Review and Update of the National Circumstances

IMPACT OF CLIMATE CHANGE ON HUMAN HEALTH IN NAMIBIA

Detlof von Oertzen, VO Consulting, voconsulting@mweb.com.na

FINAL

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1 Impact of climate change on human health in Namibia

This section presents a brief overview of the anticipated impacts that climate change is expected to have on human health in Namibia. The reader is cautioned that the section is not a medical study, but rather an assessment based on contemporary literature and statistics about climate change and health-related issues. The assessment is complemented by the opinions of a select group of Namibian climate and medical health experts.

1.1 Assessment method

To assess the impacts of climate change on human health in Namibia requires an understanding of the most likely physical effects and impacts that climate change will introduce. To this end, section 1.2 presents a brief overview of Namibia's current health system. Section 1.3 below presents a brief review, identifying the major climate impacts of relevance to Namibia; the section is based on national and international literature on the likely changes expected as a result of climate change.

A changing physical climate has implications for human health. Section 1.4 below therefore asks the question what the climate impacts identified in section 1.3 will imply for human health in Namibia. The section focuses mainly on

- temperature-related health impacts and effects
- water-borne and vector-borne diseases, as well as
- the health-related effects of food and water shortages.

Personal interviews with experts and key decision makers in Namibia's health sector were used to identify the main issues likely to impact on Namibia's health sector as the effects of climate change become more pronounced. In addition, Namibian health-related information was obtained from a variety of national sources, in particular the Namibian Demographic and Health Survey of 2006/07 (NDHS, 2008), Namibia's Health Information System (HIS) and the Namibia National Health Accounts 2001/02 – 2006/07 (NNHA, 2008). All sources used in the present review are referenced in the text.

1.2 Namibia's health system in a nutshell

Namibia's health system aims to deliver health services to the Namibian populations based on the primary health care approach (MOHSS, 2006; PDNA, 200). To this end, the country's health system is decentralized, which allows it to be and remain responsive to the needs of the population. The public health care system has been organised into functional directorates at the national and regional levels, and the provision of health services is shared between the public and the private sector. Namibia has four referral hospitals, 34 district hospitals, 37 health centres and 259 clinics under the public sector (PDNA, 2009).

Secondary and tertiary health care services provide an integral national system of referral support for primary health care services. The three intermediate/referral hospitals are Oshakati Hospital in the Oshana Region, Rundu Hospital in the Kavango Region, and Katutura Hospital in the Khomas Region. Windhoek Central Hospital serves as the overall national referral hospital. At an operational level, authority is decentralised to 13 regional management teams and their respective districts. The 13 regional directorates oversee service delivery in 34 health districts. The role of the district is to ensure efficient and effective implementation of the regionally directed programmes and projects (NDHA, 2008).

Public health services are provided through 30 public district hospitals, 44 health centres, and 265 clinics. Three intermediate hospitals and one national referral hospital provide support to these district hospitals. 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 (NDHA, 2008).

As public health services include diverse interventions, intersectoral collaboration has been recognised as an important aspect in health and social care delivery, and many partners play a role in this sector. Although the government is the main service provider, private and mission facilities continue to make important contributions, the latter are being subsidised by the government. Private sector participation is mainly focused on urban areas, providing health care through medium-sized hospitals, as well as through private pharmacies, doctors' surgeries, and nursing homes (NDHA, 2008).

Child mortality in Namibia is consistently lower in urban areas than in rural areas (PDNA, 2009). However, general life expectancy has not improved, partly because of the HIV/AIDS epidemic. According to the Namibian Demographic and Health Survey of 2006/07 (NDHS, 2008), the infant mortality rate stands at 46 per 1,000 live births, while child mortality stands at 69 per 1,000 live births, which is counted among the lowest in sub-Saharan Africa. The maternal mortality ratio has been on the increase since the year 2000, from 225 per 100,000 live births in 1992, to 271 per 100,000 in 2000, and 449 per 100,000 in 2007. This increase is despite the fact that over 70% of births are delivered in hospitals (NDHS, 2008). Some 18% of women attending first pre-birth care services are under the age of 20 years, with teenage girls accounting for some 9% of Namibia's total fertility rate (NDHS, 2008).

Adult mortality rates are higher for males than for females, and currently stand at 10 and 8 deaths per 1,000 population, respectively (NDHS, 2008). A comparison of mortality rates for the 2006-07 NDHS and the 2000 NDHS undertaken by the Ministry of Health and Social Services (MOHSS) shows an increase in adult mortality for both females and males: the summary measure of mortality for the age group 15 to 49 shows that – between the two surveys – female mortality doubled and male mortality increased by 65% (NDHS, 2008).

Household food insecurity among vulnerable female-headed households has been reported, and adequate nutrition therefore remains a concern. Malnutrition levels in children under the age of five years are as high as 38% in some of the affected regions. According to the NDHS, the prevalence of acute malnutrition was 7.5 % (NDHS, 2008).

Access to health care facilities, in terms of distance, time, and costs, can be a useful indicator of the quality of life of the population. Where health care services are available and within reach, people make use of such services for themselves and their family. Regarding the accessibility of government health facilities and services, rural households are more likely to be located nearest to a clinic than urban households (74% in contrast to 61%), and a health centre (9% and 4% respectively). On the other hand, urban households are more likely than rural households to be nearest to a government hospital (28% in contrast to 16% respectively) (NDHA, 2008).

The country has a relatively young population, with 43% of the total population under 15 years of age, and less than 4% of the total population over the age of 65. Despite rapid urbanisation, Namibia is still mainly rural, with approximately one in three persons living in urban areas. Overall, the population density is low (some 2 persons per square kilometre), 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 (NDHA, 2008).

According to the MOHSS Annual Report (MOHSS, 2006), the 10 leading causes of inpatient deaths in 2005/05 of all age groups is shown in Figure 1-1 below.

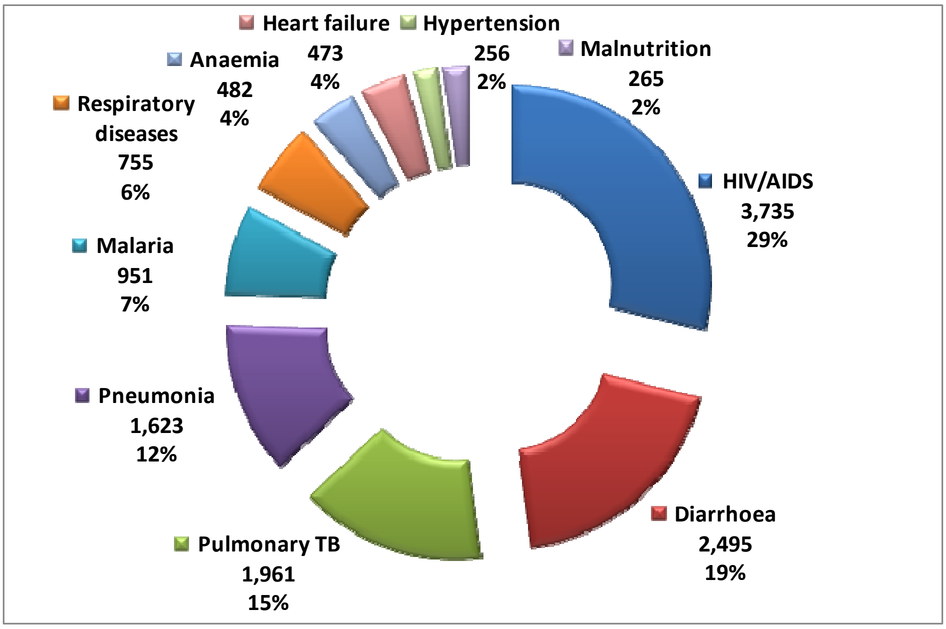

Figure 1-1: Top ten inpatient causes of death for all ages in 2005/06 (MOHSS, 2006)

In view of the realities of Namibia's health system, what are the likely changes and challenges that climate change will impose on it? And what measures will have to be taken to ensure that the national health system is adequately geared to meet the multitude of changes likely to happen in the next 50 years, including those imposed by an increasing population as well as the multitude of demographic and socio-economic changes, and changes in the occurrence of diseases and effectiveness of treatments? Of greatest interest in the context of this report will be the question how climate change will impact on the nation's health system. The next few sections will elaborate on the most important impacts that climate change is likely to exert on Namibia's health system.

1.3 Climate change impacts on Namibia

This section addresses the following question: w*hat are the most important climate change-related impacts of relevance to human health in Namibia, and when are they likely to occur?* The present section is mainly based on reports by the Intergovernmental Panel on Climate Change (IPCC), specifically their 4th Assessment Report (IPCC, 2007), as well as a recent report on the local impacts of climate change undertaken by the Desert Research Foundation of Namibia and the Climate Systems Analysis Group of the University of Cape Town, i.e. the Climate Change Vulnerability and Adaptation Assessment Report Namibia (DRFN, 2008).

The IPCC report uses the results of 23 atmosphere—ocean general circulation models (GCM) to formulate predictions about likely future climate change (IPCC, 2007). The assessment uses six distinct future greenhouse gas (GHG) emission scenarios to model the impact that the different GHG emission trajectories will have on the world's climate. It is noted that some recent literature suggests that global carbon dioxide (CO2) emissions are rising faster than the most dire ones used under the IPCC emission scenarios (Pielke et al, 2008), and some leading climate scientists have raised concern that the IPCC's predictions are still too conservative (see for example Rahmstorf, 2007; and Hansen et al, 2008).

The Climate Change Vulnerability and Adaptation Assessment (DRFN, 2008) uses global circulation models (GCMs), i.e. computer models which represent the interactions between the land surface, the atmosphere and the oceans, to formulate projections for temperature and wind regimes in the period 2046 to 2065. In addition, they also use downscaled global circulation models (DGCMs) to project the effects of climate change on rainfall for the period 2046 to 2065[1]. When GCMs are downscaled, they allow the large-scale GCM models to be used for projections at more local (spatially limited) scales.

[1] Downscaling is a method that derives local-to-regional-scale (10 to 100 km) information from larger-scale models or data analyses. The statistical method used in the study relies on developing statistical relationships that link the large-scale atmospheric variables with local/regional climate variables. The quality of the downscaled product depends on the quality of the driving – or underlying – model.

It should be noted that the assessment used several DGCMs to make rainfall projections, which resulted in a range of future climate scenarios. This is important as no single DGCM is considered absolutely superior to all others, and all DGCMs in use for southern Africa have a variety of predictive weaknesses. Also, a similar family of GCMs were used for temperature and wind projections. By using a number DGCMs / GCMs, which are all underpinned by different base-assumptions and model characteristics, climate trends rather than precise climate predictions become apparent. The discussion in the remainder of this section is therefore based on the trends shown by the various DGCMs (for rainfall) and GCMs (for temperature and wind).

1.3.1 Changes in temperature

The IPCC report states that global mean surface temperatures could rise between 1.1°C and 6.4°C by the year 2100, with best estimates lying in the range between 1.8°C and 4.0°C (IPCC, 2007; IPCC, 2007b). Most variation, especially in the latter two-thirds of this century, is due to the uncertainties related to future technology choices and associated emissions of greenhouse gases made in years to come. Here, the absolute amount of carbon dioxide and other GHGs that will be emitted by industrialised as well as developing countries, as well as the uncertainty related to behaviour changes by nations and the society at large, will play a very significant role and determine the degree of atmospheric warming in years to come (IPCC, 2007b).

The Climate Change Vulnerability and Adaptation Assessment (DRFN, 2008) uses 13 GCMs to make projections of changes in temperature[2]. As shown in Figure 1-2 below, these are presented as the minimum, mean and maximum future change in surface air temperatures for the summer period (January to March) in the years 2046 to 2065. Figure 1-3 below shows the projections for the winter period (July to September) (DRFN, 2008).

Of note is that the predicted change in temperatures is small at the coast, and increases further inland during all seasons. The projected increases of minimum temperatures during the summer months lie between 1°C to 2°C, while maximum temperature values are predicted to increase between 2°C and 3.5°C. Maximum projected increases in temperature are slightly higher during winter (2.5°C to 4°C), while the projected increases in minimum temperatures are similar to those during summer (1°C to 2°C).

[2] The assessment uses the 13 GCMs taken from the World Climate Research Programme's Coupled Model Intercomparison Project phase 3 multi-model dataset (DRFN, 2008).

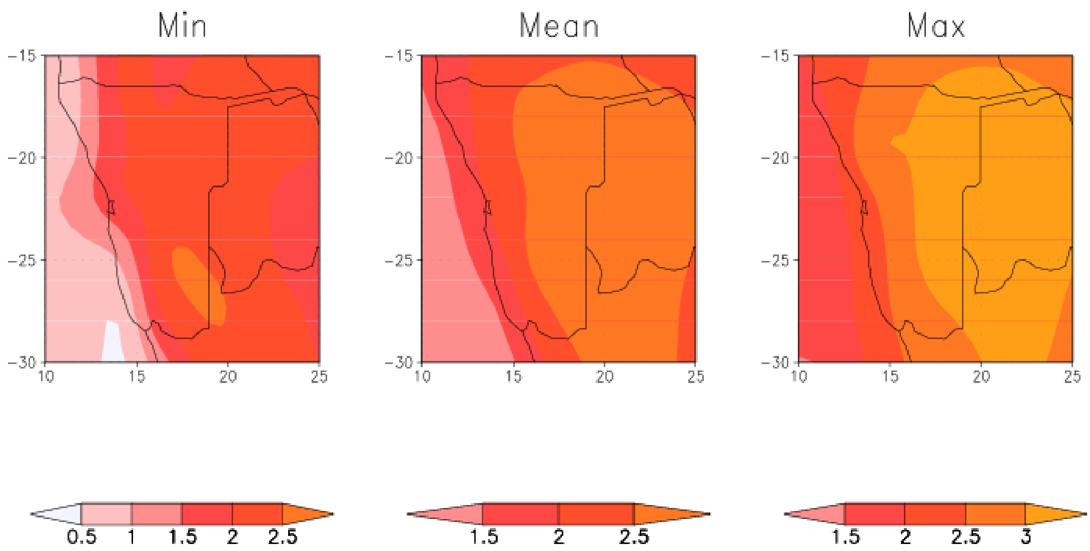

Figure 1-2: Projected increases in mean surface air temperature (in °C) in summer (January to March), minimum (left), mean (middle) and maximum (right) projected change derived from 13 GCMs (DRFN, 2008).

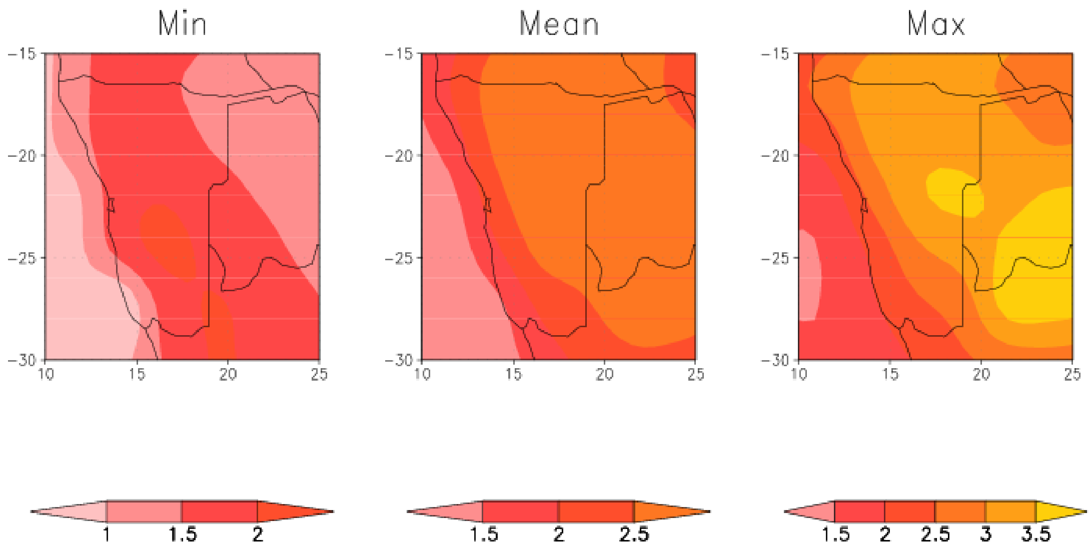

Figure 1-3: Projected increases in mean surface air temperature (in °C) in winter (July to September), minimum (left), mean (middle) and maximum (right) projected change derived from 13 GCMs (DRFN, 2008).

1.3.2 Changes in rainfall

Rainfall is a local phenomenon, and the IPCC's assessment report provides little specific information on the expected rainfall changes of direct relevance to Namibia (IPCC, 2007; IPCC, 2007b). The study by the DRFN however is more specific: Figure 1-4 below shows the projected median in total monthly rainfall change from 6 statistically downscaled GCM rainfall estimates for the years 2046 to 2065 (DRFN, 2008). Those regions where 3 such downscaled GCMs (50%) indicate wetting and 3 models indicate drying are left blank, as are regions which show increases of less than 10 mm of rainfall per month (which is equal to the expected increase in evapo-transpiration). As indicated above, the precise quantification of the magnitude of change remains a greater challenge than predicting the direction or trend of the changing rainfall pattern.

By mid century, i.e. in the period 2046 to 2065, the various downscaled climate models most consistently show an increase in late summer rainfall over major parts of Namibia, and a decrease in winter rainfall in the country's south and west. Increases in rainfall are most obvious during January to April, especially in the central and north-eastern regions. It is noted that predictions about the Cuvelai area – where some of the more recent flooding occurred – remain inconclusive.

A decrease of rainfall in the country's south-west is suggested for most months, except for February and March, but such decreases are particularly widespread during the main winter months, which are traditionally the most important rainfall months.

The projected changes in rainfall are consistent with the contemporary understanding of how climate change will manifest itself over the southern African region and are captured in regional climate models, especially in that

- 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, and that
- winter rainfall is reduced in the southern and especially south-western parts of the continent, and by implication, southern Namibia (DRFN, 2008).

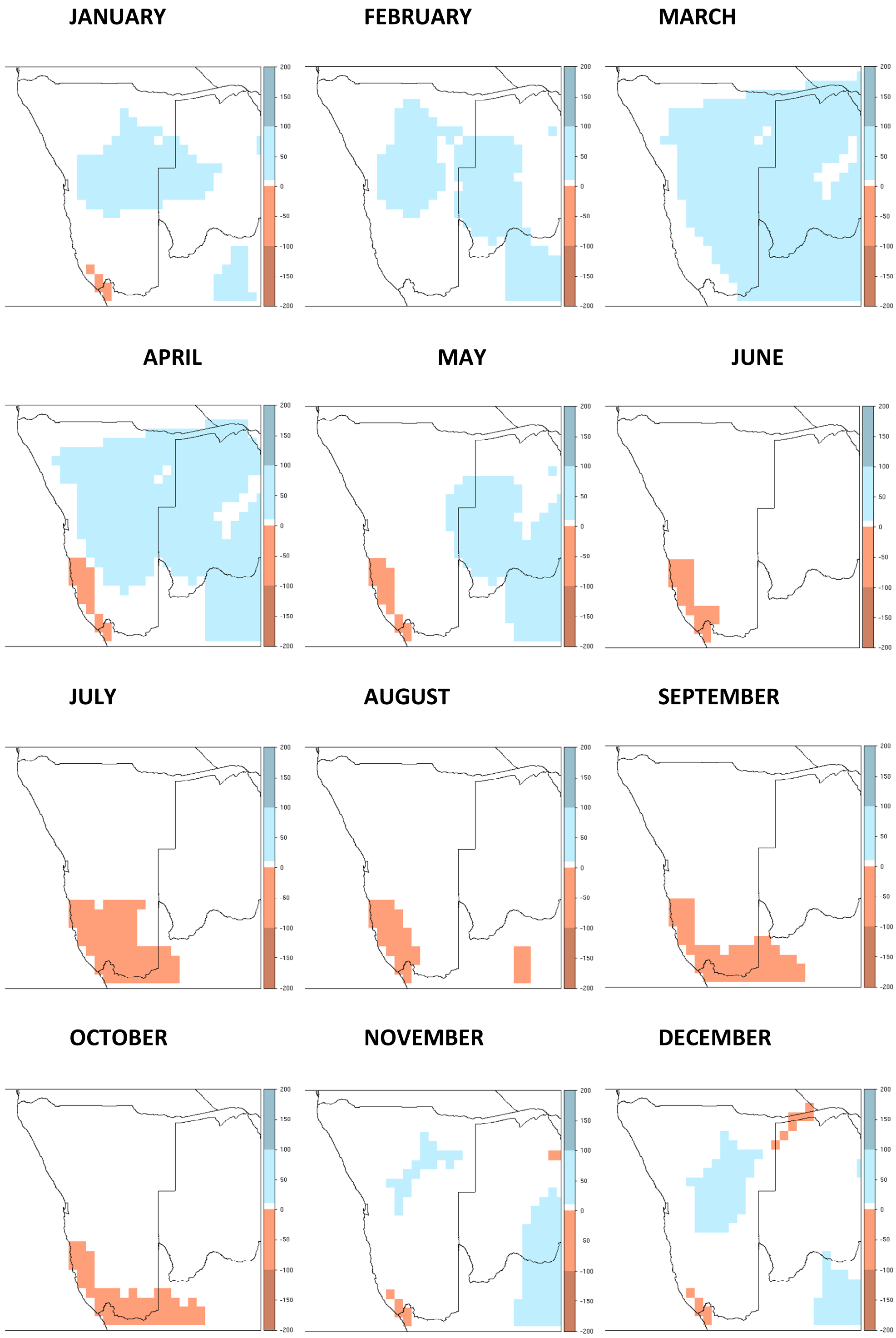

Figure 1-4: Mid-century (years 2046 to 2065) rainfall projections showing the median change in total monthly rainfall (mm per month) from 6 statistically downscaled GCMs, with blue indicating increases and orange indicating decreases in rainfall. Regions where 3 such models indicate drying while the other 3 show wetting, as well as those regions experiencing increases of less than 10 mm per month (i.e. less than the expected increases in evapo-transpiration) are indicated in white (DRFN, 2008).

1.3.3 Changes in surface wind

As noted in section 1.3.2 above, the IPCC assessment report is less valuable in cases where location-specific projections are required (IPCC, 2007; IPCC, 2007b). Here, the DRFN assessment provides more specific information: Figure 1-5 below shows the minimum, mean and maximum expected changes in surface winds in the summer period in mid-century (years 2046 to 2065), which are derived from 13 GCMs (DRFN, 2008). It is noted that minimum changes are mostly around zero, whereas maximum changes are for onshore flow from the south-west, which are highest (approximately 0.8 m/s) towards the south. Mean changes show a similar pattern, even though these are of smaller magnitude to the maximum changes, and are consistent with increased convective activity and an associated low-pressure trough over the continent during summer.

Figure 1-6 below shows the minimum, mean and maximum expected changes in surface winds in the winter period in mid-century (years 2046 to 2065), again derived from 13 GCMs (DRFN, 2008). It is noted that both the mean and maximum wind changes predicted to occur during winter indicate a similar pattern of change to those projected for summer. However, the minimum projected change also indicates increases in winds from the south-east over the ocean towards the south. Both the maximum and mean projected changes indicate increases in the southerly component of winds over the ocean. These projected changes are consistent with a retreat of mid-latitude storms (which normally bring north-westerly winds) towards the south, and an increase in the south Atlantic high-pressure system, which drives winds from the south.

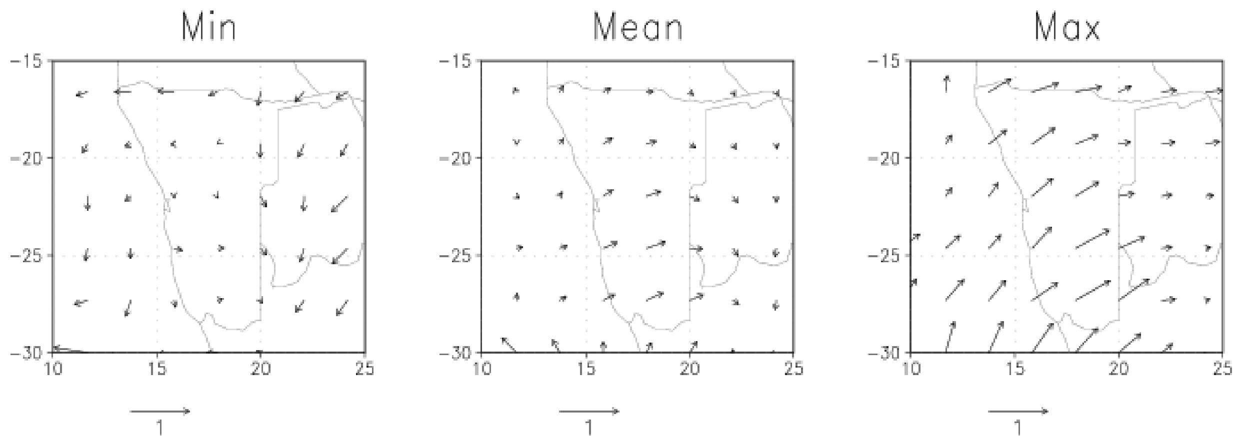

Figure 1-5: Projected changes of surface winds in summer (January to March), showing minimum (left), mean (middle) and maximum (right) changes, as derived from 13 GCMs (DRFN, 2008).

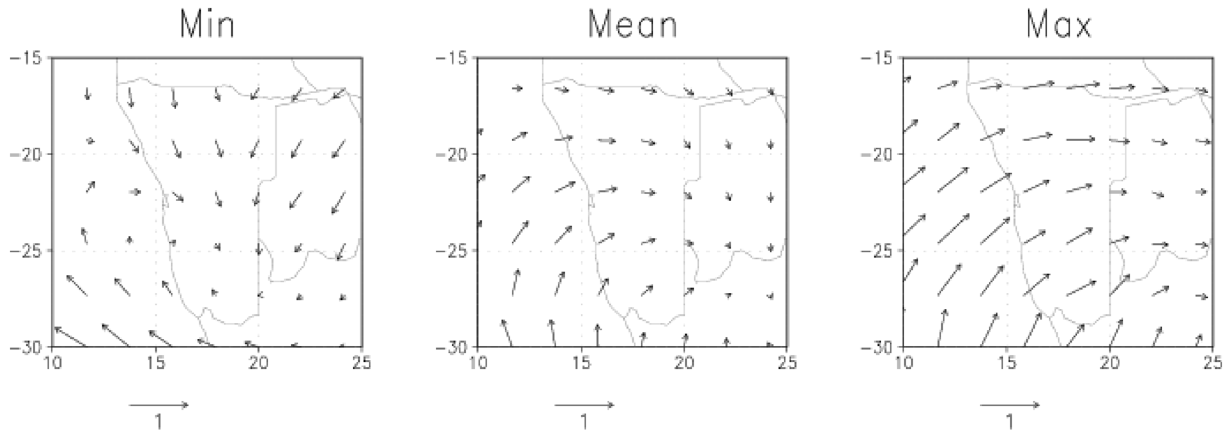

Figure 1-6: Projected changes of surface winds in winter (July to September), showing minimum (left), mean (middle) and maximum (right) changes, as derived from 13 GCMs (DRFN, 2008).

1.3.4 Historical climate change trends

Namibia's climate trends since 1960 show noticeable changes in weather extremes as well as rainfall seasonality (DRFN, 2008). Such changes are specifically seen as

- an increase in maximum temperature values
- an increase in the frequency of days with temperatures above 25°C, and 35°C respectively
- a decrease in minimum temperature values
- a decrease in the frequency of days with minimum temperatures below 5°C
- an increased length of the dry season
- a decrease in the number of consecutive wet days, with
- an associated later start and earlier cessation of the rainy season, specifically in northern Namibia (DRFN, 2008).

The observed changes in temperature extremes, the length of the dry season, as well as the rainfall intensity all underscore that the climate in Namibia tends to become drier. However, the observations also highlight that climate variability is as significant a phenomenon as the long-term climate trends. This implies that Namibia's climate variability is likely to remain a key characteristic of the country's future climate, which also has important implications for health and health-related issues in Namibia.

1.3.5 Summary of the main climate change predictions for Namibia

This sub-section synthesises the main climate change predictions for Namibia for the period 2046 to 2065, focusing on those physical variables that may become important drivers or have significant effects on human health, and therefore Namibia's health sector.

1.3.5.1 Climate variability

Year-on-year climate variability is likely to have a most significant impact on Namibia. This realisation is of significance when formulating appropriate health-related responses, especially as the number and intensity of extreme weather events increases. It is expected that local climate variability will, in some cases, offset the changes introduced by longer-term climate trends: for example, increasing rainfall intensity could offset a shortening of the rainy season. Such offsets though cannot as yet be quantified to an acceptable degree of accuracy, but will have to be kept in mind when making location-specific forecasts and/or formulating location-specific responses.

1.3.5.2 Rainfall

By mid-century, summer months are expected to see an increase in rainfall over much of the country, most significantly during January to April, and particularly in the central and northern regions. In winter, drying will occur in south-western Namibia, and will be most prominent during mid-winter months. Individual rainfall events are expected to become more intense and pronounced, especially in late summer, while rainfall seasons are likely to be shorter.

1.3.5.3 Temperature

By mid-century, summer months are expected to see minimum projected temperature increases of between 1°C and 2°C across the country, and maximum projected temperature increases of between 2°C and 3.5°C. In winter, minimum projected temperature increases are expected to range between 1°C and 2°C across the country, while maximum projected temperature increases are expected to range between 2.5°C and 4°C.

1.3.5.4 Wind

An increase of wind speeds is predicted, as both the thermal and mid-Atlantic drivers are expected to become more pronounced.

1.4 Health-related impacts of climate change in Namibia

This section addresses the following question: *what are the most important health-related effects and impacts expected due to a changing climate in Namibia?* As indicated in section 1.3 above, global climate change is expected to lead to an increase in surface air temperatures, an increase in the intensity of (late summer) rainfall events, a lengthened dry season, an increase in the general climatic variability, an increase in the evapo-transpiration rates of plants, as well as an increase in wind speeds. These external variables, 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). Such impacts on human health can best be understood when considering the effect that past regional and local changes in short-term weather events have had on humans and human health.

Changes in temperature, precipitation and extreme weather events are expected to lead to 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 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 (IPCC, 2007b; WHO, 2003).

Many of Namibia's environmental niches, currently offering livelihood opportunities to people, have little or no adaptive capacity. Yet, a considerable number of Namibians depend on such niches, for example as subsistence farmers, or by relying on the availability of (mostly) free ecosystem services. These life-supporting systems all have physical limits, and generally require lengthy timeframes to adapt to changing external pressures, such as the effects of climate change and/or human-induced impacts, or both. Change in general, whether climate induced or of other nature, is of particular concern when dealing with communities that are already weakened by poverty, malnutrition and/or the effects of systemic sicknesses and high disease burden. It is concluded that the effects of climate change, and particularly the effect of increased climatic variability, will increase the pressure on human health and health-related aspects, and lead to an increase in the overall disease burden in most communities in Namibia. Such impacts are also likely to result in new and often unexpected challenges for the Namibian public health sector that is already stretched to capacity. And, the country's health system is expected to be amongst the first witnesses to receive those individuals who have been affected by a changing climate.

It should be noted that some of the physical manifestations of climate change discussed in section 1.3 above may have positive effects on human health, for example those related to a reduction in diseases associated with cold weather. Other manifestations, such as an increase in rainfall variability, are most likely to have an overall negative impact on human health. For example, the effect of a changing climate on food crops is likely to lead to a reduction in food security, which in turn has important negative flow-on effects on malnutrition. Globally, the burden of disease and premature death related to a changing climate is expected to increase (WHO, 2003). It is concluded that climate change is not just a critical environmental issue, but is likely to be a significant health-impacting issue for humans. The following sub-sections discuss the expected health impacts that a changing climate is likely to bring about in more detail.

1.4.1 Increasing temperatures

This sub-section focuses on the question: *what are the human health impacts related to an increase in minimum, mean and maximum surface air temperatures?* It is well-documented that an increase in average and/or maximum and minimum temperatures has immediate health implications: to illustrate, the heat waves of 2003 in Europe caused up to 70,000 deaths, caused mainly from respiratory and cardiovascular diseases (Robine et al, 2008). Similarly, the California heat wave of 2006 showed large increases in admissions to hospitals related to cardiovascular and other illnesses (Knowlton et al, 2009).

Rising temperatures are also likely to generate heat-related stress, which can increase the mortality rate due to heatstroke, and lead to added vulnerability of new-borns, as well as the old and infirm (McMichael et al, 2008). In developed countries, urban populations are expected to be more adversely affected than rural ones, and people with a pre-existing respiratory disease and/or other systemic disease burden are particularly vulnerable (Ayres et al, 2009). In Namibia however, a significant proportion of rural dwellers have less access to medical services than their urban compatriots, and are therefore 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 by climate change in general, and an increase in temperatures in particular. Increasing incidences of heat stress, increased dehydration, and a reduction of the ability to cope with other stressors and/or diseases are likely to be the main effects that Namibians will suffer due to an increase in future temperatures.

Additional secondary effects on human health, caused by increases in temperatures, are likely to include

- increased water stress as a result of increasing water scarcity
- decreased crop yields
- increased malnutrition
- lower air quality (mainly in urban settings), and
- a generally increasing additional disease burden.

These aspects will be discussed in further detail below.

1.4.2 Increasing water and vector borne diseases

The effects of climate change are very likely to result in increased pressure on open water resources (IPCC, 2008; IPCC, 2007; IPCC, 2007b; WHO, 2003). This is of particular significance in northern Namibia where open water sources are used for livestock watering, and to meet human water needs. The contamination of such water sources, especially as a result of increasing pressures (between communities, and between humans and the animals they depend on) to use such resources, is very likely (IPCC, 2008). The contamination of water resources may include human and animal faeces, which may in turn cause diarrhoea, cholera, fever and related illnesses (WHO, 2003).

Communities with pre-existing disease burdens are particularly vulnerable to water borne diseases. Increased water stress will also impact on food security: crop yields are likely to be reduced as temperatures increase, leading to malnutrition and the increased vulnerability to water and vector-borne diseases. The health of domesticated animals is also likely to be affected, leading to reduced fertility, lower calving rates, while reductions of milk and meat yields are likely. A deterioration of animal health will have flow-on effects on those humans who are dependent on such animals and their products (IPCC, 2008), and increase their susceptibility to existing and new diseases.

Rising temperatures are also likely to lead to an increased frequency, greater spread and increased transmission rates of infectious vector borne diseases (Husain et al, 2008). In particular, it is recognised that temperature is the single most important physical variable that affects the rate of pathogen maturation and replication within mosquitoes (Yé et al, 2007). It was found that mosquito abundance is amplified with warming, and east African mosquito populations were found to increase by more than ten-fold with every 0.1°C increase in temperature (Pascual et al, 2006). As discussed, Namibia can expect across-the-board increases in minimum, mean and maximum temperatures. This effect in itself will imply that the population densities of such insects are likely to significantly increase.

Rainfall patterns will change as a consequence of climate change, leading to shorter more intense rainy periods. Intense rainfall events cause an increase in water runoff, and enhance the opportunities of the formation of open waters, sometimes in areas that have not previously experienced such occurrences. This implies that the prevalence of water- and vector-borne diseases and of insects benefitting from more abundant open water sources is likely to increase as the number of suitable breeding areas increases. For example, areas that have previously offered only marginal opportunities for mosquito breeding will now, as a consequence of prevailing temperature regimes and/or the availability of water, offer more permanent breeding opportunities. An increase in the burden of water-borne diseases in particular is more likely in areas experiencing flash-floods and/or an increase in competition for water resources. This implies that both flood and drought conditions will likely increase the burden from water-borne diseases.

For Namibia, vector reproduction rates, parasite development cycles and bite frequencies are expected to increase with rising surface air and water temperatures. Population increases of mosquitoes and ticks (for example those responsible for tick-borne encephalitis) are likely to become increasingly widespread, and may in time reach major population centres that have been spared of such infestation in the past. Populations who have had little or no exposure to malaria-carrying mosquitoes will find themselves at an increased risk. The question of climate change and malaria is discussed in greater detail in chapter XXX of this report.

On the other hand, climate impacts on Namibia also foreshadow that the rainy season will be shortened, and that rainfall episodes are likely to become more intense. For existing mosquito breeding areas, for example, an increase in the frequency and/or severity of heavy rains is projected. Here it can be expected that the natural egg laying and larvae breeding cycles will be disrupted by such intense weather events, and cause a decline in vector populations. The above illustrates that it is not entirely trivial to attribute the incidence and dynamics of illnesses to climate change, and it is very likely that other important local and national parameters exist that have an equal weight in determining the rate and spread of old and new epidemics (Reiter et al, 2004; Reiter, 2008). This aspect as it pertains to malaria and its likely dynamics as a result of a changing climate is discussed in more detail in chapter XXX below.

Generally, it is likely that without an added focus on health and health-related developments, urban centres in particular will find themselves increasingly exposed to new or intensified disease burdens, which are promoted as a consequence of the direct and indirect impacts that climate change will bring to Namibia. If this is to happen, the Namibian health system will be exposed to new challenges, which could include an increase in local or even national epidemics, and a variety of small- and larger-scale outbreaks of human diseases, all of which will impose added demands on the existing health infrastructure.

1.4.3 Decreasing crop yields and food security

It has not yet been conclusively investigated how climate change will impact on the availability, affordability and accessibility of food in Namibia. The Climate Change Vulnerability and Adaptation Assessment (DRFN, 2008) too was inconclusive about the net effects of climate change on mahangu and maize yields in Namibia.

However, indirect evidence of the large-scale effects that climate change is likely to have on food security can be gleaned from those years in which floods or droughts have disrupted the more normal climatic patterns, both in Namibia and elsewhere in Africa (IPCC, 2007). For as long as humans have lived in Namibia, its weather patterns have been highly variable. The occurrence of above- or below-average rainy seasons is accepted reality, but despite this acceptance in the national psyche, every drought and flood event still causes considerable social and economic harm (IIED, 2007).

In view of demographic changes, brought about by Namibia's historical labour regime, the traditional roles of women particularly in rural populations, the high prevalence of HIV/AIDS and other factors, the availability of food in rural Namibia in particular is most likely to be adversely affected by climate change. Higher temperatures, greater climatic variability, shorter rainy seasons and a longer duration of the dry season are all going to contribute to reduce crop yields, and a larger total population is expected to place traditional food supplies under increased pressure (IPCC, 2007b). This effect is also expected to increase the risk of household food security, and an increase in malnutrition is likely. It is well-documented that malnutrition weakens human disease defences, and increases mortality in the general population, with vulnerable groups such as infants and children under the age of 5 years being particularly exposed (WHO, 2003; Brown et al, 2008; Brown, 2009).

The flow-on effects of human malnutrition in general are also well-documented, and include chronic and acute child malnutrition, low birth weights, suboptimal breastfeeding, and increased disintegration of traditional community and family cohesion. These effects may also increase the rate at which community and/or family members decide to migrate, in search of more secure food resources (Black et al, 2008).

Climate change is expected to compound existing food insecurity (Cohen et al, 2008). The recent international scramble for agricultural land for biofuels has illustrated what may happen if large-scale tracts of land that have previously been used for traditional food supplies become unavailable. Already, millions of people in sub-Saharan Africa have calorie-deficient diets, and a further weakening or disruption of the food chain – irrespective of whether it is climate-induced or otherwise – will increase malnutrition and decrease food security (ActionAid, 2008).

Contemporary research suggests that southern Africa, without sufficient adaptation measures, is likely to suffer crop reduction and an overall decrease in food crops, such as maize, millet and sorghum (Lobell et al, 2008). Food-related impacts of climate change are not limited to Africa, and one study finds that half of the world's population could face severe food shortages by the end of the century, because rising temperatures reduce crop yields (Battisti et al, 2009). This is a most significant statement, as food scarcity can destabilise political systems, threaten world peace, and increase hunger, illness and death due to under-nutrition (Brown, 2009).

The increased occurrence of extreme weather events, including droughts and floods, and changing patterns of plant and livestock diseases as well as pest infestations, are likely to lead to a reduction of income from animal products, a decrease of crop yields, an increase in the risk of fire, and an associated loss of income from forests. These factors will negatively affect food production in general, and lead to a decrease in food security. Namibia's vulnerable populations, which are traditionally found in rural areas, are the most likely ones to be adversely affected by such changes, and are also probably facing an increased disease burden associated with greater food insecurity (DRFN, 2008).

A rise in international food prices, driven by climate change-induced food scarcity, is likely to increase the number of migrants to urban centres, and will increase food insecurity of both urban and rural populations. Namibian towns and cities are already witnessing increased migration and net inflow of new arrivals, many of whom then find themselves in un-serviced and/or over-populated informal areas. Unless specific measures are taken, this trend is most likely going to increase, as food-related insecurity of subsistence farmers grows as a consequence of a more variable climate, and the associated deterioration of land and animal resources. This sentiment is also echoed in a recent statement by the World Food Programme that summarises that "*in the fight against hunger we could now be facing a perfect storm of challenges, including climate change and increasingly severe droughts and floods, soaring food prices and the tightest supplies in recent history, declining levels of food aid, and HIV/AIDS, which also aggravates food insecurity" (*Sheeran, 2008).

However, a discussion of the effects of climate change on crop yields and food security should not end in a mere doomsday scenario. It is important to note that some climate-related effects on food stocks can be ameliorated by applying enhanced management practices. In addition, promoting water-efficient crops, more heat and drought tolerant plant and animal species, and switching to more adapted plant and animals in the agricultural sector can offset many of the negative repercussions that climate change is likely to exert. Adaptation to climate change, for example by changing agricultural practices, crops and/or animal species is possible, and may be the most cost-effective way to ensure continued food production on the land, while also being the best guarantor for ensuring that rural people have meaningful livelihood opportunities.

The introduction of large-scale adaptation techniques and practices in Namibia requires a deliberate and well-funded effort by all stakeholders, which in turn renders this a financial, informational and social challenge. We conclude with a recent statement from the World Agriculture Report: *"to address expected climate change challenges and impacts, a major role for agricultural knowledge, science and technology is to increase the adaptive capacity and enhance resilience through purposeful biodiversity management. Options include irrigation management, water harvesting and conservation technologies, diversification of agriculture systems, the protection of agro-biodiversity and screening germplasm for tolerance to climate change" (IAASTD, 2008).*

1.4.4 Increasing water scarcity

Easy access to safe and reliable water, and good sanitation, are essential for human health. The IPCC's 6th Technical Paper is devoted to the topic of climate change and water (IPCC, 2008), and their most important statements of immediate relevance to Namibia include:

- Observed warming over several decades has been linked to changes in the large-scale hydrological cycle, such as increasing atmospheric water vapour content, changing precipitation patterns, intensity and extremes, and changes in soil moisture and runoff.

- Precipitation changes show substantial spatial and inter-decadal variability.
- Globally, the area of land classified as very dry has more than doubled since the 1970s.
- Climate model simulations for the 21st century are consistent in projecting precipitation increases in high latitudes and parts of the tropics, and decreases in some subtropical and lower mid-latitude regions. Outside these areas, the sign and magnitude of projected changes varies between models, leading to substantial uncertainty in precipitation projections. Thus projections of future precipitation changes are more robust for some regions than for others. Projections become less consistent between models as spatial scales decrease.
- By the middle of the 21st century, annual average river runoff and water availability are projected to decrease over some dry regions at mid-latitudes and in the dry tropics. Many semi-arid and arid areas (including southern Africa) are particularly exposed to the impacts of climate change and are projected to suffer a decrease of water resources due to climate change.
- Increased precipitation intensity and variability are projected to increase the risks of flooding and drought in many areas.
- Higher water temperatures and changes in extremes, including floods and droughts, are projected to affect water quality and exacerbate many forms of water pollution.
- Globally, the negative impacts of future climate change on freshwater systems are expected to outweigh the benefits.
- Changes in water quantity and quality due to climate change are expected to affect food availability, stability, access and utilisation. This is expected to lead to decreased food security and increased vulnerability of poor rural farmers, especially in the arid and semi-arid tropics.
- Climate change affects the function and operation of existing water infrastructure – including hydropower, structural flood defences, and drainage and irrigation systems – as well as water management practices.
- Current water management practices may not be robust enough to cope with the impacts of climate change on water supply reliability, flood risk, health, agriculture, energy and aquatic ecosystems.
- Climate change challenges the traditional assumption that past hydrological experience provides a good guide to future conditions.
- Adaptation options designed to ensure water supply during average and drought conditions require integrated demand-side as well as supply-side strategies.
- Water resources management clearly impacts on many other policy areas, e.g., energy, health, food security and nature conservation.

Chapter XXX presents additional information about water-related issues and challenges arising as a result of climate change in Namibia. This sub-section therefore focuses solely on the health-related effects of such change in the country. The main health effects of a lack of access to clean water and sanitation are 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 habitat for mosquitoes and an improvement of parasitic breeding places, leading to increased incidence of water-borne and vector-borne diseases.

Changing rainfall and temperature patterns forecast to occur over the next decades are likely to make the provision of clean water, good sanitation and drainage even more complicated than it is at present. As the Namibian climate become more variable, the occurrence of droughts and floods is likely to become more frequent and intense. This implies that occasionally, increased rainfall in one season will reduce water scarcity in one region of Namibia, while other regions may suffer droughts. Namibia’s health system will most likely have to cope with more such extreme rainfall conditions, i.e. floods and associated health effects in one region, and water scarcity and its associated health implications in another.

Increasing surface water temperatures and a decreasing accessibility of water are likely to lead to declining water quality and an increase in the microbiological activities on such water resources (IPCC, 2008). Scarcity is likely to lead to an increase in migration and associated conflict; all conflicts have negative health repercussions. These effects are likely to lead to an increase in health problems, particularly in vulnerable groups, such as infants, children under the age of five, pregnant women, the elderly and those with existing disease burdens. Cities and towns depending on open water sources to meet their water demand will be faced with an increase of costs to provide and treat water, especially as water runoff in contaminated river beds increases temporarily, and populations encroach on catchment areas (DRFN, 2008).

Overall, though, an increase in temperatures coupled to a shortening of the rainy season is likely going to lead to drier conditions in Namibia. In view of the current population growth rates, Namibia is therefore likely to witness an increase in the number of people living under water stress (IPCC, 2008; Arnell, 2004). Such water scarcity is also likely to increase the conflict potential within and between communities, and lead to an increase in the country’s overall health burden.

1.4.5 Increasing climatic variability and extreme weather events

According to the IPCC, the frequency of heavy rainfall events has increased over most land areas in the last decades (IPCC, 2007). More intense and longer droughts have been observed widely since the 1970s. Changes in extreme temperatures over the past 50 years have seen less frequent cold spells, and more frequent and intense heat waves than ever before (IPCC, 2007).

The reinsurance group Munich Re states that the number of weather-related disasters has increased, from an average of less than two per year in 1950, to more than six in 2007 (Munich RE, 2008). Over the same period, average annual economic losses have risen from less than US$5 billion to more than US$80 billion. In 2007, there were 960 major natural disasters (the highest ever such figure), with more than 90% being the result of extreme weather or climate-related events, and accounting for 95% of the 16,000 reported fatalities as well as 80% of the total economic losses valued at US$82 billion (Munich RE, 2008).

As indicated above, Namibia's climatic variability is projected to increase as a result of climate change. This also implies that the number and severity of extreme weather events, for example floods and droughts, is likely to increase, both in frequency and severity.

There are a number of well-documented health effects that are directly linked to such extreme weather events. Most significantly, climate variability is likely to impact on the following:

- Partial or complete loss of potable water resources, which can lead to an increase of disease as a result of malnutrition, and/or propagation and use of contaminated water, and/or the reduction of food and the associated effects of malnutrition.
- Health problems caused by the partial or complete destruction of infrastructure, which is particularly severe if such infrastructure is related to water supply, sanitation, communication and drainage.
- Reduction of crop yields, resulting in temporary or even longer-term food shortages, poor nutrition, and malnutrition, and greater dependency from others.
- Partial or complete loss of livestock, resulting in medium- to long-term animal product shortages, poor nutrition, and malnutrition.
- Exacerbation of the health implications for vulnerable groups as a result of extreme temperatures, including elderly people and those with existing disease burdens such as HIV/AIDS, tuberculosis and malaria.
- Floods and associated open water sources, often contaminated, will have a negative impact on both human and animal health.
- Increased wind speeds and an increased frequency and severity of storms are likely to lead to a greater number of people suffering from dehydration, and dust-related complications arising from wind-induced dust pollution.
- Droughts will lead to the partial or even complete loss of crops and/or livestock, and disenfranchise those that have little or no recourse to formal insurance and/or other risk mitigation measures, leading to negative health outcomes.

- Mental health impacts, as a result of loss of life of family members and/or having to cope with a disaster, are likely to increase in both number and frequency.

1.5 Discussion of health-related impacts of climate change in Namibia

The above sections have listed a considerable number of direct health-related impacts that are expected to arise as a consequence of a changing climate in Namibia. However, while most of the above effects can be considered primary effects, it is noted that many health effects and implications are also expected to arise as a result of the secondary impacts of climate change. Such secondary, or flow-on, effects of relevance to human health include the impact of direct physical changes on

- the accessibility, availability and affordability of food and water
- an increasing competition for resources, especially water, food and arable land
- the availability of shelter, and the effects of temporal dislocation
- the increase of specific diseases, such as cardiovascular diseases, diarrhoea, malaria and cholera
- sanitation systems (refer to the detrimental effects that the recurring floods have had on the sanitation systems in Oshakati and Ondangwa)
- the social and economic impacts of an increased disease burden in society
- the occurrence of migration, and the associated effects and impacts that migration has on increasing the spread of diseases, especially in peri-urban and urban areas
- the ability of the health sector to render effective services to a large number of affected individuals (a partial failure of the national health system is likely to increase the population-wide disease burden and cause society-wide disruptions)
- the deteriorating resilience and associated economic loss in the population as a result of frequent extreme events, and/or the significance of individual events
- the availability of financial resources that can be used to mitigate the effects of a climate-induced disaster
- the ability to muster international support
- the government as well as civil sector institutional capacities, and their ability to manage multiple or extreme events.

The above are a selection of important aspects that determine Namibia's vulnerability and climate-related impact on the country's health system. Generally, countries that have well-resourced institutions, functioning early warning systems, and are pro-actively preparing their populations for the impacts of climate change, for example by actively promoting adaptation measures, face a lower risk of being overwhelmed by the cumulative effects of climate change than those countries that have little inherent resilience, few additional financial resources and/or are unprepared.

Nationally and internationally the medical fraternity seems in agreement that 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. It is also widely accepted that those countries with low or marginal abilities to manage their existing disease burden will suffer the greatest consequences as a result of climate change.

Namibia is well-advised to prepare for the quick and effective mobilisation of the required financial, infrastructural and human capacities, so as to build institutional, communal and individual capacities to adequately respond and cope with the health-related impacts that climate change will impose. Our existing national disease burden, especially in regard to the HIV/AIDS pandemic and tuberculosis, as well as the significant percentage of the population living in poverty, implies that Namibia will find the effects of climate change severely challenging. Specific recommendations to enhance the Namibian health sector's ability to cope with change are discussed in chapter XXX below.

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