Vulnerability and responses to climate change in drylands: The case of Namibia

CARIAA-ASSAR Working Paper

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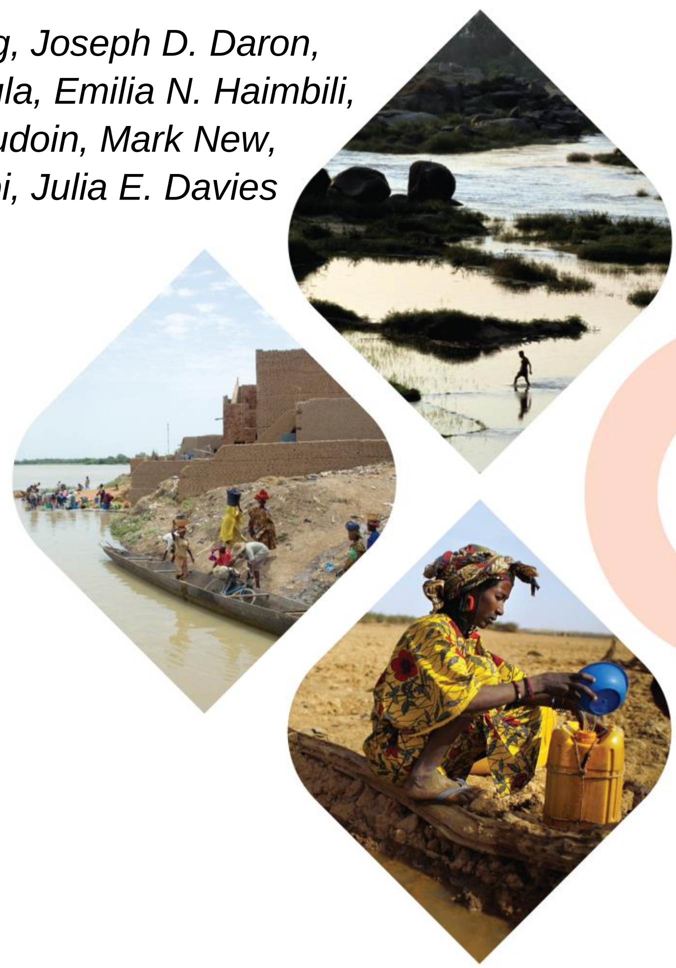

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Key Words: adaptation, development, climate change, vulnerability, responses, drylands, semi-arid, Namibia, resource management, equity, sustainability

About CARIAA Working Papers

This series is based on work funded by Canada's International Development Research Centre (IDRC) and the UK's Department for International Development (DFID) through the **Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA)**. CARIAA aims to build the resilience of vulnerable populations and their livelihoods in three climate change hot spots in Africa and Asia. The programme supports collaborative research to inform adaptation policy and practice. Titles in this series are intended to share initial findings and lessons from research and background studies commissioned by the programme. Papers are intended to foster exchange and dialogue within science and policy circles concerned with climate change adaptation in vulnerability hotspots. As an interim output of the CARIAA programme, they have not undergone an external review process. Opinions stated are those of the author(s) and do not necessarily reflect the policies or opinions of IDRC, DFID, or partners. Feedback is welcomed as a means to strengthen these works: some may later be revised for peer-reviewed publication.

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Abstract

Drylands are harsh environments exposed to substantial climate variability and change. Historically, communities have adopted several coping mechanisms. Today, however, many communities exhibit low levels of adaptive capacity due to challenges such as marginalization, underdevelopment, maladaptive policies and population growth. We use Namibia as a case study to examine the nature of vulnerability and responses to climate change in a developing dryland country. Vulnerability to climate change in Namibia is driven by underlying structural factors, including a history of inappropriate economic policies, gender disparities and colonization, which have led to chronic poverty and inequality. Climate change is expected to augment existing levels of vulnerability, as temperatures rise, rainfall decreases and seasonal climate patterns become more variable. Concurrently, the natural characteristics of drylands - including water scarcity, poor soil fertility and remoteness – make communities further vulnerable. Although a number of government-led responses have contributed to reducing the impacts of climate variability on vulnerable communities, these responses are primarily targeted at addressing immediate development needs and are therefore unlikely to be sufficient in the face of long-term climate change. Adaptive and even transformative responses need to be considered and implemented if the wellbeing and livelihoods of the people of Namibia are to be maintained and improved.

About ASSAR

All authors of this working paper are team members in the ASSAR (Adaptation at Scale in Semi-Arid Regions) project, one of four hotspot research projects in CARIAA. The international and interdisciplinary ASSAR team comprises a mix of research and practitioner organisations, and includes groups with global reach as well as those deeply embedded in their communities. The ASSAR consortium is a partnership between five lead managing institutions - the University of Cape Town (South Africa), the University of East Anglia (United Kingdom), START (United States of America), Oxfam GB (United Kingdom) and the Indian Institute for Human Settlements (India) – and 12 partners – the University of Botswana, University of Namibia, Desert Research Foundation of Namibia, Reos Partners, the Red Cross/Crescent Climate Centre, University of Ghana, ICRISAT, University of Nairobi, University of Addis Ababa, Watershed Organisation Trust, Indian Institute for Tropical Meteorology, and the Ashoka Trust for Ecology and the Environment.

Working in seven countries in semi-arid regions, ASSAR seeks to understand the factors that have prevented climate change adaptation from being more widespread and successful. At the same time, ASSAR is investigating the processes – particularly in governance – that can facilitate a shift from ad-hoc adaptation to large-scale adaptation. ASSAR is especially interested in understanding people's vulnerability, both in relation to climatic impacts that are becoming more severe, and to general development challenges. Through participatory work from 2014-2018, ASSAR aims to meet the needs of government and practitioner stakeholders, to help shape more effective policy frameworks, and to develop more lasting adaptation responses.

Why focus on semi-arid regions?

Semi-arid regions (SARs) are highly dynamic systems that experience extreme climates, adverse environmental change, and a relative paucity of natural resources. People here are further marginalised by high levels of poverty, inequality and rapidly changing socio-economic, governance and development contexts. Climate change intersects with these existing structural vulnerabilities and can potentially accentuate or shift the balance between winners and losers. Although many people in these regions already display remarkable resilience, these multiple and often interlocking pressures are expected to amplify in the coming decades. Therefore, it is essential to understand what facilitates the empowerment of people, local organisations and governments to adapt to climate change in a way that minimises vulnerability and promotes long-term resilience.

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Acronyms

CAU – Climate Analysis Unit
CCU – Climate Change Unit
CSAG – Climate Systems Analysis Group
DEA – Department of Environmental Affairs
DRFN – Desert Research Foundation of Namibia
EIF – Environmental Investment Fund
GCF – Green Climate Fund
GCM – Global Climate Model
GRN – Government of the Republic of Namibia
IPCC – Intergovernmental Panel on Climate Change
IWRM – Integrated Water Resource Management
MAWF – Ministry of Agriculture, Water and Forestry
MET – Ministry of Environment and Tourism
NCCC – National Climate Change Committee
NCCP – National Climate Change Policy
NCCSAP – National Climate Change Strategy and Action Plan
NGO – Non-Governmental Organisation
NIE – National Implementing Entity
NPC – National Planning Committee
NSA – National Statistics Agency
UNDP – United Nations Development Programme
UNFCCC – United Nations Framework Convention on Climate Change

1. Introduction

Dryland areas cover about 40% of the earth's surface and are home to more than a third of the globe's population. Despite being relatively unproductive, drylands have higher population growth rates than any other human-ecological system on Earth (Millennium Ecosystem Assessment, 2005). Significant levels of poverty are found in these areas, and the development of drylands thus poses a challenge that is important to meet, particularly as drylands are extremely vulnerable to the effects of climate change. Indeed, drylands are hotspots of vulnerability. The vulnerability of these regions is characterised by a number of interacting factors, including water scarcity, a highly variable environment, poor soil fertility and land degradation, all of which contribute to natural agro-constraints (Reynolds et al., 2007; Sietz et al., 2011). Despite histories of coping with such conditions, communities in drylands often show low levels of capacity to adapt to climate variability and change. This is a consequence of various non-climatic factors such as poverty, marginalization, underdevelopment, isolation and maladaptive policies (Maru et al., 2014). In the face of climate change, population growth and rangeland degradation, an understanding of vulnerability – and potential points of intervention – is critical for sustaining livelihoods and improving human wellbeing.

An interplay of biophysical and socio-political factors drives wellbeing and land productivity in drylands and determine whether poverty, famine and migration are realized (Safriel and Adeel, 2008). To sustain populations in drylands, 'best practice' land management is increasingly likely to be limited in effect. Rather, ingenuity and alternative livelihoods, supported by enabling policies, infrastructure and capacities, is now necessary (ibid.). This is particularly important when climate change is likely to reduce the biophysical thresholds of dryland systems, thereby reducing agricultural productivity (Thompson and Scoones, 2009). However, it should be noted that the impacts of climatic shocks are largely dependent on the context within which they occur (Fraser et al., 2011).

Namibia provides a good example of a country dominated by drylands. Here, aridity and drought conditions are intensifying as temperatures rise and rainfall variability increases. In this working paper, we use Namibia as a case study to examine the nature of vulnerability, the impacts of climate change and the current and potential responses to climate change in a developing dryland context. The impacts of climate change in Namibia will be diverse and affect many sectors of the economy, straining both social and ecological systems. People are likely to be impacted differently, according to their level of vulnerability and adaptive capacity. Building the resilience of these sectors and social groups is essential if Namibia's economy and society is to withstand the impacts of climate change and function sustainably in future.

1.1. Structure of the paper

This working paper examines the climate change landscape in Namibia in the context of the existing literature on development in drylands. It begins by providing a contextual background of Namibia, including a description of the social, economic and livelihood activities in the country (Section 2). Subsequently, in Section 3, an overview of climate trends and projections is provided. The impacts of climate change and variability across sectors is then examined in Section 4, and assessed in relation to the vulnerability and adaptive capacity of Namibian people in Section 5. Section 6 outlines the governance of climate change in Namibia, before section 7 examines existing and potential adaptation responses.

2. The Namibian context

Namibia is a dry country on the southwestern coast of Africa with a population of just over 2 million people (2 113 077 in the 2011 census) in an area of 825,615 km2 (NSA, 2011). It is the second least densely populated country in the world after Mongolia (World Bank, 2014). The country is covered by biomes ranging from sub-humid woodlands in the northeast to true desert on the west coast with large arid and semi-arid climatic regions including savanna and karoo vegetation. To add to this, Namibia has an important marine environment – the northern Benguela. Only 2% of the country is arable, 46% is viable for perennial natural pasture, 22% is forest, and the rest is arid (GRN, 2015). The rural areas in northern Namibia are communal with limited land tenure (Adams and Devitt, 1992). In south and central Namibia there is privately owned land, where livestock ranching and tourism take place (see Figure 1). Livestock is of primary importance in the agricultural sector, both in the communally-owned areas north of the veterinary control fence and the privately-owned land in the rest of the country (GRN, 2015).

The majority (57% in 2011; 67% in 2001) of Namibia's population is considered rural (NSA, 2011). Agriculture thus plays an important role, employing people in the formal economy on both communal and freehold land, as well as supporting subsistence farming, which provides the main source of income for 40% of Namibia's rural population. Subsistence farming is especially important for communities living in the Omusati, Ohangwena, Kavango and Oshikoto regions on communally owned land (NSA, 2012; Wilhelm, 2012). Along the coastline, Namibia's fisheries are very productive and play a key role in supporting the livelihoods of coastal communities. They provide an important resource to both a commercial and recreational fishery, as well as supporting some artisanal fishing (Sowman and Cardoso, 2010). Unemployment rates in Namibia are relatively high at 28.1% (NSA, 2015). The national government therefore provides social grants to pensioners, the disabled and guardians of orphans and war veterans (Chiripanhura and Nino-Zarazua, 2013). These grants reach about 30% of households in north-central Namibia (Muhangi and Acidri, 2008) and are important for sustaining the livelihoods of many families which have little or no access to alternative sources of income (Angula and Kaundjua, 2016).

Many Namibians face severe food insecurity at the household level, with most of the country's cereal requirements being imported (Werner and Rohrig, 2011; GRN, 2015). People who are disproportionately affected by food insecurity include smallholder farming communities and poverty-stricken urban dwellers (Werner and Rohrig, 2011; NPC, 2008). In north-central Namibia, where the majority of the Namibian population resides, millet and sorghum are the main food crops (Muhangi and Acidri, 2008). Other crops include beans, watermelon, squash, maize, matanga, nuts and pumpkin (Newsham and Thomas, 2009). However, production does not meet food needs (Muhangi and Acidri, 2008). Cattle are the main livestock animal that is kept, along with goats and chickens. Pigs and donkeys tend only to be kept by wealthier families. Inland fishing is also undertaken in the north (Barnes et al., 2012), and some households collect wild foods to eat, including palm fruit and marula (Muhangi and Acidri, 2008).

Work for poorer rural community members comes from weeding, harvesting and cattle herding, with in-kind payment of millet being made by wealthier farmers. Non-farm income sources include domestic work, trading, small businesses such as "cuca shops" and "shebeens", crafts such as basket making, beer brewing and manual labour in the form of erecting fencing, brick moulding and constructing huts and granaries (Muhangi and Acidri, 2008). There is an increasing trend of urbanisation in Namibia, and formally employed community members work for government, in public service jobs or in clothing factories (Pendleton et al., 2014). Many urban employees send cash remittances home to their families in rural areas (Muhangi and Acidri, 2008).

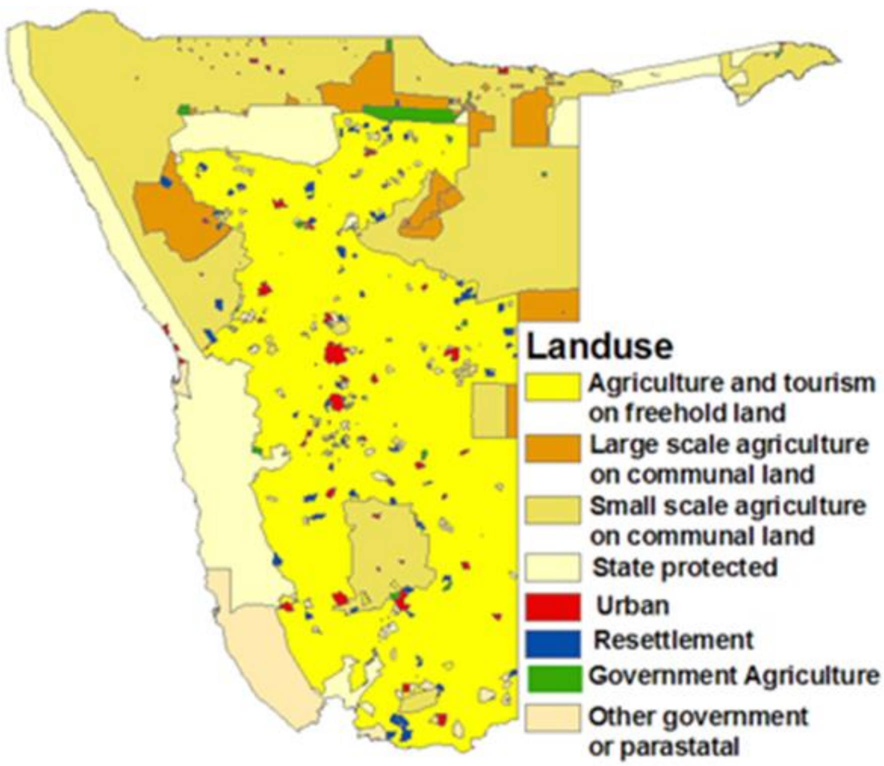

Figure 1: Landuse map of Namibia (spatial data from the Namibia Atlas project)

3. Climate trends and projections for Namibia

3.1. Namibia's present climate

Namibia is characterised by arid and semi-arid climates. Dry conditions persist throughout much of the year due primarily to the proximity of the Atlantic Ocean and the influence of the cool northward flowing Benguela ocean current that results in persistent high pressure off the coastline (Thuiller et al., 2010; Dirkx et al., 2008; Turpie et al., 2010). There is a single rainy season occurring in the summer (November to April) associated with the southward migration of the Inter-Tropical Convergence Zone (ITCZ). Average annual total rainfall varies from approximately 600 mm in the northeast to less than 50 mm in southern and coastal regions (Figure 2a and b). Coastal fog is also prevalent and acts as a vital source of water for the desert fauna and flora, providing up to five times more water than through rainfall in some coastal regions (GRN, 2015).

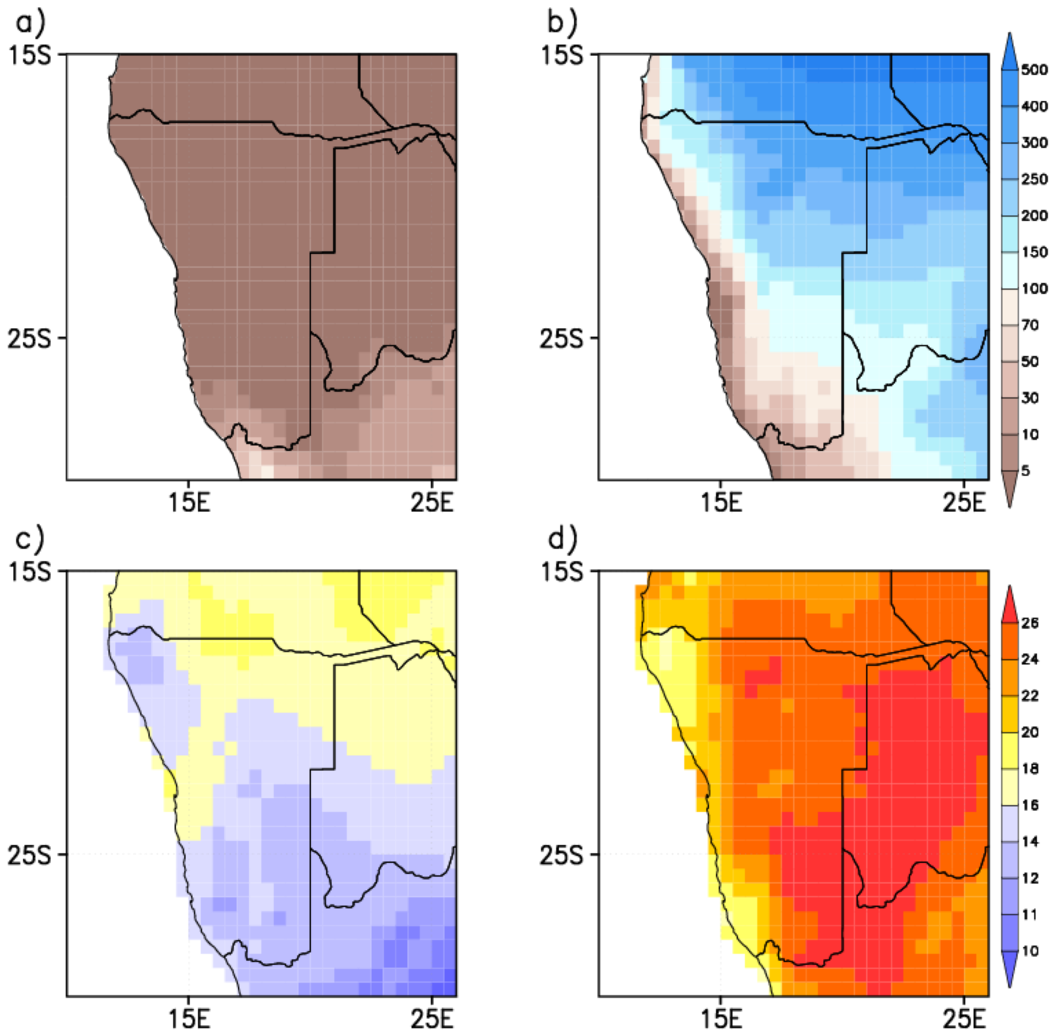

Figure 2: Spatial maps of mean a) winter (JJA) total precipitation in mm, b) summer (DJF) total precipitation in mm, c) mean winter temperature in °C, and d) mean summer temperature in °C over the period 1963 to 2012. Data taken from CRU TS3.22 dataset.

Temperatures across Namibia exhibit a large diurnal cycle, with high daytime maximum and low daytime minimum temperatures. Very high temperatures occur inland during the summer (December to February - DJF), with cooler conditions along the coast (Figure 2d). Temperatures are cooler throughout the country during winter with the coolest conditions in the south (Figure 2c). Like most of the country, northern Namibia experiences a high temperature gradient with cooler temperatures near the coast and much warmer temperatures inland. Whilst still low, rainfall amounts in the north are much higher than in central and southern regions of the country, allowing for more productive agriculture.

3.2. Historical climate trends

The climate of Namibia has varied in the past due to both natural variability and anthropogenic climate change. Observations reveal significant trends in some climate variables over recent decades, though there are discrepancies between different observational datasets available for the region, with particular uncertainty in historical precipitation trends.

Namibia has experienced significant increases in temperature over the past century (Hulme et al., 2001). Over the past 50 years the increases have been greater in winter (Figure 3a) than in summer (Figure 3b), with the largest increases of up to 0.5°C in the northeast (Daron, 2014).

The most significant impacts of climate change often manifest through changes to climate extremes. High daytime temperatures are experienced across much of Namibia in the summer months, particularly inland. During December and January, monthly mean maximum temperatures in central southern Namibia are close to 35°C (CSAG, 2016). Decreases in extremely cold days and nights, and increases in hot days and nights have been observed for the period 1961–2000, with hot extremes showing stronger trends than cold extremes (New et al., 2006). Historical changes in precipitation vary across Namibia. Though large parts of eastern Namibia have experienced increases in summer rainfall (Figure 3d) there is evidence of reductions in late summer rainfall over Namibia during the second half of the 20th Century (Hoerling et al. 2006; New et al. 2006), with northern and central regions of Namibia experiencing a later onset and earlier cessation of rains (Dirkx et al. 2008). Overall, Namibia has experienced a decrease in annual average rainfall, with the largest decreases in the March to May season (Hutchinson 1998), and increased inter-annual rainfall variability resulting in more frequent heavy rainfall events and more intense and widespread droughts since 1970 (IPCC 2007). Droughts, associated with low rainfall, and floods, resulting from heavy precipitation events, occur frequently. Between 8 and 14 droughts, and between 11 and 19 wet periods were experienced during the period 1961 to 2009 (Gilau et al. 2011).

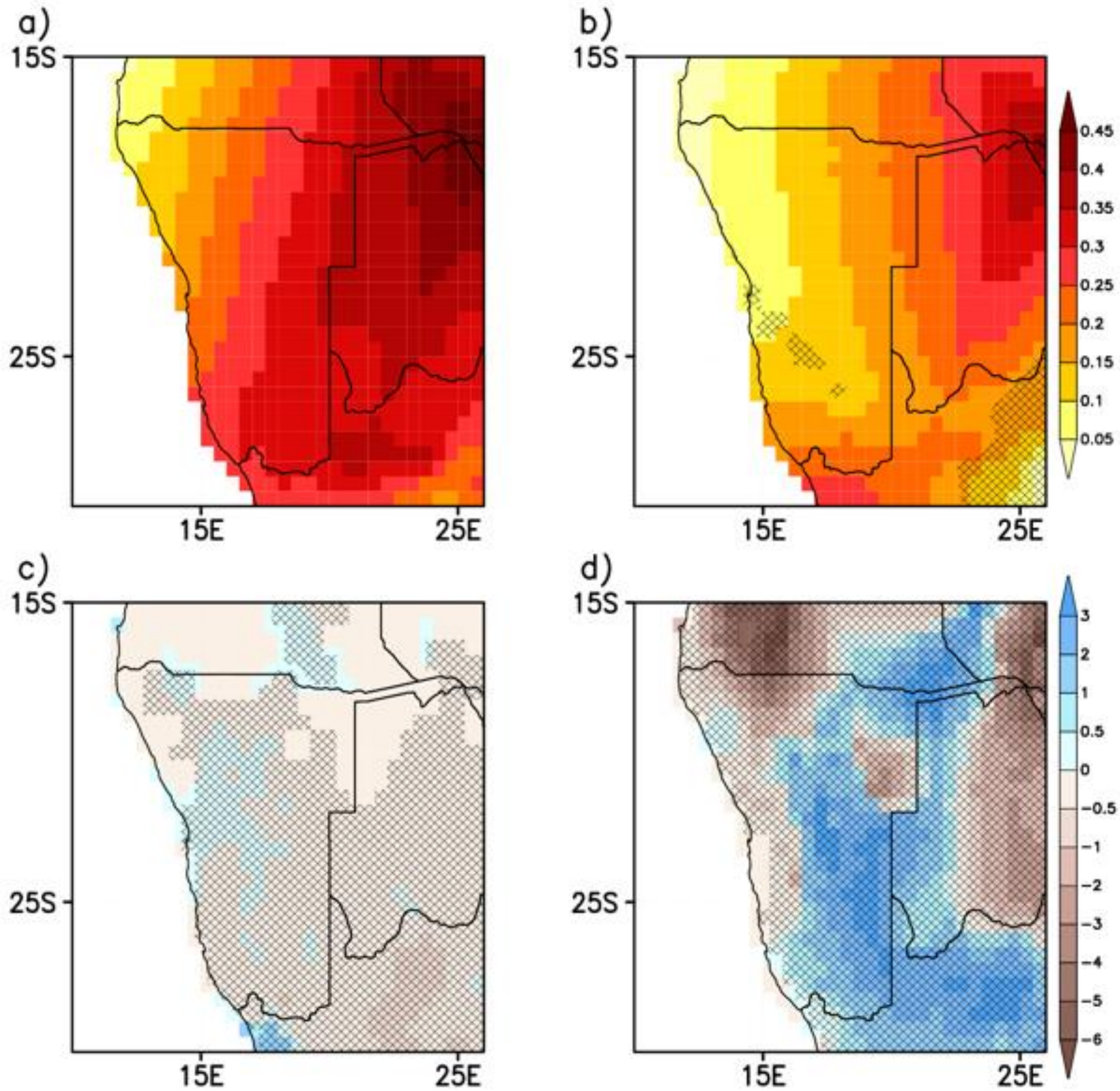

Figure 3: Spatial patterns showing the trend in mean a) winter temperature in deg C/ decade, b) summer temperature in deg C/ decade, c) winter (JJA) precipitation in mm/decade, and d) summer (DJF) precipitation in mm/decade between 1963 and 2012 at each grid cell using a linear trend. Data taken from CRU TS3.22 dataset. The Mann-kendall test was used to calculate the P-value significance above 95%. The hatching indicates the areas that are not significant.

3.3. Future climate projections

There have been some studies that have produced downscaled climate projections over Namibia (Dirkx et al. 2008; Turpie et al. 2010; Coetzee 2010; Engelbrecht et al. 2013; GRN 2015). A study by Davis (2011) downscaled six GCMs for the period 2036-2065 showing that Namibia would likely experience a decrease in annual rainfall totals and an increase in temperatures by 1.2°C in the south west to 2.8°C in the north east (averaged across the simulations). More recently, evidence from the

South African Long-Term Adaptation Scenarios (LTAS), which used the results of six statistically downscaled simulations, show similar results over Namibia. In these simulations, which assume modest increases in greenhouse gases, rainfall was projected to decrease over much of Namibia with temperatures projected to increase by between 2 and 5°C over the next century, with lower rates of warming in the south-west and the greatest warming in the north-east (DEA 2013).

The information from downscaled simulations discussed above does not fully represent all sources of uncertainty and so must be treated with caution (Daron et al. 2015). Analysis of GCM simulations from CMIP5 reveal high rates of warming and decreasing rainfall over Namibia in the coming decades (Figure 4). The Omusati climatic zone also showed a high warming rate and decreasing rainfall during JJA and DJF. The warming level for both scenarios was higher compare to Namibia during JJA and lower during DJF. The range of models in CMIP5 show temperature increases of between 2.5 and 3.3°C by 2050 and between 3.3 and 5.8°C by the end of the 21st century over Namibia (Dirkx et al. 2008; Coetzee 2010; Niang et al. 2014), where winter temperatures are projected to rise more quickly than summer temperatures. Consistent with previous studies, the maximum warming is expected inland, particularly over the Kalahari Desert (Dirkx et al. 2008; Daron 2014).

The Omusati climatic zone in northern Namibia shows high warming rates and decreasing rainfall during JJA and DJF. The warming level for both RCP4.5 and RCP8.5 scenarios is higher compared to Namibia as a whole during JJA and lower during DJF. Increases in temperature extremes are expected to continue; projections show increases in the frequency of days with maximum temperatures above 35°C and significant decreases in the frequency of days with minimum temperatures below 5°C (Dirkx et al. 2008). Projections show increases in the duration of heat waves and decreases (albeit smaller) in the duration of cold spells by the end of the 21st century compared to the end of the 20th century (CSC 2013).

Although some model projections show increasing precipitation for parts of Namibia, most models show reasonable agreement in a signal of decreasing precipitation across much of Namibia over the next century (Davis 2011; James 2013; Mariotti et al. 2014; Niang et al. 2014). Average winter rainfall is projected to decrease by around 6 mm by mid-century and around 7 to 9 mm by the end of the century, whilst mean summer rainfall is projected to decrease by around 17 to 23 mm by mid-century and 19 to 40 mm by the end of the century; noting that rainfall is almost entirely experienced in the summer season in Namibia. Some predictions show decreased increases in late summer precipitation (Dirkx et al. 2008), which contrasts with historical reductions in late summer precipitation. This also differs from an expected extension of the dry season, with a delay in both the onset and cessation of rains over southern Africa (Mariotti et al. 2014). For precipitation extremes, projections range from no change to a substantial increase in the duration of dry spells and from a slight decrease to a notable increase in the intensity of heavy precipitation events by the end of the 21st century (CSC 2013).

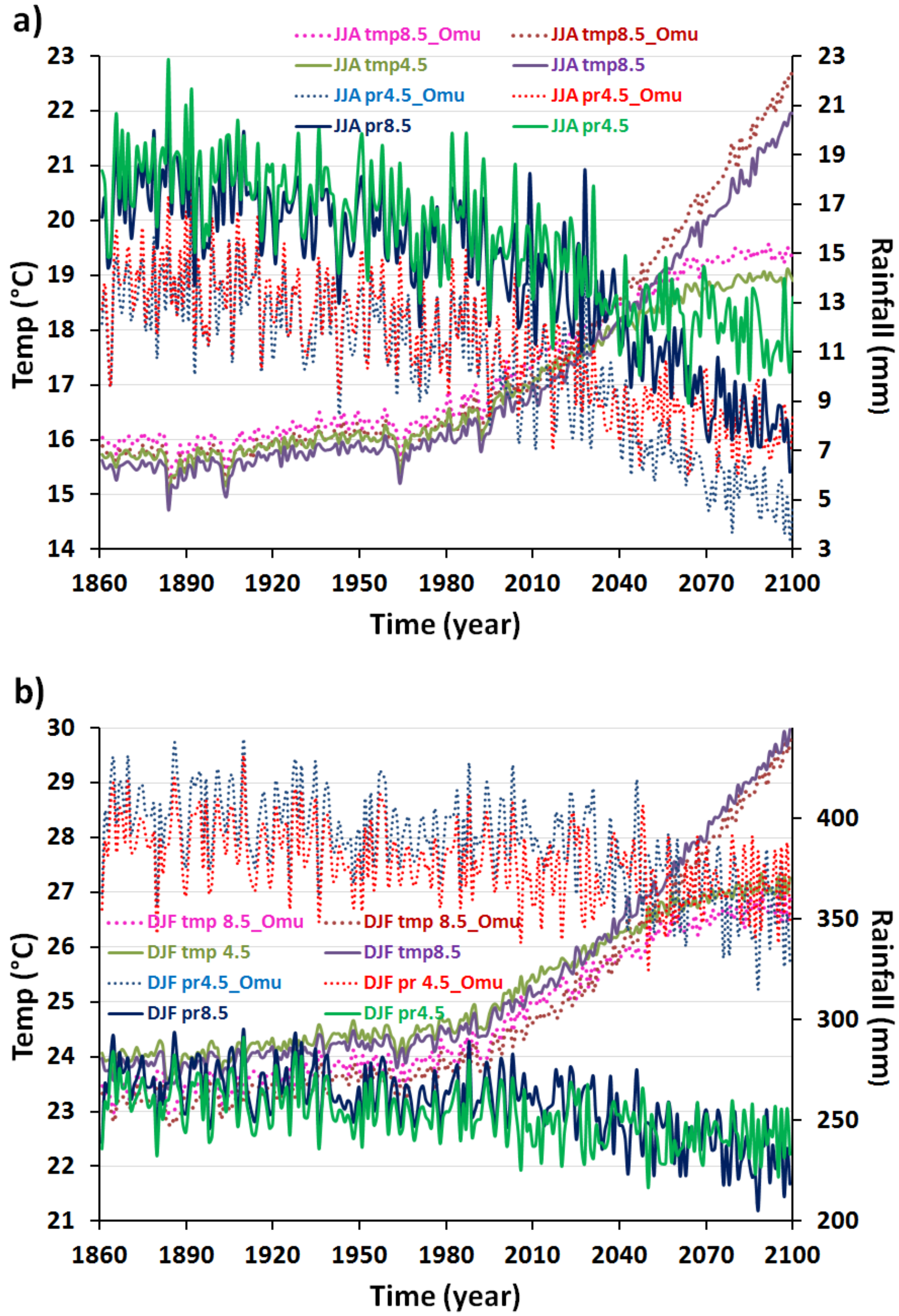

Figure 4: Time series of a) winter (JJA) and b) summer (DJF) precipitation and temperature from 1861 to 2100 from the CMIP5 multi-model mean averaged over Namibia (continuous line) and Omusati climatic zone (dotted lines) using the RCP8.5 (39 models) and 4.5 (42 models) representative concentration pathways (RCPs). The CMIP5 models for the RCP8.5 and RCP4.5 were downloaded via the KNMI Climate Explorer (https://climexp.knmi.nl).

Acknowledging uncertainties in climate change projections

Many uncertainties associated with predicting the future climate can be quantified while other uncertainties cannot (Dessai 2004). Given inherent and irreducible uncertainties in climate prediction, and with multiple non-climatic factors influencing adaptation decisions, it is argued that "climate prediction should not be the central tool to guide adaptation to climate change" (Dessai et al. 2009). Indeed, there are decision approaches to dealing with uncertain climate projections (Wilby & Dessai 2010; Weaver et al. 2013). Typically, these involve the reframing of problems to begin with decision thresholds and sensitivities. Dessai et al. (2009) suggest decision-makers assess the performance of adaptation strategies over a wide range of plausible futures. The goal of climate prediction should therefore be in capturing the plausible range of climate futures to consider in adaptation decisions (Daron et al. 2015).

4. Impacts of climate change on Namibia's economic sectors

4.1. Water

Water is an extremely scarce resource in Namibia, and even in the absence of climate change the country faces water scarcity (Reid et al., 2007). With climate change, it is expected that higher temperatures and changes in total amounts of rainfall will lead to reduced water quantity and quality in future (Kandjinga et al., 2010). Expected changes in rainfall and runoff in Namibia suggest that groundwater recharge may suffer a reduction of 30-70% across the country (MET, 2011). Surface water flows are predicted to decline by up to 15% in the Orange river system to the south, 10% in western ephemeral rivers (Barnes et al., 2012) and about 20% in the Okavango river, which flows along the Angolan border in the North, by 2080 (Andersson et al., 2006). This situation will be further worsened by increased demand from population growth and increasing water demand for irrigation and urban centres in response to heat stress (Schneider et al., 2015). This is significant as Namibia's main water use is for irrigation (45%), livestock (26%), municipalities (24%) and industry (5%) (Frenken, 2005). In the north, reduced river flows could impact on the output of the Ruacana hydropower plant, which supplies most of Namibia's domestically-produced energy and about half of the country's electricity supply (MET, 2011).

4.2. Agriculture

The agricultural land on which almost two-thirds of Namibians practice subsistence cropping and pastoralism is already marginal. Changes in temperature, rainfall variability, length of winter seasons and humidity could lead to crop failures and the reduced viability of rainfed agriculture in many areas

(Reid et al., 2007; Newsham and Thomas, 2009; Barnes et al., 2012). Some factors at play include loss of soil fertility due to changes in precipitation, temperature, vegetation and moisture levels; accentuated soil erosion due to the increased occurrence and/ or intensity of floods and droughts, and changes in crop pests and pathogen dynamics (Kandjinga, 2010; MAWF, 2012; David et al., 2013). Scenarios of loss in agricultural production expected by experts are substantial, with estimates indicating around 50% loss in production over the next 50 years (Reid et al., 2008). It is also expected that the effects of climate change will increase heat and water stress, as well as the spread of diseases, among livestock. Soil degradation and reduced vegetation cover will further affect grazing pastures and reduce livestock production throughout Namibia (Reid et al., 2007; Turpie et al., 2010; Zeidler et al., 2010). In southern Namibia, livestock carrying capacity is expected to drop by 15% over the next 50 years, making livestock farming no longer viable in some areas (Zeidler et al., 2013).

4.3. Health

The HIV/AIDS epidemic, poverty, malnutrition and other existing disease burdens are already putting strain on health services, the demand for which is likely to increase under climate change. This is not only because of the contribution of climate change to rising food insecurity and malnutrition, but also the influence of increasing temperatures and floods on the spread of vector- and water-borne diseases like malaria and cholera (von Oertzen, 2010; Zeidler et al., 2010). Other major impacts that Namibian people will likely suffer as temperatures increase include higher incidences of heat stress, increased dehydration and a reduced ability to cope with other stressors and diseases (von Oertzen, 2010). Moreover, frequent flooding could lead to greater loss of life owing to a higher number of drowning incidents.

4.4. Biodiversity

Namibia's biodiversity is highly sensitive to the effects of climate change. Fortunately, Namibia's substantial protected area system is likely to help conserve much of its biodiversity and prevent total extinction in future. However, even with conservation efforts, almost half of the country's endemic plant species are expected to experience contracted ranges of more than 30% by 2080. There are also expected to be reductions in vegetation cover, net primary productivity and reductions in deciduous broad-leaved trees by 2050 due to drying and warming. Similarly, the range of C4 plant functional types will likely decrease by 2050 because of increased CO2 levels. At the same time, there may be an increase in C3 plant functional types (Thuiller et al., 2006). These changes are projected to result in substantial shifts in species diversity, vegetation structure and function (Midgley et al., 2005; Thuiller et al., 2006). Under climate change scenarios, Tree and Shrub Savanna biomes are expected to reduce significantly, whilst the most arid biomes (Desert and Nama Karoo) are expected to expand by 20% by 2050 and 43% by 2080. Bush encroachment is projected to increase in the north-eastern parts of the country, and forest and savannah fires are likely to become more intense and widespread (Mendelsohn et al., 2005). Changes in grass biomass ranging from a 10% reduction in the Woodlands of the northeast, around a 5% reduction in the Savanna and a 10% reduction in the southern Karoo areas is also estimated (Midgley et al., 2005). Associated with changes in vegetation, temperature and humidity levels is the loss of ecosystem services such as water purification and filtration, the availability of medicinal plants and the provision of biomass energy (David et al., 2013).

4.5. Tourism

Tourism makes substantial contributions to Namibia's economy, both directly and indirectly (GRN, 2015). Climate not only influences the environmental conditions in which to conduct tourism activities comfortably, but has an impact on biodiversity, which is a major drawcard for tourists. Changes in temperature, vegetation, water and the location of wildlife will, for instance, hinder wildlife safaris, water sports and backpacking activities in Namibia and in the Kgalagadi south east district of Botswana (Barnes et al., 2012). Thus, significant impacts on the country's GDP and on individuals relying on tourism as main source of income are expected (ibid.). The effects of climate change, particularly increasing temperatures, also affects operational costs associated with tourism, such as cooling of facilities. Extreme events such as floods can damage infrastructure and affect accessibility, as well as increase the incidence of vector-borne diseases like malaria. These factors can lead to the tourism sector being potentially vulnerable to the impacts of climate change. Part of Namibia's attraction as a tourist destination is also due to political stability. However, climate change may increase the risk of political conflict (GRN, 2015).

4.6. Infrastructure

Floods in Namibia have become an almost annual occurrence (Gilau et al., 2011). In the highly populated areas of north-central and north-east Namibia, many houses and businesses are situated in or near floodplains, where they are at risk of being destroyed. Roads are also frequently flooded, which restricts access to homesteads and services such as schools and healthcare facilities (Zeidler et al., 2010; Deickmann et al., 2013). It is expected that these impacts are likely to increase into the future as more frequent and intense flooding events occur. This will affect not just buildings and roads but also railways, dams, water pipes, electricity transmission facilities, communication infrastructure and sewerage and drainage systems (UNDP, 2010; Zeidler et al., 2010; Tamayo et al., 2011). Villages may also be disconnected from public services and access to schools may be negatively affected (IECN, 2011). While floods interrupt electricity supply, so do extended periods of drought. During low rainfall periods, the level of the Kunene river drops, thereby reducing the amount of electricity that the country's hydropower plant is able to generate (NamPower, 2015). One of the positive side effects of damaged infrastructure after floods is increased work in the construction industry.

4.7. Mining

The mining sector contributes significantly to the economy. This sector requires electricity (drawn from hydropower generation) as well as large quantities of water (Puz, 2000). In times of drought, low levels of water supply compromise mining operations (KPMG Global Mining Institute, 2014). Sea-level rise and extreme weather events associated with climate change are also likely to affect the stability and effectiveness of mining infrastructure and equipment, environmental protection and site closure practices, and the availability of transportation routes. Climate change may also impact the availability, stability and cost of water and energy supplies required in mining industries (ibid.).

5. Vulnerability and adaptive capacity sectors

5.1. Sensitivity to climate change

In Namibia, people's vulnerability to climate is fundamentally driven by broader social, political, economic and structural factors that shape their ability to maintain secure livelihoods (Ribot, 2014). These factors - including a history of inappropriate economic policies, gender disparities and colonisation - have led to chronic poverty and inequality in the country, as well as marginalisation (Jauch et al., 2011). This is evidenced by limited: employment (NSA, 2015), capacity to engage in economic activities (Dirkx et al., 2008; MET, 2011), literacy and education (NSA, 2011), financial capacity, access to loans (Zeidler et al., 2010; Giorgis, 2011; Nyambe and Belete, 2013) and access to public services (NSA, 2011; Amadhila et al., 2013). As a result, there is a strong reliance on natural resources and many livelihoods depend on rain-fed crop and livestock farming (Muhangi and Acidri, 2008; Newsham and Thomas, 2009; GRN, 2014). The provision of ecosystem services also forms a key element of rural livelihoods (Reid et al., 2007; Brown, 2009). For example, people collect wood for fuel and to make poles for building; and gather wild food plants, medicinal plants and raw material for crafts (Barnes et al., 2012). This is in spite of the harsh environmental conditions associated with dryland ecosystems in Namibia and globally, which make people particularly sensitive to any shifts or anomalies in climate. (CSC 2013).

Of further concern in dryland areas of Namibia is the increasing degradation[1] of rangelands and the deterioration of natural resources (Klintenberg et al., 2007; Gremlowski, 2010), which is occurring as a consequence of rising population densities and the mismanagement of resources (Klintenberg et al., 2007; Zeidler et al., 2010; MET, 2011). The increasingly limited access to fertile land for crop production and livestock grazing compounds the effects of extreme hot and dry conditions, and the frequent occurrence of floods (Klintenberg et al., 2007; Kuvare et al., 2008; Angula and Menjono, 2014). In addition, there is a low diversity of livelihoods and few alternatives to agriculture (Gremlowski, 2010). Within agriculture, too, there are significant challenges. Existing crops are susceptible to drought and livestock are sensitive to heat stress and disease (Turpie et al., 2010; Zeidler et al., 2010). Yet, there is limited crop diversification (Newsham and Thomas, 2009) and people are often reluctant to sell livestock in drought years due to factors such as low market prices and a cultural attachment to livestock. This can cause vulnerable communities to suffer great losses of investment when extreme drought conditions strike (Muhangi and Acidri, 2008). These factors, along with existing climatic and socio-economic conditions, contribute to making an already food-insecure region more insecure in the face of increased extreme events associated with climate change.

[1] Some authors postulate that land degradation is not a major concern in Namibia (Kreike, 2009) and that vegetation change cannot be attributed to humans and/or livestock (Rhode, 1997).

5.2. Differentiated vulnerability

Although Namibia is categorised as an upper middle-income country, it exhibits extremely high levels of poverty and the third highest inequality in the world, in part due to a history of colonisation (Jauch et al., 2011; UNDP, 2014). So, while some citizens are relatively well-off financially, others experience extreme poverty. This has implications for vulnerability to climate variability and change. In the agriculture sector, for example, many privately-owned, often commercial, farming areas in Namibia are dominated by livestock farming. This is in contrast to semi-arid areas in South Africa and Zimbabwe, where game farming dominates (Lindsey, 2011). These “freehold” commercial farmers face similar risks to subsistence livestock keepers, whose livestock are highly sensitive to heat stress (Barnes et al., 2012). However, commercial farmers have more resources than communal farmers and so are better able to sustain their livestock and have the option of claiming from insurance. This also applies to commercial rainfed cropping and irrigated agriculture, the latter of which uses about 75% of Namibia’s water, with irrigation schemes being found along perennial rivers on the northern and southern borders of the country (GRN, 2015). Whilst these commercial crop farmers are sensitive to climate, they have greater resources with which to adapt when compared to subsistence and small-scale farmers.

Some social groups are also more vulnerable than others due to their different levels of engagement in social and economic activities, and their variable access to natural, financial, technical and informational resources. In particular, women, female heads of households, children, the elderly, the chronically ill, and marginalised groups have been identified as being among the most vulnerable in Namibia (GRN, 2015). Gender inequality is of particularly concern, given that 52% percent of Namibia’s population is female and 44% of households are female-headed. In the Ohangwena, Omusati and Oshana regions, there are more female- than male-headed households (NSA, 2011). Gender inequality stems from historical patterns where, in the past, women did not have the same rights in decision making or hold equal access to financial, material and information resources (Angula, 2010). For example, historically, women did not have the right to be allocated land (Angula and Menjono, 2014) and widows were dispossessed of their valuable assets, such as cattle, after their husband’s death (Newsham and Thomas, 2011). As such, women generally have less access to cattle and agricultural equipment today (David et al., 2013).

Although the literacy and education levels are similar for men and women, 43% of women are unemployed versus 30% of men (NSA, 2011). Women and girl-children are often more affected by the impacts of climate change because they are responsible for providing food and collecting fuelwood and water for the family. All of these roles are made more difficult by drought conditions (Angula and Menjono, 2014). In addition, a woman’s voice is often absent in decision-making and climate change discussions at the local level (Angula et al., 2012). Although women make day-to-day decisions affecting food security, men typically make decisions regarding the allocation of resources and how the household responds to drought, floods, pest outbreaks and other climate change-related disasters (Angula and Menjono, 2014).

The importance of overcoming gender inequality in Namibia is now recognised, and the National Gender Policy (2010) aims to reduce gender inequality to overcome poverty (GRN, 2010). The Policy also acknowledges that climate change has a significant impact on the livelihoods of women and girl-children, and includes a provision to involve women in the development of climate change-related policies and programmes (ibid.). Gender-based violence, which is exacerbated by the stresses associated with the impacts of drought on livelihoods and welllbeing, is also a prominent issue evidenced by the National Plan of Action (GRN, 2012).

The chronically ill, most of which suffer from HIV/AIDS are also particularly vulnerable to the current and potential impacts of environmental and climate change (GRN, 2015). The overall prevalence rate of HIV in Namibia is 17%. 7% percent of all people living with the disease are under the age of 15 and 60% of HIV-affected people are women. The HIV / AIDs prevalence rate for women between the ages of 35 and 44 and 30% (Ministry of Health and Social Services, 2014). AIDS-related illnesses prevent people from being able to work, both in subsistence farming and in paid jobs. This leads to a loss of income and food security and, ultimately, reduced adaptive capacity (MET, 2011; Wilhelm, 2012; Zeidler et al., 2013). HIV/AIDs also places a strain on health care services, social networks and economic activities, thereby reducing the ability of communities and government to provide and maintain basic healthcare standards and services (Ziervogel and Drimie, 2008). Children and the elderly also have low adaptive capacity because they depend on others for their survival. 28% of all children in Namibia are orphans or are considered vulnerable, and 2% of households are headed by children. Of the children who have lost one or both parents, nearly 50% of cases were attributed to HIV/AIDS (MET, 2011).

The marginalised communities of the San, Ovatue, Ovatjimba and Ovazemba are historically disadvantaged and continue to make up the majority of poverty-stricken households in the country. For example, the San community in Omaheke and Otjozondjupa regions of Namibia constitute about 80% of the very poor households in these regions. These households survive largely on pensions, food aid, casual work and piecework (Kiaka et al., 2012). Even with targeted programmes that prioritize the improvement of their living conditions, these groups have benefited very little from development since independence (ibid.). However, the National Planning Commission aims to develop a strategy for mainstreaming marginalised communities. This is envisioned as a way to improve their livelihoods, augment community organisation and integration, and ensure access to education for all (NPC, 2015).

Urban areas and vulnerability to climate change

Over 60% of Namibia's population resides in rural areas. However, as a response to the lack of livelihood opportunities in these areas, rural to urban migration is an increasingly common feature found in Namibia, and indeed in drylands globally (Reynolds et al., 2007). Yet, there is insufficient understanding of how people in urban areas have managed to secure livelihoods and how climate change will impact urban areas in Namibia.

In Windhoek, Namibia's capital, there are already serious concerns about meeting future water demands and providing adequate housing and sufficient services for the growing urban population. Windhoek has a population of 330,000 people, 35% of which are migrants from rural northern Namibia (NSA, 2011). This number is expected to grow as droughts and floods become more frequent and intense, and as seasonal rainfall patterns become more variable, affecting rural livelihoods. Urban areas like Windhoek are not all well equipped for a large influx of people, and food insecurity is a common feature among migrants (Pendleton et al., 2014). Food and other goods are imported into the city, which is already water-scarce. The closest perennial river is 750km away, the ocean is 300km away, all potable water resources within 500 km have been exploited, and long droughts are common (Lahnsteiner and Lempert, 2007). Surface water is obtained from dams and groundwater is extracted from boreholes, but this alone is not enough to meet the city's growing water demand.

In north-central Namibia, there is also migration into smaller urban areas such as Oshakati, although these towns experience slightly different climate-related challenges. Oshakati town is the capital of Oshana region in Namibia, with a population of about 37,000 people. Here, flooding of the Cuvelai river basin is common. Flooding occurs when the small waterways that cover the flat landscape and channel water towards Etosha pan overflow during periods of intense rainfall in Angola to the north (NASA Earth Observatory, 2009; MET, 2011). However, there is insufficient infrastructure, resources, planning and know-how to capture this water for productive use. As such, rather than being a valuable resource, it impacts negatively on the lives of vulnerable people, who frequently have to be evacuated from flood-prone regions.

5.3. Adaptive capacity

In Namibia, much of the adaptive capacity that exists, especially at the regional (subnational) and national level, is generic capacity. In other words, capacity related to dealing with development more generally. This does not necessarily translate to specific capacity to deal with the impacts of climate change (Nyantakyi-Frimpong and Bezner-Kerr, 2015). This type of capacity is inadequate for dealing with both current and future climate risk and the inequality and poverty that exists.

While at the local level, remote communities can be well equipped to cope with climate variability and change (see section 7 on responses to climate variability), they are often marginalized, chronically disadvantaged and can battle to secure resources to respond to changes in the climate (Maru et al., 2014). Communities are thus concerned that they will not be able to deal with an increasing frequency of extreme events (Newsham and Thomas, 2011). Limited capacity to respond to the effects of climate change leads to increased vulnerability of communities and sectors. A number of factors contribute to low adaptive capacity, including informational, technical, infrastructural, political, financial, attitudinal and cultural issues. This capacity is limited at both the individual and household level, and at the national institutional level in many cases. Many of these factors, which are outlined further in the below sub-sections, are likely to play out in other drylands globally.

Information, awareness and communication

A lack of information, awareness and sufficient networks of communication provide substantial gaps in responding to climate change in Namibia. Limited awareness about climate change, its impacts and adaptation options means that there is poor understanding of the problems and potential solutions (Dirkx et al., 2008). There is a particular lack in understanding of solutions at a system scale, such as watershed management and fisheries management, for which an ecosystem-based approach should be taken (Cochrane et al., 2009; Turpie et al., 2010). Such solutions are important because of the far-reaching benefits that they have.

Limited information is available in terms of seasonal forecasts and early warnings, as well as climate scenarios and information on adaptation options (Giorgis, 2011; MET, 2011). Without this information, it is hard for farmers and regional and national authorities to adjust their decisions. In instances where there is information, the information is often not adequately shared between government departments (Dirkx et al., 2008). Likewise, there is a lack of capacity in boundary organisations that might translate the science and local knowledge into messages relevant for policy and practice and facilitate dialogue between different groups (MET, 2011). In cases where there is information available on possible responses, securing buy-in for implementation is prevented by misunderstanding around the benefits versus the costs of adaptation and the effectiveness of adaptation measures (ibid). Traditional knowledge provides another source of information that is relevant to coping with extreme conditions. Yet, existing traditional agroecological knowledge is not used to inform agricultural extension work (Newsham and Thomas, 2009). Knowledge of coping mechanisms that have historically been used are also being lost through rural to urban migration, poor oral transfers of traditional knowledge across generations and, as a result of changes in government, stricter land management regulations (Dirkx et al., 2008; Kuvare et al., 2008; Newsham and Thomas, 2009; MET, 2011; Pendleton et al., 2014).

Financial capital, technical resources and infrastructure

As with most developing countries, the availability of financial resources can be a limiting factor. Poor access to alternative employment opportunities means that finding income through employment is challenging (Dahlberg and Wingqvist, 2008). A lack of financial and technical resources has led to a large proportion of the workforce having limited education and skills. There are also insufficient extension services to provide advice to farmers and inform their decisions regarding adaptation options (MET, 2011; Thomas, 2012). Low access to financial capital also prevents rural and urban communities from investing in alternative approaches or responses such as installing rainwater tanks or buying farm implements or seed (Dirkx et al., 2008; Stern et al., 2009). Many farmers also do not have insurance policies for their agricultural enterprises, which means that they are at risk of experiencing significant losses when there is an extreme weather event. Even those who do have insurance can remain exposed as insurance companies do not always cover sufficiently for flood damage. Thus, communities that are vulnerable because of poor zoning and settlement location near floodplains are more marginalised (IECN, 2011; Nyambe and Belete, 2013). This is an example of how political, social and economic systems create security for some, whilst leaving marginalised groups more vulnerable (Taylor, 2013).

In Namibia, climate change generally has a low priority relative to other issues. This means that insufficient resources are allocated to address the complex problem in an effective way (MET, 2011). Although there are drought provisions, this is a short-term response. Generic issues relating to financial restraints lead to limited infrastructure for the provision of livelihoods (e.g. access to markets). However, there are some efforts under way, including through the newly formed agro-marketing and trade agency, which aims to enable marketing through new fresh produce business hubs (AMTA, 2015). Limited access to the provision of other generic services such as water, electricity, health and transport services make communities more vulnerable to the effects of climate change (Wilhelm, 2012; Amadhila et al., 2013). More specific technical constraints include limited capacity to access, interpret, translate and communicate climate change information to policy makers and the public for decision making and limited technical capacity to provide advice and implement measures (MET, 2011; Kandjinga et al., 2010; David et al., 2013). At the implementation level there is also the constraint of access to technologies (e.g. lack of access to drought resistant seed varieties) (GRN, 2014).

Politics and institutions

Many of the factors mentioned above, including lack of information, financial and technical resources, contribute to limited institutional capacity. A number of other generic issues lay the foundation for insufficient institutional capacity in Namibia. These include limited service provision (NSA, 2011; Amadhila et al., 2013), lack of decentralization (Larsen, 2003; Sinvula, 2005), limited public participation in policy development, limited implementation of policy, strategic and institutional uncertainty, institutional fragmentation and political factors (Dirkx et al., 2008; MET, 2011). Examples of these factors include the limited implementation of the Decentralization Policy (1997) (Ministry of Regional Local Government and Housing, 1997), a lack of integration of land management policy and land management at the local level (Newsham and Thomas, 2011), reluctance to make unpopular decisions such as limiting stocking rates (Turpie et al., 2010) and inadequate effort towards developing guidelines for town and settlement planning, enforcement of regulations and raising awareness about the risks and impacts of floods (UNDP, 2010).

There are also factors more specific to the climate change issue that contribute to limited institutional capacity to respond to climate change in Namibia. These include the positioning of climate change as an environmental issue (Ndeleki and Zeidler, 2010) which, along with other factors, manifests in limited mainstreaming of climate adaptation into activities, policy and planning (Reid et al., 2007;

Dirkx et al., 2008; Amadhila et al., 2013). This includes inadequate integration of policies and programmes across ministries and a lack of integration of climate change efforts, including through insufficient coordination between government departments and between donors (Reid et al., 2007; Dirkx et al., 2008). Not only are there policy conflicts and limited cohesion in policies with regard to climate change, but there is also a dearth of appropriate policy (Dirkx et al., 2008; MET, 2011).

The strategic planning and implementation that is conducted is mostly short-term with limited long-term planning for future scenarios (Turpie et al., 2010). In addition, planning conducted at the national level for implementation at the local level does not sufficiently consider the local context and relevant barriers and enablers (Ndeleki and Zeidler, 2010). There are different priorities at local and national scales and a lack of consideration of traditional approaches and community needs, with climate change not being a priority for regional authorities (Dirkx et al., 2008; MET, 2011). There is also inadequate integration of local knowledge systems into planning and practice (Newsham and Thomas, 2011), resistance within government to form effective partnerships with civil society and a lack of community empowerment (Kandjinga et al., 2010; Turpie et al., 2010; David et al., 2013). Further, government support mechanisms (including drought relief, pensions, social grants and other government programmes) hinder the implementation of adaptation measures that reduce risk, as people become reliant on this assistance (MET, 2011). Dependency also means that they have reduced capacity for innovation. In some cases, it has also resulted in weakened social relationships and networks, a consequence of which is that people have become less willing to help their neighbours, which is a traditional coping mechanism (Newsham and Thomas, 2011). The challenge of government assistance reducing adaptive capacity is also seen in other remote drylands in Botswana and Australia and is considered potentially maladaptive (Maru et al., 2014). However, it should be recognised that some form of social protection is needed in order to support the most vulnerable.

Attitude and culture

Attitude plays a role in affecting the capacity of communities and institutions to respond to the effects of climate change. Resistance to implementing new measures because of social acceptability, stigmatism and a lack of acceptance of risk prevents communities from realising the benefits of opportunities for adaptation (Dirkx et al., 2008). Traditional coping strategies such as a reliance on social networks are strained during more frequent extreme events. Cultural traditions and norms can also increase vulnerability by stalling changes required to respond to the effects of climate change. For example, a reluctance to reduce livestock numbers leads to traditional livestock owners not selling their herds and experiencing huge losses during extreme hot dry periods (Muhangi and Acidri, 2008). A mindset that also serves as a barrier to adaptation is dependence on government support and lack of innovation and initiative among individuals, as discussed in the previous section. Namibians could borrow lessons from other countries where farmers are being innovative to combat the effects of climate change. For example, in Ghana, most farmers use innovative practices such as such as zai pits and trash lines, intercropping, use of manure for composting and tiered-ridges (Nyantakyi-Frimpong and Bezner-Kerr, 2015).

6. Governance of climate change adaptation

Although the climate change agenda has been embraced to varying degrees on the ground, it is firmly placed on the national policy agenda. The Namibian government ratified the United Nations Framework Convention on Climate Change (UNFCCC) in May 1995 and have submitted their Initial, Second and Third National Communications (GRN 2002, MET, 2011; GRN, 2015). The Climate Change Unit (CCU) coordinates climate change activities at the local, regional and national levels and assists with planning, development and implementation of activities (MET, 2011). The CCU is located institutionally within the Directorate of Environmental Affairs (DEA), and was set up in 2001 through the Ministry of Environment and Tourism (MET). This unit has been responsible for overseeing the coordination of climate change issues in Namibia, and thus the development and submission of National Communications to the UNFCCC. In order to support the CCU, MET, and line ministries with climate monitoring, research and assessment, the national Climate Analysis Unit (CAU) was set up at the Meteorological Services Division of the Ministry of Works and Transport (MWT).

The CCU is also supported by the multi-sectoral National Climate Change Committee (NCCC) that reports to the Cabinet of Namibia. The NCCC was established in 1999 to oversee and coordinate climate change activities at the national scale and to advise the government on climate change related issues such as obligations to the UNFCCC and the adoption of policies and strategies (GRN, 2015). NCCC is chaired by the MET and the deputy chair is the National Meteorological Service of the Ministry of Works and Transport. It has membership from the Disaster Management Unit (DMU) in the Office of the Prime Minister, other Sector Ministries, international organisations e.g. United Nations Development Program (UNDP), Red Cross, European Union, embassies, higher learning institutions (e.g. Polytechnic of Namibia and University of Namibia) and non-governmental organizations (NGOs) such as the Desert Research Foundation of Namibia (DRFN) (GRN, 2015). In 2011 the Ministry of Environment and Tourism, the designated lead agency responsible for climate change in Namibia, signed off on Namibia's National Climate Change Policy (NCCP) which encourages the implementation of adaptation measures and recognises the cross-cutting nature of climate change and the importance of mainstreaming climate change across sectors. In 2015 the Desert Research Foundation of Namibia was accredited as the National Implementing Entity (NIE) for the Adaptation Fund. In 2016 the Environmental Investment Fund (EIF) was accredited as the NIE for the Green Climate Fund (GCF).

7. Responding to climate change

Adaptation responses need to be viewed on a continuum of addressing the root causes of vulnerability and basic development, to those that more explicitly consider climate change. Namibia's president, Hage Geingob, is committed to reducing poverty in Namibia. Hence, there is a focus at the national level on addressing poverty and inequality, although it remains to be seen how this will play out on the ground (New Era newspaper, 2015). The focus of government on addressing poverty issues is important in contributing to reducing vulnerability to climate change.

More specific to climate change is the threat posed by droughts, floods and sea-level rise, that have been acknowledged by the government. A number of responses aimed at reducing the vulnerability of the Namibian population have been implemented to help cope with these hazards. These cover Namibia's priority areas of water, agriculture and disaster risk reduction (MET, 2011). However, these are mostly short-term autonomous responses, while long term strategic planning for adaptation to climate change remains limited. Similar to other countries globally (Berrang-Ford et al., 2011), most of the responses to climate change reported for Namibia are focused on agriculture and are incremental and project-based, rather than being transformative and focused on the system level. Although relevant policies and programmes exist in many cases, interventions at different levels from policy to the ground have been financed from outside of the country and implemented by non-governmental bodies. For example, the development of the national climate change policy was funded by the UNDP and prepared by consultants. The existing measures are not strategic, long-term interventions and are unlikely to be able to address the threat posed by the long-term nature of the climate change challenge. However, there are some existing government policies and programmes that are more specific to climate change (as outlined below), as well as previous and current responses in rural communities.

7.1. Government policies and programmes

A number of government policies, including those on disaster risk reduction and water management, are relevant to responding to climate change in Namibia. The National Drought Policy and Strategy (1997) was developed by a task force with financial assistance from the United States Agency for International Development (USAID). The main objectives of the policy are to sustain household food security and access to potable water, enable farmers to adopt self-reliant practices to drought risk, maintain livestock herds, minimise degradation to natural resources, enable quick recovery from drought, maintain health and finance drought relief (GRN, 1997).

The 2009 Disaster Risk Management Policy (GRN, 2009) was developed to reduce disaster risk and build resilience to disasters. This policy was followed in 2011 by the Disaster Risk Management Plan (GRN, 2011), then the Disaster Risk Management Act of 2012 (GRN, 2012a) and, subsequently, the Namibia Drought Relief Response Plan of 2013 – 2014 (GRN, 2013). The response plan provided guidelines for coordination and response to the 2013 drought, including drought relief, financing emergency assistance through the National Disaster Management Fund, the distribution of input vouchers to affected farmers and the maintenance of an emergency seed reserve (Angula, 2010; Wilhelm, 2012). Contingency plans for flood response also exist. Also relevant to responding to climate change is Namibia's National Rangeland Management Policy and Strategy, which aims to "reduce vulnerability of rangeland users and managers to the adverse impacts of climate change" (MAWF, 2012a). The Water Resources Management Act (2013) provides for "the management, protection, development, use and conservation of water resources" (GRN, 2013a), which is important given the impacts of climate change on water quantity and quality.

In 2011, a National Climate Change Policy (NCCP) was developed (MET 2011a). This policy process was enabled by UNDP and the policy itself was initially developed by Versacon consultants. The NCCP serves as a legal framework to formulate and implement strategies and action plans to address climate change. The policy devises a number of strategies in this regard, including: water harvesting during the rainy season, diversification of food, conservation agriculture and dryland farming systems, development and implementation of a climate-induced disaster management strategy and integrated water resources management. The 2013 National Climate Change Strategy and Action Plan (NCCSAP) (MET, 2013) was supported by UNDP and funded by the Government of Japan and GIZ, and was developed through a consultative process. The overarching aim of the plan is to build Namibia's adaptive capacity and identify potential adaptation options, especially those with mitigation co-benefits.

To increase food production and ensure food security, the Ministry of Agriculture, Water and Forestry (MAWF) has put in place various initiatives which would be seen as autonomous adaptation, including: i) the Green Scheme Projects, which are aimed at encouraging the development of irrigation-based agronomic production (Barnes et al., 2012; GRN, 2015); ii) the Omahenene Project, which focuses on breeding suitable, drought-resilient varieties of pearl millet and sorghum (MAWF, nd); iii) community forestry projects focusing on sustainable forest management (MAWF, nd [a]); iv) the urban and peri-urban horticulture development project, which includes micro-irrigation, improved crop varieties and efficient water use for contributing to increased food security (MAWF, nd [b]); and v) the construction of earth dams to harvest water for agriculture and livestock (Informante, 2015). In addition, the Ministry of Fisheries and Marine Resources and the Ministry of Trade and Industry have developed six community-based intensive freshwater aquaculture facilities in the Omusati, Okavango and Caprivi regions for producing tilapia and catfish for local distribution (FAO, 2007).

To address water scarcity and supply, Namibia applies a framework of shared water resource management and Integrated Water Resources Management (IWRM) (Kuvare et al., 2008; MET, 2011; GRN, 2013; GRN, 2015). IWRM is implemented at the basin level by 11 Water Basin Committees responsible for water resource management (MET, 2011). Among other things, the committees provide guidelines for addressing vulnerabilities and developing adaptation strategies at the basin level.

7.2. Rural responses to climate change in Namibia

Communities that live remotely in drylands are expected to have experience in dealing with uncertain, arid conditions and many have therefore developed beneficial practices that enable resilience and build adaptive capacity (Reynolds et al., 2007; Maru et al., 2014). With a substantial proportion of the Namibian rural population living in uncertain climatic conditions and at great distances from basic services, there is a history of using traditional approaches for coping with climate variability. Some coping mechanisms that have been used in the past have the potential to increase the resilience of communities, but are not always adequately employed or sufficient. These responses would be considered autonomous as they have been carried out independently and have not necessarily been applied with climate change in mind. Some of these response mechanisms are outlined below:

i. **Indigenous land unit system:** Using different 'land units' to decide which crops to grow and where to grow them, depending on the environmental and climatic conditions. For example, when it is a wet year, it is better to plant on elevated land, whereas in dry years it is better to plant on low-lying ground (Newsham and Thomas, 2009).

ii. **Diversification of crops, livestock and livelihoods:** The diversification of livelihood activities into off-farm activities is increasingly employed to reduce dependence on subsistence agriculture and increase resilience to uncertain rainfall regimes (Dirkx et al., 2008; Newsham and Thomas, 2009; Angula, 2010; Turpie et al., 2010; Newsham and Thomas, 2010; Wilhelm, 2012). Likewise, the diversification of crops and animals has been undertaken to increase adaptive capacity in agricultural production (Kuvare et al., 2008; David et al., 2013). In particular, new crop varieties and improved breeds of livestock are selected. These include heat-tolerant livestock breeds and drought resistant crops such as early maturing Okashana millet with a three month growing season (Kandjinga et al., 2010; Zeidler et al., 2010; MET, 2011; Newsham and Thomas, 2011; Wilhelm et al., 2012; David et al., 2013).

iii. **Adjusting planting and harvesting times:** Some early warning and seasonal climate forecasting systems are used to assist farmers in deciding when and what type of crop variety to plant for the coming season (Kandjinga et al., 2010; GRN, 2015). Farmers also delay planting, use a combination of early and late planting, and/or plant multiple times within a season (Dirkx et al., 2008; Gremlowski, 2010; GRN, 2015). Some farmers also use traditional seasonal forecasting to inform their farming decisions (Newsham and Thomas, 2011).

iv. **Soil and water management activities:** Several soil and water conservation practices, including conservation agriculture, are employed to moderate the impacts of increasingly erratic rainfall and/or prolonged droughts on agricultural productivity (MET, 2011a; David et al., 2013). Conservation agriculture practices that are being used include conservation tillage, crop rotation, intercropping and the use of manure and fertilizer (Kandjinga et al., 2010; Zeidler et al., 2010; MET, 2011; David et al., 2013; GRN, 2015). The most prevalent water resource management practice applied at the local level is rainwater harvesting, for example collecting runoff from rooftops for domestic consumption (Sturn et al., 2009; Kandjinga et al., 2010; Turpie et al., 2010; David et al., 2013; GRN, 2015). Drip irrigation systems are also used by commercial farmers to increase the efficiency of their water consumption (MAWF, 2012). Water demand management is practiced at mines in Namibia, which promote the reuse and recycling of water (Puz, 2000). Some mines (e.g. Trekkopje uranium mine) have strict water management strategies that include water standards, eco-design and targets to reduce annual water use (ICMM, 2012).

v. **Supplemental feeding, watering and accessing alternative water and land resources for livestock:** Livestock are provided with supplementary feeding and water by farmers during drought periods (Kandjinga et al., 2010). Farmers also move their livestock to cattle posts (Klintenberg et al., 2007), or areas where they can access water and where pasture is in a better condition (Newsham and Thomas, 2009). The sale of livestock is sometimes practiced during prolonged dry seasons when the survival rate is expected to be low (David et al., 2013). (ICMM, 2012).

vi. **Strategies for sharing and accessing food:** Surplus grain and fodder is stored in traditional grain storage facilities for use during years of poor harvest (Newsham and Thomas, 2009). Social networks are relied on during tough years, for example neighbours, family and friends share their food when drought or flood causes harvest failure (David et al., 2013). Similarly, remittances from family members living in urban areas are relied on (Angula, 2010).

Responding to water scarcity in urban areas

As a means to supplement existing natural water sources, which are increasingly scarce, Windhoek uses reclaimed water from the Goreangab Water Reclamation Plant (Lahnsteiner and Lempert, 2007). There are also strict water supply and use regulations (ibid.) and measures in place such as pressure reduction and the use of efficient showers and toilets (Dirkx et al., 2008). Since the start of potable reuse in 1968, no outbreaks of waterborne disease or health effects have been attributed to the use of reclaimed water and successful education campaigns have led to public acceptance (Boucher et al., 2011). Until 2011, Windhoek was the only city in the world using reclaimed water (Lahnsteiner and Lempert, 2007; GRN, 2015).

Rural-urban migration is increasing as people seek alternative livelihoods in Windhoek and other urban areas in Namibia, which poses another urban challenge associated with the effects of climate change (Pendleton et al., 2010). A growing population and increased water demand has necessitated the construction of a third reclamation plant (Namibian Sun, nd). In the town of Oshakati, heavy flooding in 2008, 2009 and 2011 led to an engineered response to reduce flood risk. This included the excavation of new connections between existing ephemeral rivers ("oshanas") and construction of a 23km long and ~2m high dike, 4 new bridges, a sluice, 11 harvesting basins and a new 100m long siphon securing supply to the drinking water processing plant (IMDC, nd).

8. Conclusion

Namibia is highly exposed to climate variability and the effects of climate change, which are expected to worsen in coming decades. The majority of Namibia's population resides in rural areas, and many communities have historically relied on traditional ecological knowledge and employed innovative adaptation strategies to maintain their natural-resource based livelihoods. However, despite their history of coping with harsh environmental and climatic conditions, many communities today are struggling to deal effectively with increasing climate variability and extremes, including shifting seasonal rainfall patterns, droughts and floods. The low adaptive capacity of local communities in

Namibia stems from several underlying structural factors that are often characteristic of developing dryland countries globally, such as poverty, inequality, marginalization and isolation. Various other challenges contribute to low adaptive capacity across governance scales – from the individual or household to the national institutional level, and across the rural-urban continuum. These include deficits in financial resources, information, technology and infrastructure, as well as political, attitudinal and cultural issues.

The Government of Namibia has committed to addressing climate change, and has developed various policies, plans and programmes that either directly or indirectly relate to this complex issue. However, most of the adaptation measures and responses mentioned are autonomous and aimed at building generic capacity. In other words, these measures have been put in place to address issues other than climate change, such as social and economic development. Perhaps, in a developing dryland country like Namibia, it is important to meet pressing development needs first. It is also essential that the root causes of vulnerability to climate change are understood and addressed (Wisner et al., 2004). Encouragingly in this regard, poverty eradication and improving food security continues to be a priority of the state, with some national responses being focused on addressing root causes, such as gender inequality. However, there is also a need to focus more specifically on planned adaptation and to introduce more targeted responses that consider, explicitly, how the climate might change in the future.

Climate change scenarios and the potential impacts thereof should thus be integrated into development planning such that future development takes place in a 'climate compatible' manner. For example, infrastructure should be built to factor in increasingly variable and extreme temperatures and precipitation. Such an approach is needed not only at the national scale but also at the local level, where long-term climate information could help to inform possible pathways for adaptation, some of which could contribute to addressing broader transformation and development goals.

Achieving a more climate-resilient and sustainable development pathway in Namibia will likely require shifts in adaptation governance structures, which are currently centralized at the national level, as well as changes in the systems that are reinforcing low adaptive capacity, rather than building systemic resilience to climate change. In addition, existing governance systems and their associated government programmes will need to be re-envisioned such that they enable the development of alternative livelihoods, as opposed to focusing predominantly on the promotion of climate-sensitive sectors such as agriculture. Transformation of livelihoods will be particularly necessary for communities whose livelihoods are likely to become less viable in the face of climate change (for example, small-scale livestock and rainfed crop farming – albeit in some areas only). The transformation of livelihoods will require changes in policies, institutions and governance to enable the mobilisation of financial, technical and infrastructural resources and flow of information, raising of awareness and changing of attitudes. Namibia is a country where such innovations are possible, as evidenced by the implementation of the water reclamation plant in Windhoek and water demand management more generally. This atmosphere of possibility, combined with access to global funding from the Adaptation Fund and Green Climate Fund, opens the door for opportunities to work towards different ways of implementing adaptation.

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