate change vulnerabilities for water resources: impacts of changes in rainfall, runoff and drainage in Namibia's northern regions. *Source: DRFN (2008)*

The ephemeral rivers of southern Namibia flow mainly as a direct response to surface runoff. There is little to no delayed surface or subsurface runoff and definitely no baseflow. For most of the year ephemeral rivers are dry, flowing only briefly with characteristic 'flash floods' when enough rain has fallen over their catchments. Thus it is important to understand the impacts of climate change on runoff and river flow in Namibia's ephemeral basins. For the Vulnerability and Adaptation Assessment (DRFN, 2008), rainfall-runoff modelling for catchments of the Hardap and Naute dams in the Fish River Basin was undertaken in collaboration with the Department of Water Affairs. Attempts were further made to assess impacts on safe dam yields.

The Fish River is the most important southward flowing ephemeral river, which, together with its tributaries, drains a large part of southern Namibia into the Orange River. There are two state dams on this system in Namibia. Hardap is the largest impoundment in Namibia which provides water to the town of Mariental and to an irrigation scheme downstream of the dam. Naute is a smaller dam on the Löwen River, a tributary of the Fish downstream of Hardap, that provides water to Keetmanshoop and to a date plantation. The Fish River Canyon in the lower reaches of the river falls within a national park, and is a popular tourist destination, including a hiking trail.

To assess the impact of changes in rainfall on runoff in Namibia, the Namibian Rainfall/Runoff Model (NAMROM) was applied as Namibia is a semi-arid to arid county and its runoff is characterized by a negative serial seasonal correlation (De Bruine et al., 1993). This means that the model purposefully takes rainfall in previous seasons into account, because good rainfall in the earlier seasons increases vegetation cover to such an extent that the runoff potential is actually reduced. The opposite also applies. As this feature is not integrated in most commonly used rainfall/runoff models, NAMROM was developed and gradually modified during the 1990s by McKenzie and Grobler (1992), Mostert et al. (1993) and DWA (Republic of Namibia, 1998).

Table 5.4: Overview of climate vulnerability for water resources: impacts of changes in rainfall, runoff and drainage in Namibia's southern regions. *Source: DRFN (2008)v*

Climatic issue	**Model agreement**	**Direction of change**	**Primary impact**	**Secondary impacts**
Rainfall / runoff	Rainfall-runoff models for southern Namibia do not agree on direction or magnitude of change	**For the south:** Majority of downscaled models predict an increase in total rainfall for 2080-2100 (modelled data only available for the south of Namibia)	**For the south:** **Hardap catchment:** Only half of the models substantiate increased runoff **Naute catchment:** Increased runoff according to 2/3 of models	**Dam yield:** ► Mixed signals for impact on 95% safe dam yield for Hardap ► Increase for safe dam yield for Naute for majority of models
		10% reduction in rainfall over highlands in SA that feed the Orange River	25% reduction in flow of Orange River	Mouth of Orange River may close; negative consequences for the Ramsar site

The NAMROM model was applied to six downscaled rainfall scenarios for a future period comprising 20 or 30 years between 2070 and 2100. CSAG provided the downscaled daily rainfall data for the six GCMs for the locations of Mariental and Keetmanshoop.

The majority of downscaled GCMs indicate that annual rainfall in the period 2080-2100 will increase in both the Hardap and Naute catchments, with the most likely increases in the late summer months (DRFN, 2008), which could lead to increases in runoff with positive effects for sustainable dam yields in the Fish River catchment. Possible increases in runoff into the Naute dam, and safe dam yields, would be beneficial for tourism, water supply to Keetmanshoop, crop irrigation, and downstream ecosystems. Signals are, however, less clear for runoff and dam yields in the sub-catchment of the Hardap dam, which services downstream users such as farmers, tourist lodges, and hikers in the Fish River Canyon. The results must, however, be interpreted carefully and further research may be required to better understand rainfall-runoff relationships under climate change.

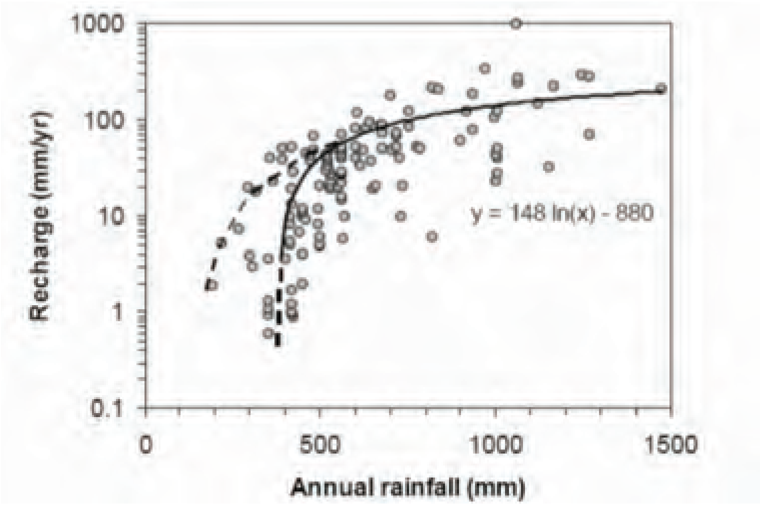
Increased temperatures in the southern regions will seriously affect the lifespan of ephemeral pans, as well as the rate of evaporation from dams. It will also increase transpiration of riparian vegetation, which will have an effect on groundwater.

5.4.2 IMPACT AND VULNERABOLITY OF GROUNDWATER

Although there is a strong correlation between rainfall and groundwater recharge, recharge to groundwater systems is determined by numerous factors and is difficult to measure (Christelis and Struckmeier, 2001). Groundwater systems also respond more slowly to climate change than surface water systems as they have a longer lag time than surface water systems. Due to all these uncertainties, it is difficult to make general statements about the vulnerability of groundwater systems to climate change, and the following synthesis is of a very preliminary nature.

Figure 5.14 illustrates what would happen to groundwater recharge in a location that currently receives about 500 mm rainfall per year, in a scenario that projects a decrease of mean annual rainfall, possibly by as much as 20%, i.e. to 400 mm (Cave et al., 2003). Under current conditions, about 40 mm/year of recharge should reach the local aquifer, but following this scenario by 2055 this would be substantially reduced to well below 10 mm per year. The figure further shows that groundwater recharge becomes negligible for rainfall lower than about 400 mm/yr, thereby possibly neglecting information of recharge of alluvial aquifers in ephemeral basins such as the Kuiseb River.

Figure 5.14: The relation between rainfall and groundwater recharge for Southern Africa. *Source: Cave et al. (2003)*



Higher evaporative losses can lead to decreased run-off and reduced recharging of the groundwater. A global assessment of the impacts of climate change on groundwater resources, based on basic rainfall / recharge relationships (Kundzewicz et al., 2007) suggests that groundwater recharge in south-western Africa may suffer a reduction of between 30% (HADCM3 simulation, A2 and B2 emission scenarios) and 70% (ECHAM4 simulation, both scenarios) across Namibia (Table 5.5). A potential exception could be found in the recharge of alluvial aquifers that have their origins in central areas of Namibia, where more late summer convective rainfall is projected by mid-21st century (a trend already observed), leading to slightly increased frequency and duration of floods in ephemeral rivers and thus recharge.

Table 5.5: Overview of the vulnerability of water resources to climate change: impacts of changes in rainfall on groundwater recharge and non-climatic stressors. *Source: DRFN (2008)*

Climatic issue	Model agreement	Direction of change	Primary impact	Secondary impacts
Rainfall / groundwater recharge	Global models agree on direction of change, not on magnitude. (Only limited amount of work has been undertaken so far)		Reduction in recharge of 30-70%	► Increase in pumping costs and reduced potential for boreholes critical to livestock production and management ► Lower water table in alluvial aquifers with negative impacts on water levels in springs, wells and waterholes. Affects riparian vegetation, animals and people.
CO_2	Yes	Shift in dominant vegetation type from grassy savanna to arid and semi-arid shrubland	Increase in bush encroachment in north-eastern quadrant of Namibia	Negative impact on groundwater recharge
Non-climatic stressors (crosscutting):				
Population growth and economic development: water demand will surpass currently installed abstraction capacity between 2015 and 2020				
► Expected increase in demand for water in the mining sector ► A considerable increase in demand for water in irrigated agriculture				
► Insufficient water demand management in small and medium sized towns and villages; ► Tariff setting insufficiently focused on 'conservation tariffs' and matters of equity				
► IWRM / Basin Management not implemented in all basins (committees not yet operational) ► Poverty reduces the capacity and willingness to pay for scarce resources				

A lowering of the groundwater table will decrease available water for the vegetation and is likely to result in die-off of some vegetation. The cost of water supply on Namibian farms is already high and increasing depth to the water table will not only result in higher fixed costs for drilling but also increase the cost of pumping the water.

5.4.3 FUTURE WATER SUPPLY AND DEMAND

Any adverse change to the aquatic systems will usually be compounded and exacerbated by human impact. It is predicted, even without the additional stresses of climate change on the water resources, that demand will have surpassed the installed abstraction capacity by 2015, due to population growth and economic development. In fact a doubling of the demand for water is expected in the next 10 years, mostly due to increased irrigation requirements, even though water productivity in irrigated agriculture is considerably lower than in other sectors. In relation to changes in global economic development, the mining sector may also experience growth that leads to further increases in demand for water, not foreseen earlier.

5.4.4 ADAPTATION IN THE WATER RESOURCES SECTOR

Namibia aims to address its increasing water scarcity through both supply- and demand-side interventions within a framework of Integrated Water Resources Management (IWRM), by involving all stakeholders and affected economic sectors. Since current climate variability and future increases in variability are the greatest threat to water availability in Namibia, adaptation responses should draw on its experience in innovative mechanisms to address water scarcity and expand implementation of such approaches countrywide and at all times. 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.

T**he conjunctive use of surface and groundwater resources** [using these together to minimise evaporative losses] has been explored and implemented in some areas, and should be further developed. Namibia is seen as a leader in Africa in this approach. For example, artificial recharge of alluvial aquifers can be done by collecting water in a reservoir upstream of an aquifer, resulting in the collected water recharging the aquifer. Groundwater resources can be used as a reserve or back-up, while surface water is used at a faster rate to reduce evaporation losses.

Water banking or managed artificial recharge, which has been tested in the Windhoek aquifer, is another example of conjunctive water use. Surface water from the Von Bach Dam is purified in a water treatment plant and stored underground in the Windhoek aquifer, which lowers evaporation and overflow losses at the dam. The stored underground water can be extracted in years that the surface water sources (the three dams providing Windhoek with water) cannot provide enough water. Also, the pumping of water immediately out of the shallow Omatako Dam into the deeper Von Bach Dam, where evaporation is reduced, improves the efficiency of the supply sources.

Improvement of **water demand management** (WDM) practices, especially addressing the effectiveness of water management in local authorities, will become necessary.

Namibia's methods for implementation of WDM are (Heyns et al., 1998):

- A clear demand management policy and implementation strategy based on sound economic and social principles
- Good water supply operational practices by authorities
- Effective use of water by all consumers
- Maximise water re-use
- Public awareness
- Pricing policy
- Legislation
- Incentives for retrofitting
- Water efficient devices

It has been estimated that the introduction of WDM in towns and settlements in Central South Water Supply Area (CSWSA) can reduce current and future (2030) demand by approximately 25% (NamWater, 2007). The report further suggests that investment in expansion and upgrading of physical infrastructure can be delayed when WDM measures are introduced.

Demand management is also required in the agricultural, industrial, mining and tourism sectors. Livestock numbers and their water demand should be closely monitored. In view of reduced drainage in perennial rivers the sustainability of large irrigation projects that use large amounts of water must be reviewed. Alternatively resources should be allocated to introduce more efficient irrigation techniques such as drip irrigation and crops that add more economic value. During 2008 the mining sector used approximately 9.1 Mm^3 which represents 2.8% of the total water requirement. The expected water requirement will increase to 13.8 Mm^3 which represents only 1.8% of the total expected water requirements in 2030. It appears that mines are able to exploit economies of scale in water saving techniques, such as large scale recycling. Water use in the tourism sector is expected to increase significantly, and demand management needs to focus on sensitizing staff and tourism operators on water use efficiency.

With the uncertainties involved in climate change predictions for Namibia, WDM makes sense as a “no regrets” type of investment. Although WDM is not a substitute for supply augmentation in a developing country such as Namibia, it can contribute to cost savings by deferring the capital infrastructure expenditure and reducing operational costs.

With increased impoundment of ephemeral rivers and groundwater abstraction in response to rising demand and expected reductions in surface water availability, it is furthermore essential to **monitor and control groundwater use more strictly** across the country to ensure sustainable management of this resource. Ecosystem services in ephemeral rivers could further be supported by releasing water from dams to allow sufficient recharge to sustain the riparian vegetation. In addition it would be relevant to monitor the condition of riparian woodlands and to introduce measures to prevent the loss of woodlands.

Policy and legal framework: The government of Namibia considers Integrated Water Resources Management (IWRM) as an important tool for ensuring sustainable use of water resources, and IWRM is strongly supported by the water sector policy framework. Regulations for the water sector are being developed in parallel to the process of reviewing the draft Water Resources Management Act. The Ministry of Agriculture Water and Forestry currently also oversees a process of developing an IWRM Plan for Namibia. It is intended that the plan will be formulated taking into account the predicted impacts of climate change. As such the water sector provides an enabling environment for IWRM; however the delay in finalisation of the Water Act slows down the implementation of the good intentions in the policies. It is therefore recommended that priority be given to finalise the Act.

Stakeholder engagement: Within the IWRM concept the basin is considered the key entity at which the management of natural resources can be discussed and negotiated between stakeholders. The approach actively supports the decentralisation of management functions to basin management committees. In this regard Namibia is divided into 11 river basins and the Ministry is in the process of establishing basin management committees. The Basin Management Approach may assist in raising awareness of the vulnerability to climate change amongst communities, but more resources and capacity building are required to gain experience with the approach. Responsibilities of basin management committees vis a vis large institutional stakeholders need to be clarified in order to ensure that water managers can address the challenges faced by climate variability and climate change.

The implementation of basin management in Namibia has turned out to be a slow process, with only three of 11 identified basins having established basin management committees and efforts are ongoing in 3 other basins (DRFN, 2009). The slow process is attributed mainly to the lack of a legal framework for the committees (commencement of the Act) and limited technical and financial capacity at the various levels. Policy makers and implementers should focus on strengthening the capacity of stakeholders to participate meaningfully in IWRM initiatives.

5.5 AGRICULTURAL SECTOR

The following reports prepared for the SNC were used for this section: Climate Change Vulnerability and Adaptation Assessment (DRFN, 2008) and Research on Farming Systems Change to Enable Adaptation to Climate Change (University of Namibia, 2008). Farming in an arid country such as Namibia is a challenge at the best of times, and even more so if the sector is to contribute directly to the GDP and not only act as a social safety net. Resource poor farmers who depend for the most part on primary resources will find it difficult to deal with increasing climatic constraints. Projected climate change-driven impacts on agricultural production, and thus food availability and supply, are given prominence in the draft National Climate Change Policy (Republic of Namibia, 2010a).

5.5.1 IMPACT AND VULNERABILITY OF CROP PRODUCTION

As part of the Climate Change Vulnerability and Adaptation Assessment (DRFN, 2008), the vulnerability of crop production was assessed for the Rundu and Grootfontein regions, using a biophysical modelling approach, with a focus on the effects on yields and planting windows. Unfortunately, there is a discontinuity in climate information available to inform such studies in the present (using observed climate) and for the far future (GCM or downscaled projections). This study was based on good quality data, but not many stations have the required lengths or completeness of data required for training the downscaled models, and subsequently neither for crop modelling. In addition, crop models have their own shortcomings.

Correlations between the observed climate trends, related to maize production, and model projections could not be found, e.g. projected planting windows for the Rundu region indicate an earlier start to planting, contradicting the observed trends of later planting. Similarly, the projected extended planting windows into March for millet production in Grootfontein are in conflict with the observed trend, which indicates earlier cessation. It should be noted that in these cases none of the observed trends were statistically significant. In the simulations Rundu yielded inconclusive results throughout; simulations for maize and millet for the Grootfontein region project better cropping conditions around the middle of the century. The results from the crop modelling highlighted many uncertainties and gaps in the models, which require further research.

Although the cereal sub-sector makes a minor contribution to total agricultural economic output, it is important in terms of its contributions to food security and export earnings. This sector is sensitive to climate variability and change, and yield tends to oscillate accordingly. The areas planted vary over time and this may present statistical problems in portraying impacts.

The periodic fall in cereal outputs due to drought or floods create cereal deficits, which increases cereal imports and prices. Market distortions make determining impacts on secondary markets such as millers difficult, while extreme occurrence of drought and floods puts tremendous pressure on the government budget and reliance on external sources. With climate change, these occurrences are expected to be frequent thus necessitating huge budget appropriations for the national drought relief programme /fund.

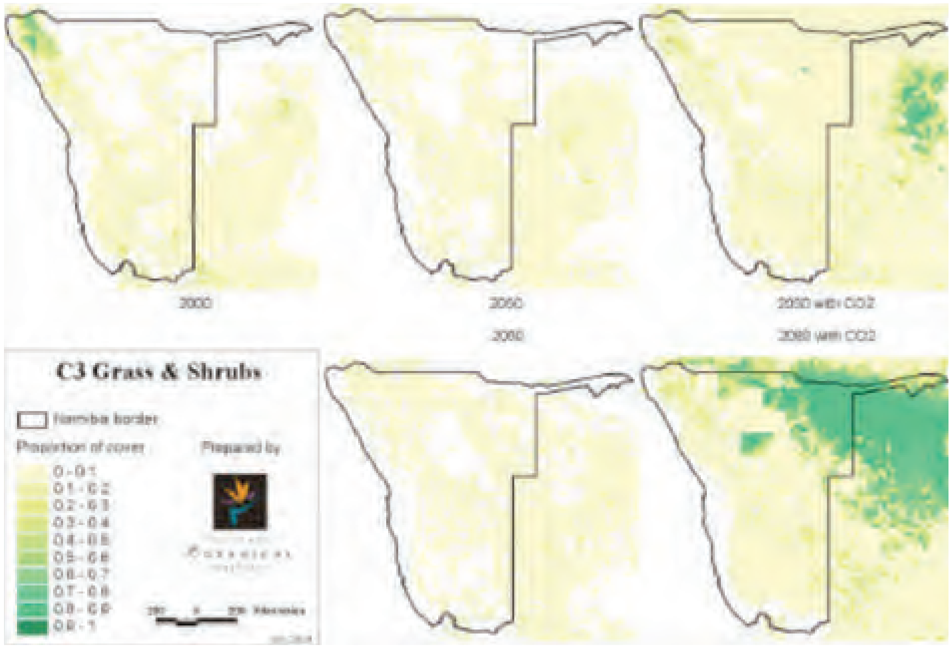


Figure 5.15: C_3 Grass and shrub cover in 2000, 2050 and 2080 (with and without CO_2). *Source: Midgley et al. (2005)*

5.5.1.1 The Green Scheme

The Green Scheme (GS) aims to encourage the development of agronomic production and enhance the contribution of agriculture to GDP, stimulate private sector investment, combat poverty and achieve social development of communities within suitable irrigation areas. The potential of irrigation is based on current water resources, but biophysical and socioeconomic limitations may emerge under a future changing climate. The Scheme aims to add some 27 000 ha of irrigated land to the current areas covering ~ 10 000 ha. The current schemes consume ~ 160 Mm^3 water, which amounts to about half of the nation's average total water demand (Republic of Namibia, 2006). It is envisaged that about 33% of the extended area will be put under vegetable production; ~ 9000 ha requiring ~ 110 Mm^3 water per year. The larger area, 18 000 ha, is likely to be put under grains requiring ~ 180 Mm^3 water per year.

22 000 ha (81%) of the new proposed schemes lies west along the Kavango river, with the remainder spread throughout the country. Under climate change, with a projected decrease in rainfall of 10%, areas with annual rainfall of 500 – 800 mm (most proposed GS sites), may experience reductions in perennial drainage of 30-60%. The schemes are based on 5% abstraction of river flows, but the potential loss in drainage may affect the viability of the scheme.

Whereas irrigation schemes have the great advantage of mitigating against current dry conditions and future drying, the impacts on yields are unclear since they depend on complex interactions between water supply, temperature and rising atmospheric CO_2. Warmer winters would broaden the spectrum of potential winter crops, whilst the risk of plant diseases under irrigation with possibly higher humidity is higher. Increased temperatures will increase water demand.

The envisaged significant increase in irrigated crop production will require considerable investments for both infrastructure and training of farmers, as management expertise needs to be strengthened significantly.

5.5.2 IMPACT AND VULNERABILITY OF LIVESTOCK PRODUCTION

The effect of climate change on the livestock sector is experienced through changes in quality and quantity of vegetation, availability of fodder, heat stress, and the occurrence of climate related animal diseases. Indirectly, these factors impact on livestock productivity parameters such as conception and calving rates, mortality rates and meat quality.

5.5.2.1 Rangelands

Namibia is characterised by major seasonal changes in both composition and quantity of grazing. Climate change is likely to result in a forced expansion of grazing activity into areas of marginal productivity, which places extreme pressures on an already stressed ecosystem. Additionally, significant changes in vegetation structure and function are projected due to climate change, including the fertilisation effects of rising atmospheric CO_2. The dominant vegetation type (Grassy Savanna) may lose its spatial dominance to Desert and Arid Shrubland vegetation types (Midgley et al., 2005). Expansion of novel woody vegetation types in the wetter north-east regions of the country has been projected (Figure 5.15).

Bush encroachment has had a discernible effect on the national cattle herd (in both communal and commercial areas) in the past 40 years, with losses amounting to N$ 700 Million per annum (de Klerk, 2004). Carrying capacity in infested areas is reduced to half or even less of its original value. With the projected climate change-driven increase of this phenomenon in the relatively 'good' agricultural zones in Namibia (the north-eastern part of the country) it becomes a matter of national importance to address this issue, ideally seeking solutions to the benefit of the economy. As such, initiatives which utilise the bush are being identified and actively supported.

As temperatures increase, forest and savanna fires are likely to become more intense and extensive, and may result in significant ecosystem changes that would affect biodiversity in the form of accelerated species loss, or changes in species composition. An average of 43% of Caprivi and 34% of Kavango land are burnt each year over 5 years (Mendelsohn and El Obeid, 2005), while the southern parts only burn land when there is an abundance of dry grass following wetter summers. Changes in the fire and grazing regimes during the past century are thought to have contributed to bush encroachment over large parts of southern Africa. Future

Sector	Nama Karoo	Central Areas	North-eastern areas	North-central areas
Livestock	-100%	-35%	-10%	-15% to -30%
Smallstock	-15% to -50%			
Irrigated crops	20%	-15% to 0%	20%	15%
Dryland crops		-100%	-20%	-50%

Table 5.6: Likely impact of climate change on agricultural production.
Source: Reid et al. (2007)

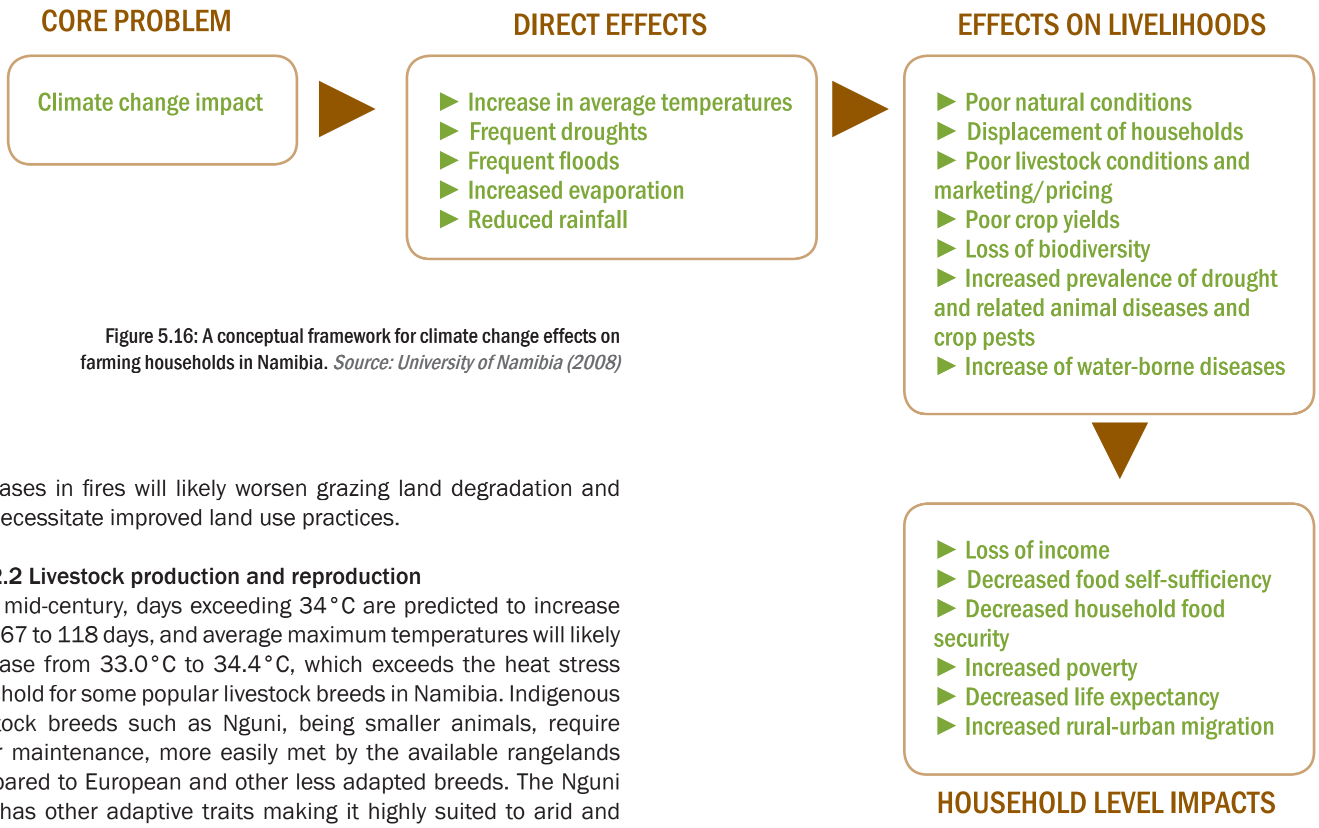


Figure 5.16: A conceptual framework for climate change effects on farming households in Namibia. *Source: University of Namibia (2008)*

increases in fires will likely worsen grazing land degradation and will necessitate improved land use practices.

5.5.2.2 Livestock production and reproduction

By mid-century, days exceeding 34°C are predicted to increase from 67 to 118 days, and average maximum temperatures will likely increase from 33.0°C to 34.4°C, which exceeds the heat stress threshold for some popular livestock breeds in Namibia. Indigenous livestock breeds such as Nguni, being smaller animals, require lower maintenance, more easily met by the available rangelands compared to European and other less adapted breeds. The Nguni also has other adaptive traits making it highly suited to arid and hot environments. Dairy cattle are likely to face severe pressure in extensive systems, and could become unviable if adaptation measures are not implemented.

Reduced pasture availability and quality, and heat stress in sheep is reported to result in changes in ovulation rates, reduced ram fertility, pregnancy toxemia (ewes dying), neo-natal lamb mortality, fewer births, and lower lamb growth rates. Welfare issues in intensive industries such as live sheep exports also become a concern when average and extreme temperatures increase. Karakul sheep are very well adapted to the harsh climatic conditions of the arid and semi-desert areas of southern Namibia. Karakul production is thus less vulnerable compared to many other breeds.

5.5.2.3 Water

Water demand by livestock is strongly related to temperature and is therefore likely to increase as temperatures rise. Reduced water supply and larger distances from water sources can limit production directly through reductions in metabolic rates and feed intake and indirectly by reducing the area grazed through restriction of distance traveled from watering points. Increased grazing pressure near watering points, combined with reductions in rainfall and plant cover, could contribute to land degradation and soil erosion in the sheep producing regions. This process serves to reduce pasture productivity through loss of valuable soil nutrients. Erosion may also be an issue with the suggested increases in extreme daily rainfall events, especially where these follow on dry periods and low vegetation cover.

5.5.2.4 Disease and parasite impact

Warming and changes in rainfall distribution will lead to changes in the spatial or temporal distributions of those livestock diseases sensitive to moisture, such as Anthrax, Blackleg, Dermatophilosis, Haemorrhagic Septicaemia, Haemonchosis and some vector-borne diseases.

5.5.2.5 Market and economic impacts

There is evidence of marginal downward pressure on domestic livestock prices during times of drought (due to increased marketing and deteriorating animal condition) and a slight upward pressure on livestock prices in periods immediately after droughts as supply decreases. In times of drought the export of quality meat cuts decline, leading to Namibia not meeting its quota allocation for meat exports to the European Union (EU), with significant impacts on foreign exchange earnings. The impact of climate change on the dairy sector is expected to be mainly through increased input prices resulting from shortages and greater demand. For example, farmers have to purchase additional fodder to feed their milk cows. Prices of karakul pelts are not very sensitive to drought, but are influenced by other factors such as reduced demand from international consumer markets.

Table 5.7: Overview of vulnerability of the agricultural sector to climate change. *Source: DRFN (2008)*

Climatic issue	Model agreement	Direction of change	Impact
Maximum temperatures	Yes	Warming: (increases of between 1°C and 3.5°C in summer, and 1°C to 4°C in winter) Hottest days become more frequent (observations across weather stations in Namibia)	►Reduced livestock productivity due to heat stress (based on a multitude of physiological responses / thresholds) ► Increased water demand from livestock, thus reduced grazing distances ► Meat quality reduced due to lack of marbling ► Increased grazing pressure around water points leading to increased erosion ► Higher crop water demands reduces dryland cropping potential ► Increased concerns for animal welfare in intensive industries such as live sheep exports ► Possibly higher vector dispersal and pathogen load ► Animals more susceptible to pathogens due, amongst other, a loss of endemic resistance
Minimum temperatures	Yes	Warming (reduced frequencies of days with temperatures below 5°C)	► Reduced small stock mortality due to less severely cold nights ► Increased potential for winter crops (irrigated)
Total rainfall	No: ►Information from GCMs for Southern Africa not always in line with downscaled modelling for Namibia ►Modelling for Namibia is merely conclusive for central and north-eastern regions	► Observed historic trends depict a significant increase in the duration of the dry season, shortening of the rainy season and a decrease in the number of consecutive wet days. ►Projections for the future vary: literature based on GCMs predominantly suggests drying in Namibia as over Southern Africa ►Downscaled models predict an increase in late summer rainfall over central and north-eastern regions for mid-century ► Models predict a drying trend in the south-west of the country ► Downscaled models predict an increase in total rainfall for the late 21st century (data only available for the south of Namibia)	► Shift in dominant vegetation type from grassy savanna to arid and semi-arid shrubland ► Loss in Net Primary Productivity of Namibian rangelands, as well as forage quality ► Later onset in the season reduces planting windows for crops ► Reduced precipitation in catchment areas of perennial rivers can lead to significant losses in drainage density ► Increased competition for natural resources by land users ► Decreases in groundwater recharge projected which increases pumping costs and reduces potential for boreholes critical to livestock production and management in Namibia
Rainfall intensity	Yes: Downscaled predictions are an accepted part of climate change projections for Southern Africa	► Trends in increased rainfall intensity in the central area of Namibia are already observed ► Downscaled models predict increased rainfall intensity for the mid 21st century, associated with late summer convective rainfall and changes in atmospheric circulation, particularly in central and north-eastern regions (excluding the Cuvelai)	► Possibly an increased risk of flooding due to increases in intensity and extreme events ► Effect on run-off, dam yields and groundwater recharge all insecure ► Concentration of rainfall events later in season possibly may allow for easier crop management (i.e. timing) ► Possibly higher load of vectors and pathogens on livestock due to increased humidity at times
Evapotranspiration	Yes	Increased evapotranspiration to be expected due to significant warming	►Increase algal blooms and salt concentrations in water storage facilities ► Higher crop water demands reduces dryland cropping potential
CO_2			► Shift in dominant vegetation type from grassy to arid and semi-arid shrubland ► Projected increase in bush encroachment in north-eastern quadrant of Namibia
Non-climatic stressors (crosscutting)			
Dualism in the agricultural sector makes policy formulation difficult			
Land tenure: lack of collateral in communal areas			
Land tenure: lack of secure tenure rights in communal areas discourages long-term investment and commercialization of agriculture			
Land tenure: high population densities lead to constrained access to fields and grazing areas in northern communal areas			
Limited access to critical inputs in many rural areas hampers agricultural productivity, exacerbated by lack of sustainable land management practices			
Low levels of formal education limit access to off-farm employment and the development of alternative livelihood strategies (e.g. SMEs)			
Limited number of capable institutions in rural areas for advancing, interpreting, communicating and applying knowledge for integrated land and water management in lieu of climate change			
Market requirements regarding frame size (livestock) reduce desirability of indigenous (adapted) breeds			
Unrealistic pressure on agricultural sector to be an economic driver promotes overexploitation of scarce resource base			
Population growth adds to pressure on land and water resources and contributes to conflicts, in particular if high dependence on subsistence agriculture persists			
HIV/AIDS decreases life expectancy and increases morbidity and the number of dependents and orphans that households have to support. This has a negative impact on financial and human resources and labour productivity, with potentially negative impacts for food security			
Capacity for social organization and support in communities in various regions of the country appears to be dwindling			

An economic study by the International Institute for Environment and Development (IIED) predicts a decline of between 1.1% and 3.1% in Namibian GDP, based on a 'best-' and 'worst-case' scenario for the country in the coming 20 years (Reid et al., 2007). The activity share of cereal production is likely to decline by between 8.4% and 17%, livestock production is predicted to decline between 19% and 48.4%, whilst subsistence agriculture is likely to suffer a decline between 33.5% and 74.6%. Commercial crop production, based on expectations resting on the Green Scheme, is suggested to increase by between 10.2% and 1.3%, respectively, for the two scenarios. These simulations give an indication of what would happen to the economy if no adaptation would take place and the full brunt of climate change was felt. These losses are valued at between 1.5% and 3.5% of GDP, with the communal farming sector hardest hit, further contributing to income inequality in Namibia. These results are based, in part, on the likely impact of climate change on agricultural production as in Table 5.6.

5.5.2.6 Vulnerability of farming households

The impact of climate change on farming can be conceptualised within the framework of its impact on household food security and poverty. Understanding the interactions between climate change and poverty is critical to understanding local and global trends of climate change impacts. Such an understanding is, in turn, vital to the development and implementation of effective strategies to mitigate the effects of climate change. Figure 5.16 illustrates a conceptual framework on how climate change affects the farming households in Namibia. While the impact of climate change is felt across all farming communities, being rich or poor, communal or commercial, its impact transcend it more on the poor people living in marginalized areas.

However, livelihood systems in Namibia currently experience a number of interlocking socio-economic stressors, other than climate change and climate variability. These include, for example, human health (sections 2.18 and 5.8), equitable access to land (section 2.5), gender inequality, population growth (sections 2.17 and 5.3.2), and increasing competition for shared resources. In discussing the social impacts of climate change it is important to note that a complex interaction of such stressors affects the social status of Namibians and climate change induced impacts adds only one dimension to this status.

In conclusion to this chapter the following table (Table 5.7) summarises the main issues pertaining to climate change vulnerability in Namibian agriculture, depicting whether there is agreement in the model/literature as to the predicted change, the direction (and magnitude where available) of the change; the impact this will have on the agricultural sector in Namibia; and a summary of non-climatic stressors which influence the vulnerability of particularly rural Namibians in agriculture.

5.5.3 ADAPTATION IN THE AGRICULTURAL SECTOR

The capacity of a farming system to adapt to changing weather and climate conditions is chiefly based on its natural resource endowment and associated economic, social, cultural and political conditions. Namibia's ability to adapt to climate change will be informed by its aridity, environmental sensitivity, population growth trends and high densities in northern areas and internal migration, high dependence on natural resources (particularly agricultural land), widespread poverty amongst some sections of the population, decline in effective traditional land management systems, and lack of access to credit and savings.

5.5.3.1 Technological adaptation

This suite of options can involve increased diversification into drought and/or temperature tolerant species, or improved practices in crop and livestock husbandry and land management. The following adaptation strategies are currently employed in Namibia and should be continued:

- **Irrigation and water harvesting technologies:** these need to be selected to maximize water efficiency and to be accompanied by other crop management practices such as use of crops with high levels of water use efficiency. Irrigation is only suitable along reliable water sources, on suitable soils, and where markets are developed.
- **Conservation agriculture systems:** minimum tillage, crop rotation and the use of soil cover lead to improved soil characteristics, water infiltration and retention. A lower workload mitigates the impacts of rural migration and HIV/AIDS on farm labour.
- **Crop diversification initiatives:** mixing various staple and cash crops provides some hedging against erratic rainfall and shorter seasons, with potential sales of higher value food and non-food crops.
- **Use of improved crop varieties:** if supported by the necessary inputs and specialist advice, this would significantly improve yields; more research is required for better postharvest characteristics, non-traditional crops, and policy/governance and farmer guidelines.
- **Increase seed and fertilizer availability:** Consistent access to quality seed ensures the resilience of the production base, which provides the inherent capacity of a country to respond to, and mitigate the impacts of a disaster. The current agreement with a Cooperative regarding the maintenance of a strategic pearl millet seed reserve is important and must be maintained.
- **Increasing use of protected cultivation and livestock systems (e.g. greenhouses, net houses):** these provide favourable growing conditions but are technologically demanding and expensive. Infrastructural developments can play an important role in de-coupling livestock production from external climatic factors, and hold particular promise in intensive systems (such as dairy, chicken and pork production) but can also mitigate the impact of the worst heat and other extremes in extensive systems.
- **Shared water resource management:** refer to sections on water resource management (section 5.4.4).
- **Early warning systems:** farmers are periodically hit by livestock diseases, drought and crop failure, and then rely on the Government to declare a disaster situation which is a protracted process. Early warning management, contingency and response plans need to be improved.
- **Drought mitigation measures:** These include the financing of emergency assistance through the National Disaster Management Fund, the distribution of input vouchers to affected communal farmers, the maintenance of an emergency seed reserve, the promotion of agricultural technologies and practices for arid environments, and support for household and national level strategic food reserves.
- **Livestock management strategies:** these include the use of fall-back grazing areas (livestock mobility), mixed small stock and large stock herds of various breeds, use of savings and credit mechanisms, the purchase of supplementary feed, intensified animal disease management, and the abstraction of groundwater for livestock when surface water becomes unavailable.

Whilst these strategies deal with current climate variability and shocks, predicted changes in climate for Namibia have additional implications for agricultural productivity. With changes in precipitation and hydrology, temperature, length of growing season and frequency of extreme weather events, considerable efforts would be required to prepare Namibia to deal with future climate-related impacts in agriculture. The following additional adaptation options will be pursued in Namibia:

Crop modelling: Simulation models for predicting crop growth and development as affected by soil and weather conditions, agronomic practices and cultivar traits are attractive tools for crop improvement and management in the face of climate change. The availability of data with the necessary geographic detail, coupled with human resource capacity in modeling, is currently the major limitation rather than the computational capability or basic understanding of crop responses to climate. Capacity building has begun in the use of the Decision Support System for Agrotechnology Transfer (DSSAT) V.4 model as applicable to the current and future Namibian situation. The overall aim of such adaptation is to make the best use of climate as a resource for agriculture by enhancing the capabilities of agriculturalists, agribusiness and organisations to respond to climatic variations and climate change.

Crop germplasm conservation/evaluation and breeding: Improved crop varieties have the potential to enhance yields under erratic rainfall and increase food security. Efforts towards crop improvement thus far have focused on millet, sorghum and various legumes, but indigenous crops and tree species can also play a major role under changing climatic conditions. Pressure on these indigenous resources is increasing the urgency to domesticate and commercialise them, entailing germplasm collection, conservation, evaluation (e.g. with respect to stress tolerance and pest/disease resistance), breeding, and utilisation. The National Plant Genetic Resources Centre (NPGRC) devotes a major effort in this regard, and currently houses 3,010 accessions, representing about 1,140 wild species and 1,870 crops. There exists an urgent need to undertake, purposely and systematically, a greatly increased strategic research effort in this field, and to capacitate research and extension personnel in the relevant agro-ecological zones.

Improvement and conservation of indigenous livestock breeds: Research, characterisation, partial conservation and dissemination of local adaptable, heat tolerant and disease resistant livestock species and breeds is either lacking or requires strengthening. Farmers need technical guidance from professional breeders, and all Livestock Improvement Project activities must mature to be based on sound scientific and economic principles. For example, the Nguni is a low input cattle breed, ideal for production in poor communal areas, and adapted to harsh local environmental conditions. However, owing to its poorer production performance compared to exotic breeds, apparent conflicting messages from industry stakeholders promoting the exotic breeds, and market forces, farmers are pursuing a strategy of exploiting their existing gene pool by crossbreeding with exotics. This is threatening the genetic erosion of the Nguni breed, and thus the government's objectives of conserving and promoting indigenous stock. Thus there is a need to introduce incentives while considering *ex situ* and *in situ* conservation. Infrastructure and facilities at some of the existing research stations have already been improved, while new stations have also been established.

5.5.3.2 Policy framework

Namibia's policy framework for the agricultural sector is well developed, and includes the National Agriculture Policy (1995), the overarching national level Vision 2030 and the Poverty Reduction Strategy (1998), the Drought Policy and Strategy (1997), the National Water Policy (2000), and other policies pertaining to the ownership of land, HIV/AIDS, gender, decentralization, and education. A number of policies that are relevant to climate change are thus in place, and most are considered as of high quality. However, understanding of these policies, as well as subsequent implementation and coordination between sectors and within sectors is often sadly lacking. The newly established Country Pilot Partnership (CPP) Program for sustainable land management provides a practical opportunity to translate policies into practice, as it serves as a vehicle of continuing the momentum gained under the Namibian Program to Combat Desertification (NAPCOD).

5.5.3.3 Institutional/household level behavioural/managerial changes

Adaptation at the farm-level focuses on tactical decisions farmers make in response to seasonal variations in climatic, economic, and other factors. These tactical decisions are influenced by a number of socioeconomic factors that include household characteristics, household resource endowments, access to information (seasonal and long-term climate changes and agricultural production) and availability and access to formal institutions, including input- and output markets. For effective adaptation at this level, perceptions of current and future climate are important, and improved communication and information dissemination should be established to guide behavioural adaptation.

In a context of climate change and increased pressure on local resources there is a major need for improving social organisation and local adaptive capacity, to counteract dwindling social support and increasing conflict in communities. The exchange of information between service providers e.g. researchers, and communities needs to be strengthened, for example through boundary organisations and associated networks. It is important that research is linked to existing local knowledge of climate related hazards and involves local communities in exploring adaptation decision making.

5.6 SEA LEVEL RISE, THE COASTAL ZONE AND FISHERIES

5.6.1 IMPACT AND VULNERABILITY OF THE COASTAL ZONE TO SEA LEVEL RISE

According to CSA, LaquaR and Lithon (2009) (refer to description of the study under section 5.2.3.7), under the short-term climate change scenario (2030), intermittent effects of storm damage and coastal erosion would occur, but with limited damages. However, port activities at Walvis Bay would be extensively disrupted. Total expected financial impacts are estimated at N$ 2.42 billion.

The consequences of the Polar Ice Melt Scenario could be profound. The prime effect of the rapid sea level rise over the longer term future is the permanent inundation of low lying coastal areas, leading to the wholesale disruption of infrastructure and services along the coast. As there will be sufficient warning and time to adapt, it will be important to plan ahead and to put appropriate policies in place. Total expected financial impacts are estimated at N$ 32.2 billion.

The Sea Level Impact Scenario for Walvis Bay (2030): With the sandspit still in place in 2030, enhanced coastal erosion from the sea level rise of 20cm will lead to a likely coastal set-back estimated at almost 100m. Such levels of set-back may well not be acceptable, and so previously unprotected parts of the coastline may need to have new coastal defenses built to prevent erosion close to the town of Walvis Bay itself. With the protection of the

The Black Tern.
Source: CSA, LaquaR and Lithon (2009); identified by Rod Braby, NACOMA

Pelican Point sandspit removed, sea level rise of LLD+2m on an annual basis, and of LLD+3m from extreme sea levels with a return period of 100 years, would inundate much of the town.

A range of coastal responses can be expected for Namibia as a result of sea-level rise (NACOMA, draft): biogeophysical effects such as increasing rates of coastal erosion; increased flooding, inundation and displacement of wetlands and lowlands; impairment of water quality into freshwater aquifers and estuaries due to increased salt intrusion; and reduced protection from extreme storm and flood events.

5.6.1.1 Impacts on property, infrastructure and water resources

Notwithstanding the great deal of uncertainty with regard to the future expansion of urban areas along Namibia's coast, the potential damage and destruction of fixed infrastructure and property due to the sea level rise scenarios was assessed (CSA, LaquaR and Lithon, 2009).

The sea levels under the various scenarios described above were mapped onto existing mapping to establish the level of ingress into what is currently dry land. The inundation maps were used to visually illustrate the sea level rise impacts on the four major Namibian coastal towns (Henties Bay, Swakopmund, Walvis Bay and Lüderitz) that were certain to be influenced by such changes. It was determined that Henties Bay, Swakopmund and especially Lüderitz would only suffer relatively minor impacts. Walvis Bay, however, due to its extremely low elevation is at high risk, compounded by the fact that it is one of Namibia's largest towns having the largest sea port and contributes significantly to the national economy and GDP.

Water was identified as a key concern for all human settlements along the Namibian coast due to dependence on freshwater aquifers (which are already under threat at current sea levels and need to be continuously managed). Maintaining current supply would be viable; however, there would be restrictions that would likely dampen growth. Desalination is already considered a viable option for fresh water supply, especially for the uranium mining industries in the Erongo Region. The siting of future supply points would be an important factor.

In the near future, most of the coastal towns would likely be able to effectively deal with the impacts of severe weather conditions without having to resort to extreme measures (CSA, LaquaR and Lithon, 2009; NACOMA, draft), and that costs would be moderate, compared to the local economies. It is clear, though, that a great amount of planning is needed for long term adaptation strategies, especially at Walvis Bay, to ensure that current and future infrastructure at this bustling port is safeguarded for continued economic activity.

5.6.1.2 Environmental impacts of sea level rise

The coastline of Namibia stretches for 1500km and is vulnerable to the effects of sea level rise, through processes such as coastline erosion, flooding and saltwater intrusion. These processes could have severe impacts on the natural ecosystems of the coast (fauna and flora), and thus impinge their ability to provide ecosystem services such as: provision of food (fishing), recreation, atmospheric carbon sinks, flood attenuation, replenishment of groundwater, filtering of run-off and air pollution, oxygen production and tourism attraction.

In general, an increase in coastal erosion and risk of landslides due to sea level rise, storm surges and changes in rainfall can be expected. Coastal systems such as dunes and beaches will not have enough time between storms (increased frequency and intensity) to replenish themselves (sediment transport and deposition). Although coastal erosion is likely to impact on Swakopmund and Walvis Bay in different ways due to their location and topography (Swakopmund is on relatively high ground), the stresses on ecosystem services induced by sea level rise will undermine the resilience of socio-economic sectors that are dependent on those.

A rise in mean sea level rise is projected to slowly inundate wetlands and lowlands resulting in an increase in salinity of estuaries and aquifers. This is projected to be detrimental for coastal areas as they provide spawning and nursery grounds for many fish species. Increased salinity in these areas is likely to lead to the decimation of organisms that are not resistant to the high saline environment. This in turn could affect shore birds that rely on these organisms for foraging habitat during their migration and nesting. Namibia currently supports large numbers of migratory birds on local and international levels. If major intertidal habitat losses occur as a result of destructive wave action during sea storm surges or permanent inundation of saline waters with mean sea level rise, this would jeopardise the ability of the Namibian coast to continue to support its current migratory and shore bird numbers. The island Important Bird Areas (IBAs) would be at particular risk since they could be flooded as a result of sea level rise, thus becoming unavailable for breeding (Rod Braby [NACOMA], pers. comm.).

Sea level rise will also lead to raised water tables, which could allow an encroachment of polluted water into wastewater treatment facilities, and thus increase the probability of sewage overflow, with the associated human and ecological health hazards. Increased groundwater levels are likely to enhance the vulnerability of communities that are located in low-lying areas, especially when rain and sea storm water is no longer be able to dissipate, thus exacerbating flooding impacts.

5.6.1.3 Impact on fisheries

The most obvious impacts that sea level rise is likely to have on these resources are inherently coastal, particularly in the shorter term. With the projected increasing frequency, intensity and duration of sea storm surges, it is the coastal/marine interface that is likely to be put under the most pressure as habitat changes, destruction, and changes in primary production are very likely to have adverse effects on the coastal spawning and nursery grounds and thus reduce the replenishment rates of the natural stocks. In the longer term, the effects of mean sea level rise is likely to impact upon primary production in coastal systems but may largely be dependent upon variations in the nutrient concentrations caused by changes in ocean current patterns and upwelling regimes (Harley et al., 2006). The Benguela upwelling system, with high rates of offshore transport, is proposed to favour producers by transporting herbivorous zooplankton out of the near-shore system. The deposition and decomposition of surplus phytoplankton biomass on the sea floor have been linked to large eruptions of methane and hydrogen sulphide, which in turn lead to hypoxia and increased mortality of near-shore animals such as rock lobsters and Cape hake (Bakun and Weeks, 2004).

Namibia's marine fisheries are threatened by possible changes to the ocean current on the west coast. The fisheries rely on nutrient-rich upwellings of the cold Benguela Current. Any change in the frequency, timing or distribution of the upwelling (for example by future changes in the distribution and intensity of winds) will influence production, and significantly impacts on the overall economy. Already a warmer sea surface temperature has been noted over the northern Benguela region off the coast of Namibia. This warming trend may be one of several environmental factors that have contributed to declining fish stocks experienced in recent years. However, it is impossible to say with certainty what impacts climate change has on Namibian fisheries at this stage (Reid et al., 2007). This is because no studies have looked directly at climate change impacts, and the effects of fishing are likely to be far more important than shifting environmental conditions. Links between environmental variability and fisheries dynamics are also poorly understood and large environmental anomalies or extreme events, such as the 'Benguela Niño', have negative impacts that far outweigh other incremental changes in the system. Despite this, it is clear that changes have occurred and it is uncertain whether they can be attributed entirely to fishing impacts.

5.6.2 ADAPTATION TO SEA LEVEL RISE

The extent of the damage induced by sea level rise can be significantly reduced by preparedness, developing adaptive capacity and pre-emptive actions. Given that these adaptation actions involve costs of their own, the difficulty is in knowing what to do where and when.

The full set of risks associated with sea-level rise in Namibia are complex but include: (1) the direct threat of damage to infrastructure, property, human life and the environment; (2) the risks of foregone tourism revenue, disrupted economic mobility and the opportunity cost associated with the need to reallocate resources to disaster relief and reconstruction efforts; and (3) the risk of piecemeal or uninformed responses to sea-level rise that make things worse by amplifying the problem, inducing unforeseen consequences, or transferring the risk to people who are less able to deal with it.

It is not possible to predict the exact nature and timing of sea-level rise events long in advance (although the accuracy of 5 days forecasts is improving rapidly and combined with tides tables can provide short-term warning), or to provide definitive protection against the wide range of impacts that sea-level rise events can induce. In the context of this uncertainty, adaptation responses that retain options, and promote continued monitoring and flexibility are most valuable.

From a financial perspective, sea-level rise adaptation options in Namibia can be divided into (1) no regrets options – desirable, low cost, high benefit options should be pursued even if climate change was not a threat, (2) sea-level rise specific responses that save more money than they cost and (3) sea-level rise specific options that are necessary (to save human life or heritage value) but are costly (Table 5.8).

From a methodological perspective, adaptation options can be divided into (1) infrastructure and hard engineering responses (such as sea-walls, dolosses and raising the level of harbours), (2) soft and biological responses such as the retention of wetlands and riparian vegetation in estuaries, beach and sandspit replenishment, the planting of dune vegetation to ensure dune buffers are retained and the cultivating of kelp beds that dissipate wave energy, and (3) socio-institutional responses such as enforced coastal buffer zones, early warning, insurance market and planned relocations.

Selecting and applying these options is not effective when undertaken in an ad-hoc and reactive manner, but is most effective when part of an integrated coastal resource management strategy that takes cognisance of Namibia's existing development priorities and programmes. Adaptation strategies which are dynamic and have an increased range of coping responses in order to deal with climate variability are best managed according to the principles of Integrated Coastal Zone Management (ICZM). ICZM aims to reconcile the economic, social, recreational and cultural objectives of the coastal zone, within the limits set by the carrying capacity of the coast. Namibia is currently developing its National Coastal Policy (Rod Braby [NACOMA], pers. comm.) which will strengthen the implementation of ICZM.

It should be noted that ICZM is not a one-country effort. The protection of coastal integrity must be undertaken as a concerted effort by neighbouring countries. Lack of consultation between countries that share a coastline would lead to sheltered and perhaps conflicting policies that undermine the biophysical and economic integrity of the coastline as a whole. To this end, Namibia became a participant of the Benguela Current Large

Increasing priority

	Costly but necessary	Financially rational	No regrets
Socio-institutional responses	Public insurance or bail-outs. Planned relocation of industry and communities.	Early warning system, informed private insurance	Coastal buffer zones, vulnerability mapping
Biological and soft-engineering responses	Beach drainage	Beach and sandspit replenishment. Dune vegetation programmes	Retaining wetland vegetation, kelp bed management
Infrastructure responses	Sea-walls, barrages, raising the harbour at Walvisbay,	Off-shore reefs, dolosse	

Table 5.8: Decision support matrix for adapting to Namibian sea-level rise. *Source: CSA, LaquaR & Lithon (2009)*

Marine Ecosystem (BCLME) programme. The BCLME was a regional initiative between Angola, Namibia and South Africa to manage in a sustainable and integrated manner the living marine resources in the Benguela Current. It developed a legal framework to deal with trans-boundary environmental issues that are shared by these countries. The BCLME programme has now been replaced by the Benguela Current Commission (BCC). The BCC is currently in its interim phase, and is running a Science Program until 2013. Adaptation within this sector should be planned and implemented within this framework.

NACOMA has embarked on a programme to develop Environmental Management Plans (EMPs) for all the Namibian coastal towns, which include climate change vulnerability and risk assessments and required adaptation responses. For Swakopmund (NACOMA, draft), these include measures to deal with the impacts of sea level rise and beach erosion, sustainable management of potable water resources, development of alternative water sources (e.g. desalinisation), and adequate stormwater systems.

Table 5.9 provides a summary of options for adaptation to sea level rise for Namibia.

5.7 CBNRM AND TOURISM

5.7.1 IMPACT AND VULNERABILITY OF TOURISM

Climate change could impact tourism in Namibia directly, by impacting on the tourism resource base (DRFN, 2008). Climate informs the appeal of a travel destination, and climate change-induced local environmental change – including habitat change, changes in landscape characteristics, changes in vegetation cover, biodiversity loss, decreasing water availability, increased frequency and severity of natural hazards (droughts, floods), coastal erosion, and increased incidence of vector borne diseases (like malaria) also impact on tourism. To date, no specific study has been undertaken to examine the direct impact of climate change on tourism in Namibia.

However, studies of the impact of climate change on vegetation and ecosystems in Namibia (Midgley et al., 2005) and a climate change vulnerability assessment with a particular thematic focus on the agriculture and water sectors (DRFN, 2008) have been done. A more variable and unpredictable climate, with more frequent and severe natural disasters (droughts and floods), and hotter and drier conditions, could lead to declines in vegetation cover and significant change in vegetation structure and function, with some of the grassy savannah converting to arid and desert shrubland. These changes would have a significant impact on tourism in Namibia, since most of the tourism activity in Namibia is nature-based, including landscape and game viewing and trophy hunting, and thus dependent on the integrity of the natural resource base. Specifically, loss of habitat, loss of biodiversity and increases in temperature, humidity and malaria would impact negatively on tourism.

On the other hand, it has been suggested that to the extent that climate variability and change will shift viability of land use systems away from agriculture and livestock production systems based on exotic species toward indigenous biodiversity production systems, climate change impacts on the tourism resource might not be as significant as in other sectors in Namibia and the tourism potential might even expand. A study on the impact of climate change on protected areas in Namibia, currently underway, is expected to shed more light on the impact of climate change on Namibia's natural tourism resource.

The indirect impacts of climate change on the future of the tourism sector are likely to be of greater relevance. There is evidence of significant changes in international consumer awareness and attitudes, with increasing consumer concerns regarding the carbon footprint of long-haul air travel to distant tourism destinations. These consumer concerns are resulting in greater consumer reluctance to engage in such travel for tourism purposes and greater willingness-to-pay for tourism products and services that are environmentally more friendly and have a smaller carbon footprint (Davidson, 2009).

Table 5.9: Summary of options for adaptation to sea level rise, with comments on costs, benefits, potential adverse consequences and suitability for Namibia. *Source: CSA, LaquaR & Lithon (2009)*

Option	Costs	Benefits	Potential for adverse consequences	Suitability in Namibia
Effective communication campaigns	Potentially very low cost	Many benefits. Allows individuals to make own decisions with regards to risk. May absolve government from responsibility.	Limited. May induce over-reaction from public. Could affect a region's competitiveness.	Highly suitable and does not negate the possibility of other measures.
Apply legislation	Low	Use of laws and zoning regulations to reduce property and infrastructure development in environmentally sensitive areas and areas at risk of being impacted by sea level rise and increasing storm surges	Potentially, the methods for determining the land areas not to be developed due to risks of sea level rise and increasing storm surges would be based on uncertain models for climate change and sea level rise.	Highly suitable
Research and monitoring	Low	Detailed and practical information about the status of sea level rise and storm surges along Namibia's coast, and about site specific conditions such as at the Pelican Point sandspit in Walvis Bay	Limited	Highly suitable
Vulnerability mapping	Low	Increased knowledge of priority areas that are most vulnerable to sea level rise and storm surges	Accuracy of mapping is dependent on uncertain models for climate change and sea level rise	Highly suitable
Insurance market correction	Very low cost provided research is available.	Many benefits. Over long term can be expected to guide investment in coastal areas.	May result in higher insurance premiums and higher number of uninsured in which case it will burden the poor most. Uninsured may fall back on government support in times of disaster.	Highly suitable as long as effectively managed.
Early warning system	Can be very low cost.	Multiple benefits. Allow individuals to respond in line with their risk aversion and exposure. Most effective where options for risk reduction exist e.g. evacuation plan, barrage.	Low, but requires public credibility and clear understanding as to the appropriate response.	Highly suitable. Can be used in conjunction with other options.
Wetland and estuary rehabilitation	Can be low cost, provided wetlands are not built upon..	Limited impact with regards to sea-level rise, but multiple biodiversity and aesthetic benefits.	Low	Highly suitable as a first step wherever wetlands and estuaries exist. Does not forego the option of more drastic measures at a later stage.
Beach and dune replenishment	Moderate, but ongoing. US$ 1,200-1,500 per mete of beach)	Can provide highly effective defence.	Low provided sand is suitable in size and harvested from an appropriate source. Requires intimate understanding of nearshore currents and wave action.	Suitable for many sandy beaches along Namibian coastline, including the Pelican Point sandspit.
Beach face drainage	Reported to be comparable to beach replenishment.	Results in sand accretion, has achieved satisfactory results in Europe.	May result in saline encroachment into groundwater. High energy costs.	Unproven in Namibia but may assist in protecting sandy beaches. Not recommended as a first option.
Raising infrastructure	Expensive especially were supporting infrastructure has to be raised to remain aligned. Costs are roughly $100 million to raise New Orleans levees one foot above normal (Leatherman and Burkett, 2002).	Allows continued functioning of infrastructure and infrastructure networks such as ports and roads.	May be difficult to know how high to raise infrastructure - "how safe is safe enough". Raising roads creates problems under bridges where clearance becomes inadequate.	Suitable to protect ports and certain roads and weirs.

Sea walls	High and ongoing maintenance costs. R3,000 – R 30,000 per meter.	Can provide effective protection from wave action in particular. Allows continued occupation and business. Walls can be raised and fortified incrementally as the sea rises.	High. Walls can be overtopped, can displace wave energy and cause heightened erosion. Walls create a false sense of security. Restrict public access.	Can be suitable to protect existing infrastructure that is difficult to relocate. Not recommended as part of new planning measures. Can be employed at the base of cliffs and possibly at the Pelican Point sandspit.
Barrages and barriers	Very expensive	Can provide effective protection for settlements and properties that can be easily barricaded e.g. those based on estuaries.	High. In the future barrages may be closed most of the time which will damage ecosystem and restrict movement.	May be suitable in the future at lagoon and estuary sites, after other options have been exhausted.
Rock armour and gabbions	Depends on availability of rock. Can be low cost where local rock is available.	Can be used to stabilise sea-cliffs.	Very high. Often increases erosion, unsightly. Rocks in mesh cages frequently break free from their cages.	Generally not suitable, although gabions may be considered amongst the possible options to protect the Pelican Point sandspit.
Groynes	Moderate. An unverified web source cites the cost of groynes to US$ 90 per meter, although clearly some groynes are more expensive than this.	Limited benefits for storm surges and changes in mean sea level	High. Alters current and sand circulation. Unsightly.	Not suitable.
Managed retreat	Compensation to property owners, lost public infrastructure, loss of real estate. May result in public liability and can involve protracted negotiation.	The most reliable and long-term solution to sea-level rise. May create new wetland and estuarine habitats.	Relocation of people and infrastructure can generate new social and environmental risks. Foregoes the option of less dramatic measures. Knowing how far to retreat can be difficult.	An option that may be considered in the future, especially if the extreme-impact scenarios associated with the melting of polar ice caps should be realised.

5.7.2 ADAPTATION IN THE TOURISM SECTOR

5.7.2.1 Sustainable tourism

Namibia should address these concerns and respond to growing demand for sustainable tourism by exploiting for marketing purposes Namibia's negligible carbon footprint (the country is effectively a net carbon sink – see Chapter 3) and its excellent reputation for nature conservation (38% of the country is under one or the other kind of conservation regime) and in particular pro-poor nature conservation (CBNRM initiatives, see section 2.8 and below). Building on this reputation, Namibia should actively seek to market the country as a "carbon-neutral", "fair trade", "pro-environment" and "pro-poor" tourism destination. To this end, Namibia should explore available certification opportunities (eco-certification, fair-trade certification, carbon credit certification), support use of appropriate technology (renewable energy use) in the tourism sector, develop carbon offset products, and link the production and sale of fully certified carbon credits with existing high-quality conservation, sustainable resource management and pro-poor rural development programmes, under an appropriate brand name (Davidson, 2009).

5.7.2.2 CBNRM Conservancies, tourism and adaptation

Conservancies spread wildlife-based land use systems, contribute to rural development and poverty reduction through enhanced rural income generation, diversity land use systems away from traditional systems based on livestock and agriculture, and in this way diversify rural income sources and livelihoods. All of these benefits improve the capacity of rural ecosystems, rural land use systems, and rural livelihood systems to adapt to the effects of climate change.

Wildlife is generally better adapted than livestock to the current ecological and climatic conditions in arid Namibia, and can be expected to be more resilient and adaptable to projected increases in climate variability and to climate change. For this reason, wildlife-based land use systems tend to be more appropriate and productive and have higher economic returns under marginal dryland conditions, which translates into greater capacity of wildlife-based land use systems to adapt to future climate variability and change.

Rural development through conservancies increases the resources rural people have to cope with the impact of future climate variability and natural disasters like droughts and floods on their livelihood systems. This makes rural people less vulnerable

and increases their adaptive capacity.

Finally, diversified systems, whether ecological or socio-economic, are intrinsically more adaptable to external and internal changes. This implies that both land use diversification and associated income diversification, brought about through conservancies, contribute to climate change adaptation.

5.7.2.3 CBNRM data collection and archiving

The Conservancy programme regularly collects economic, social and environmental performance data and information for all conservancies on an ongoing basis. This includes data on aggregate performance indicators and on environmental performance indicators (including the size of wildlife populations on a species by species basis). An Event Book system has been introduced as a basis for the systematic day-to-day monitoring of environmental indicators and events which is being extended to cover social and economic events and process indicators as well. Event, process and performance data from each conservancy are being collated and stored in a national conservancy information system (CONINFO) which comprises databases as well as metadatabases containing bibliographic information. CONINFO is in the process of being made accessible via the Internet. A similar data and information system based on an adapted version of the Event Book system is being started by the Community Forest programme. With improvements in these data gathering systems (e.g. the need to extend natural resource monitoring to natural resources other than wildlife, such as water resources, and biological monitoring systems in grazing areas), a valuable information base is being built which can be used towards effective climate change monitoring and adaptation for both the natural resource base and the tourism-related activities which is supports.

5.8 HEALTH SECTOR

5.8.1 IMPACT AND VULNERABILITY OF HUMAN HEALTH

The projected climate changes for Namibia, both individually and cumulatively, are expected to affect human health, and have an impact on human health-related aspects, principally through a complex set of interdependent interactions (WHO, 2003; DRFN, 2009). Several separate health conditions are likely to emerge at more or less the same time, all requiring the same resources and rapid attention.

Climate change will drive short- and long-term changes in the physical environment, many of which will have a direct as well as indirect impact on human health. For example, recent floods in northern Namibia have been linked to outbreaks of cholera, while the devastating effect that humans suffer as a result of drought are well-known in Namibia. In this way, climate change, and particularly the effect of increased variability, is expected to add additional pressures to the social environment that is, in many cases, already burdened by poverty and health challenges such as the HIV/AIDS pandemic, tuberculosis, malaria, malnutrition and others. Even small increases in climate-sensitive conditions, such as the occurrence of diarrhoea and malnutrition, are likely to result in large increases in the total national disease burden in Namibia. Such impacts are also likely to result in new challenges for the Namibian public health sector and existing health infrastructure that is already overstretched.

5.8.1.1 Increasing temperatures

Increasing temperatures cause rises in respiratory and cardiovascular diseases, heat-related stress, increased dehydration, and reduced ability to cope with other stressors and/or diseases, and can lead to added vulnerability of newborns, as well as the old and infirm. Rural Namibians with poorer access to medical services than their urban compatriots are considered relatively more vulnerable to the effects of heat stress. In cases of pre-existing medical conditions and/or extreme levels of poverty, existing vulnerabilities are likely to be worsened. Rising temperatures will exacerbate other impacts on health arising from increased water stress, decreased crop yields and increased malnutrition, and lower air quality (mainly in urban settings).

5.8.1.2 Increasing water and vector borne diseases

Open water sources will likely suffer from increasing contamination resulting from increased pressure from humans and animals, who often share these water resources (particularly in northern Namibia). This contamination may in turn cause diarrhoea, cholera, fever and related water borne illnesses (WHO, 2003). Both flood and drought conditions will likely increase the burden from water-borne diseases.

Rising surface air and water temperatures are likely to increase the frequency, greater spread and increased transmission rates of infectious vector borne diseases, such as mosquito-borne malaria and tick-borne encephalitis. Shorter, more intense rainfall events cause an increase in water runoff, formation of open waters and thus more breeding areas for the malaria-carrying mosquito, sometimes in areas that have not previously experienced such occurrences. On the other hand, flooding in existing mosquito breeding areas could disrupt the natural egg laying and larvae breeding cycles and cause a decline in mosquito populations.

It is likely that, given that the pre-requisites of mosquito breeding are met, marginal areas bordering current endemic zones will experience higher mosquito occurrences and therefore an increased number of malaria cases in future. Such sporadic occurrences may in time increase the range of endemic areas, with malaria even reaching areas that have previously had little or no exposure to the disease (including some major population centres). Human populations could be encouraged to migrate out of malaria-prone areas. The year-on-year climate variability is of particular importance, as the transmission cycle is likely to be broken in rainfall-poor years, which in turn decreases the immunity of the local population. The management of sporadic malaria episodes, and ongoing management in malaria endemic areas will continue to play a cardinal role in determining if and how malaria will be affected by climate change.

In summary, the available evidence does not yet allow a conclusive statement about the response of malaria in the face of a changing climate. However, it seems probable that Namibia-specific climate change predictions imply an expansion and increased spread of non-endemic malaria in future.

5.8.1.3 Decreasing crop yields and food security

How climate change will impact on the availability, affordability and accessibility of food in Namibia is not yet clear (DRFN, 2008, section 5.5). However, indirect evidence can be gleaned from those years in which floods or droughts have disrupted the more normal climatic patterns. Highly variably rainfall patterns in Namibia have always been an accepted reality; nevertheless, the availability of food in rural Namibia in particular is most likely to be adversely affected by climate change, driven by reductions in crop yield and increasing populations. Increases in malnutrition are likely, weakening human disease defenses, and increasing mortality, particularly in children. Secondary effects include continued disintegration of traditional community and family cohesion, rising conflict relating to competition for food and land (notably amongst subsistence farming communities), and increased rates of community/individual migration to more secure food resources, usually towns and cities.

5.8.1.4 Increasing water scarcity

The projected overall negative impacts of climate change on Namibia's water resources (section 5.4) are likely to make the provision of sufficient safe, reliable and affordable water, good sanitation and drainage even more complicated than it is at present. These services are essential for human health and lack thereof leads to diarrhoeal and other diseases caused by biological and/or chemical contaminants. An increase of dehydration in water scarce areas is very likely. Poor drainage in human settlements increases exposure to contaminated water and provides breeding habitat for mosquitoes and parasites, leading to increased incidence of water-borne and vector-borne diseases.

Water scarcity is likely to lead to an increase in conflict within and between communities, and in migration and its associated impacts on increasing the spread of diseases, especially in peri-urban and urban areas. This will challenge urban health services. Cities and towns depending on open water sources to meet their water demand will be faced with an increase in costs to provide and treat water, and mitigate the effects of climate induced multiple or extreme events.

5.8.1.5 HIV/AIDS

Climate changes as projected for Namibia could lead to substantial impacts on human health, as outlined above. Whereas under ordinary circumstances disease-bearing microbes would not likely infect human beings, they have a major impact on populations with reduced immune responses. Under these stressful circumstances there is an increased risk of attracting communicable diseases, including infection with TB or HIV (UNDP, 2004).

The HIV/AIDS epandemic, in combination with poverty and a reduced capacity of institutions to respond (the triple threat), has already reduced the resilience of households and communities, especially in rural areas of Namibia. Hence, an increase in the occurrence of shocks that may be brought about by climatic change and increased climatic variability is expected to further exacerbate the precarious situation of the HIV/AIDS-affected farm household population.

The national response to the floods and droughts in recent years has underscored the realisation that HIV/AIDS has not yet been adequately mainstreamed in emergency management practices. The floods caused substantial disruptions in the delivery of HIV/AIDS-related services, including treatment of opportunistic infections, and the provision of ARV-therapy. The disruption was attributed to: a) the inaccessibility of health facilities; b) lack of funds amongst those who needed treatment; c) lack of food, inadequate knowledge and support systems for ARV-adherence. Other HIV/AIDS-related programmes and services also suffered, such as HBC and psychosocial services, the distribution of condoms and support to OVCs, including feeding programs through schools (PDNA, 2009).

A shortage of emergency food supplies affected people living with HIV, as well as other vulnerable groups such as chronically ill persons and OVCs. In addition, the temporarily relocation of fairly large numbers of people in camps implied an increase in the risk of HIV-infection, for young people and women in particular, some of whom resorted to transactional sex as an option to obtain food and other goods and services in the camps. Overall, disaster induced setbacks in the management of HIV/AIDS lead to further loss of resilience at household level, and can even trigger the transition to full blown AIDS, with further impacts on families and communities.

5.8.2 ADAPTATION IN THE HEALTH SECTOR

Namibia should build capacity on all fronts to adequately respond and cope with the health-related impacts of climate change. It should be noted that adaptation to climate change within other sectors, notably water resources (section 5.4), agriculture and food security (section 5.5), and disaster management (section 5.9) can also offset many of the negative repercussions that climate change is likely to exert within the health sector (via the linkages outlined above).

Within the health sector, two types of responses are required. On the one hand, immediate year-to-year health imperatives driven by slow-onset linear changes in weather patterns (and thus disease) will require well-planned public health responses. For example, the encroachment of malaria into new areas can be met by improvement and intensification of current efforts. These responses include enhanced vector control, better promotion and distribution of mosquito nets, more efficient and timely distribution of anti-malarial drugs, improved pre-emptive spraying campaigns, and an enhanced diagnosis and treatment regime. On the other hand, different response measures are required to meet the demands on the health system brought about by abrupt and/or fast-onset changes, which can give rise to large-scale epidemic outbreaks. These include large-scale social upheaval, as well as a number of secondary effects that extreme climatic events are likely to bring about. The latter are more likely to be effectively dealt with under the umbrella of a nationally coordinated emergency response.

In order to ensure that Namibia can effectively meet these climate-linked health challenges, an integrated health system-wide response is required. To complement and strengthen existing policies and programmes e.g. for malaria and HIV/AIDS, the following steps should be taken to address the expected impacts of a changing climate on the Namibian health system:

- enhance and further mainstream climate-related awareness
- improve access to timely and relevant information
- undertake scenario development and pro-active planning to address both fast-onset and slow-onset climate-induced events
- strengthen the policies required to effectively address both slow-onset and catastrophic events
- develop health-centred adaptation strategies
- climate-proof the public health system
- strengthen water and sanitation systems

Specifically for malaria management, the following data, monitoring and analytical needs have been identified:

- **Incorporate climate-specific data in malaria analyses:** Malaria data should be re-analysed, taking into account climate-specific data and malaria-climate correlations; use this for predictive, preparatory and response purposes.
- **Strengthen malaria forecasting capabilities:** This will reduce infections and save lives, and reduce response times and costs incurred for prevention and control.
- **Enhance malaria-specific weather data to allow for malaria-climate correlations:** A network of meteorological stations positioned strategically across the malaria endemic areas of Namibia could provide the additional climatic indicators of

relevance to malaria control.

Specifically for HIV/AIDS management, the following policy needs have been identified:

- Improved surveys are required of the prevalence and impact of HIV/AIDS on the Namibian population, and specifically the impact on the public sector e.g. focusing on sectors that play a major role in the response to climate change. This should inform the development of adequate strategies to mitigate the impacts on their staff.
- Increasing efforts to mainstream HIV/AIDS and adaptation to climate change in the rural agrarian sector, and particularly vulnerable farming households, are needed. This will require capacity building and awareness raising on linkages between climate change, human health, HIV/AIDS and rural development.
- Integrating a "hotspots" framework with early warning systems could lead to the early identification of crisis situations, and strengthen the initial response to emergencies resulting from droughts or floods, but also the response to slow-onset shocks related to HIV/AIDS and droughts.
- More efforts should be undertaken in mainstreaming HIV/AIDS in disaster risk reduction and response. This implies meeting the needs of affected households both during and shortly after emergency situations, as well as improving the preparedness for HIV/AIDS during emergencies, e.g. through the preparation of contingency plans.
- Clearly identify, through cross-sectoral discourse, how vulnerabilities related to HIV/AIDS and climate change should best be addressed in the Namibian context.

5.9 DISASTER RISK MANAGEMENT

Namibia has lately experienced an increase in natural disasters, such as floods and droughts (DRFN, 2008). In 2009 for instance, many communities were severely affected by floods in the north central, Kavango and Caprivi regions, which led to infrastructural damage, loss of crops and livestock, and loss of human life. The predicted impacts of climate change are likely to increase the frequency of such disasters. Rural people in particular, who are generally poor and vulnerable, will be adversely affected by such disasters.

Namibia's disaster risk management is committed to international risk reduction initiatives such as the Hyogo Framework for Action and the Africa Regional Strategy for Disaster Risk Reduction. The disaster risk management strategy recognises disaster risk reduction as a frontline defense in adapting to impacts of climate change. However, disaster risk management is currently primarily response oriented, as the framework and capacity for emergency preparedness and disaster risk reduction are generally lacking (PDNA, 2009). In response to the threats brought by climate change, the capacity for disaster risk preparedness, contingency planning and risk reduction, rather than disaster response, should be strengthened. Spatial planning e.g. vulnerability and risk mapping, that takes ecosystem requirements into consideration has the potential to markedly reduce flood related costs. This tool should be used in the training of current and future town/urban planners, engineers responsible for infrastructure development, and those responsible for managing ecological systems and environmental health.

Information flow and communication between formal structures at national and regional level and communities need to be improved, encompassing both scientific intervention measures and traditional coping mechanisms at local level (e.g. migration to higher elevation in flood plains). Community based adaptation practices based on current risk management, identification of risks that are priorities to the vulnerable, and acknowledgement of barriers within the local context, can increase the effectiveness of adaptation to climate change.

Improved monitoring and documentation of the occurrence and intensity of extreme events, using a variety of tools including physical measurement, can be used to inform infrastructure and settlement development in disaster-prone areas. Capacity for early warning needs to be expanded, requiring additional resources at all levels to strengthen the weather station network and a well-trained staff establishment. This must be accompanied by an improved disaster information management and communication system.

HIV/AIDS related matters, as well as related issues pertaining to social vulnerabilities and poverty, must be integrated into the disaster management framework.

Development of pro-poor disaster insurance schemes should continue. These could include community-run initiatives, mutualities, direct sales schemes run by insurance companies (e.g. savings and credit schemes and funeral cover linked to natural disasters), the use of income generated by CBNRM-run conservancies to cover

Table 5.10: Scenariosused for the simulation of the vulnerability of the economy of Namibia to climate change. *(Reid et al., 2007)*

Scenarios	Crop production	Cereal production	Livestock production	Traditional agriculture	Fish stock change
Scenario 0					
- no climate change	+20%				
Scenario 1					
- best case agriculture	+10%	-10%	-20%	-40%	
Scenario 2					
- worst case agriculture	no change	-20%	-50%	-80%	
Scenario 3					
- fall in fish stock	+20%				-50%
Scenario 4					
- combined 1 and 3	+10%	-10%	-20%	-40%	-50%
Scenario 5					
- combined 2 and 3	no change	-20%	-50%	-80%	-50%

		Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
GDP (market prices), total % change		0.1	-1.1	-3.1	-2.4	-3.2	-5.8
GDP (factor cost), total % change		0.1	-1.0	-2.6	-2.0	-3.2	-4.8
Current activity share, % of total GDP at factor cost		**% change in activity share of total GDP at factor cost**					
Cereal production	0.5	0.0	-8.4	-17.0	0.9	-7.6	-16.3
Other crop production	1.0	19.2	10.2	1.3	22.3	12.9	3.7
Livestock production	4.0	0.0	-19.0	-48.4	1.2	-18.0	-47.9
Traditional agriculture	1.5	0.0	-33.5	-74.6	4.7	-30.7	-73.8
Fish production	5.5	-0.1	0.4	1.0	-45.2	-45.0	-44.8
Fish processing	2.0	0.0	0.1	0.4	-43.5	-43.4	-43.3
Mining	15.0	-0.1	0.5	1.6	2.3	2.8	3.8
Meat processing	0.5	0.0	-6.7	-33.7	0.9	-4.6	-32.7
Grain milling	1.5	0.0	-0.1	-0.5	0.1	0.0	-0.4
Manufacture of beverages	3.5	0.0	0.1	0.2	0.9	1.0	1.1
Other industry	7.5	-0.1	0.4	1.1	1.8	2.2	3.0
Construction	2.0	0.0	0.2	0.5	0.8	1.0	1.3
Water supply	1.0	0.1	-0.4	-0.9	0.9	0.4	0.0
Electricity supply	2.0	0.1	-0.1	-0.4	1.4	1.2	1.0
Private services	31.5	0.0	0.3	0.7	1.8	2.1	2.7
Government services	21.0	0.0	0.0	0.0	0.1	0.1	0.0
TOTAL	**100**	**0.1**	**-1.0**	**-2.6**	**-2.0**	**-3.2**	**-4.8**
% change in income from base year for different household groups, by current main source of income							
Urban, wage and salary		0.3	-1.1	-3.8	-10.0	-11.3	-13.7
Urban, agr and business		0.7	-1.4	-6.8	6.9	4.5	-3.2
Urban other		0.3	-1.4	-4.6	-9.9	-11.5	-14.5
Rural, wage and salary		0.3	-1.1	-3.8	-10.0	-11.3	-13.8
Rural, agr and business		0.8	-1.7	-8.3	10.1	7.2	-2.2
Rural other		0.0	-4.9	-12.2	-8.0	-13.1	-26.9

Table 5.11: Results of the simulation of the vulnerability of the economy of Namibia to climate change, based on the scenarios given in Table 5.10. *(Reid et al., 2007)*

human-wildlife conflict losses, and partner-agent models.

5.10 VULNERABILITY OF THE NAMIBIAN ECONOMY

An economic analysis of the potential impacts of climate change on the Namibian economy was conducted by Reid et al. (2007). Namibia's advanced Natural Resource Accounts (NRA) helps to evaluate the contribution of the environment to national wealth by developing so-called 'satellite' accounts for natural assets such as fish, forests, wildlife, water and minerals. Data from the NRA can be fed into the conventional national economic accounts. This capability potentially allows for sound sustainable development planning that includes natural resources as well as man-made or owned assets - a clear advantage for policymakers in economies such as Namibia's, which is so dependent on natural resources.

In NRA, natural assets are valued in two ways. First, the values of the total natural resource stocks are measured. These are treated as capital assets in the stock or asset account. Second, their annual contribution to national income in terms of direct use values is measured in the production or flow account. Changes in the capital stock from year to year are also reflected in the national income. In this study, data from the NRA was fed into a computable general equilibrium (CGE) model, which uses actual economic data to determine how economies respond to policy or other changes. Simulations were based on six different scenarios (Table 5.10).

The scenarios described above were analysed in terms of total effect on GDP and on income distribution across enterprises and households within the country. The results are presented in Table 5.11.

The results revealed that under a best-case scenario, agricultural impacts would be partly offset by improved water distribution, there would be no impact on fisheries and the overall GDP would fall by only about 1%. Under a worst-case scenario, large-scale shifts in climate zones would reduce agricultural and fishing outputs, and the overall GDP would fall by almost 6% over 20 years. However, this estimate constitutes only a fraction of possible climate change impacts because it considers only two economic sectors - agriculture and fisheries - and ignores impacts such as those on health, infrastructure and energy that relate less to natural resources and that other country studies have shown to be significant.

Namibian natural resource experts have further worked to quantify, as much as possible, the economic impacts of climate change on Namibia's natural resource base. Estimates of how climate change will affect various sectors, and subsequent translation into economic impacts, can only be best guesses. Expert estimates suggest, however, that over 20 years, annual loses to the Namibian economy could be between 1 and 6% of GDP - that is, between £35 million and £100 million - if no action is taken to adapt to climate change.

Combining data from the NRA with Namibia's Social Accounting Matrix (SAM) provides the chance to see who will be hit hardest by the impacts of climate change on the environment. The SAM is a database that provides information on activities in different economic sectors and helps identify the poverty status of different groups. Evidence from low-income countries around the world suggests that the people likely to be most affected by climate change are the poorest and most vulnerable. And in Namibia, results show that climate change impacts will hit the poor hardest, with employment opportunities constrained and a substantial decline in wages, especially for unskilled labour.

Even under the best-case scenarios generated by the CGE model, subsistence farming will fall sharply. In the worst-case scenario for agriculture, labour intensive livestock farming is hit hard, and while high-value irrigated crop production could thrive, employment creation in this area would be minimal. Thus, even under the best-case scenario, a quarter of the population will need to find new livelihoods. Displaced rural populations are likely to move to cities, which could cause incomes for unskilled labour to fall by 12 to 24% in order to absorb the new workers. Income distribution in Namibia is already one of the most uneven in the world and this inequality is likely to increase, with significant implications for future social cohesion, if no counteracting policies are put in place.

5.11 BARRIERS TO ADAPTATION

People may not adapt sufficiently to climate change for a variety of reasons. Climate may be perceived to pose little risk relative to other hazards and stressors and therefore given low priority, which becomes quite clear in the Namibian Poverty Profiles.

- Knowledge of options to reduce climate risks or the means to implement adaptation measures may be lacking
- Expected costs of adaptation may exceed the expected benefits, especially if these have not been quantified as is the case in Namibia
- Uncertainty about the future may make it difficult to decisively implement adaptation measures in a specific time frame
- Irreversible consequences of some adaptations may delay choices until some of the uncertainty is resolved
- Incentives may be distorted in ways that may either discourage choices that reduce risks or encourage riskier choices, e.g. drought aid can perpetuate overstocking if not implemented well
- Sometimes the action or inaction of others can be an obstacle to adaptation at the local level, an issue of critical importance in open access resource regimes
- Some may believe that reducing their own risk is the responsibility of others, particularly the Government
- Proposed measures are not technically feasible, not socially accepted, their effectiveness has not been demonstrated, they are not economically viable, institutional capacity or human skills are lacking, they are not compatible with existing policies, transboundary issues are involved.

A Namibia specific study (Republic of Nambia, 2005c) differentiated between the following barriers to adaptation to climate change in Namibia:

- Insufficient awareness (information limited to specialists and access to research by stakeholders)
- Political and institutional barriers (implementation of policies, low public participation)
- Socio-cultural barriers (technology stigmatation and techno-focus, as well as a different local priority than national ones at times)
- Financial barriers (types and conditionality of funds, insufficient pricing of resources, and lack of access to private funding)

5.12 ENERGY FOR RURAL ADAPTATION

Power capacity shortages experienced in the SADC region (Southern African Development Community) since 2007 suggest a looming energy crisis in Southern Africa. In addition to complicating the huge challenge of electrification throughout the region, the energy crisis has cross-sector implications as energy and economic development are inextricably linked. Given the imminent, widespread threat of such a crisis, adaptation that accounts for the impact of climate change in the energy sector is a matter of the highest urgency (DRFN, 2008).

Adaptation in the energy sector can take place on supply or demand sides or, preferably, both. Energy production adaptation works towards long-term energy security—a perspective that must promote the use of renewable and energy efficient production technologies and relieve the dependence on non-renewable, volatile and environmentally unsound resources. On the other hand, energy demand adaptation focuses on the decrease of energy consumption through the use of energy efficient and renewable energy devices and technologies. The energy policy adopted by Namibia will to a large extent determine its development path (low carbon vs. high carbon development path) and Namibia's contribution to climate change mitigation.

Natural resource management and access to renewable energy and energy efficiency technologies are at the core of energy security for rural Namibians. Owing to low population densities and remote locations of rural communities, grid-electricity infrastructure development and maintenance require significant investments. Consequently, small-scale, renewable power production, such as solar, wind, and biomass based electricity generation, proves to be the only viable way for Namibia to achieve widespread electrification.

Additional priority measures to promote energy-related adaptive capacity include:

- Initiatives that relieve the dependence on climate influenced fuel sources, such as firewood. These include fuel efficient stoves and cookers, and solar home technology.
- Strategies to decrease the impact of external climate conditions (e.g. insulation, ceilings, shading, building orientation), and increase the efficiency of internal space heating and cooking

5.13 NATIONAL CLIMATE CHANGE POLICY: ADAPTATION PROJECTS

Following a process of analysis and consultation, the following adaptation themes have been identified by Namibia (Republic of Namibia, 2010a) as receiving priority attention (refer to Table 8.1 for details):

5.13.1 THEME 1: Food security and sustainable resource base

In Namibia, climate change is predicted to severely influence variability of rainfall, shortening of rainy season, increases in temperature, increase potential evapotranspiration and sea level rises etc. Predicted increases in aridity and hence droughts will in turn influence agricultural production, forestry, fisheries resources, water resources, biodiversity as well as different ecosystems. These impacts will affect food availability and supply. Climate change will negatively impact on food security and the natural resource base in Namibia. In particular, the poor and vulnerable, especially women and children will be severely affected. Therefore, under the theme of food security and sustainable resource base, the following strategic aims shall be undertaken:

Sector	Actions
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 ►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

5.13.2 THEME 2: Sustainable Water Resources

Water is a vital resource in Namibia. The combined effect of climate change and predicted water demand due to population growth and development indicate that water resource management needs special attention in order to safeguard the available water resources while meeting the demands of competing needs for water. The need for integrated water resources management therefore cannot be overemphasized. The Climate change strategy will therefore undertake the following regarding 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 transboundary cooperation regarding water resources
- • Support institutional and human capacity building in water resources management and use

5.13.3 THEME 3: Human Health and well being

One of the objectives of Vision 2030 is “ensure a healthy, food-secured and breastfeeding nation, in which all preventable, infectious and parasitic diseases are under secure control, and in which people enjoy a high standard of living, with access to quality education, health and other vital services, in an atmosphere of sustainable population growth and development”. Namibia is also committed to the achievement of the Millennium Development Goals (MDGs). Health issues are also included in the medium term national development goals (NDP3) under Key Results Area 5, Quality of life. Protecting health from the impacts of climate change is an emerging priority for the public health community. Improved risk assessment is necessary to inform decision-makers about the broad range of health impacts due to climate change. The strategy will therefore address 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
- Support action plans against HIV/AIDS

5.13.4 THEME 4: Infrastructure

Climate change is likely to affect infrastructure. Impacts may be caused by increases in temperature, more frequent and intense rainfall events, rising sea levels and sustained and extreme droughts. More intense and frequent rainfall events can challenge water, wastewater and sewerage treatment systems for instance by increasing turbidity and sedimentation, or cause direct flood damage to above ground aquifers. These may increase corrosion of buried infrastructure.

Predicted impacts of climate change in Namibia are likely to affect infrastructure including houses, buildings, roads, railways, dams, water pipes, electricity transmission, sewerage and communication and drainage systems. High sea level rise could inundate the coastal town of Walvis Bay, Namibia’s only deep water harbour. In highly populated areas of north central and north east Namibia which are flood-prone, houses are frequently destroyed and roads flooded, restricting access to homesteads. Impacts of climate change on infrastructure will further be severe where housing and settlements are poorly planned and developed. The economic cost of impacts of climate change on infrastructure damage, insurance claims and repairs and reconstructions, though not easy to estimate, is likely to be very high. The strategy shall therefore need to address impacts of climate change on the coastal zone, transport sector and housing and settlement and shall therefore:

Sector	Actions
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 ►Adaptation against future sea level rise
Housing and settlement	► Improve infrastructure spatial planning and development in urban and rural areas ► Improve formal and informal settlement patterns and housing ►Climate-proof existing and future housing and other infrastructure

6. Measures to mitigate climate change

6.1 INTRODUCTION

This chapter of Namibia's SNC deals with measures planned to mitigate climate change through a reduction in GHG emissions (as presented in Chapter 3). Even though Namibia's contribution to global GHG emissions is negligible and it is shown to be a net sink of carbon dioxide, the country is nevertheless committed to reducing its GHG emissions where this is financially and environmentally feasible. The primary source of information is the Namibia Energy Review for the UNFCCC (Republic of Namibia, 2007b).

6.2 METHODOLOGY

Namibia's measures to mitigate are informed by its sources and sinks of GHGs and thus this chapter on mitigative measures is closely interlinked with the Greenhouse Gas Inventory (Chapter 3). From the outset it must be noted that, for the most part, a high-level or macro-descriptive approach is taken and the use of models and forecasts have been minimal. Thus the methodology is somewhat static and costs, benefits and impacts presented are only indicative. The following steps were taken and technical resources used:

1. Drawing on various sources of data, a detailed GHG inventory was conducted using a Reference Approach and a Source Categories Approach. This is described in the GHG Inventory Chapter (Chapter 3).
2. The most intensive GHG sources and sinks were identified based on the gG CO_2e contribution to the atmosphere.
3. Measures to curb emissions in the case of intensive sources were identified and measures to retain or increase sequestration in the case of intensive sinks were identified.
4. Strategically aligned with Namibia's national circumstances and development plans, five broad potential mitigation measures were identified and their feasibility investigated in greater depth.

The methodology employed in each case will be dealt with as each measure is detailed in turn. However, before doing so a brief introductory section contextualising Namibia's GHG emissions profile is necessary.

6.3 THE NAMIBIAN CONTEXT: Sources and sinks of GHGs

Namibia is a net sink of GHG emissions, sequestering more on annual basis than the nation emits (Chapter 3). This is due to the fact that Namibia imports between 50% and 70% of its electricity from South Africa, has a very low population number and population density and small industrial and agricultural sectors. Taking a sectoral approach, the most significant variables in this equation are the energy sector, the agricultural sector and the land use change and forestry sector. The energy and agricultural sectors emitted 2200Gg and 6738Gg of CO_2e, respectively. The land-use change and forestry sector sequestered 10560Gg of CO_2e. What is also of importance is the growth in the contribution, or the understanding thereof, of each sector since the previous 1994 GHG inventory. Driven in part by certain methodological improvements between the two reference years, energy and agriculture showed a growth in emissions of 15.5% and 81.5% in the six years, respectively. Land use change and forestry showed to increase sequestration by 84.7%.

Looking at each of these sectors in more detail shows that within the energy sector, transport is the most intensive contributor to GHG emissions, adding to 1025Gg CO_2e to the atmosphere in 2000. That amounts to more than 50% of emissions from the energy sector.

In the agricultural sector it is the cattle farming industry that contributes most significantly to the sectors emissions, adding 195Gg of CH_4 (methane) per annum. That amounts to almost 80% of the sectors emissions.

Lastly, in the land use and forestry sector, a major sink of emissions in Namibia, the major contribution comes from the extensive bush encroachment occurring across the country. This anthropogenic sink brought about by land use practices is estimated to occur over an area of approximately 26 million hectares. While deforestation and poor forest management are sources of emissions their contribution is very small. The net result is a significant carbon sink which means that Namibia is sequestering more carbon than it is responsible for emitting.

Taking the above into account, especially the observations made regarding transportation and land use and forestry, the mitigation measures outlined below are in line with the nation's emissions profile. The lack of a measure directed specifically at mitigating emissions from cattle ranching is likely to be due to the economic importance of the sector and the cost of emissions reductions there.

6.4 INVESTIGATIONS INTO POTENTIAL MITIGATION MEASURES

Each of the five potential measures is dealt with in turn and will be presented in a similar format. In some cases measures are already underway, however the majority of what is laid out below is research and planning based, essentially looking into financial, economic and social feasibility as well as potential emission reductions.

6.4.1 MITIGATION MEASURE 1: Fuel switching

Assessment of the costs and benefits of fuel switching for motor vehicles

Transport fuels form a significant portion of Namibia's energy demand. This is due to Namibia's large area, dependence on private transport, and the economy's reliance on large volumes of imports that come into the country on land. Transport demand is strongly linked to economic growth and as such petroleum products will continue to dominate the country's energy demand well into the future. All Namibia's transportation fuel needs are met by imports. Regardless of the main aim of emission reductions, it is thus only prudent to develop a degree of energy diversity and flexibility as a hedge for the economy against fuel supply disruptions and international crude price shocks.

There are a wide range of alternative vehicle fuels commercially available globally, including compressed Natural Gas (CNG), Liquefied Natural Gas (LNG), Liquefied Petroleum Gas (LPG), Ethanol, Methanol, and Biodiesel. However, the only option currently available in Namibia is LPG for petrol (mogas) driven vehicles. Namibia has substantial natural gas resources in the Kudu Gas Field (see section 2.11), and as yet no petroleum resources. With the development of the Kudu Gas Field, LNG and CNG would become additional options. Use of Kudu gas to provide an alternative transport fuel will provide Namibia with its own resources and reduce the economy's vulnerability to imported fuels. Biodiesel from oil crop production is expected to be available by 2012, whilst ethanol from woody biomass is also another future option. This assessment focuses on the potential of LPG as an alternative vehicle fuel in Namibia.

The following methodology has been used:

- Investigate the current vehicle stock and on road fuel consumption using data sourced from the Namibian Traffic Information System (NATIS);
- Determine the trends in the vehicle stock and draw implications for the future;
- Determine vehicle fuel use by different commercial activities;
- Describe the current vehicle stock running on LPG and their fuel use;
- Describe the environmental and economic impact of motor vehicle fuel use;
- Identify options and opportunities for fuel switching and improved fuel use efficiency;
- Identify key issues that need to be addressed to promote fuel switching and improved fuel use efficiency.

Liquid petroleum fuels for transport fuel consumption constituted over 70% of Namibia's total energy demand in 2006. The main transport fuels in Namibia are petrol (unleaded and lead replacement fuel), used in most of the light passenger and light load vehicles, and diesel, used by almost all the heavy load and special vehicles. All petroleum products are imported from refineries in South Africa. The petroleum products demand has been increasing by an average of 4.4% per year between 1999 and 2006 (Table 6.1). This rate of increase is expected to continue due to the strong link between transport fuel use growth and economic growth in Namibia.

The Namibian vehicle population is dominated by passenger sedan vehicles (46%) and light commercial vehicles (light load vehicles) (42%), which together constitute 88% of the national registered vehicle population. In 2007, the total population of registered vehicles was 233,640. The majority of passenger

Table 6.1: Transport petrol and diesel consumption. *Source: Namibian Traffic Information System (NATIS)*

Year	Petrol[1] (t)	Diesel[2] (t)
1994	165,934.0	218,883.0
1999	216,815.6	291,660.2
2000	229,954.9	312,693.1
2001	223,204.7	321,607.8
2002	232,431.9	381,295.8
2003	235,282.9	365,306.5
2004	251,282.0	390.098.6
2005	243,750.3	389,838.7
2006	230,623.0	382,694.8

[1]Calculated from liters of fuel, using specific weight of petrol at 775kg/m³
[2]Calculated from liters of fuel, using specific weight of diesel at 845kg/m³

vehicles (more than 68%) in the country are older than 1997 whilst more than 74% of commercial vehicles are 1997 or younger. Data from a small number (5) of vehicle dealerships indicates that about 95% of passenger sedan vehicle and 70% of light load vehicles run on petrol. The only option currently available for fuel switching in Namibia is LPG and this is expected to remain the case for the next five years or so. Currently only petrol vehicles can be converted to run on LPG. Thus, it is estimated that the total number of vehicles that can potentially convert to be able to also use LPG is about 69,000 light commercial vehicles (light load vehicles) and 101,800 passenger sedan vehicles.

There is currently only one company providing conversions in Namibia and current estimates are that it costs N$4500-N$7000 to convert a vehicle (depending on type and engine capacity). A conversion should take between six and eight hours. A further limitation is that the supply and distribution network are underdeveloped and there is a lack of public awareness regarding the availability of this option and benefits of conversion. Only Windhoek, Oshakati and Walvis Bay have filling stations. All conversions need to take place in Windhoek. Significant investment is required to deal with the above shortfalls.

In terms of the emissions, a conversion of 170,800 vehicles would reduce CO_2e emissions by 20% when compared to the current baseline of the petrol and diesel fuel mix used in this vehicle population. On an annual basis this would amount to approximately 140,000 tCO_2e per year.

Furthermore, such a mitigation measure would result in a saving of the foreign exchange required to import fuel. In 2006, the import of refined petroleum products amounted to N$3,972 million. 35% of this or about N$1,390 million was accounted for by petrol (Mogas 93 and ULP 95). About 20% of this (N$ 278 million) could be saved with fuel switching to LPG. Furthermore, this could offer significant carbon revenue.

Looking ahead, there is potential for further alternative vehicle fuels such as biodiesel, and ethanol that could be produced in Namibia. Biodiesel is estimated to become commercially available in 2012 subject to the success of implementing the Namibia National Oil crop for Energy Roadmap (2006) within the framework of Vision 2030, and the planting of 63,000ha of Jatropha. Ethanol production from woody biomass (invader bush) feedstock could also be a price competitive option.

Table 6.2 is a summary of the afore-mentioned findings in terms of the priority actions, their potential impact and timeframes.

A number of constraints currently exist to the promotion of fuel switching and improved vehicle fuel use efficiency and it is recommended that an energy efficiency policy to create a conducive environment for achieving these goals be introduced. Such a policy would address issues such as:

- The institutional framework (e.g. a special Department within the Ministry of Mines and Energy specifically charged with the promotion of vehicle fuel efficiency and fuel switching);
- Incentives for fuel switching (e.g. tax relief, direct taxation, credits);
- Mandates (e.g. for specific fleet vehicle fuel switching e.g. taxis and commercial and government fleets);
- Development of standards that are uniform harmonised with Namibia's SADC partners;
- Funding research, development and demonstration projects;
- Public education on the advantages and use of alternative fuels, and improving vehicle fuel use efficiency;
- Advocacy and leadership through example (converting government fleets to alternative fueling).

Table 6.2: Priority actions for fuel efficiency and fuel switching

Fuel Type	Action Areas	Issues to be addressed	Expected Outcomes	Timeframe for achievement
Petrol	Improving vehicle fuel use efficiency through better driving habits, awareness on fuel efficiency and improved vehicle testing	► Information on vehicle fuel efficiency of vehicles on the market ► Information on good driving habits ► Strengthen vehicle testing	Fuel efficiency and carbon dioxide emission savings of up to 19% per year.	3 years from start of start of implementation of actions
	Fuel switching to LPG	► Capacity to convert vehicles Increase LPG fuel distribution and fuelling points ► Public awareness on advantages of LPG as a vehicle fuel ► Government and local government leadership in converting to LPG ►Incentives for switching to LPG	Savings of up to 20% of petrol and carbon dioxide emissions per year	Within 3 years of start of activities
	Blending with ethanol produced from invader bush	► Establish collaborative links with overseas groups' currently involved in piloting ethanol from cellulose. ► Strengthen local research capacity on bush utilization.	Savings of up to 15% in petrol and carbon dioxide	5 – 10 years
Diesel	Blending with biodiesel from Jathropa at rate of 5%	Implementation of Energy Oil Crop Roadmap	Savings of up to 5% diesel per year	
TOTAL			Up to 54% savings in petrol and petrol GHG emissions per year/ Up to 5% savings in diesel and diesel GHG emission /y	Up to 39% within 5 years and additional 15% in 10 years Within 10 years

As mentioned, these activities do have potential to access investment through the Clean Development Mechanism (CDM). However, a major constraint is the capacity for preparing projects for CDM. More capacity building should be granted to the Designated National Authority for CDM in Namibia as well as for project developers.

6.4.2 MITIGATION MEASURE 2: Clean energy

Assessment of feasibility and economic investment in cleaner energy in Namibia

The methodology employed here is broad and descriptive, essentially limited to an overview of the clean energy market in Namibia and the developments and limitations experienced.

Since the presentation of Namibia`s Initial National Communication (INC) to the UNFCCC (Republic of Namibia, 2002), cleaner energy or renewable energy market in Namibia has witnessed a dramatic progress. This is particularly so in the four year period 2003 to 2006 with regard to the delivery of commercially, institutionally and technically sustainable energy services by solar energy to the household, institutional, commercial and agricultural sectors. This is evidenced by the following:

- A total of 1,479 solar home systems (SHSs) were sold
- A total of 1,315 solar water heaters (SWHs) were sold reducing 1.7 tCO_2e per year each on average
- A total of 968 photovoltaic pumps were sold reducing 2.6tCO_2e per year each on average
- A total of 345 solar cookers were sold

The key investment challenges still, however, remain and there is further potential that needs to be fostered. Overall, mitigation projects qualifying to clean energy in Namibia include solar, wind, natural gas for cars, biogas, biomass, geothermal, afforestation and agroforestry projects, improved stoves and charcoal kilns. Currently electricity demand is approximately 520MW but this is estimated to increase to 1300MW by 2035 under the medium growth forecast (Figure 6.1). Furthermore, as mentioned, 50-70% of the nation's power is imported from South Africa. As such, a strong rationale exists for public support, would be investors and sponsors in the exploitation of clean energy in Namibia, due primarily to many economic, environmental, health, job creation, enterprise competitiveness and security benefits these technologies offer.

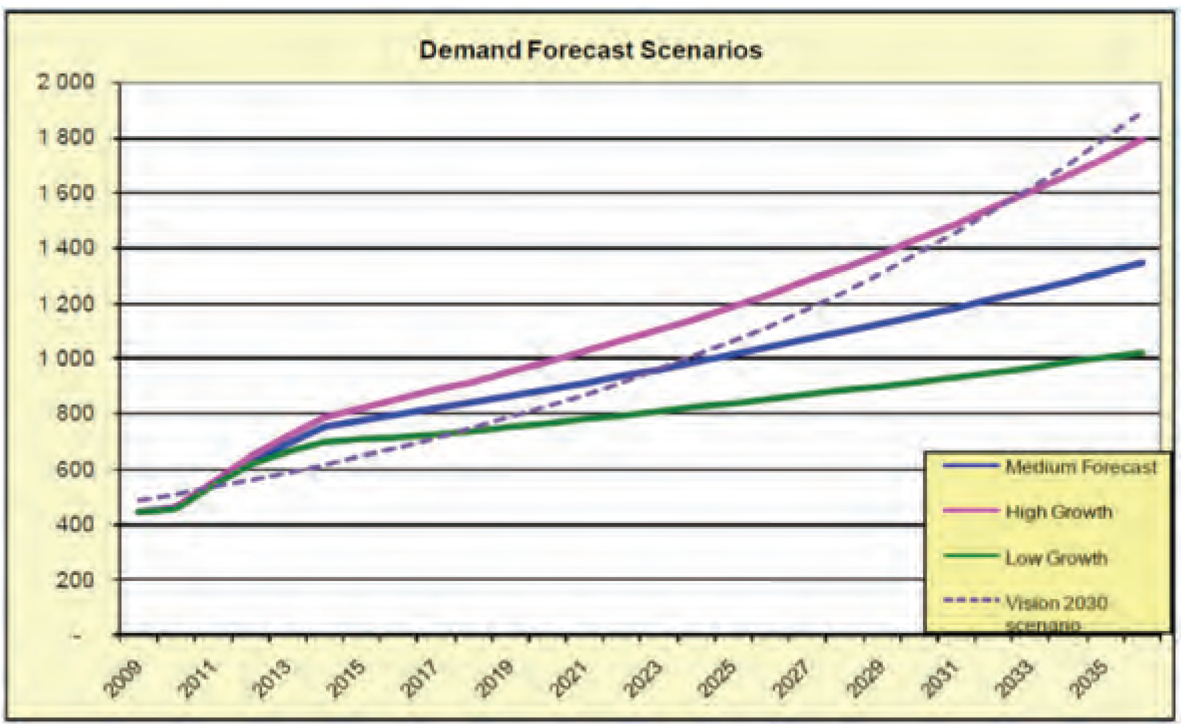
Although non-renewable, a positive development in light of the above is that Natural Gas is soon (2013) to come online in Namibia. The 800 MW Kudu Gas Project in Oranjemund is estimated to have cost N$ 7.137 billion. The combined cycle gas turbine power project (CCGT) will use natural gas from the Kudu Gas Field, located 170 km off-shore.

Coupled with the above developments, there is a growing international support for clean energy from which Namibia as a developing country and Non-Annex 1 Party can benefit.

In this regard, Namibia's local financial market is driven by the UNDP Barrier Removal to Namibia Renewable Energy Programme (NAMREP). The programme mission is to increase affordable access to sustainable energy through the further development of a market for Renewable Energy Technologies (RETs) in Namibia through the removal of technical, financial, social, institutional, capacity, public awareness and social acceptability barriers. A main focus has been solar and in this context NAMREP developed an effective loan financing schemes in 2004 named "Solar Revolving Fund" and administered by Konga Investment (Pty) Ltd. The NAMREP is in its second phase although this comes to an end in December 2010.

Policies and drivers such as these have driven the development of proposals and feasibility studies into clean energy sources for development such the Lüderitz Wind Farm (50MW), the Baynes and Divundu Hydro Schemes (265MW and 50kW, respectively), and the Orange River Small Hydro Scheme (various projects ranging

Figure 6.1: Namibia Demand Forecast. *Source: NAMPOWER*



between 5 and 35MW). In addition, the Tsumkwe Energy Project will see the establishment of one of Africa's largest solar-diesel hybrid mini-grids (500kW) in early 2011.

However, one of the most significant barriers to widespread implementation of clean and proven energy efficient technologies in Namibia is the lack of reliable and commercially available financing for end users, developers, contractors, manufactures and vendors. The problem is not a lack of available funds in general but the lack of available funds at the local financial institution levels. Virtually all funding needs to be sourced through multi- and bi-lateral development agencies or banks.

The projects briefly touched on above are feasible for Namibia yet a great deal of progress is needed from the Namibian capital markets so that public sources, multilateral and bilateral, are able to leverage the financing gap associated with demonstrations and barrier removal, market development and transformation. A strategy for looking ahead should encompass the following:

- Create the enabling environment to free the flow of local capital for the financing of clean energy and CDM projects;
- Support local commercial banks as an important source of clean energy loans and debt funds, and project bundling. They should be provided with capacity building, technical assistance, and risk sharing support in the form of credit lines, guarantees and revolving funds critically needed by end-users and SMEs;
- There should be a single platform for attaining Namibia's cleaner energy objectives on which all donors and investors can co-ordinate their assistance. This represents a move away from an ad hoc donor-by donor and project-by-project approach;
- Clearly stated long term objectives and corresponding measurable and time-bound targets for clean energy projects in Namibia should be considered.

6.4.3 MITIGATION MEASURE 3: Solar technology for local entrepreneurship

Assessment of the potential for building local entrepreneurship in Namibia in respond to Clean Development Mechanisms and research in most suitable solar technology options

The basic conditions required for the sustainable development of the renewable energy sector in Namibia is the development of technical capacity to promote renewable energy and the raising of public awareness on renewable energy. This led the Government of Namibia, through the Ministry of Mines and Energy (MME) to design policies condusive to the development of small renewable energy enterprises and fostering new RETs entrepreneurship in Namibia.

As mentioned above NAMREP was a programme designed to address these needs by removing the technical, financial, social, institutional capacity, public awareness and social acceptability barriers in the sector. In the area of technical capacity building, it is documented that NAMREP has to date trained about 140 RETs technicians, government officials and NGOs throughout the country. This has also helped to decentralise renewable energy SMEs as a way of making renewable energy technical skills available countrywide. This has resulted in 30 technicians setting up SMEs spread across all 13 regions of the country, extending renewable energy services.

In addition to NAMREP a further development is the establishment of the Renewable Energy and Energy Efficiency Institute (REEEI). It was launched in 2006 under the Polytechnic of Namibia.

The Clean Development Mechanism (CDM) is a flexible market mechanism under the UNFCCC Kyoto Protocol that provides the opportunity for Namibia to benefit from investing in emission reducing development projects. However, performance has been exceptionally poor, not only in Namibia but in Africa as a whole. There are a number of reasons driving this; of relevance here are those reasons that Namibia has some control over. This is linked to technical capacity and political understanding and will. It must be noted that this is not only limited to the CDM, but that the CDM provides an established development channel that must be utilised. However, the issues outlined below can be applied to the situation more generally.

Most successful CDM projects in emerging economy countries have complementary technical assistance components to help ensure achievement of programme objectives. Technical assistance support can include marketing, training, information dissemination, market development and consumer outreach. Subsequently, capacity building efforts and local capacity support are needed to strengthen the skill sets of Namibian institutions such as NAMREP and REEEI and individuals in a number of areas to facilitate the successful CDM projects. Specifically, it is important that a focus be given to particular technologies or renewable resources. Due to the solar resource in Namibia and the maturity of the market globally, Namibia has taken a strategic perspective and focused on solar projects. The following needs can be outlined:

- Technical ability support for system design, installation and maintenance of solar systems at SME level because renewable energy technology needs continuous adjustment to local constraints;
- Support for the establishment of rural micro-enterprises for RETs to mobilise entrepreneurship and business and providing a broad knowledge and application of techniques;
- Capacity support for the adoption of nation-wide regulatory policy to enforce standards for RETs perceived as barriers that prevent the roll-out of renewable energy projects in the country;
- Capacity building through tenders for reason that RETs SMEs are not proficient to bid competitively upon invitation of bids relevant to RETs projects;
- Support for capacity development at the level of programme staff;
- Support for conducting technology transfer /dissemination as more RETs technicians need to undergo regular theoretical and practical training in the design, installation and maintenance of solar systems to equip them to initiate projects and apply appropriate project management procedures;
- Capacity building in terms of local experts to identify, promote and appraise potential CDM projects; many projects elsewhere failed to qualify for CDM status largely because of design shortcomings.

The needs above seek to uncover common characteristics in solar technology, technical capacity in dealing with renewable energy issues and developing local entrepreneurs. Mitigating these barriers will require policy based tools, regulatory interventions, financial structuring, institutional support, market-based mechanisms and awareness and capacity building. As the sector faces considerable financing needs which cannot all be mobilised from public sources, overcoming these constraints is a major challenge for Namibian policymakers, and the way in which these constraints are overcome will to a large extent determine the country's ability to achieve a more sustainable energy mix and make a contribution to climate change mitigation.

In light of this, looking beyond solar, interventions are sought to commission research into profiling the entire country to obtain up to date wind regimes, to encourage sustainable development and sustainable energy resources in wind park projects for Namibia through REEEI. Furthermore, to accelerate the roll-out of NAMREPs solar street lights projects, NAMREP intends to commission research to assess the feasibility and viability of this approach, which can be used as a basis for local governments and municipalities to buy in.

6.4.4 MITIGATION MEASURE 4: Improve energy efficiency in buildings

Assessment of the economic and costs and benefits of improving lighting and energy efficiency or demand side management in public and other buildings

The costs of saving energy through the particularly large, untapped demand-side energy efficiency potential in Namibia is cheaper than the cost of adding new supply capacities. It is as much an energy resource as an option in the marketplace today, including conventional fuels. As Namibia faces a 3% growth in energy demand per year, energy efficiency has the potential to be an integral part of future energy supply strategies. Improved energy efficiency in government buildings, the fishing and mining industry, agriculture sector, transport sector and residential properties could lead to lower energy use overall.

Improving energy efficiency through reduced distribution losses is an important area for Namibia to focus on. Reduced distribution losses through engineering and provision of adequate resources are an important offset to CO_2 emissions, particularly in view of coal-based Paratus Plant and the heavy fuel oil based Van Eck Plant.

For example:

- The exchange programme of 900,000 compact fluorescent lamps (CFLs) with incandescent light bulbs will reduce national energy consumption by some 22GWh per annum, and reduce the demand by some 20MW which amounts to costs of approximately N$ 0.64 million per MW.
- After a complete replacement of Electric Water Heaters to Solar Water Heaters, annual energy consumption will reduce by 156GWH over ten years, and reduce the demand by some 52MW, which equates to costs of N$ 8.3 million per MW.
- Expanding ripple control measures to most larger Namibian towns will lead to demand shift of between approximately 19MW and 27MW, equating to about N$ 1,9 million per MW.
- It is expected that around 58GWh per annum could be saved through efficiency measures in the commercial and industrial sector by implementing energy audit, as well as 16MVA in consumer demand.

A number of countries worldwide have extensive experience in the effective promotion and utilisation of energy efficiency measures, realising dramatic benefits for their economies in terms of energy savings, carbon saving, jobs and investment, and as a way forward, Namibia should replicate. This requires putting in place a favourable regulatory framework bolstered by long-term national policies which aim to minimize primary demand, improve the energy efficiency of facilities and equipment and rationalise energy use.

6.4.5 MITIGATION MEASURE 5: Review forestry's contribution

Review of the forestry sector activities and their impact on Namibia's green gas balance

Plants and particularly trees (owing to their relatively large biomass per unit area of land) make an important contribution to the global carbon cycle and balance. Land clearance and deforestation increase the rate at which carbon is released into the atmosphere. As it currently stands, Namibia sequesters about 10,560Gg per annum thanks to its biomass resources (Chapter 3). This means that forestry related measures could make a significant contribution to the mitigation of climate change, and forestry management could enhance the role of forests in climate change mitigation through:

- Halting deforestation;
- Promoting reforestation and afforestation;
- Maintaining or enhancing long-term on site carbon stocks in forests and woodlands;
- Minimising disturbances to litter and soil, to avoid carbon emissions and soil degradation;
- Ensuring energy efficiency in woodland management operations and the conversion of harvested trees to products;
- Matching timber and wood fuel production to contribute to the reduction of fossil fuel consumption.

Namibia's forest resources (Table 6.3) play an important role in the economy and provide for a variety of uses. The uses with more significant impact to the carbon balance are:

- Energy; charcoal and firewood
- Land clearance
- Construction timber (poles and posts in the rural areas)
- Industrial wood in the form of raw materials for pit sawing and sawmilling
- Wood carvings and crafts

Forest woody volume		
Region	**Density (m^3/ha)**	**Volume (m^3 x 1000)**
Caprivi	21.37	30,916.0
Erongo	0.10	635.9
Hardap	0.10	1,096.6
Karas	0.05	805.4
Kavango	18.00	87,269.4
Khomas	0.25	921.5
Kunene	0.20	2,303.1
Ohangwena	20.00	21,388.0
Omaheke	2.00	16,888.0
Omusati	3.22	8,538.4
Oshana	0.90	781.4
Oshikoto	11.44	44,237.3
Otjozondjupa	3.90	41,080.3
Total		**256,861.3**

Table 6.3: Namibian Forest Woody Volume. *Source: Department of Environmental Affairs (DEA), Ministry of Environment and Tourism (MET)*

Product	Suitable annual yield (1000 m^3/yr)	Annual harvest (1000 m^3/yr)	Resource usage gap (1000 m^3/yr)
Fuel wood	16,293.5	1,022.7	15,270.80
Poles	2,715.6	334.4	2,381.20
Saw timber	171.3	0	171.3
Total	19,180.40	1,357.10	17,823.30

Table 6.4: Forest harvest.
Source: Department of Environmental Affairs (DEA), Ministry of Environment and Tourism (MET)

In reviewing the forestry sector activities and their potential impact on Namibia's greenhouse gas balance, it is found that Namibia will continue to be a carbon sink. Impacts on the greenhouse gas balance in the future are likely to result from the change to community management of most of Namibia's forest resources and the extent to which this will impact fire management in particular. Land clearing for agricultural production, invader bush utilisation and oil crop production are other future impact. All are unable to compete with the amount of carbon accumulation in Namibia's biomass as a result of bush encroachment and forest conservation.

- The total harvest of forest resources in Namibia is 1.357 million cubic meters per year compared to a sustainable yield of 19.18 million cubic meters. Use is only 7 % of sustainable yield. This gives a net woody biomass accumulation of 17.8 million cubic meters per year (Table 6.4). It can be concluded that:
- Namibia's woody biomass stock is a significant carbon sink and will be able to keep Namibia as a net sink. It should be managed in such a way as to maintain it and enhance it.
- The forestry activities planned within the context of the strategic plan are likely to have little impact on net carbon accumulation by Namibian woody biomass resources.
- The situation will require constant monitoring to detect and understand any changes in the greenhouse gas balance from forestry.

In this regard, it is recommended that:

- The collection of data for assessing carbon stock in the inventories of community forests, stocks in each managed area destroyed by fire, or reduced due to forest clearing for agriculture and the energy used in the course of forest management activities as part of forest management activities,
- Monitoring of impact of community managed forests on the carbon balance of each stand, as part of community forest inventories.
- Regular reporting of the carbon sink situation in the different forest stands be incorporated into the current forestry reporting framework
- REDD+ be assessed as a way of conserving the above by providing economic incentives for sound forest management.

6.5 CONCLUSION

Although Namibia is considered a net carbon sink it is important that the country still make an effort towards climate change mitigation measures. Using a broad descriptive approach this chapter has shown what those measures currently are and made recommendations as to what other potential measures need to be taken so as to reduce emissions. While using the greenhouse has inventory to inform the proposed measures is an important first step, taking an overarching perspective it can be concluded that a vital second step is to conduct a far more rigorous analysis of the potential measures available with a particular focus on monetizing the costs and benefits involved. Only then can Namibia make informed decisions as to how best to mitigate and what specific measures to invest in.

6.6 NATIONAL CLIMATE CHANGE POLICY: Mitigation projects

Following a process of analysis and consultation, the following mitigation themes have been identified by Namibia as receiving priority attention (refer to Table 8.1 for full list):

6.6.1 THEME 1: Sustainable energy and low carbon development

Namibia does not contribute significant amounts of greenhouse gasses to global emissions (du Plessis, 1999, Hartz and Smith, 2008). Although Namibia will be preoccupied with climate change adaptation because of its vulnerability to climate change, activities to mitigate shall be carried out to contribute to GHG reduction but more importantly to make positive contribution to the development path especially on energy use.

The 2000 Namibia's greenhouse gas inventory revealed that agriculture and energy sectors are the most important sources of emissions while the land-use change and forestry sector is most important with respect to removal of emissions (Hartz and Smith, 2008). Hence the energy sector is a high priority for climate change mitigation in Namibia.

As a developing country, the development path that will be adopted especially with regards to energy (e.g. low carbon development path vs. high carbon path) and policies on developments in agriculture and the land-use change and forestry sector will influence the extent of contribution of Namibia to stabilising GHG and hence

climate change mitigation. As Namibia becomes industrialised, in line with Vision 2030, it is most likely that we shall need to develop or transfer some technologies from developed countries to ensure that Namibia follows a low-carbon path growth. The Namibia strategy on climate change adaptation and mitigation will therefore:

- Improve efficiency of energy production and use
- Develop and improve renewable energy
- Reduce GHG emissions from Agricultural sector (crops and livestock) sector
- Reduce GHG emissions from land use, land-use change and Forestry
- Reduce GHG emissions from Industries (e.g. construction, mining)
- Enhance GHG sinks
- Manage rural and urban waste

6.6.2 THEME 2: Transport

Transport is an important socio-economic sector in Namibia considering the sparse population and heavy reliance of importation of many commodities from South Africa. The transport infrastructure in Namibia is well developed and highly rated (Republic of Namibia, 2002). The transport sector includes railway, roads networks, sea and air travel. Railway engines are diesel powered. Namibia has recently intensified extension of the railway lines to the densely populated north-central regions of Namibia and to the neighbouring Angolan border. In addition, construction of railway line to connect the Walvis Bay harbour to neighbouring countries such as Zambia, Zimbabwe and northern Botswana. Passenger transport, mainly through taxi services (sedans) and minibuses and long distance buses is on the increase. Air travel, especially for tourists and business people, is also gaining popularity. There is high mobility of people in Namibia as reflected in the increasing number of cars registered in Namibia. The populations of vehicle in Namibia is dominated by passenger sedan and light commercial vehicles; these two comprised about 88% of the national registered vehicle population in 2007 (Republic of Namibia (2007).

Vehicles contribute their share to GHG emissions. In Namibia in particular, long haul national and international road transport of commodities and cargo as well as passengers within and without Namibia contribute to GHG through exhaust emissions of carbon. In 2004, transport was responsible for 23% of world-wide energy related GHG emissions and 74% of these were induced by road vehicle usage. The spectre of increased vehicle ownership and usage in Namibia implies that there is a resulting increase in GHG emissions even if it may contribute little to the global GHG emissions. In addition, such increase may result from usage of old, used highly polluting vehicles. Emissions from the transport sector represent the fastest growing source of GHG in the world. They argue that as developing nations quickly move to catch up with the motorisation levels of developed nations, the sheer number of private vehicles may overwhelm any advances made in cleaner fuels. It is not surprising that IUCN recommended to the COP14 that Parties should urgently plan and promptly implement policies and measures for mitigation, with special attention to land use, land use change, forestry, agriculture, livestock and from energy, transportation and urban and industrial sectors of their economies (UNFCCC COP14 agenda item 4).

In Namibia, transport fuels make up a large proportion of energy demands. Since the transport demand is closely linked to economic growth, petroleum products will continue to dominate energy use both now and in the future (Republic of Namibia, 2007b), despite the polluting nature of these fossil fuels. Vehicle fuels such as Compressed Natural Gas (CNG), Liquefied Natural Gas (LNG) and Liquefied Petroleum Gas (LPG), ethanol and methanol and bio-Diels can be used but in Namibia, only LPG for petrol driven vehicles is available (Republic of Namibia, 2007). The advantage of these alternative fuels is that they are less polluting. The Namibia Climate change strategy recognises that the transport sector can contribute to climate change mitigation and therefore will:

- 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
- Promote use of public transport

7. Other information

7.1 STEPS TAKEN TO INTEGRATE CLIMATE CHANGE INTO POLICIES AND DEVELOPMENT PLANNING

Policy, legislative and institutional framework for climate change:

7.1.1 LEGAL AND POLICY FRAMEWORK

By virtue of the crosscutting nature of climate change, it is imperative that all the sectors evaluate the impacts of climate change and find strategies towards adaptation and mitigation. The next section discusses the key existing policy frameworks that inform Namibia's climate change response.

7.1.1.1 The Constitution of Namibia

The Constitution of Namibia highlights the need to develop and implement policies to maintain the ecosystems, ecological processes and biological diversity for the benefit of the present and future generations. The predicted negative effects of climate change may compromise the ability of the State to fulfil its constitutional obligations. The State, through its various government agencies and departments and in full partnership with the non-governmental and private sectors, has developed and will continue to develop preventative and adaptive activities to address environmental and climate change issues and problems.

The Constitution of the Republic of Namibia is the law above all laws in the land (article 1(6)). The Constitution lays the foundation for all policies and legislation in Namibia, and contains several key environmental clauses relevant to the sustainable use of natural resources. The mandate of the Ombudsman in relation to the protection of the environment is indispensable. In essence, the Ombudsman serves as guardian and protector of the Constitution insofar as it relates to the activities of the legislature and executive. The environmental duties of the Ombudsman are of particular importance when it comes to the:

- over-utilisation of living natural resources
- irrational exploitation of non-renewable resources
- degradation and destruction of ecosystems
- failure to protect the beauty and character of Namibia, and
- failure to take appropriate action to call for the remediation, correction and reversal of activities related to the above through means that are fair, proper and effective.

7.1.1.2 Vision 2030

Namibia's Vision 2030 (Republic of Namibia, 2004) provides long-term alternative policy scenarios on the future course of development in the country at different points in time until the target year of 2030. One of the long-term aims of Vision 2030 is available clean water, and productive and healthy natural wetlands with rich biodiversity. The successful implementation of appropriate and effective climate change adaptation and mitigation measures will contribute to the realisation of Vision 2030 goals. In particular, it is anticipated that adaptation to climate change will avert impacts that would otherwise hinder reduction in poverty and improvement of human health and standard of living.

7.1.1.3 National Development (NDP) Plans

The duration of Medium Term National Development Plans is 5 years. Namibia's First National Development Plan (NDP1) covered the period 1995/6 - 1999/2000. During this period, the Namibian economy was particularly dependent on primary production, which is vulnerable to climatic factors. In Namibia's Second National Development Plan (NDP2), for the period 2000/01 - 2005/06, strategies were adopted for increased diversification of the economy. Furthermore, in response to the heavy reliance on natural resources for the country's economic activities, the promotion of environmental and ecological sustainability became one of the key national strategies. It was recognised that the arid and fragile environment places a limit on economic development.

The current NDP3 (text available at http://www.npc.gov.na) spans the five-year period 2007/8–2011/2. The predominant theme of the NDP3 is defined as accelerated economic growth through deepening rural development, while the productive utilisation of natural resources and environmental conservation are key result areas. It states that the country is threatened by fluctuating climatic and weather conditions and that the lack of water is perhaps the single most important constraint to economic development. Vision 2030 regards the sequential five-year NDPs as the main vehicles for achieving its long-term objectives.

NDP3 (NPC, 2008) seeks to achieve the following national development objectives:

- Equality and social welfare
- Peace, security and political stability
- Productive and competitive human resources and institutions
- Competitive economy
- Enhanced quality of life
- Productive utilisation of natural resources and environmental sustainability
- Knowledge based economy and technology driven nation
- Regional and international stability and integration

7.1.1.4 National Poverty Reduction Action Programme (NPRAP)

In response to the poverty problem, the Government formulated the National Poverty Reduction Action Programme (NPRAP) in 2000 (NPC, 2002). It is a people centred poverty reduction approach in line with Vision 2030, and tries to tailor poverty reduction efforts to regional needs, as established in regional poverty profiles. The NPRAP is based on four priority themes. The first of these entails the creation of a prosperous nation through the development of Namibia's transport and manufacturing industries within the southern African region, investment in education, and guaranteeing health for all Namibians. The second priority theme entails the promotion of agriculture, tourism and small- and medium-scale enterprises as new income-generating opportunities for the poor. The third theme covers the need to improve safety nets for the poor. Finally the fourth theme relates to the need to use public resources efficiently in order to ensure a positive impact on poverty reduction. The NPRAP policies include:

- The provision of free basic education, with an emphasis on quality and affordability for the poor
- Free primary health care services, with priority to response to epidemics such as HIV/AIDS
- Food security
- Land reform in the agriculture sector, and
- Strengthened safety net through the provision of labour-intensive work programmes and pensions, grants and other financial assistance.

7.1.1.5 Pollution Control and Waste Management Bill

IIn terms of ozone depleting substances (ODS) and their contributions to climate change, Namibia provides for a broad range of sectoral legislation. One legal instrument of specific importance with regard to climate change is the Pollution Control and Waste Management Bill. The proposed legislation aims to:

- Promote sustainable development
- Provide for the establishment of a Pollution Control and Waste Management Unit
- Prevent and regulate the discharge of pollutants to the air, water and land
- Make provision for the establishment of an appropriate framework for integrated pollution prevention and control
- Regulate noise, dust and odour pollution
- Establish a system of waste planning and management, and
- Enable Namibia to comply with its obligations under international law in this regard.

7.1.1.6 Environmental Management Act

The Environmental Management Act (EMA) provides the environmental framework legislation for Namibia. Environmental management principles relevant to climate change laid down in the Act include:

- To conduct environmental assessments of all projects that may affect the environment or the use of natural resources
- To promote sustainable development in everything that affects the environment
- To adopt the best possible methods for reducing waste or pollution at its source
- To promote reduction, reuse and recycling of waste, and
- To take precautions to prevent environmental damage.

7.1.1.7 National Policy for Disaster Risk Management in Namibia

The National Policy for Disaster Risk Management in Namibia recognises that disasters of different kind, severity, and magnitude occur in Namibia and are caused by a wide range of factors. Disasters lead to the destruction of infrastructure and habitats, environmental degradation, and loss of human life and wildlife. Also at risk are livelihoods of individuals, especially the rural poor, due to increasing vulnerability related to changing demographics, technological and socio-economic conditions. Factors that increase vulnerability to disasters include climatic variability, environmental degradation, unplanned construction in high-risk zones, and other impacts of climate change. This National Policy for Disaster Risk Management will contribute to attainment of sustainable development goals in line with Vision 2030 through strengthening national capacity to reduce risk and build community resilience to climate change. To this end, the National Policy for Disaster Risk Management aims to:

- Minimise the loss of human life, property and damage to the environment from hazards of natural, technological, and ecological origin
- Advocate an approach to disaster risk management that focuses on reducing risks especially to populations who are most vulnerable due, to poverty and a general lack of resources
- Advocate for shared awareness and responsibility to reduce disaster risk in homes, communities, places of work, and in society generally
- Give effect to the application of co-operative governance on issues concerning disaster and disaster risk management among the levels of government and allocate responsibilities in this regard to relevant stakeholders
- Facilitate involvement of the private sector, non-government organisations, communities and volunteers in disaster risk management
- Facilitate partnerships between the State and the private sector, non-government organisations and communities.

Implementation of the National Policy for Disaster Risk Management in Namibia is very relevant to the climate change response in lieu of the projected increases in climate related disasters such as floods and droughts

7.1.1.8 White Paper on Energy

The White Paper on Energy recognises the renewable energy potential of Namibia in the form of rich gas reserves, hydropower and plentiful solar and wind resources. The White Paper encapsulates a comprehensive energy policy that will ensure that energy demands by the productive sectors of the economy continue to be met, while giving due attention to historically neglected people, including poor urban and rural households. In particular, rural electrification and access to other commercial fuels is promoted by the White Paper. It is evident that the emphasis of government to promote use of renewable energy through the establishment of adequate institutional and planning framework, the development of human resources, public awareness, and suitable financing systems all link very well with energy related climate change issues. The White Paper on Energy in Namibia will be instrumental in addressing low carbon development and sustainable energy issues. The paper focusses on energy efficiency, environmental impact assessments for major development projects including energy related projects, private sector investment in renewable energy and rural electrification, rural water supply, and solar water heating. The climate change and energy policies will be implemented in a manner that promotes synergies between them.

7.1.2 Namibia National Climate Change Policy (NCCP)

It is clear that Namibia, its people and natural resources are, extremely vulnerable to predicted impacts of climate change (Chapter 5). It is also apparent that although some efforts are underway to test adaptation approaches and understand the impacts of climate change better, Namibia has lacked a framework that defines the country's response in a systematic approach based on priorities for the short, medium and long term. The impacts of climate change are already felt in Namibia and delaying a response will increase the country's vulnerability to climate change. While the magnitude and implications of climate change impacts are still uncertain, Namibia needs to be proactive to generate awareness, build capacity and address climate change issues as a matter of urgency.

The Namibian government has recently finalised the National Climate Change Policy (NCCP). The NCCP defines the country's vision and objectives for tackling climate change. The main purpose of this policy is to provide the legal framework and overarching national strategy for the development, implementation, monitoring and evaluation of climate change mitigation and adaptation activities. The policy promotes the enhancement of synergies amongst sectors, policies and stakeholders for effective and efficient climate change mitigation and adaptation. In addition, the policy facilitates identification of sector and cross-cutting climate change strategies and actions for implementation to lower Namibia's overall risks, and the risks of the most vulnerable groups and sectors. It should be noted that all climate change interventions must adequately address gender issues. The policy also provides legal basis for resource mobilisation to address climate change adaptation and mitigation. It is thus in line with the key existing policy frameworks, including Vision 2030 and the National Development Plans (currently NDP3).

Namibia has little control over the causes of climate change, yet is highly vulnerable to the effects. The Year 2000 Greenhouse Gas Inventory (Chapter 3; Hartz and Smith, 2008) reveals that Namibia does not contribute significant amounts of GHGs to global emissions. Therefore Namibia's current primary focus is to build and secure the appropriate long-term sustainable resources for adaptation to the effects of climate change. For mitigation, Namibia will predominantly focus on low carbon development and sustainable energy. Namibia shall, however, explore and utilise available global mitigation techniques for the country's economic benefit, such as through the Clean Development Mechanism (CDC) of UNFCCC.

7.1.2.1 Key climate change issues in the NCCP

The NCCP serves as a legal framework within which to formulate and implement a strategy and action plan to address the challenges of climate change. In order to adequately address the impacts of climate change, sectoral strategy will be devised in the following sectors:

- Sustainable access to water
- Food security and sustainable resource base
- Agriculture
- Forestry
- Biodiversity and ecosystem services
- Human health and wellbeing
- Fisheries and marine resources
- Infrastructure
- Sustainable energy and low carbon development
- Education, training, capacity building and institutional strengthening
- Research and information needs
- Public awareness, participation and access to information
- Disaster reduction and risk management
- Financial resource allocation, mobilisation and management
- International cooperation and networking
- Technology development and transfer
- Policy and legislative development
- Gender issues and child welfare
- Vulnerable groups

7.1.2.2 Guiding Principles of the NCCP

Mainstreaming climate change into policies, legal framework and development planning

Given Namibia's vulnerability to climate change, the Namibian government recognises the need to the prioritise climate change issues and integrate climate change into sectoral policies, as well as mainstreaming climate change into development planning to ensure that it is addressed at appropriate levels at all times. There is a need to mainstream youth, gender, child welfare and vulnerable groups into climate change responses at local, regional and national levels. This mainstreaming shall be integrated into existing policies and laws; and shall be supported by all government agencies especially at local and regional levels, non-governmental organisations (NGOs), community-based organisations (CBOs) and Faith Based Organisations.

Sustainable development and ensuring environmental sustainability

The government recognises the need for Namibia to develop in such a way as not to compromise the ability of current and future generations to meet their needs. In recognition of Namibia's reliance on natural resources, it strongly advocate the sustainable and equitable use of natural resources as catered for in existing policy instruments, legal and development instruments and, where necessary to enhance the enabling environment.

Stakeholder participation in climate change policy implementation

The government recognises the importance of meaningful participation in the planning, development and implementation of climate change activities at local, regional and national level. The policy recognises the need to ensure the participation of women, children and other vulnerable/ marginalised groups and individuals, as well as, the use of appropriate local knowledge for adaptation. The role of the participation of Non-Government Organisations (NGOs), Academic Institutions, Community Based Organisations (CBOs) and Faith Based Organisations and the private sector in climate change adaptation and mitigation is viewed as important. In particular NGOs , CBOs and Faith Based Organisations should contribute to climate change awareness and advocacy.

Awareness generation, education, training and capacity building

The need for and importance of raising awareness building capacity and empowering stakeholders at local, regional and national levels and at the individual, institutional and systemic levels to ensure a collective and timely response to climate change is emphasised. It is also recognised that in order to foster long-term capacity for climate change in Namibia, there is a need to appropriately integrate climate change into the education system to generate awareness and capacities at the early stages of educational development in the country.

Human rights-based development

The Namibian government recognises and embraces the fundamental rights of humankind and further recognises the prediction that the most severe effects of climate change will be felt by the rural poor, women, children and marginalised groups/ individuals. It thus advocates for the practicing of human rights-based development in accordance with national and international law at all times during implementation of climate change response activities.

Promote and address 'adaptation' and 'mitigation' as key approaches

Namibia is vulnerable to climate change for reasons already mentioned. In light of Namibia's vulnerability and the risks associated with climate change, this policy seeks to provide a response tailored to local, regional and national conditions, such that the country can effectively and efficiently mitigate and adapt to climate change. The Namibian government advocates for the development of adaptation and mitigation measures that will reduce Namibia's vulnerability to climatic variability and change while addressing the needs of the most vulnerable social groups and sectors. This will ensure that Namibia's development trajectory is climate resilient and focused on sustainable livelihoods of the most vulnerable, as well as the socio-economic and economic viability of current sectors.

Public, Private Partnership

The role of the private sector in climate change adaptation and mitigation is important. The government shall encourage the development of public private partnerships that shall contribute to climate change adaptation and mitigation. The private sector can also play a role in raising funds, the development and transfer of technology for climate change adaptation and mitigation as well as capacity building for climate change.

7.1.2.3 Policy objectives

The objectives proposed for the Namibia Climate Change Policy are:

Objective 1:

To develop and implement appropriate adaptation strategies and actions that will lower the vulnerability of Namibians and various sectors to the impacts of climate change.

This will be achieved through the adoption and successful implementation of appropriate and effective climate change adaptation measures. Achievement of this objective will significantly contribute to the attainment of national development goals and long-term national vision.

Objective 2:

To develop action and strategies for climate change mitigation

This will be achieved through the development and implementation of renewable energy and energy use efficiency, Clean Development Mechanism (CDM) and enhanced carbon sinks.

Objective 3:

To integrate climate change effectively into policies, institutional and development frameworks in recognition of the cross-cutting nature of climate change.

Most existing policies relevant to climate change were developed at a time when climate change was not a national or global problem. Although the Ministry of Environment and Tourism (MET) is the designated lead agency for climate change response in Namibia, the cross cutting nature of climate change issues has ramifications for diverse activities in other government ministries. It is envisaged that the Namibia Climate Change Policy will help enhance synergies to ensure climate change and other issues are effectively, efficiently and cost-effectively addressed by relevant sectors and stakeholders. This objective will be achieved through the harmonisation of policies and laws to reflect an integrated approach to planning, decision making and implementation with respect to climate change. As far as possible, climate change shall be mainstreamed into sectoral policies.

Objective 4:

To enhance capacities and synergies at local, regional and national levels and at individual, institutional and systemic levels to ensure successful implementation of climate change response activities.

At all levels capacity regarding climate change lags behind the requisite standards in Namibia for historic reasons. This matter warrants immediate action across the whole spectrum of national activities, both within and outside government. Given the grim predictions of the effects of climate change on rural poor communities, women, children and marginalised groups, it is imperative to increase awareness and knowledge about climate change, as well to empower people to participate in the planning, development and implementation of appropriate responses to climate change.

Objective 5:

To provide secure and adequate funding resources for effective adaptation and mitigation investments on climate change and associated activities (e.g. capacity building, awareness and dissemination of information, etc.)

It is imperative that adequate funding resources are secured for short, medium and long-term adaptation and mitigation responses to climate change. In addition, funding should cover awareness generation, capacity building and education about climate change to ensure that people at all levels can participate effectively in climate change interventions. Such funding will be provided through Namibia's treasury budgetary allocation using set procedures. The

Namibian government shall ensure that Namibia leverages the best possible access to available climate change funding. Such funding can be accessed through international bodies like the UNFCCC to meet international obligations, provided that such funding results in projects that are in line with Namibia's domestic sustainable development needs.

7.1.3 INTEGRATION OF CLIMATE CHANGE INTO NATIONAL POLICIES AND LEGISLATIVE DEVELOPMENT

The government of Namibia has many legal and policy instruments. Examples include the Constitution of Namibia, NDP3, the National Land Policy, the National Drought Policy and Strategy, the Agriculture Policy, the Poverty Reduction Strategy and Action Plan of Namibia, a policy on desertification and the National Policy and Strategy for Malaria control, to mention a few. Most of these sector specific policies were developed without due consideration of climate change because at that time, climate change was not regarded as a serious issue.

However, it is now known that climate change will affect some of these sectors and therefore it should be considered. For instance, climate change is expected to severely affect the agriculture sector and so the Agriculture Policy needs to integrate climate change issue in order to address predicted impacts of climate change. While some sector policies may address elements of climate change, there is a need to identify issues of climate change commonality amongst sector policies in order to enhance synergies, facilitate cost effectiveness and avoid duplications of effort. In addition, new policies may need to be developed to address climate change. Furthermore, the National Climate Change Policy shall make room for climate change policy review.

Specific concerns which warrant policymakers' attention include:

- **Strengthening of social protection policies:** Against the background of the highly variable climatic conditions and the risk of extreme events, it is important that policy be developed to safeguard the limited productive assets of vulnerable rural Namibians by means of targeted, pro-poor disaster insurance schemes (DRFN, 2008). Apart from protecting productive resources of the rural population, policy should target the diversification of the rural economic environment and strengthen rural-urban linkages. These policy directions should receive adequate attention during the formulation **of a rural development policy and strategy**, which is currently lacking in Namibia's policy framework.

- A national debate to **clarify the expectations of the agricultural sector to national development, also in lieu of climate change**, should be initiated to streamline policies aimed at the sector (DRFN, 2008). Outright conflicting goals prevail which further undermine the potential of this vulnerable sector as well as the sustainable use of the environment.

- **Support to renewable energies**, a sector in which Namibia is very well endowed, should be rendered (DRFN, 2008; Republic of Namibia, 2007b). Against the background of climate variability and climate change, support to the fledging economic use of biomass (invader bush) is a priority. In addition, Namibia's capacity to benefit from the CDM needs to be developed.

- **Pricing mechanisms** in the water, land and electricity sectors should reflect the real scarcity of the goods. Incentives and disincentives (including equitable or pro-poor pricing mechanisms and conservation tariffs) should be devised which prompt resource stewards to be prudent in resource use.

- There is an urgent need for the **identification of adaptation packages** which could address critical climate change challenges in the short, medium and long term. These packages would consider which combination of technological, behavioral, institutional and policy mechanisms would yield the biggest cumulative benefit.

- Although a National Climate Change Policy has now been developed, it is still largely unknown whether sector policies address climate change or not, and no information and data is available about the extent to which **existing policies could exacerbate vulnerability to climate change and encourage mal-adaptation** (Republic of Namibia, 2010a).

7.1.4 REGIONAL AND INTERNATIONAL PROTOCOLS AND CONVENTIONS

7.1.4.1 SADC climate change related policies and strategies

Namibia is a member of the Southern African Development Community (SADC) and participates in a number of relevant regional treaties and policies. Despite the current lack of a SADC climate change specific policy and strategy, Namibia recognises the need to co-operate at regional level in the development and implementation of climate change adaptation and mitigation interventions, and will recognize climate change policy at SADC level should it come into existence. The government will also align with relevant African Union (AU) policies, which are in line with SADC policies that refer to climate change aspects. These include but are not limited to:

- SADC Regional Biodiversity Strategy
- SADC Protocol on Forestry
- SADC Regional Agriculture Policy
- Lusaka Agreement (2008) - Southern African Development Community (SADC) Regional Policy Framework on Air Pollution
- SADC Regional Water Policy and Regional Strategy (RWSP)
- NEPAD
- Trans-boundary Water Resources Management
- SADC Protocol for Fisheries
- SADC Protocol on Shared Water Courses
- SADC Protocol on Energy
- SADC Protocol on Transport, Communication and Meteorology

Namibia shares all of its major perennial rivers with its neighbours, and controls none of their major catchments (Figure 7.1). The SADC Protocol on Shared Watercourses outlines the guidelines for the usage of water from shared watercourses in the SADC countries. The guidelines cover issues ranging from equitable and reasonable usage of water to the responsibilities to inform basin states about environmental and other changes in water usage. This protocol has been one of the main reference points for Namibia's negotiations with other basin states on the usage of water from shared rivers. Several agreements have been made between Namibia and her neighbours to co-ordinate transboundary water issues:

- Permanent Joint Technical Commission on the Kunene River (JPTC) between Angola and Namibia (1990);
- Permanent Joint Water Commission (JPWC) between Namibia and Botswana which deals with the utilisation of

water resources from the Kwando-Linyanti-Chobe, the Zambezi and the Okavango rivers (1990);

- Permanent Water Commission on the Orange River between Namibia and South Africa (with a specific agreement on the Vioolsdrift and Noordoewer Joint Irrigation Scheme) (1992); and
- Permanent Okavango River Basin Water Commission (OKACOM) between Angola, Botswana and Namibia (1994).

Namibia has also established its first transboundary conservation area with South Africa in the Ai-Ais Richtersveld region, and is also investigating the establishment of further transboundary conservation areas in the Skeleton Coast Park / Parque Nacionale do Iona (with Angola) and the Caprivi Region (with Botswana, Zambia and Zimbabwe). The Orange River Mouth is a Ramsar site shared with South Africa.

7.1.4.2 Millennium Development Goals

In 2000, Namibia signed the Millennium Declaration, adopted by the United Nations, which sets out key challenges that face humanity worldwide. The Declaration is a determined promise by UN member States to address these challenges and establishes concrete measures for assessing progress and performance through a set of interrelated goals. While these goals aim to address specific issues, they are interrelated and raise cross-cutting issues that need to be addressed at national levels to achieve the goals by 2015. The MDG's clearly reflect major challenges that are addressed the in medium term National Development goals (NDPs) and the long-term Vision 2030 of Namibia. Climate change will directly and indirectly impact on the achievements of the MDGs.

7.1.4.3 UN Conventions and other International Environmental Conventions and Policies

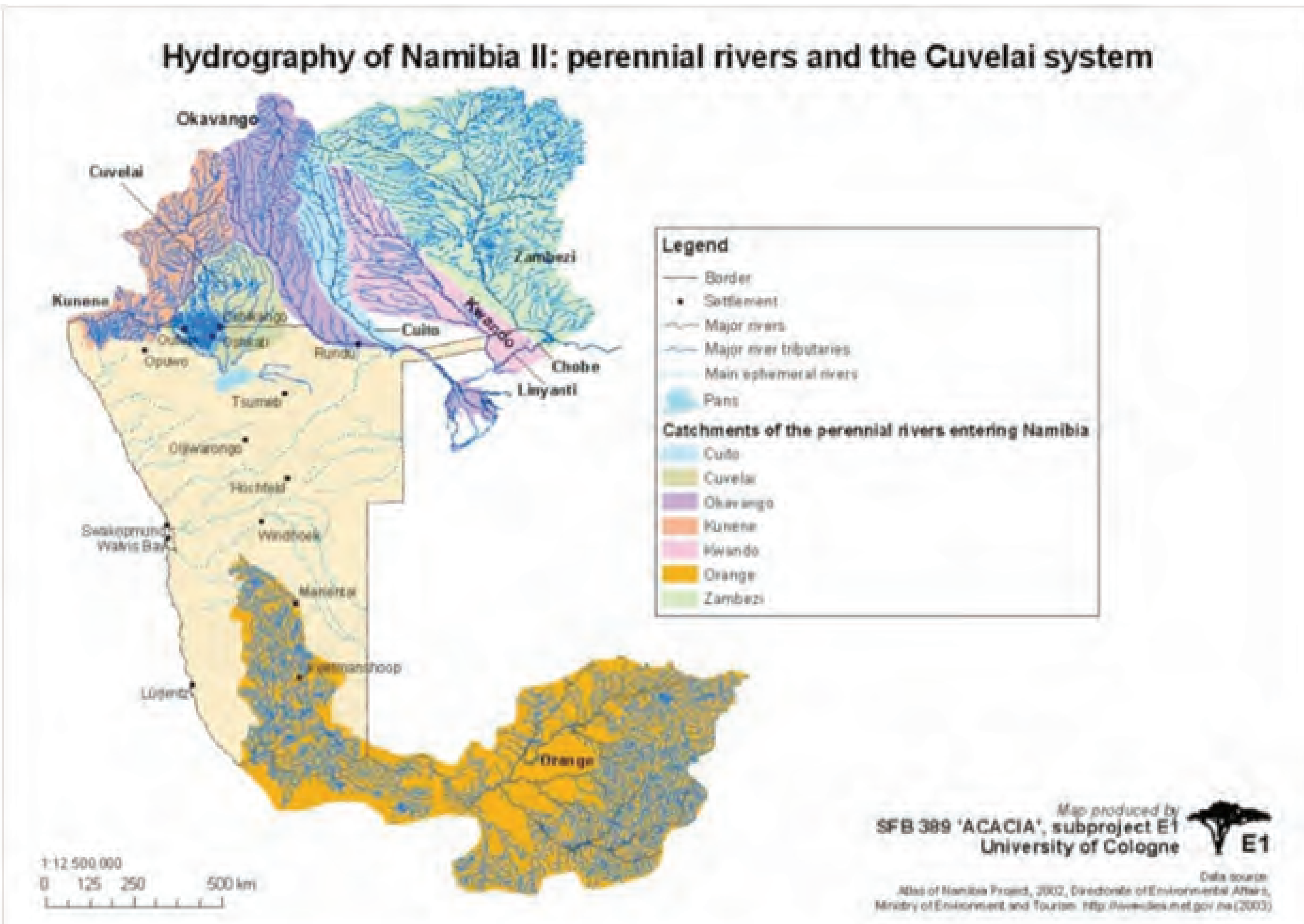
In Namibia and most other SADC member countries, climate change is receiving increased attention. During the 1992 United Nations Conference on Environment and Development (UNCED), also known as the Rio or Earth Summit, three Conventions were developed;

- the United Nations Framework Convention on Climate Change (UNFCCC)
- the United Nations Convention to Combat Desertification (UNCCD)
- the United Nations Convention on Biological Diversity (CBD).

The UNFCCC allows for the introduction of Protocols to the Convention. The first is the Kyoto Protocol, which came into force on 16 February 2005. Namibia, like all other SADC members, has signed and ratified both the UNFCCC and the Kyoto Protocol. As a non-Annex I Party to the Protocol, Namibia is not bound by specific targets for GHG emissions, however a number of global initiatives are being implemented, through donor and other support, to assist in the operationalisation of the UNFCCC. To ensure sustainable development while taking into account the issues of climate change, the government will:

(a) Continue to play a proactive role to ensure the protection

Figure 7.1: Hydrography of Namibia. Perennial rivers and the Cuvelai system, illustrating river systems shared with neighbouring countries Angola, Zambia, Botswana and South Africa. *Source: University of Cologne, data from Atlas of Namibia (Mendelsohn et al., 2002)*



of the regional and global environment and cooperate with the international community in promoting adaptation and mitigating strategies.

(b) Align with and strictly enforce the existing international climate change legislative and regulatory framework.

(c) Align with the Bali Road Map, Nairobi declaration and Bonn Agreement

Namibia has also committed to a number of other Multilateral Environmental Agreements:

- Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention, 1971)
- Convention on the International Trade in Endangered Species of Wild Flora and Fauna (CITES, 1973)
- Vienna Convention on the Protection of the Ozone Layer (1985)
- Montreal Protocol on Substances that Deplete the Ozone Layer (1987)
- Basel Convention on Transboundary Movements of Hazardous Wastes and their Disposal (1989)
- Convention for the Protection of World Cultural and Natural Heritage (1998)
- Benguela Current Commission (BCC), a regional initiative between Angola, Namibia and South Africa to manage in a sustainable and integrated manner the living marine resources in the Benguela Current.

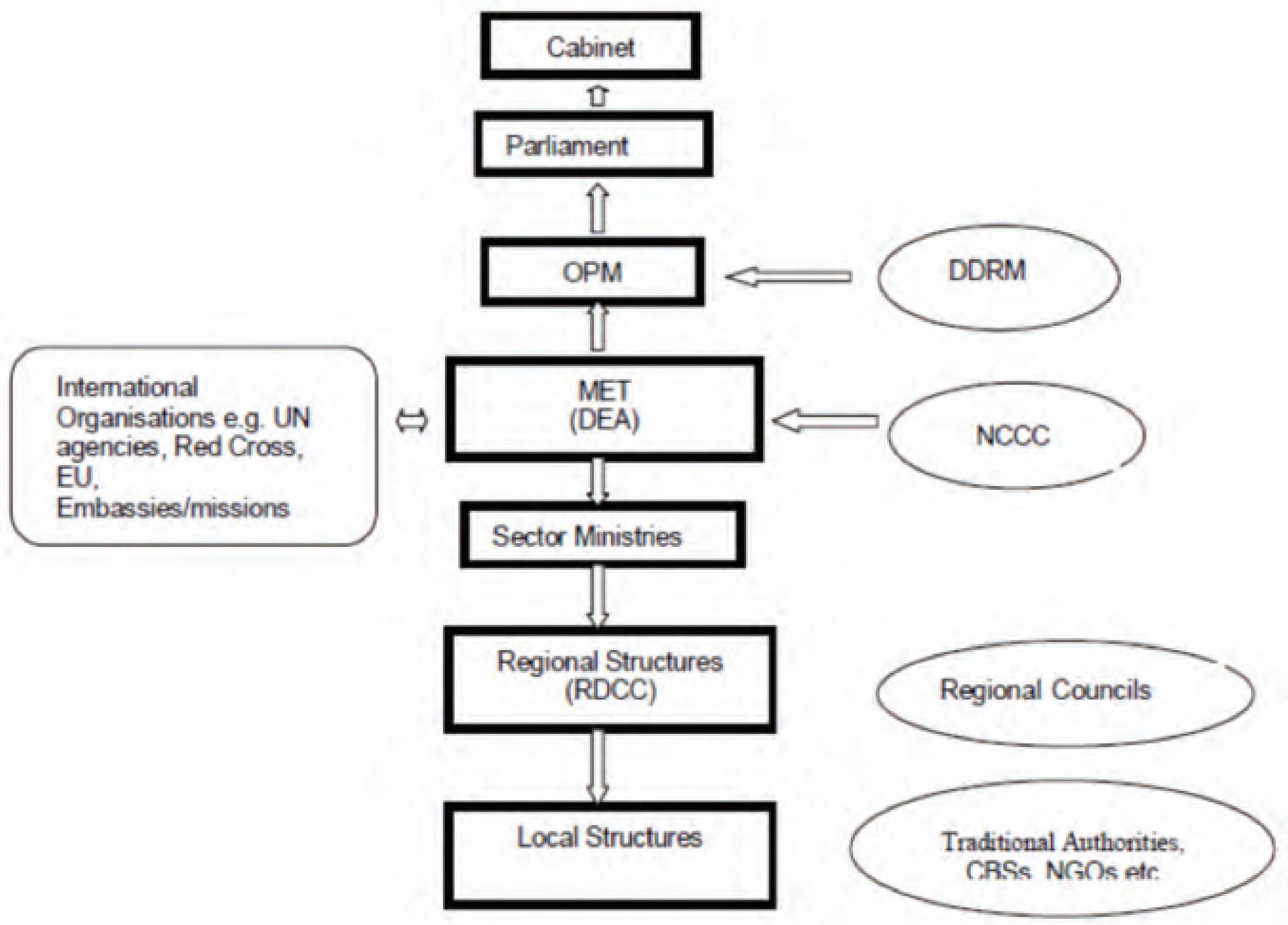
7.2 INSTITUTIONAL ARRANGEMENTS

The Cabinet of Namibia is the Government agency with overall responsibility for all decisions around Climate Change Policy (Figure 7.2). The Parliamentary Standing Committee on Natural Resources and Economics advises Cabinet on relevant policy matters. The Ministry of Environment and Tourism (MET) is the climate change coordinating Ministry. Through the Climate Change Unit (CCU) established within the Directorate of Environmental Affairs (DEA), the MET has been responsible for overseeing the coordination of Climate Change issues in Namibia, and thus the development and submission of National Communications in order to fulfil the country's obligations under the Convention.

The CCU is supported directly by a formalised multi-sectoral National Climate Change Committee (NCCC) for sector-specific and cross-sector implementation and coordination advice and guidance. The NCCC was established early in 2001 by the MET to direct and oversee further obligations to the UNFCCC. The mandate of the NCCC is to:

- Develop national positions on climate change issues through intersectoral dialogue to feed into all relevant international fora, including Conference of the Parties to the UNFCCC, meetings of the Subsidiary Body on Scientific and Technical Advice, and other international and regional meetings;
- Oversee the development of Namibia's ongoing national communications to the UNFCCC, including programme and project proposals to be included therein;
- Define Namibia's climate change capacity building needs and institutional requirements, and devise an effective strategy for meeting these;
- Devise a national strategy for adapting to climate change with emphasis on Namibia's extreme vulnerability as an arid African nation;

Figure 7.2: Institional structure for policy implementation



- Oversee the implementation of the Clean Development Mechanism (CDM) and other bilateral and multilateral mechanisms; and
- Carry out work as needed by way of subcommittees, through the co-option of additional members or advisors as appropriate.

The NCCC is chaired by the Ministry of Environment and Tourism, Directorate of Environmental Affairs (MET DEA). The deputy chair is the National Meteorological Service in the Ministry of Works and Transport (MWT NMS). The NCCC reports to the Permanent Secretary of the Ministry of Environment and Tourism (MET) via the head of the Directorate of Environmental Affairs (DEA). The NCCC has the powers to establish working groups and subcommittees as needed.

Climate change affects many sectors, therefore various Ministries, Organisations and Agencies actively implement climate change related issues. The Climate Change Unit (CCU) within the MET will assist directly with planning, development, implementation and coordination of climate change activities at the local, regional and national levels. Existing local and regional structures will be used for implementation at those levels. Where functions of line ministries have been successfully decentralised, these will be used to support local and regional level implementation and coordination.

At present a function exists within the Meteorological Services Division of the Ministry of Works and Transport (MWT) that carries out climatic monitoring, research and assessment. This unit will serve as the national Climate Analysis Unit (CAU) that will support the CCU, MET, NCCC and line ministries with pertinent information and data for informed planning and decision making about climate change issues. The implementation arrangements should cater for feedback loops through monitoring and evaluation to ensure that activities are relevant, appropriate and targeted at local and regional levels.

Additionally, civil society, industry, local government, NGOs, CBOs, educational and research institutions and others have an important role to play in supplementing the more formally constituted government structures in terms of public awareness, public debate, and focus on local and thematic issues.

7.3 RESOURCE MOBILISATION FOR POLICY IMPLEMENTATION

7.3.1 GOVERNMENT PROVISION

Climate change is a development issue that threatens the achievement of national development goals including Vision 2030, therefore the Government of Namibia shall make budgetary provision per sector based on needs assessments to address aspects of climate change adaptation and mitigation. Of particular support is the Climate Change Unit which should receive adequate budgetary allocation to facilitate its climate change coordinating role.

7.3.2 GOVERNMENT TO SECURE AND MOBILISE RESOURCES

The Government shall mobilise adequate human and material resources for the effective and efficient implementation of a National Climate Change Policy (NCCP). The study currently underway (2010) to assess the required investment and financial flows (IFF) to adequately address climate change shall be used as a guideline to plan for resources to become available for climate change activities. Multilateral, bilateral and donor funding avenues will be considered and explored, as well as private sector, insurance, risk management, and market-based instruments. The country will improve access to financing through more efficient procedures and governance.

It is imperative for Namibia to increase capacity at individual, institutional and systemic levels for an appropriate response to climate change. Such interventions shall include human resource development through focused training, mentoring and learning-by-doing approaches, enhancing observation, research and knowledge management; strengthening communication, education and awareness-raising at all levels, especially at the local and community levels; strengthening and using regional networks of information and knowledge sharing; developing tools, methods and technologies and supporting their application; encouraging and strengthening participatory and integrated approaches in planning and decision making, including the meaningful participation of civil society; sharing experiences, information and best practices of African countries; assessing, strengthening and mobilising the capacities of existing relevant facilities and institutions in Africa.

7.3.3 GOVERNMENT TO FACILITATE PUBLIC PRIVATE PARTENERSHIP

The Government shall explore and facilitate the establishment of Public Private Partnerships that will contribute both monetary and human resource capacity to address climate change adaptation and mitigation. Government shall encourage the private sector to invest in climate change adaptation and mitigation. Activities should entail securing resources and managing them, allocating them equitably based on priority groups of sectors, and mobilising resources and the management thereof.

7.3.4 MONITORING AND EVALUATION (M&E)

The Government is aware of the need to monitor and evaluate climate change variables, impacts and interventions, to ensure that they respond to the national, regional and local circumstances, and the need for mitigation and adaptation. Indicators defined in NDPs and the MET Strategic Plan will be used to measure progress and performance. Where possible these indicators could be extended to cater for activities, sectors and institutions dealing with climate change issues. The Government will develop measureable and verifiable indicators to gauge this policy implementation. The Ministry of Environment and Tourism and the Meteorological Services of Namibia shall play a vital role in regular and ad hoc monitoring. In addition, the government will further establish sites in regions to monitor and evaluate climate change effects over time.

7.4 ROLES AND RESPONSIBILITIES OF OTHER STAKEHOLDERS

7.4.1 General Public

The Namibian government recognises that civil society has a role to play in climate change interventions. It is well known for example that the rural population is predominantly poor and predicted to bear the brunt of climate change effects. Yet civil society can contribute significantly to climate change adaptation and mitigation through the adoption of climate change interventions that will reduce the predicted impacts. Active participation of the public in awareness regarding climate change campaigns, access to climate change information and adoption of climate change interventions is encouraged from civil society.

7.4.2 Private Sector

The government recognises the pivotal role which the private sector should play in addressing climate change adaptation and mitigation. The cross-cutting and multi-sectoral nature of the impacts of climate change requires collaboration and establishment of smart partnerships between various stakeholders including the private sector. There are many ways in which the private sector can contribute to climate change adaptation and mitigation. These include but are not limited to provision and mobilisation of financial and other resources, technical assistance as well as capacity building for climate change adaptation and mitigation. The private sector should be engaged in low carbon development and renewable energy ventures.

7.4.3 Non Government Organisations (NGOs), Faith and Community Based Organisations

Involvement of NGO and Faith and Community based organisations is critical to bring awareness of the impacts of climate change and also mobilisation of financial and other resources to local communities for climate change adaptation and mitigation. The government recognises that these NGOs and CBOs already play an important role in the disaster recovery efforts of the country. It is foreseen that these institutions will advocate for climate change adaptation and mitigation. These NGOs and CBOs shall be encouraged to assume the role of coordinating and integrating efforts amongst various stakeholders in order to address climate change issues.

7.4.4 Training and Research Institutions

The Namibian government recognises the role of training institutions, at different levels including pre-primary, primary, secondary school, colleges and tertiary levels, in training, research, capacity building and public awareness regarding climate change adaptation and mitigation. Training institutions at different levels will contribute to research and capacity building of well-trained scientific, technical and managerial persons who will understand and become actively engaged in climate change adaptation and mitigation. Decisions regarding interventions need to be informed by scientific knowledge. Research institutions, therefore shall play an important role to generate relevant climate change scientific information that shall be accessible to the public and decision makers. The government envisions that tertiary and research institutions shall undertake research to quantify likely impacts of climate change and develop practical solutions for adaptation to and mitigation of climate change.

7.4.5 The Media

The media will play a key role to inform and educate the public regarding climate change. The media shall be encouraged to take an active role to obtain accurate information about the causes and impacts of climate change world-wide and in Namibia and interventions to address climate change adaptation and mitigation. The media should be at the forefront of facilitating public awareness about climate change. The media shall be at the interface of translating scientific information on climate change and disseminating it to various stakeholders in a manner that is easily understood. Media coverage of climate change issues is pivotal to ensure adequate availability and supply of climate change information to communities which shall empower local communities to undertake appropriate action or interventions.

7.4.6 International Development Partners

The Namibian government appreciates the continued assistance of international agencies as they support efforts of the Government of Namibia to achieve human and socio-economic development. It is anticipated that the support of international agencies to human and institutional capacity for climate change interventions, as well as capacity to adapt and mitigate climate change by various stakeholders shall be enhanced by this policy. The Policy seeks to ensure that the pivotal role played by the international agencies shall be encouraged and supported at national, regional and local levels.

7.5 OPPORTUNITIES

Climate change could bring economic opportunities to Namibia. Urbanisation, when associated with the entrance into the formal economy, can stimulate economic growth in the secondary and tertiary sectors. Some of the market entrants will pay taxes and increase public revenue. Also, essential services can be supplied and targeted in a more cost-effective manner (e.g. provision of clean water in a suburb vs. in a remote village).

The existence of the Clean Development Mechanism (CDM), and recent policy decisions in Namibia to establish a unit in the DEA to allow Namibian projects to benefit from this transfer mechanism, offers a great opportunity for rural Namibia to engage in the global trend of expanding the use of biofuels, especially in the energy and transportation sectors, through energy portfolio standards and incentives to growers and consumers. The bush encroachment problem in particular could become an opportunity, with energy farming becoming a new driver of the Namibian rural economy, supported by the implementation of rapidly developing biomass-to-liquid technologies. CDM projects should also look at promoting reforestation, afforestation, and improved land-use practices in ways that enhance overall productivity and delivery of ecological services, while simultaneously sequestering carbon. Clearly, any such interventions warrant careful attention to environmental impacts, biodiversity concerns, and energy and water inputs; the debate on the merits of biofuels is well documented.

Namibian experience with Community Based Natural Resource Management (CBNRM) has provided an opportunity for communities to diversify traditional systems as a source of revenue for rural communities. At the same time, this provides an opportunity to find synergies between climate change adaptation and improved natural resource management, with tangible financial benefits for rural communities. CBNRM fosters the devolution of decision-making to the local resource users, strengthens institutions on the ground and allows for much better choices regarding resources compared to centralized systems of decision-making. The continuous shift towards game farming in the commercial farming areas reflects the realisation of the opportunity to harness the environmental and economic potential of the highly adapted wildlife in rural Namibia.

8. Constraints and gaps, and related financial, technical and capacity needs

8.1 FINANCIAL RESOURCES AND MANAGEMENT NEEDS

Adequate resources, including finances are required in order to undertake climate change adaptation and mitigation. The New Delhi Work programme recognises the need for adequate financial and technical resources to ensure effective implementation of the activities of Article 6 of UNFCCC. Since Namibia contributes very little to greenhouse gas (GHG) emissions, its preoccupation focuses on adaptation to the effects of climate change. Financial and other resources are needed in the quest for adaptation. UNFCCC through the Bali Action Plan also recognised the importance of funds. Since all activities of climate change adaptation and mitigation will require financial and other resources, the national climate change policy will make provision of how financial and other resources will be secured, allocated, mobilised and managed. Such funding sources should include adequate allocation for the exploration of appropriate off-setting opportunities in the various sectors.

Long-term investment in research and development is required to enhance capacity in research, development and innovation to address the Namibian challenges of climate change across the key vulnerable sectors. A deliberate and emergent financing strategy for research and development need to be created within a stakeholder participatory planning process.

8.2 TECHNOLOGY DEVELOPMENT AND TRANSFER

In order to address climate change mitigation and adaptation, the need for development of new technologies and transfer of existing appropriate technologies cannot be overstated. New and clean energy technologies need to be developed to reduce greenhouse gas emissions while technologies also need to be developed to address climate change issues related to water shortages for agricultural production, drought resistant crop varieties and livestock breeds and food security. The African Ministerial Conference on the Environment (AMCEN) in May 2009 in Nairobi reaffirmed that the development and technology transfer are critical to the achievement of both adaptation and mitigation programmes in Africa. Technology transfer and development is one of the four pillars of the Bali Action Plan, but more importantly can benefit adaptation and mitigation initiatives. The role of technology in the socio-economic growth of Namibia is enshrined in both Vision 2030 and the NDP3 (one key Results Area of NDP3 is knowledge based economy and technology driven nation). The National Climate Change Policy identifies technology development and transfer to be a key issue for which strategies and action plans should be developed.

In the agricultural sector, critical technologies required for adaptation to climate change have been identified (University of Namibia, 2008). The breeding and selection of indigenous and locally-adapted plants and animals, as well as the selection and multiplication of crop varieties adapted or resistant to adverse conditions, must be promoted. Biotechnology can contribute to agricultural productivity and food security. Seed science and technology including seed health and testing are not adequately addressed and coordinated. There is a need for a seed health laboratory that farmers can turn to for disease identification.

Other examples include the technological options required to respond to sea level rise, such protective structures and flood control measures (CSA, LaquaR and Lithon, 2009).

Namibia also requires technical assistance for the development of clean energy technologies and alternative energy sources (such as wind mapping, and fuel from invasive woody biomass) (Republic of Namibia, 2007b). Most successful CDM projects in emerging economy countries have complementary technical assistance components to help ensure achievement of programme objectives. Technical assistance support can include system design, installation and maintenance of solar systems at SME level; marketing, training, information dissemination, market development and consumer outreach. Subsequently, capacity building efforts and local capacity support are needed to strengthen the skill sets of Namibian institutions such as NAMREP and REEEI and individuals in a number of areas to facilitate the successful CDM projects. Specifically, it is important that a focus be given to particular technologies or renewable resources. Due to the solar resource in Namibia and the maturity of the market globally, Namibia has taken a strategic perspective and focused on solar projects.

8.3 RESEARCH, SYSTEMATIC OBSERVATION AND INFORMATION

In Namibia, as in most developing countries, climate change and its impacts are not well understood, despite some key studies being completed in preparation for the compilation of this SNC. This is partly due to the fact that climate models still suffer from great uncertainty in projecting the future climate. Research into climate change impacts, adaptation and mitigation responses also needs to be strengthened. Climate change research needs to be properly coordinated and the benefits optimised to meet the needs of policy makers in Namibia. Attention needs to be focused on projects that will assist with mitigation of, and adaptation to climate change and address specific areas of vulnerability. Further, development and demonstration projects are required to show the advantages and acceptability of a variety of technologies related to climate change. There are some solid foundations in this area on which to build including, inter alia, renewable energy demonstration projects and the long-term environmental observation networks such as LTER and BIOTA Southern Africa. In addition indigenous adaptation mechanisms and strategies need to be researched to determine their effectiveness and replicability. Research results obtained in Namibia or elsewhere shall form the basis for the development and implementation of evidence-based strategies and action plans for adaptation and mitigation of impacts of the climate change.

Research needs for adaptation to climate change are not sufficiently articulated within the national sectoral research programmes. Programme formulation with clearly set out, widely understood, and multi-stakeholder coordinated priority setting mechanisms will facilitate the implementation, monitoring and evaluation of well-thought government initiated research programmes. A formal multi-disciplinary research programme review, evaluation, and monitoring exercise for Namibia is proposed to ensure that proper guidance is given to all research institutions, professionals and other stakeholders such as the farming and fishing communities.

Specific identified research needs include:

Strengthen systematic meteorological observation and improve climate and hydrological datasets (DRFN, 2008):

- There is a marked paucity in readily available weather data due to diminishing numbers of weather stations across the country taking continuous measurements.
- Climate, and in particular precipitation is very location-specific in semi-arid climates such as Namibia's. To obtain a better understanding of how rainfall patterns have evolved over the past century, meticulous screening of available data is required. It is furthermore important to fine-tune methods in climate research to allow for assessing the inter- and intra-annual variability. A more detailed analysis of local data will contribute to improved quality of climate and impact modelling in certain sectors, and is likely to further contribute to improved decision-making processes and disaster risk preparedness.
- The catchment areas of Namibia's critically important perennial rivers lie mostly across international borders, and smooth exchange of data is required with e.g. Angola and Zambia to improve the quality of impact modelling (rainfall-runoff relations) and to contribute to more informed policy decision-making processes in Namibia.

Coordinated data management for agriculture (University of Namibia, 2008)**:**

- There is no formal system for agricultural data management in Namibia. The current practice is ad hoc oriented for incoming, internal, and outgoing information among the diverse farming service providers. There is a need to maintain and enhance the collection of accurate physical, economic and social data that will enable the development of models that predict the impacts of climate change on agriculture.
- Vulnerability in the agricultural sector can be reduced by developing monitoring capabilities, and enhancing the responsiveness of the agricultural sector to forecasts of production variations and food crises. A pilot assessment designed to monitor climate variability while enhancing adaptation of farming systems is needed.

Disaster preparedness and vulnerability mapping:

- In order to enhance disaster preparedness, vulnerability mapping - both in a technical sense (using remote sensing techniques) and in a participatory manner - should be undertaken (DRFN, 2008). The former will assist in delineating areas where rare flood events could occur, and thus inform the development of infrastructure. The latter will allow for the identification of adaptation strategies based on the needs and priorities of those living in disaster prone areas. It might also contribute to the revival of indigenous coping strategies.
- There is a need for better cooperation between the Early Warning and Information Systems Unit of MAWF with the Emergency Management Unit of the office of the Prime Minister, for improved assessment of, and response to the short- and long-term impacts of adverse natural events on agriculture-based livelihoods (University of Namibia, 2008). This should be done through the establishment of a historical climate data archive, improvements in monitoring tools for systematic meteorological observations, and information tools on the characteristics of farming system vulnerability, including critical thresholds and coping mechanisms.

Research into agricultural technologies and production systems:

Future research needs to enable adaptation to climate change have been identified in the following key areas (University of Namibia, 2008; section 5.5.3.1):

- Crop germplasm conservation/evaluation and breeding
- DSSAT crop model simulation and validation
- Ricardian approach-based study

Other monitoring-based research:

- Monitor ecosystem and biodiversity changes and their impacts
- Monitor sea level rise and its impacts

Indigenous knowledge:

- Conduct inventories and associated research on traditional / indigenous knowledge and coping practices

Carbon sequestration by anthropogenic ecological disturbances (Hartz and Smith, 2008):

- Conduct scientific studies that will significantly improve our understanding of the impact of invader bush encroachment on Namibia's greenhouse gas profile (see section 3.8.2). This should include data collection and monitoring of carbon stocks for forest inventories, the impacts of fire and forest clearing on carbon stocks, and the impacts of community forest management (CBNRM conservancies and forests) on stand carbon balance (Republic of Namibia, 2007b).
- Clarify the details of pre-anthropogenic baseline ecological conditions in Namibia (see section 3.8.3).

Fuel switching and fuel use efficiency (Republic of Namibia, 2007b)

Conduct research, development and demonstration projects of alternative fuels and fuel use efficiency (see section 6.4.1).

Wind and solar energy (Republic of Namibia, 2007b)

- Wind regimes across the whole country need to be profiled, for incorporation into sustainable energy wind park projects through REEEI.
- Research is required into the feasibility and viability of NAMREP's solar street lights projects, for soll-out in towns and cities across Namibia.

Develop research capacity:

Establish a centre for research and training on climate change

Economics of climate change:

- Undertake studies on the cost of adaptation and mitigation
- Study macroeconomic and sectoral impacts of climate change

Furthermore, **a greenhouse gas data collection unit** within a Government body should be established (see section 3.8.1), with the responsibility of collecting relevant, reliable and comprehensive data for:

(i) improved greenhouse gas inventories
(ii) technical support of carbon credit funding applications

8.4 EDUCATION, TRAINING, CAPACITY BUILDING AND INSTITUTIONAL STRENGTHENING

The complex nature of climate change requires the involvement of well-trained scientific, technical and managerial staff that will not only understand climate change but also be involved in adaptation to climate change. Namibia will also need institutional structures that are adequately equipped and able to provide facilities and finances to support programs and activities of climate change adaptation and mitigation. Section 2(d) of Article 9 of the UNFCCC calls on parties to provide advice on "ways and means of supporting endogenous capacity building in developing countries" while article 6 of UNFCCC states that parties shall promote and as appropriate, facilitate and cooperate on education, training, outreach and public awareness. Education, training and capacity building should involve multiple stakeholders, including the government, NGOs, research institutions, local communities and international organisations. Building and strengthening human and institutional capacity to address climate change shall be a fundamental component of Namibia's climate change strategy, and shall:

- Strengthen human resource capacity building for climate change
- Mainstream climate change in national, local and sector policies, development plans and programmes
- Strengthen institutional capacity for climate change management
- Mainstream climate change in the media
- Develop and implement educational programmes 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.
- Establish a Climate Change Resource Centre and a Climate Change Database

More specifically, the following needs have been identified (DRFN, 2008; Republic of Namibia, 2007b):

- In view of the extent of flood related damage currently experienced, the capacity to undertake spatial planning, including town and regional planning and engineering, should be strengthened to include ecosystem requirements (this would for instance avoid malls/roads in depressions [oshanas] without any storm-water provisions).
- Boundary organizations in Namibia should be strengthened to facilitate climate change feedback loops between science institutions, policy makers, and land users. This requires capacity to access, interpret, translate and communicate climate change science and concomitant local level indicators. Communicating climate change considerations is considered a particular challenge due to the complexity of the issues, as well as the diversity of target groups that need information (politicians, policy makers, and farmers).
- Capacity building for academics and professionals to apply and interpret climate models and impact models in sectors that are considered critical for the development of Namibia, with the aim to build a broader understanding of the vulnerability of various sectors to climate variability and change. Such capacity building should further focus on the application of economic principles to quantify/compare the impacts of certain changes and policy interventions to foster fact-based decision-making when allocating very scarce public resources to certain adaptation programmes or interventions. This will require more in-depth analysis of certain sub-sectors in e.g. the agricultural sector.
- Capacity building for the identification, preparation and appraisal of potential CDM projects; many projects elsewhere failed to qualify for CDM status largely because of design shortcomings.
- Capacity building for local commercial banks as an important source of clean energy loans and debt funds, and project bundling.
- Further theoretical and practical training of RETs technicians, government officials and NGOs throughout the country, to make renewable energy technical skills available countrywide. This to be accompanied by capacity support for the adoption of nation-wide regulatory policy to enforce standards for RETs perceived as barriers that prevent the roll-out of renewable energy projects in the country. As the sector faces considerable financing needs which cannot all be mobilised from public sources, overcoming these constraints is a major challenge for Namibian policymakers, and the way in which these constraints are overcome will to a large extent determine the country's ability to achieve a more sustainable energy mix and make a contribution to climate change mitigation.

8.5 PUBLIC AWARENESS, PARTICIPATION AND ACCESS TO INFORMATION

Climate change is likely to exert its greatest impact on the natural resources of Namibia, therefore threaten the livelihoods of the majority of local people who live in rural areas. Public awareness will empower stakeholders, especially local subsistence and commercial farmers to participate in adaptive response activities. One objective outlined in Vision 2030 is to transform Namibia into a "knowledge based..... nation". It is because of the importance of such an objective that the theme of "knowledge-based economy and technology driven nation", was included in NDP3. In order to effectively address adaptation and mitigation, the public needs to be aware and have access to accurate, up-to-date information in order to effectively participate in climate change issues. The National Climate Change Policy therefore promotes mainstreaming of public awareness, participation and access to information as a key issue of concern and importance to climate change.

For example, in the agriculture sector, the establishment of an Adaptation Information and Advice Service for improved communication and awareness is proposed (University of Namibia, 2008). Bringing climate change rather than just climate variability into focus as an additional element in normal strategic planning and climate risk management in agriculture requires awareness raising and capacity building. Efficient and planned awareness, incorporating climate change considerations in policy and programme communications, will foster an increased understanding and integration of scientific knowledge into farm management decisions and incorporate issues of climate change adaptation into education and training packages directed at agricultural industries. Sources of climate change information and advice on adaptation strategies in the farming communities are not generally available; a climate change information and advice service would satisfy this need.

8.6 INTERNATIONAL COOPERATION AND NETWORKING

Climate change is a global problem and its effects cross national boundaries. For instance, although Namibia contributes very little to greenhouse gasses, it will severely suffer from the adverse effects of climate change. The global nature of climate change necessitates exchange and sharing of data, information and expertise at regional and international levels in order to enhance appropriate and effective responses. There is a wealth of data on climate change adaptation and mitigation programmes and activities, as well as good case studies from different parties to the UNFCCC which can be shared and some adopted and adapted. In addition, lessons learned and best practices to capitalise on offsetting opportunities could be accessed through cooperation and networking and could be developed and implemented through bilateral or multi-lateral frameworks. The National Climate Change Policy makes provision for international cooperation, collaboration and networking in order to tap into this wealth of information, data, expertise, and financial and other resources to benefit efforts by Namibia to address climate change. This will include promotion of international North-South and South-South collaborative research that will facilitate generation of climate change adaptation and mitigation evidence-based information.

8.7 PROPOSED CLIMATE CHANGE ADAPTATION, MITIGATION AND CROSS-CUTTING PROJECTS

The Namibia climate change strategy, giving rise to the Action Plan, is based on three main responses: adaptation, mitigation and tackling cross-cutting issues through adaptation and mitigation. Each of the three aspects is subdivided into themes. Adaptation addresses four themes, mitigation addresses two themes, and cross-cutting issues addresses eight themes. Cross-cutting issues relate to issues that will be addressed through multi-sectoral and multidisciplinary activities.

The Action Plan summary presented in Table 8.1 is based on a more detailed action plan (Republic of Namibia, 2010a) which gives in detail specific proposed activities to address each strategic aim through adaptation or mitigation. For each strategic aim, an “action sheet” has been prepared which contains the following information; aspect, theme, strategic aim, objective, rationale for the strategic aim, proposed activities, time frame, participating agencies and an estimate of financial resources required. The following time frames are implied; short-term implies 5 years or less, medium term is between 5-10 years and long-term is more than 10 years. This aligns well with timeframes used for the National Development Plans (NDPs).

Table 8.1: Proposed Climate Change Action Plan for Namibia (Republic of Namibia, 2010a)

ASPECT	ADAPTATION
Theme	**T1: Food security and sustainable resource base**
Strategic aims Agriculture Forestry Fisheries Coastal zone Biodiversity	SA1: Development of climate resilient cropping/ agriculture / production systems
	SA2: Development of climate resilient crop varieties / cultivars
	SA3: Diversification of agriculture and livelihoods
	SA4: Development of climate resilient livestock breeds
	SA5: Adaptation against drought
	SA6: Conservation, utilisation and sustainable development of forest resources
	SA7: Conservation, utilisation and sustainable development of fisheries and aquaculture (incl. marine and freshwater aquaculture)
	SA8: Conservation, utilisation and sustainable development of the coastal zone and its resources
	SA9: Conservation, utilisation and development of biological resources and maintenance of ecosystems to ensure environmental sustainability
Theme	**T2: Sustainable Water Resources**
Strategic aims Water	SA1: Conserve and manage watershed / catchment areas
	SA2: Promote integrated development and management of water resources
	SA3: Promote conservation and sustainable use of water resources
	SA4: Improve trans-boundary cooperation regarding water resources
	SA5: Support institutional and human capacity building in water resources management and use
Theme	**T3: Human Health and well being**
Strategic aims Human Health Sanitation HIV/AIDS	SA1: Adaptation to climate change related health risks
	SA2: Assessment of impacts of climate change on human health and well being
	SA3: Expansion of health facilities and network to remote areas
	SA4: Improve capture, management, storage and dissemination of health information
	SA5: Improve access to sanitation and water
	SA6: Increase human resources capacity and improve efficiency
	SA7: Support action plans against HIV/AIDS
Theme	**T4: Infrastructure**
Strategic aims Coastal zone Housing & settlement	SA1: Develop a climate change Infrastructure risk assessment guidelines and methodology
	SA2: Improve infrastructure spatial planning and development in urban and rural areas
	SA3: Improve drainage and sanitation facilities in rural and urban areas
	SA4: Adaptation to floods
	SA5: Adaptation against future sea level rise
	SA6: Improve formal and informal settlement patterns and housing
	SA7: Climate-proof existing and future infrastructure

ASPECT	MITIGATION
Theme	**T1: Sustainable energy and low carbon development**
Strategic aims Energy Land use, land use change and Forestry	SA1: Improve efficiency of energy production and use
	SA2: Develop and improve renewable energy
	SA3: Reduce GHG emissions from Agricultural (crops and livestock) sector
	SA4: Reduce GHG emissions from land use, land-use change and Forestry
	SA5: Reduce GHG emissions from Industries (e.g. construction, mining)
	SA6: Enhance GHG sinks
	SA7: Manage rural and urban waste
Theme	**T2: Transport**
Strategic aims Transport	SA1: Promote the development of alternative modes of service delivery to reduce carbon emissions
	SA2: Promote development of climate change resilient transport infrastructure
	SA3: Diversify transport energy sources
	SA4: Improve motor vehicle fuel efficiency
	SA5: Promote use of public transport

ASPECT	CROSS-CUTTING ISSUES FOR ADAPTATION AND MITIGATION
Theme	**T1: Capacity building, training, and institutional strengthening**
Strategic aims Education, Training	SA1: Strengthen human resource capacity building for climate change
	SA2: Main-stream climate change in national, local and sector policies, development plans & program
	SA3: Strengthen institutional capacity for climate change management
	SA4: Mainstream climate change in the media
	SA5: Develop and implement educational program on climate change and its impacts
	SA6: Promote and facilitate development of educational materials on climate change
	SA7: Facilitate and support training of scientific, technical and managerial personnel in climate change
	SA8: Develop disaster risk reduction capacity building plans and programmes for climate change
	SA9: Establish Climate Change Resource Centre and Climate Change database
Theme	**T2: Research and information needs**
Strategic aims Modelling Data collection Monitoring Costing	SA1: Collect data and model climate change an national, regional & local levels
	SA2: Monitor ecosystem and biodiversity changes and their impacts
	SA3: Conduct climate-proof research
	SA4: Undertake research on sea level rise
	SA5: Establish a centre for research and training on climate change
	SA6: Conduct Inventories on traditional / indigenous knowledge and coping practices
	SA7: Undertake studies on the cost of adaptation and mitigation
	SA8: Study macroeconomic and sectoral impacts of climate change
Theme	**T3: Public awareness, participation and access to information**
Strategic aims Awareness, Participation & Access to information	SA1: Awareness raising and public education on climate change
	SA2: Promote and facilitate development of public awareness materials on climate change
	SA3: Facilitate access of climate change information to the public and other stakeholders
	SA4: Promote public participation in addressing climate change and development of adequate responses
Theme	**T4: Disaster Reduction and Risk Management**
Strategic aims Early warning & preparedness, Risk reduction, Rick management	SA1: Improvement of disaster forecasting and early warning systems
	SA2: Improvement of disaster preparedness and post-disaster recovery
	SA3: Manage risk against loss of income, property and livelihoods
	SA4: Develop climate change impact and risk assessment programme
	SA5: Institutionalise and strengthen risk disaster management, create mechanism and capacity at all levels of government and communities.
Theme	**T5: Financial resource mobilisation and management**
Strategic aims Source funding Access to resources	SA1: Identify resource requirements including funding to support implementation of climate change activities
	SA2: Facilitate access to and efficient management and use of resources (credit, education decision-making) including funds for climate change adaptation and mitigation
Theme	**T6: International cooperation and networking**

Strategic aims Collaboration, Linkages and Networking	SA1: Strengthen and enhance international collaboration, linkages and networking among stakeholders involved in environment and climate change related issues
	SA2: Participate in regional and international cooperation programs and activities on climate change
	SA3: Promote international North-South and South-South collaborative research that will facilitate generation of Climate change adaptation and mitigation evidence-based information
	SA4: Facilitate achievement of UN environment international obligations under various Conventions especially UNFCCC and Treaties
Theme	**T7: Technology development and transfer**
Strategic aims Development of technology and Transfer of Technology	SA1: Promote and support development of technologies for mitigation and adaptation
	SA2: Promote and support technology transfer for mitigation and adaptation
Theme	**T8: Legislative development**
Strategic aims Legislation	SA1: Review and update existing legislation to reflect climate change issues
	SA2: Develop new sector or national policies that address emerging climate change issues

8.8 INVESTMENT AND FINANCIAL FLOWS (I&FF) TO ADDRESS CLIMATE CHANGE IN NAMIBIA

Namibia is one of 19 countries worldwide[1] participating in a UNDP supported project on assessing Investment and Financial Flows to address Climate Change in key sectors of the economy. The assessment aims to provide financial information on the expected costs of mitigation and adaptation to selected key sectors, over an approximately 20 years planning framework. Such information would be used to show-case the investment needs for effective adaptation and mitigation sector efforts, both to national and international policy and decision-makers, and to provide a strong planning foundation for future investments.

In terms of **adaptation**, Namibia initially intended to assess I&FF relating to adaptation needs in the Land Use, Land Use Change and Forestry (LULUCF) sector. In Namibia, the scope of the LULUCF sector is interpreted to include key production systems, i.e. (1) Agriculture, including both crops and livestock, (2) Forestry, (3) Fisheries (inland), (4) Tourism, (5) Wildlife and (6) the underlying Ecosystem Services[2]. However, due to time constraints and practical issues, it was decided to focus the assessment on the two sub sectors (crop and livestock production) within the agriculture sector.

In terms of **mitigation**, Namibia selected to assess the energy sector. The energy sector is central to development opportunities for Namibia in the future. Southern Africa as a whole is challenged by an energy crisis, and it is therefore of great importance for Namibia to position herself in a proactive manner to address future energy needs in the context of mitigation of climate change. It is expected that investment opportunities can be leveraged for the sector through this association.

The studies identified the adaptive and mitigative measures needed to address the impact of climate change, and estimated the financial requirement to implement them. A prescribed methodology was used, based on the guidebook provided by the UNDP. The overall I&FF adaptation assessment period is from 2005 to 2030, informed by the NDP2, NDP3 and Vision 30 timeframes. The conceptual framework for the assessment was developed through working group discussions, and brainstorming ideas from the team and the capacity support experts. Key uncertainties and methodological limitations are outlined in the reports.

8.8.1 ADAPTATION – LULUCEF/Agriculture Sector Assessment

The assessment (Republic of Namibia, 2010a) quantified the investments and financial flows (I&FF) required for the two subsectors of Namibia's agricultural sector to adapt to the effects of climate change. Current investment was assessed, and an estimate calculated of the potential financial requirements needed to replace a share of the currently low productive agriculture with more improved production technologies, by means of improved breeds and improved crop varieties, in order to adapt to the effects of climate change.

Another important objective of the assessment was to empower the participant experts with knowledge related to the I&FF assessments aimed at climate change adaptation in the agricultural sector, to enable them to participate in future assessment work, to include all the agricultural subsectors. The future assessment work will provide an integrated and coordinated evaluation of Namibia's financial needs to combat the effects of climate change in general, and hence strengthen its current and future negotiating position at national and international platforms.

Two broad scenarios were used, namely the Business as Usual scenario and the Adaptation to Climate Change scenario. The following adaptation measures were used:

[1] Algeria, Bangladesh, Bolivia, Colombia, Costa Rica, Dominican Republic, Ecuador, Gambia, Honduras, Liberia, Namibia, Nepal, Nicaragua, Niger, Paraguay, Peru, St Lucia, Togo, Turkmenistan, and Uruguay.

[2] According to the UNFCCC guidance, the Land Use, Land Use Change and Forestry (LULUCF) sector includes six broad land use categories: (1) Forestland, (2) Cropland, (3) Grassland, (4) Wetlands, (5) Settlements, and (6) Other land. In Namibia, the National Climate Change Committee (NCCC) decided that in the country context it is important to tackle Climate Change (CC) and Climate Change Adaptation (CCA) in all these land use categories, also taking into consideration that land use change, including the conversion from one land use type to another but also in terms of degradation is a pressing environmental issue that needs to be addressed. Consequently it is understood that the LULUCF sector encompasses key production systems, which in Namibia's terrestrial context would primarily be: (1) Agriculture, including both crops and livestock, (2) Forestry, (3) Fisheries (inland), (4) Tourism, (5) Wildlife and (6) the underlying Ecosystem Services, and which are practiced in the various land use categories in and integrated manner.

Adaptive measures for crop production

- Scale up of irrigation schemes
- Mechanisation of subsistence crop production
- Training of famers on crop production

Adaptive measures for livestock production

- Additional extension services to farmers
- De-bushing to improve rangeland productivity
- Switching to game production
- Choice of breeding livestock: climate resilient breeds
- Livestock number reduction in communal area to carrying capacity of communal rangeland (implementations needed urgently)

Under the Business as Usual scenario, both crop and livestock production or output is negatively affected by climate change. Under the Adaptation scenario, the proposed adaptive / mitigative measures were found to reduce the negative impacts of climate change on crop and livestock production.

8.8.1.1 Crop sub-sector

Estimates were made of Investment Flow (IF), Financial Flow (FF) and O&M costs required for each adaptation measure aimed at addressing the impact of climate change on the various production systems/investment. The projection scope covers the following production system:

- **Rain-fed subsistence** – IF and FF are estimated or assumed to be zero, while O&M costs are estimated to be US$40.63 million in 2005 and are projected to decline to US$26.73 million by 2030. Investment Flows into rain-fed mechanization by all investment types is projected at US$0.18 million in 2010 and estimated to increase to US$2.36 million by 2030. While Financial Flows are estimated/assumed to be zero, Operations and Maintenance (O&M) costs are projected to increase from US$ 2.76 million in 2010 to US$ 68.39 million by 2030.
- **Rain-fed commercial** - IF and FF are projected/assumed to be zero from all sources of funding for the rain-fed commercial production system. The O&M costs are projected to decrease to US$3.00 million by 2030 from their peak of US$6.00milion in 2005.
- **Irrigation commercial** - IF into irrigation schemes across the country is mainly done by government and commercial farmers and is projected at US$14.43 million in 2010, and is expected to be constant throughout to 2030. FF is projected/assumed to be zero throughout to 2030. O&M costs for irrigation commercial are projected to increase from US$7.53 million in 2005 to US$37.05 million by 2030.

Total Investment flows required from all sources of funding into the various adaptation measures is projected to increase from US$14.61 million in 2010 to US$16.79 million by 2030. While financial flow is estimated/assumed to be zero. Total Operation and Maintenance costs are projected to increase from US$ 54.18 million to US$135.17 million by 2030.

The incremental annual IF & FF estimates by investment for the various adaptation measures are:

- **Rain-fed subsistence** - IF and FF from household and other sources is assumed to be zero. Households are expected to provide US$21.1 million of equities and debts to cover O&M costs to 2030.
- **Rain-fed mechanization** - households and corporations are not expected to make an investment or financial flow and O&M costs, while government is estimated to provide US$4.3 million from its domestic funds. Bilateral ODA will be required to provide US$1.7 million. The total investment fund is estimated at US$6.2 million. FFs are estimated/assumed to be zero. Households will spend USUS103.6 million for the O&M costs under rain fed mechanization. O&M costs by government and corporations are estimated /assumed to be zero under this production system.
- **Rain-fed commercial** - In terms of IF and FF households, corporations and government and ODA are assumed to spend nothing. Household are also assumed to spend nothing on O&M costs under rain fed commercial. But corporations are expected to spend US$4.9 million of their domestic equity on operational and maintenance costs.
- **Irrigation commercial** - For irrigation commercial production system it is estimated that corporations will be required to invest US$25.7 milllion of domestic equities. Under the same production system it is projected that corporations will be required to spend US$12.3 million on operational and maintenance costs.

Under commercial irrigation schemes it is also estimated and expected that corporations will cover part of investment by borrowing funds from the domestic financial markets to the tune of US$28.8 million. That means total domestic sources are expected to provide US$54.5 million for investment and US$12.3 million for O&M costs.

Foreign Direct Investments (FDI) flows to commercial irrigation schemes are projected at US$38.1 million, while foreign borrowing is estimated at US$28.8 million. It is estimated that foreign sources will be required to provide a total of US$66.9 million to the commercial irrigation schemes. Therefore total corporate funds for IF is estimated at US$121.5 million, while total O&M costs are projected at US$12.3 million.

Furthermore, it is estimated that government will be required to provide US$38.1 million for irrigation commercial, while foreign borrowing by government to mitigate the impact of climate change is estimated at US$38 million. Bilateral ODA is estimated to provide US$38.1 million, while multilateral ODA will also be required to provide US$ 38.1 million.

Therefore the total fund from foreign sources to government is estimated at US$114.4 million and total funds government require to finance irrigation commercial is estimated at US$273.9 million. Government O&M costs for commercial irrigation is projected at US$12.3 million. The total investment flows required for the various types of investments is estimated to be US$280.1 million, while O&M costs are projected at US$7.4 million.

8.8.1.2 Livestock sub-sector

IF on extension services by government is estimated at US$0.22 million in 2006 and projected to decline to US$0.17 million by 2030. FFs are estimated at US$0.1 million in 2007 and projected to be US$0.11 million by 2030. The O&M costs are estimated at US$6.67 million in 2006 and are projected to decline to US$0.92 million by 2030.

Additional Extension Services - IF is estimated at US$0.14 million in 2010 and US$0.17 million by 2030, while FF is estimated at US$0.13 million by 2011, projected to increase to US$0.58 million by 2015, and then decline to US$0.11 million by 2030. The O&M costs are estimated at US$4.53 million in 2010 and are projected to decline to US0.92 million by 2030.

Destocking - The losses associated with this adaptive measure are estimated at US$-0.01 million in 2010 and projected to increase to US$ -0.13 million by 2030.

Choice of Breeds - IF is estimated at US$174.33 million in 2010, and projected to decline to US$18.39 million by 2030, while O&M costs associated with it are estimated at US$1.26 million in 2010 and projected/anticipated to increase to its peak of US$4.12 by 2016, before decline to US$2.51 million by 2030.

Game Switching - IF is estimated at US$46.30 million in 2010 and is projected to decline to US$41.29 million by 2030. O&M costs associated with game switching are estimated at US$ 5.63 million in 2030 and projected to increase first to US$19.96 million by 2018, before declining to US$11.49 million by 2030.

De-bushing – IF and FF is assumed to be zero, while the O&M costs for de-bushing are estimated at US$88.13 million in 2010, but projected to decline to US$9.92 million by 2030.

The Incremental Cumulative Discounted IF, FF and O&M estimates by Investment type, Investment Entities and Funding Sources for the different adaptation measures are:

Extension Services – IF by households and corporations is zero, while government provides US$-0.13 million for IF and US$-0.21 million for O&M costs. Bilateral ODA provide US$-0.06 million for IF and US$-0.09 million for O&M costs. The total government funding amounts to US$-0.19 million for the IF and US$0.30 million for O&M costs.

Additional Extension Services – Government will be required to provide US$6.38 million for IF, US$4.15 million for FF and US$32.36 million for O&M costs from domestic sources. Bilateral ODA will invest an approximate of US$2.74 million, spend US$1.78 million on financial flows and about US$13.87 million on O&M costs. Total funds for Additional Extension Services amount to US$9.12 million for IF, US$5.93 million for FF and US$53.27 millions for O&M costs.

Destocking - The total cumulative amount needed for destocking is projected to accumulate to US$-1.91 million mainly for O&M costs.

Choice of Breeds - Households investment is expected to accumulate to US$73.61 million, mainly from domestic sources, while the O&M costs are estimated to accumulate to some US$47.29 million. Corporation investments are expected to accumulate to US$339.21 million, while from foreign sources is projected to accumulate to US$145.37 million. Therefore the total investments by corporations into choice of breed are projected to accumulate to US4484.58 millions.

Government funds for investment in choice of breed, mainly from domestic sources is projected to accumulate to US$642.07 million, while funds from foreign sources for investment into choice of breed accumulate to US$275.17 million.

In total government funds for investment choice of breed is projected to accumulate to US$917.24 million, while the O&M costs by government is estimated to amount to US$.76 millions. Total funds required for choice of breed is projected to accumulate to US$1.475.42 million for IF and US$63.05 million for O&M costs.

Game Switching – Households' O&M costs on game switching is forecasted to accumulate to US$249.07 million for the period, while corporation's investments in game switching is projected to accumulates to US$48.58 million which is mainly from domestic sources. The funds for corporations from foreign sources are projected to accumulate to US$20.82 million. The overall corporation investment in game switching is projected to have accumulated to US$69.40 million

Government's O&M costs on game switching, is projected to accumulate to US$58.12 million, while those funds sourced from foreign sources for the same costs items is projected to accumulate to US$83.02 million and the total funds is projected to be US$332.10 million.

De-bushing – Households' expenditure on O&M is projected to accumulate to US$24.25 million, while the expenditure by corporations on O&M is projected to be US$ 211.10 million, mainly from domestic equities. Foreign sources are projected to provide about US$90.47 million. The total O&M costs for de-bushing by corporation is projected to accumulate to US$301.57 million. While government O&M costs are estimated to accumulate to US$300.7 million mainly from domestic sources and O&M cost to be incurred by foreign sources is projected to accumulate to US$128.90 million.

8.8.2 MITIGATION – Energy Sector Assessment

This assessment (Republic of Namibia, 2010b) quantified the required investments and financial flows (I&FF) to mitigate the effects of climate change for Namibia's energy sector.

The assessment of the energy sector should feed into the overall IFF assessment. This will provide an integrated and co-ordinated evaluation of Namibia's financial needs to combat climate change and hence strengthen its negotiating position at national and international platforms.

The energy and agricultural sectors are central to Namibia's economic growth and development, and at the same time, the country's GHG emissions are mainly from these two sectors. There exists considerable GHG mitigation potential, and thus opportunities for investments, both local and foreign. Adaptation and mitigation measures for the agricultural and energy sectors have been identified as key responses of national interest, especially since they are directly linked to the national policies, development plans and Vision 2030. This study quantified the required investments and financial flows to mitigate the effects of climate change for Namibia's energy sector.

Currently, the total electricity demand far exceeds electricity supply (refer to Chapter 6) and additional generating capacity is a strategic imperative. This study addressed both supply (electricity generation) and demand (transport) options.

The un-electrified rural households bear a burden to purchase different devices to provide power. Rural households spend about USD 44.05 million on Investment Flows (IF) mostly for purchasing generators with an associated USD 507.94 million on operation and maintenance (O&M), whereas the government spends a total of USD 22.86 million in generators (IF) and USD 7.10 million in O&M. It appeared that the corporate sector did not spend a cent on hydropower, coal or diesel for energy in 2005.

Other expenditure falling on the Government relates to investment in both Hydro and Coal (US$786 million and US$232 million, respectively), as well as operation and maintenance for the same power sources (US$205 million for Hydro and US$99m million for Coal).

If no new investments are made, Namibia will suffer a power crisis. This study recommends that there should be four new Hydro investments and one new Coal investment, namely:

- US$ 368 million in 2012 on the Ruacana (Hydro) 4th turbine (95MW)
- US$ 210 million in 2013 on Orange River (Hydro) 1st Phase
- US$ 210 million in 2017 on Orange River (Hydro) (105MW)
- US$ 500 million in 2019 on Baynes (Hydro) (assuming 550MW to be shared 50/50 with Angola)
- US$ 500 million in 2015 on Walvis Bay (Coal). However, coal can be replaced by Wind and Solar energy sources in the mitigation scenario.

A great need exists for Namibia to achieve a greater level of energy self-sufficiency. The main concern is that the price of imported electricity from South Africa will rise in future, once South Africa no longer has power to spare.

In the transport subsector, it is expected that the vehicle population will swell with the growth in GDP and human population, which implies greater GHG emissions. In order to mitigate the GHGs from the transport subsector, less carbon-intensive fuels should replace the conventional petrol and diesel. Since Namibia has already implemented the use of LPG, it is worth continuing with this option. In this regard, the IF by households as investment entities, in terms of equity and debt, would stand at US$ 5.8 billion, while the O&M costs would account for about US$ 2 billion. In the corporate sector the IF in terms of domestic equity stands at US$ 653 million with associated OM costs at US$ 206, while the IF, in terms of domestic borrowing, stands at US$ 1.5 billion with US$ 482 as OM costs. In addition, the government, as an investing entity, would have an IF standing at US$ 215 million from domestic funds with an additional of US$ 22 million for FF and the OM costs of US$ 75 million. The government is expected to receive US$ 92 million from bilateral ODA with an associated FF of about US$10 million.

In this regard, the total household funds stand at US$ 5.8 billion, corporates at US$ 2.2 billion, and government at US$ 307 million of which US$ 92 is donor funding. All in all, the total capital required for mitigation in the transport sector is summed to stand at US$ 8.3 billion for IF, US$ 32 million for FF and US$ 2.7 billion for OM costs. In this regard, it can be concluded that, of the total capital required for mitigation in the transport sector, households account for 70% of the total capital, followed by corporate at 26%, while government only accounts for the remainder of 4%.

Sunset over Swakop, Namibia, near the Trans-Kalahari Highway.
Photograph by Stewart Aston

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Appendices

Appendix 1: List of contacts for data (Namibia Greenhouse Gas Inventory)

Organisation	Contact's surname	Contact's name	Tel.No	Fax No	email	Comments	Sector
Barlows (paint)		Robert	280 4200			Paint consumption estimate	Solvents
Bokomo Mills	Hite	Eugene	264466			Flour milling	Industrial
Caltex Fuel Database	Peens	AP	27214037296		ajpeens@ absamail.co.za		
Prime source of liquid fuel data	Fuel						
City of Windhoek (Engineering)	Cronje	Gerhard	290 2103	2902404	glc@windhoekcc. org.na		
Section Engineer Waste water	Waste						
City of Windhoek (Engineering)	Menges	Jurgen	290 3450			Microbiologist	Waste
City of Windhoek (Engineering)	Beukes	Jaco	290 2755			Section Engineer Solid Waste	Waste
CRIIA	du Plessis	Pierre	254766 / 220117			Advice on IPCC system	General
Etosha Fisheries		Grizzel	064 215600			Fishing and fuel info	Industrial
Independent	Bester	Bessie	251956			Bush - wide experience, good source	Land
Luxembourg Cooperation (NPC)	Verlinden	Alex	238 2042	239376	alex.verlinden@		
GIS / vegetaition and bush fires	Land						
Meat Board	Schutz	Willie	275 830		willie@nammic. com.na		
Excellent stock and slaughter data	Agriculture						
MeatCo (Okahandja)	du Preez	Hannes	062 501061			Abattoir fuel usage	Fuel
MeatCo (Windhoek)+A22	Hobling	Tony	321 6000			Abattoir fuel usage	Fuel
Ministry of Agriculture, Water and Forestry	Bamhare		208 7505			Contacted - stock info source elsewhere.	Agriculture
Ministry of Agriculture, Water and Forestry	Coetzee	Marina	2087111 / 2529 ?			GIS land use - agricultural classification	Land
Ministry of Agriculture, Water and Forestry	Hailwa	Joseph	208 7330 / 7663			Background information and contacts	Land
Ministry of Agriculture, Water and Forestry	Espach	Celeste	208 7070			GIS expert	Land
Ministry of Agriculture, Water and Forestry (Katima)	Beatty	Robin			robin.bt@gmail. com		
Fire management	Land						
Ministry of Environment and Tourism	le Roux	Johann	271281			GIS data to 2004	Land
Ministry of Environment and Tourism (DEA)	Nghitila	Te	284 2751			Background information and contacts	General

Organisation	Contact's surname	Contact's name	Tel.No	Fax No	email	Comments	Sector
Ministry of Environment and Tourism	Lindeque	Malan	284 2333			Now PS MTI	General
Ministry of Environment and Tourism	Griffin	Mike	237553			Background information and contacts	General
Ministry of Mines and Energy	Nghishoola	Emmanual	2848322			Fuel statistics	Fuel
Ministry of Mines and Energy	Iiita	Joseph	284 8312			Background information and contacts	General
Ministry of Mines and Energy	Uutoni	Selma	284 8322			Director Energy, background information and contacts	General
Ministry of Works, Transport and Communication (Civil Aviation)	Gunzel	Tobias	702215			Civil aviation - real time TLA data	Fuel
Namibia Agronomic Board	Brock	Christof	379 500			Excellent source on grains and horticulture	Agriculture
Namibia Agronomic Board	Nel	Madeline	379506			Flour and grain info.	Industrial
Namibia Breweries	Lukashic	Rolf	320 4999			Brewery fual and output data	Industrial
Organisation	Contact's surname	Contact's name	Tel.No	Fax No	email	Comments	Sector
Namibia Dairies	Krier	Llewellyn	299 4734			Confrmation of dairy data	Agriculture
Namibian Agricultural Union	Margraff	Harald	237838			Dairy cattle information	Agriculture
Namibian Charcoal Producers Association (Grootfontein)	Enslin	Willem	067 306225 / 240084			Producer and good source	Land
Namibian Charcoal Producers Association (Otjiwarongo)	Coetzee	Desmond	062 503838			Producer information	Land
Namibian Manufacturers Association	Fourie	Hennie	299 5000	2995271	nmc@ppnam.com		
Background information and contacts	Industrial						
NamPower	Carstens	Rinus	205 2331		Rinas.Carstens@ nampower.com. na		
Backgroud information	Energy						
NamPower	Kasai	Eli	2052216			Power data	Energy
NamPower	Langehoven	Piet	2052111			van Eck power station	Energy
Namwater	Enslin		71000			Closed cement plant information	Industrial
Namwater	Muisoor	Hendrik	712061		muisoorh@ namwater.com.na		
National water statistics	Waste						
National Botanical Institute	Strobach	Ben	202 2040			GIS / vegetaition	Land
National Planning Commission	Sindano		283 4111			Limited power statistics	Energy

Organisation	Contact's surname	Contact's name	Tel.No	Fax No	email	Comments	Sector
National Remote Sensing Centre (MAWF)	Shapala		208 7331	222830		GIS / vegetation info	Land
NATIS	Brock	Wilfred	284 7203			Registered vehicle data	Fuel
Petroleum Wholesaler's Association	Schmidt	Harald	228839			Taxed fuel data - confirmation provision	Fuel
Polytechnic (REEEI) and AMUSHA cc	Schutt	Harald	232333	237823	REEEI@ polytechnic.edu. na		
Informed on renewables	Energy						
RAISON	Mendelson	John	254962			not contacted but has broad data	Land
TransNamib	Dempsey	Jack	298 2022	2982710	Jack.Dempsey@ TransNamib. com.na		
Bulk freight statistics	Fuel						
TransNamib	Englebrecht	Sakkie	2982606			Now retired - referred Wessels Swanepool for loco data	Fuel
United Fisheries	Pronk	Willie	064 217500			Fishing and fuel info	Fuel
Weatherly Mining and Smelting	Nolte	Hans	081 122 8505			Smelter fuel use	Fuel

List of Figures

List of Tables

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