SPONSORED BY

Federal Ministry of Education and Research

SASSCAL
Southern African Science Service Centre for Climate Change and Adaptive Land Management
WWW.SASSCAL.ORG

WAMINA: Sustainable and climate adapted Water Management in Mining Industry of Namibia

SASSCAL-Namibia Node

Windhoek, February 2023

TABLE OF CONTENTS

CHAPTER 1: BACKGROUND INFORMATION

In the mining industry, the impact of climate change and how the industry can respond to it has increasingly been a topic of discussion over the past decade. In Namibia, mining is no stranger to harsh climates; much of the mining industry operates in inhospitable condition of water stressed to water scarcity areas. The forecast of hazards such as floods, water-stress, drought, and heat indicate that the effects will get more frequent and intense, increasing the physical challenges to mining operations. This is more delicate because Namibia is one of the most arid countries in the world. The pressure on freshwater resources is felt by most of the mines across the country where groundwater is the main available water source. This resource is under immense pressure from increasing urban population, agricultural and industrial growth.

Similar to other countries across the globe, in Chile, 80 percent of copper production is located in extremely high water-stressed and arid areas; by 2040 it has been estimated to be 100% (Rüttinger, 2016). In Russia, 40 percent of the nation's iron ore production, currently located in high water-stressed areas, is likely to move to extreme water stress by 2040 as well (Rüttinger, 2016). It is evident that water is an integral part of all mining operations, and no mine can operate without water. In this respect, it is crucial that mining sector, communities, and other stakeholder groups work together to manage water resources effectively. Sustainable water use is an emerging concept within the industry which supports the sustainable and equitable production and use of water in mining operations in the era of climate change.

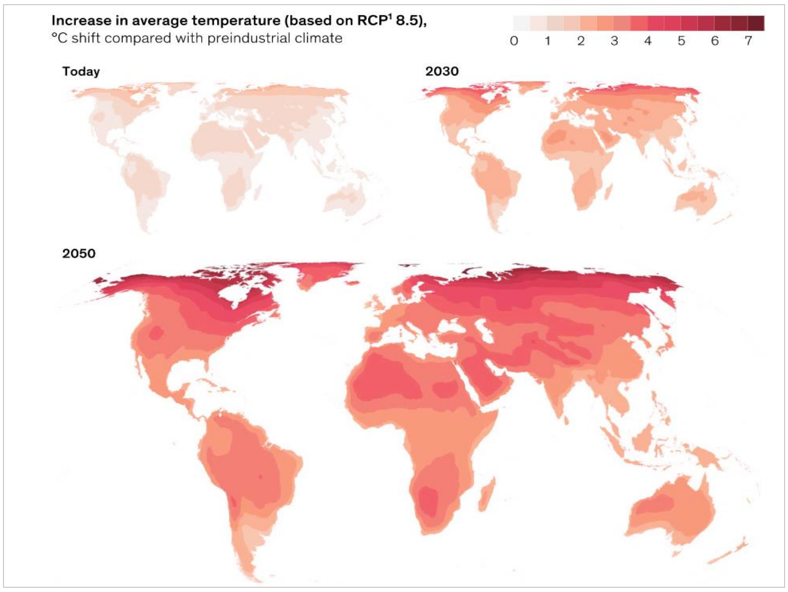


Figure 1: Global average temperatures are expected to increase between 1.5 and 5 degrees Celsius relative to today in many locations by 2050.

Global water resources are under increasing pressure and it is widely recognized that a holistic approach to water management is required in order to achieve resource sustainability and to secure future access and operation of mines (Musiyarira et al., 2017). Climate change is expected to place more pressure on available water resources, with some regions predicted to become much drier and other regions wetter and by 2040, extremely water stress is expected in some parts of the world as indicated in figure 2 below.

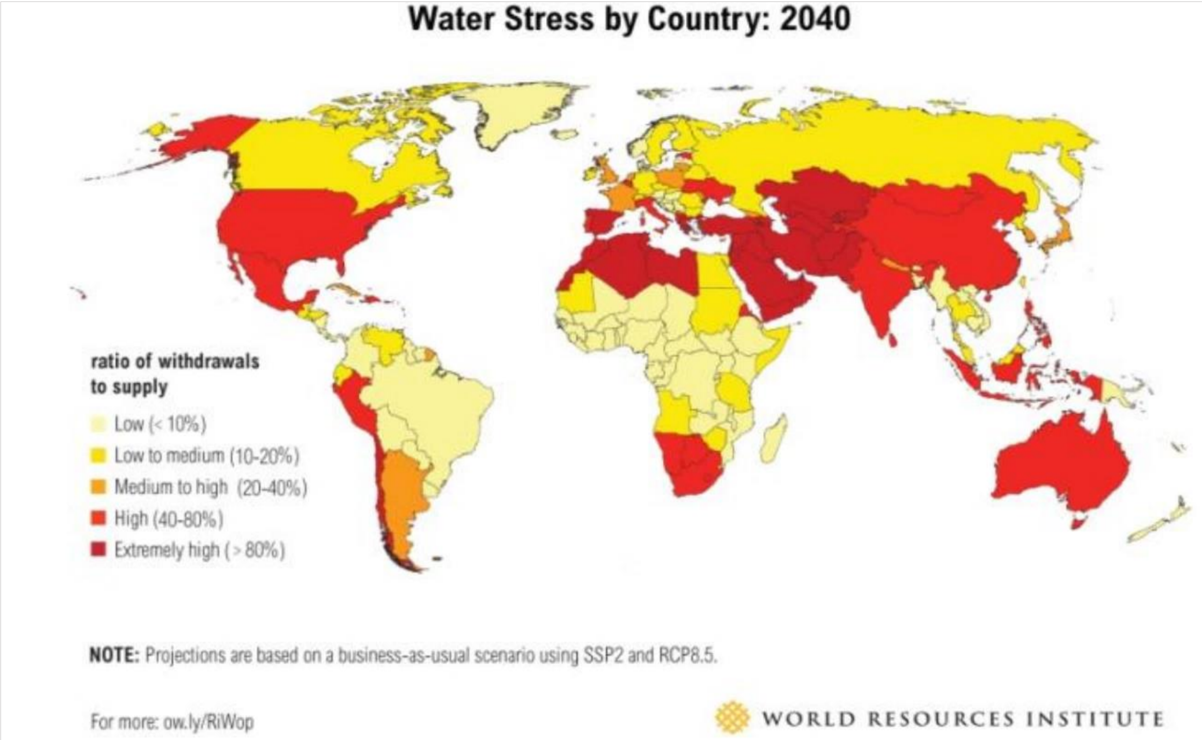


Figure 2: Water stress by country (Source: Maddocks, A. et al., 2015)

The effect of climate change is felt globally, for example the per capita of fresh water availability is steadily decreasing and the trend will inevitably continue as the world's population grows (Rüttinger, 2016). Many regions of the world are reaching a point of "freshwater stress", where freshwater resources can no longer support the demands of human populations also affecting mining operations (Rüttinger, 2016). In respect to this global problem, the approach to water management cannot remain business as usual as it needs a paradigm shift in the implementation of the best practices which minimize the potential for adverse environmental, social, and economic impacts. In this paper, an overview of mining industry in Namibia is discussed as well as climate change and water use in respect to mining industry.

1.1. Objective

1. Overview of challenges faced by mining industries in Namibia due to climate change and sustainable use of water.

The mining sector plays a key role in socio-economic development of many resource-rich economies. The sector has been and remains the backbone of the economy as reflected by its average annual economic growth, contribution to GDP, job creation, income generation, and a key source of government fiscal receipts and foreign exchange earnings, among others (Iiyambo, 2010; Krugmann & Alberts, 2012; Musiyarira et al., 2017). The sector has also led to the establishment of towns while remaining committed to the achievement of national goals of poverty reduction, employment creation and skills development (Krugmann & Alberts, 2012). There are various natural resources mined in Namibia including diamonds, uranium, copper, gold, lead, tin, lithium, cadmium, zinc, salt and vanadium, all together contribute to about 25% to the country's income (Musiyarira et al., 2017). However, this sector requires energy which sometimes is driven from hydropower generation as well as large quantities of water to operate. Notwithstanding the foregoing, however, the sector remains susceptible to water insecurity and climate change (KPMG Global Mining Institute, 2014).

To add complexity, Namibia is a primary source for gem-quality diamonds mined inland and offshore, and is the fifth-largest producer of uranium in the world (Musiyarira et al., 2017). Namibian mines are distributed across the country (figure 3), known to produce additional products such as gem quality rough diamonds, uranium oxide, special high-grade zinc and acid-grade fluorspar, as well as gold bullion, blister copper, lead concentrate, salt and dimension stone (Christina, 2006).

Tragically, most of these mines are found in water-stressed areas and they are increasingly in competition with different users, presenting challenges to the security of supply. The future of mining companies and society depends on the availability of freshwater resources, which are increasingly under pressure.

Most of the Namibian mining activities occur in the Central Namib, an ecologically sensitive area containing parts of the Namib-Naukluft and Dorob National Parks, where the climate experiences low and erratic rainfall, soaring temperatures and strong seasonal winds that cause high water evaporation rates (Iiyambo, 2010). According to Christina (2006) the potential for significant impacts is greater when mining occurs in remote and environmentally or socially sensitive areas. Mining activities can have both positive and negative environmental, economic, and social impacts on communities. For groundwater, as rainfall decreases there is a strong tendency towards increase groundwater use. Figure 3 below shows the distribution of mines in some parts of the regions in Namibia.

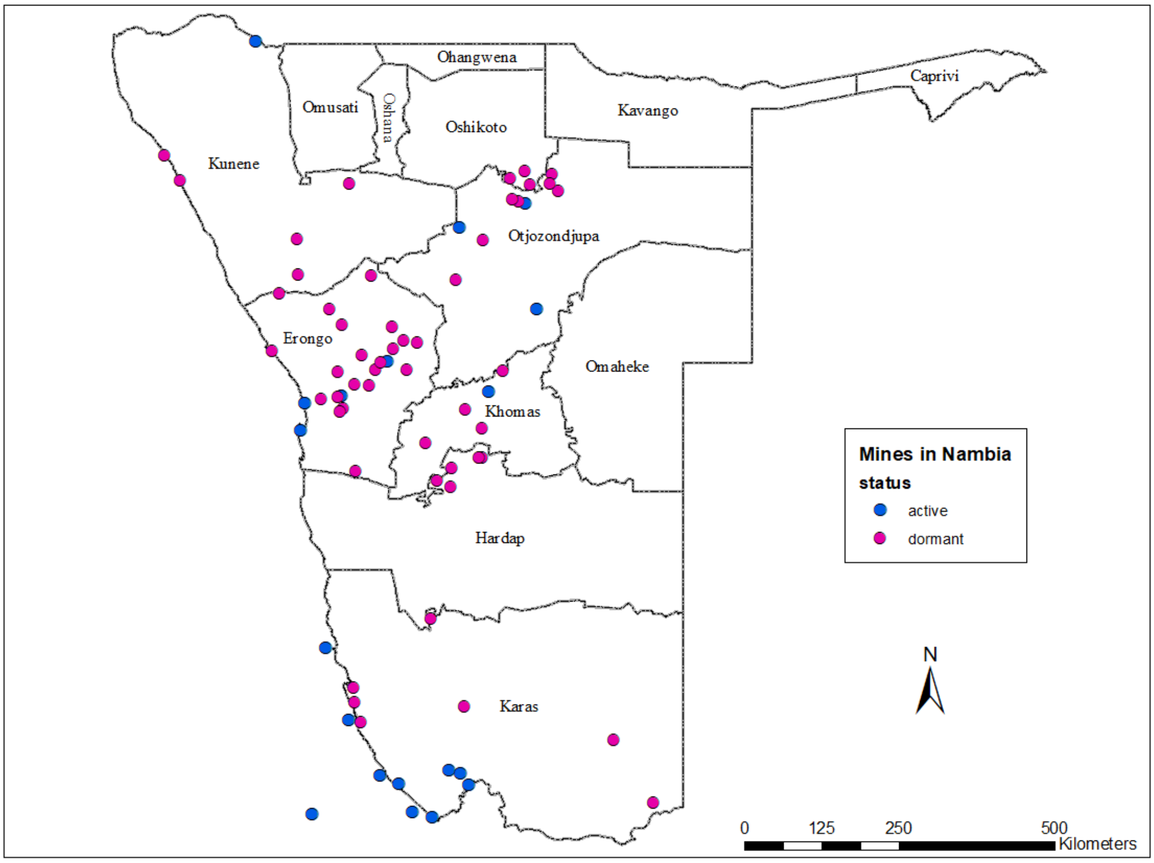


Figure 3: Data source (Ministry of Mines and Energy). Map of Mines in Namibia

In times of drought, low levels of water supply compromise the mining operations (KPMG Global Mining Institute, 2014). Furthermore, the sea level rise and extreme weather events associated with climate change are also a threat to 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 especially that they are already operation in harsh environment. Table 1 is a representation of water use in various sectors in Namibia. Although the mining industry's overall "water footprint" is relatively small compared to other sectors, most mining companies have recognized the importance of fresh water and the need to take actions to reduce mining industry's water consumption. Despite the efforts, water consumption is still projected to increase. In 2008 it was recorded at 16.1 Mm^3, by 2030, water consumption is projected to be at 20.3 Mm^3. According to the Chambers of mines, about 50 million cubic meter of fresh water per year is required for about seven operational Uranium mines (KPMG Global Mining Institute, 2014).

Table 1: Water demand projections [Mm3] in Namibia. Source: (IWRM Plan Joint Venture Namibia, 2010)

Consumer group	2008	2015	2020	2025	2030
Urban	66	80	91.1	103.5	117.2
Rural Domestic	10.3	10.6	10.9	11.1	11.4
Livestock	86.8	86.8	86.8	86.8	86.8
Irrigation	135.3	204.6	344.6	379.8	497.2
Mining	16.1	17.2	18.1	19.1	20.3
Tourism	19.1	27.5	31.9	35.2	38.9

To improve resiliency and reduce water demand, mining companies will have to use water sustainably during their operations. This involves recycling of used water and reduce water loss from evaporation, leaks, and waste. They can reduce evaporation by putting covers on small and medium dams and other water sources. In the long term, more capital-intensive approaches can be practiced. New water infrastructure, such as dams and desalination plants, is expensive but sometimes necessary. Companies can also rely on so-called natural capital, like wetland areas, to improve groundwater drainage.

CHAPTER 2: NAMIBIA'S CLIMATE CHANGE INFORMATION

2.1 Namibia's Rainfall Trends and Spatial Distribution

Namibia's rainfall decreases from northwest to southwest and majority of the country is characterised by desert conditions (Henschel, et al., 1998). In addition to low rainfall, Namibia has generally low but highly variable precipitation ranging from a maximum of about 650 mm/a in the northeast to less than 50 mm/a along the coast (Wilhelm, 2012). It is estimated that country-wide on average only about 2% of the rainfall ends up as surface run-off and as little as 1% of the rainfall effectively recharges groundwater resources (Zeidler et al., 2010). Given the country's very dry and unpredictable climate, water availability, i.e., secure, equitable and universal access to fresh water – tends to be a critical limiting factor for social well-being and economic development. This highlights the need for an efficient use and effective management of scarce water resources and puts a premium on water security. Namibia is characterised by arid and semi-arid climates where much of its mining industries operates. 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 (Colin, 2010; Noureldeen et al., 2020). 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). 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 (World Bank Group, 2021).

The annual rainfall for the past 40+ years suggests that the driest and wettest years occurred in the past 12 years for most parts of Namibia (see figure 4, 5 & 6 below). The rainfall was high in Zambezi region and other Northern regions as seen in the figures below, but due to its extreme variability, water security continues to be a problem across all regions. A downward trend in rainfall over the past 40 years is observed. This shows how climate change could potentially result in a decrease in water availability across the country, because of the potential decrease in rainfall in the coming years. Eventually affecting many sectors including mine operations due to water shortage

The north-eastern and central and south-eastern received above average rainfall.

The central and north-western, western, and south-western part of Namibia received below average rainfall.

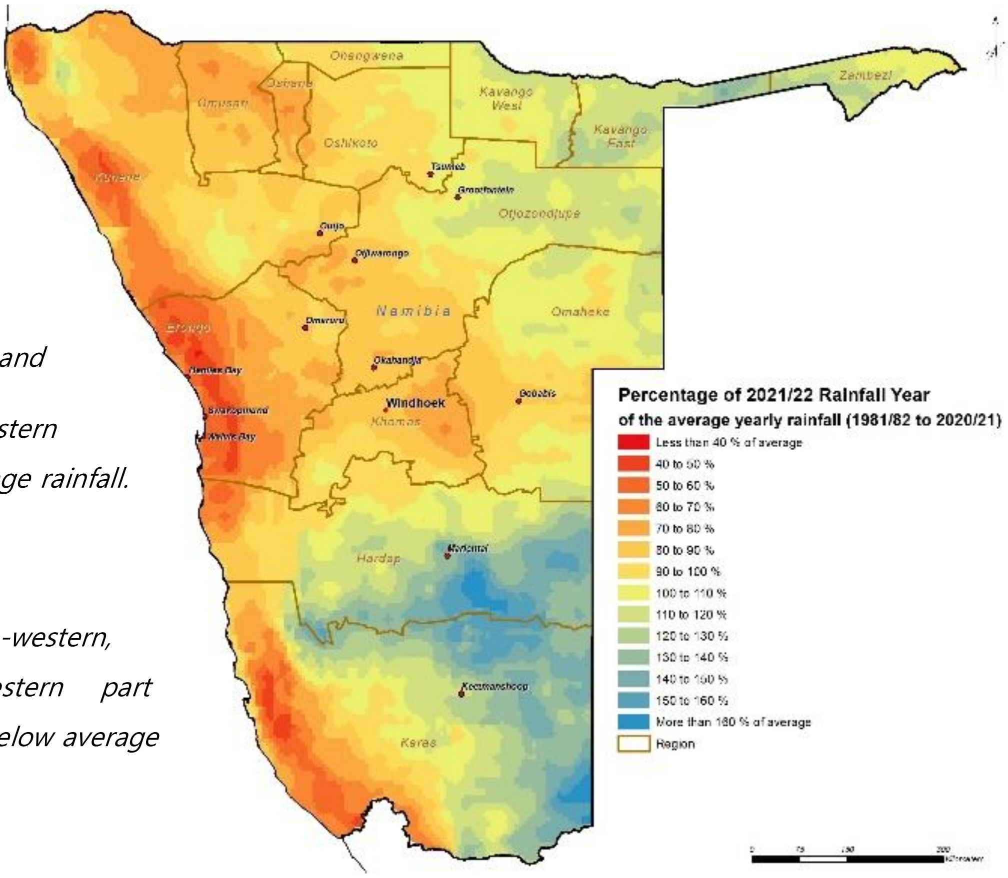


Figure 4: Rainfall spatial distribution

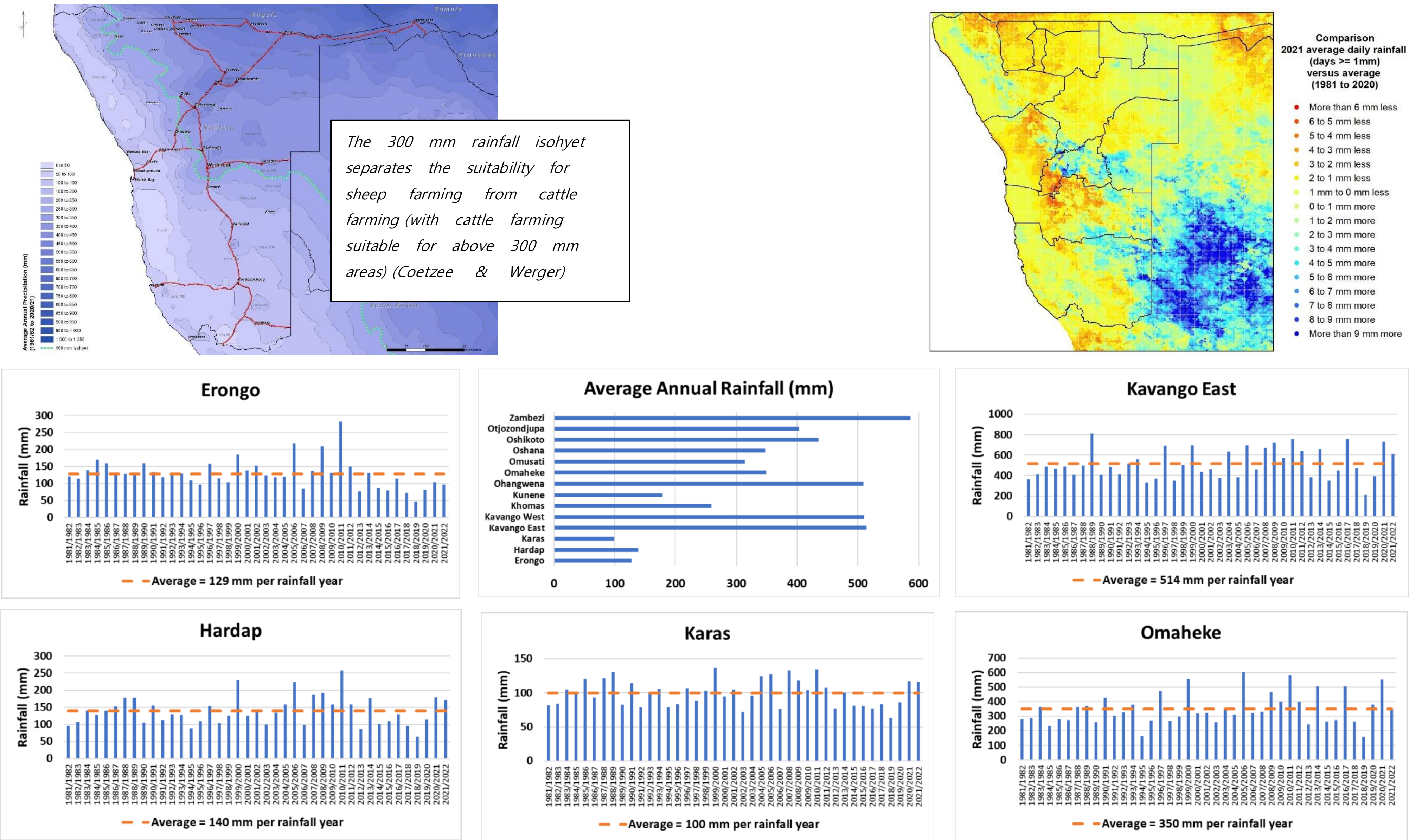


Figure 5: Average Annual Rainfall (mm) by Region, Source: SASSCAL 2022. Data Source: CHC Chirps 2.0

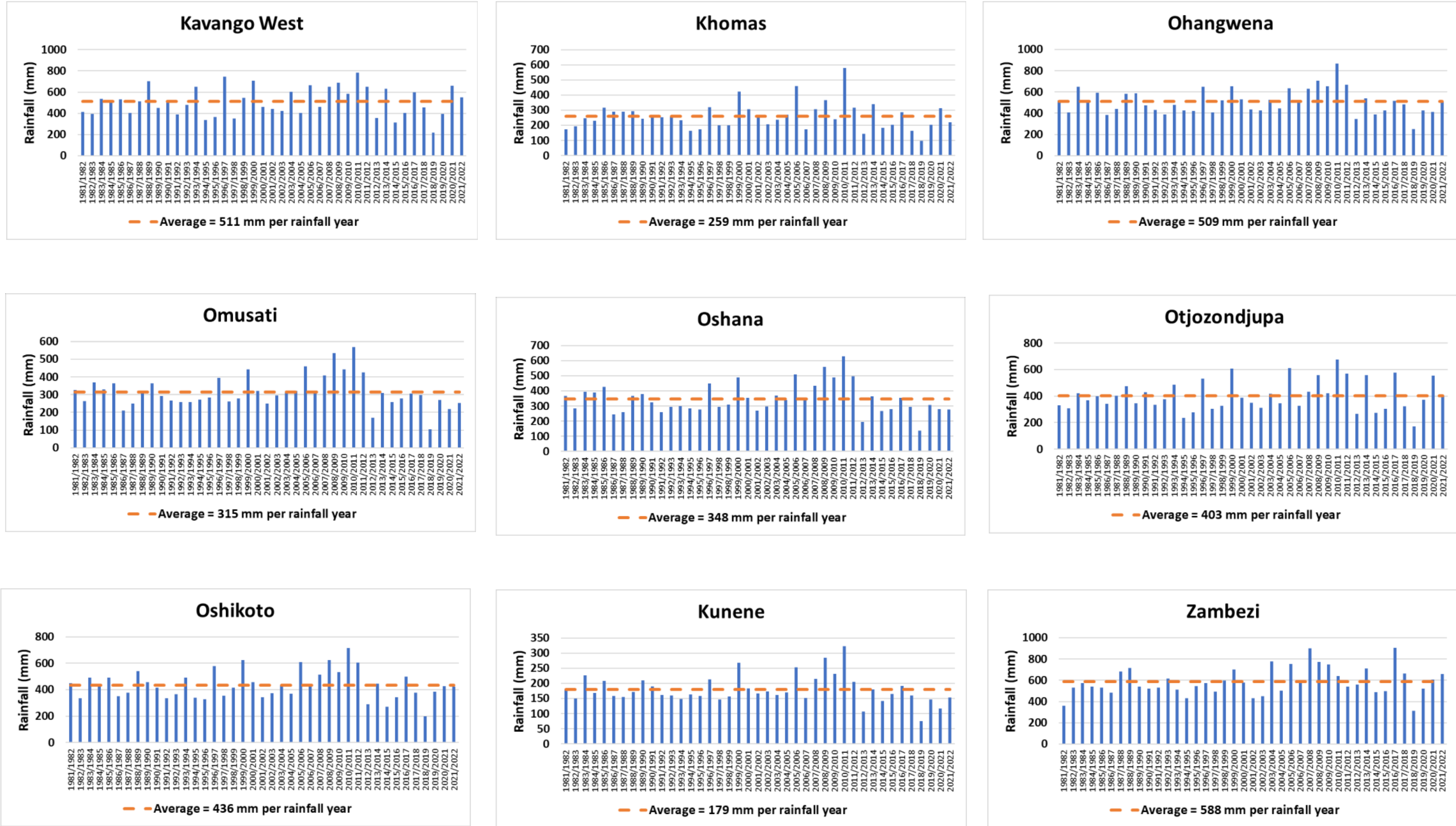
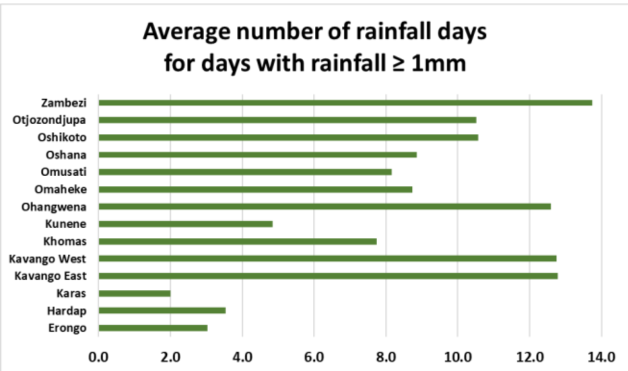
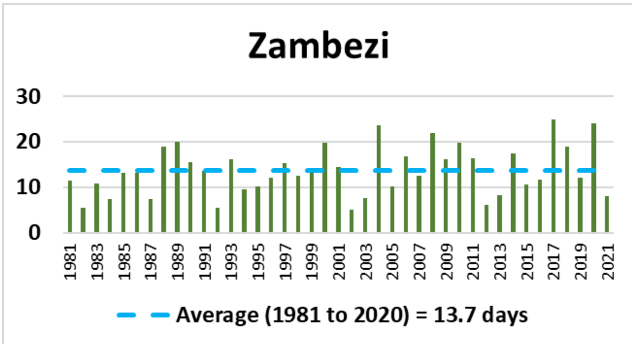


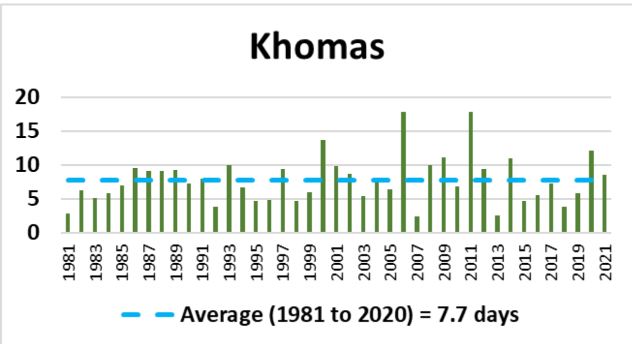
Figure 6: Average Annual Rainfall (mm) by Region, Source: SASSCAL 2022. Data Source: CHC Chirps 2.0

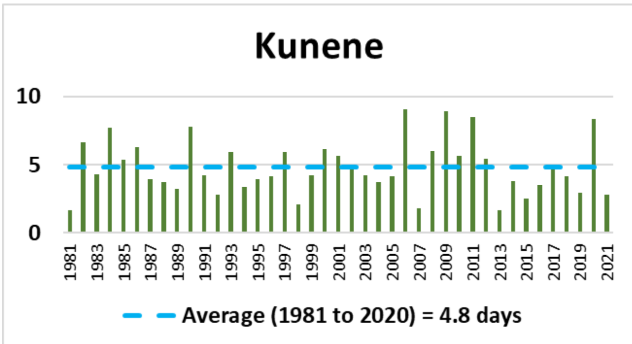
2.2 Climate Indices

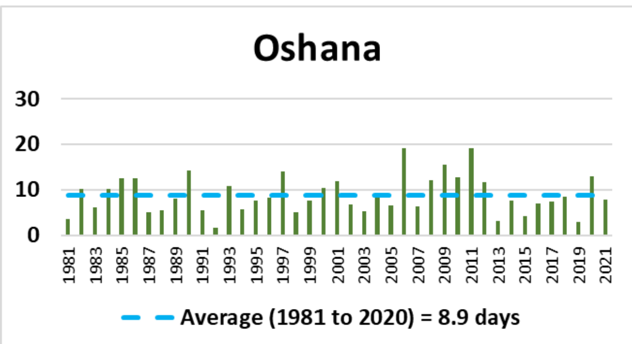
A lot of important information on a rainfall season is lost by just analyzing monthly or annual data. The monthly analysis, as well as the annual rainfall total, provide no insight on the rainfall frequency and pattern that are relevant to, amongst other, flood producing rainfall events, the creation of valuable pasture and crop production. To this end, the WMO proposes a number of climate indices, which include the SDII, the Simple Precipitation Intensity Index, that summarizes the number of rainfall days and average daily rainfall for rainfall days with more than or equal to 1 (one) mm of rainfall. It is clear from the regional graphs, that a high number of rainfall days does not imply "good" rainfall, if these didn't produce significant downpours (see fig 7 below).

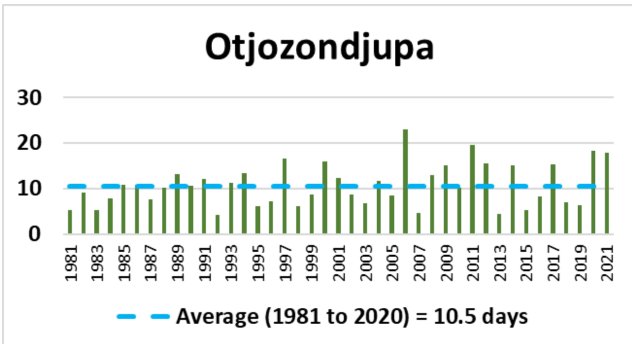












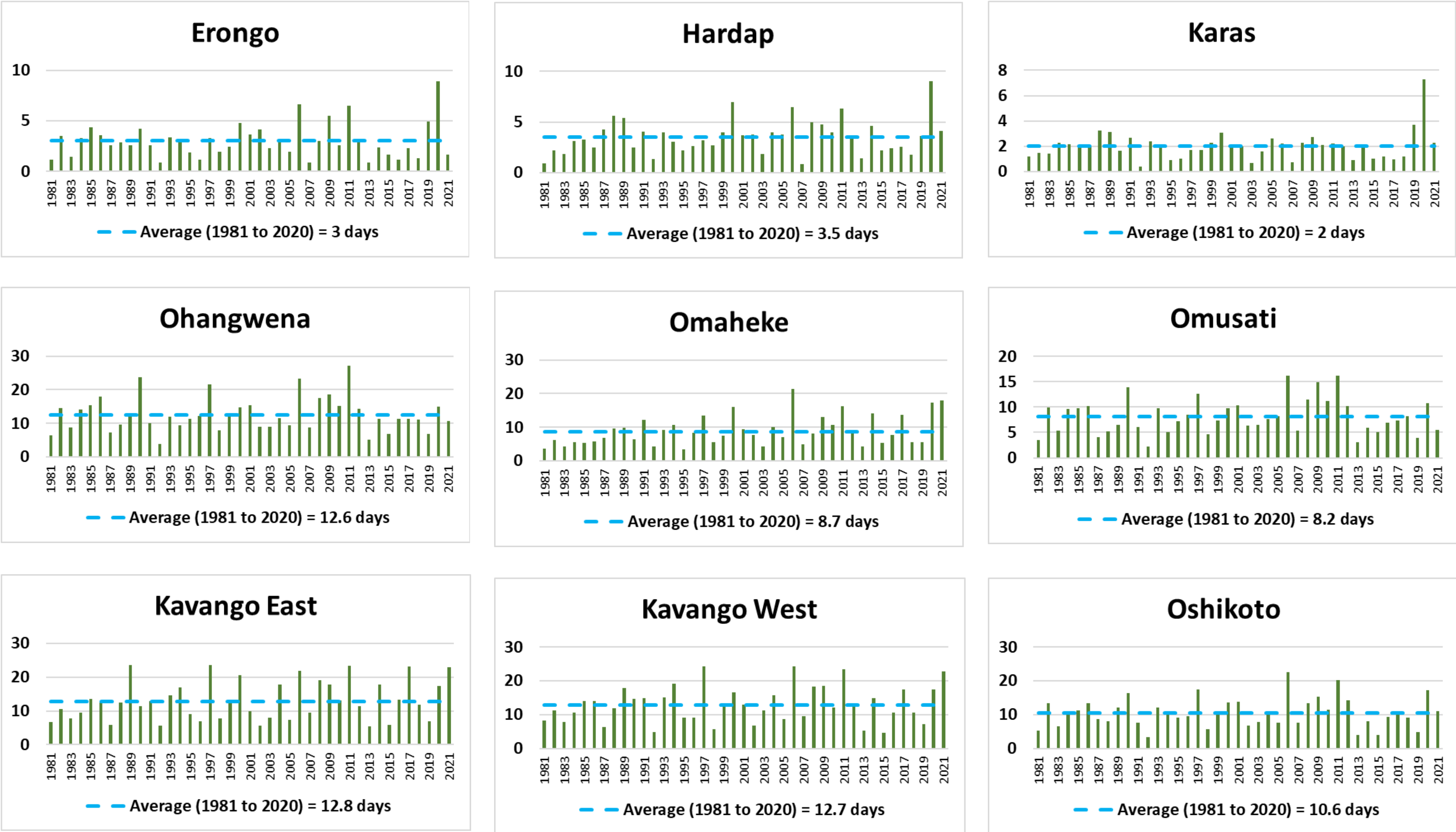


Figure 7: Average Number of Rainfall days for days with rainfall. Source: SASSCAL 2022. Data Source: CHC Chirps 2.0

2.3 Rainfall projection in Namibia

While rainfall trends in Namibia are highly variable, GERICS analysis indicates total precipitation rates are likely to reduce by as much as 19% by the 2080s (Dirkx et al., 2008). The largest decrease in projected rainfall is for the typical dry season, April to October, with likely reductions from 5% to as much as 65% (Cubasch et al., 2001). Meanwhile, the country's typical wet season, November to March, is expected to receive a small increase in precipitation (Zeidler et al., 2010). The greatest reduction for the interior of the country will occur from December to February. Other projections indicate that the Northern and central parts of the country where most of the population is found, may experience a decline in rainfall to a more significant degree than other parts of the country (Wilhelm, 2012) as presented in figure 8.

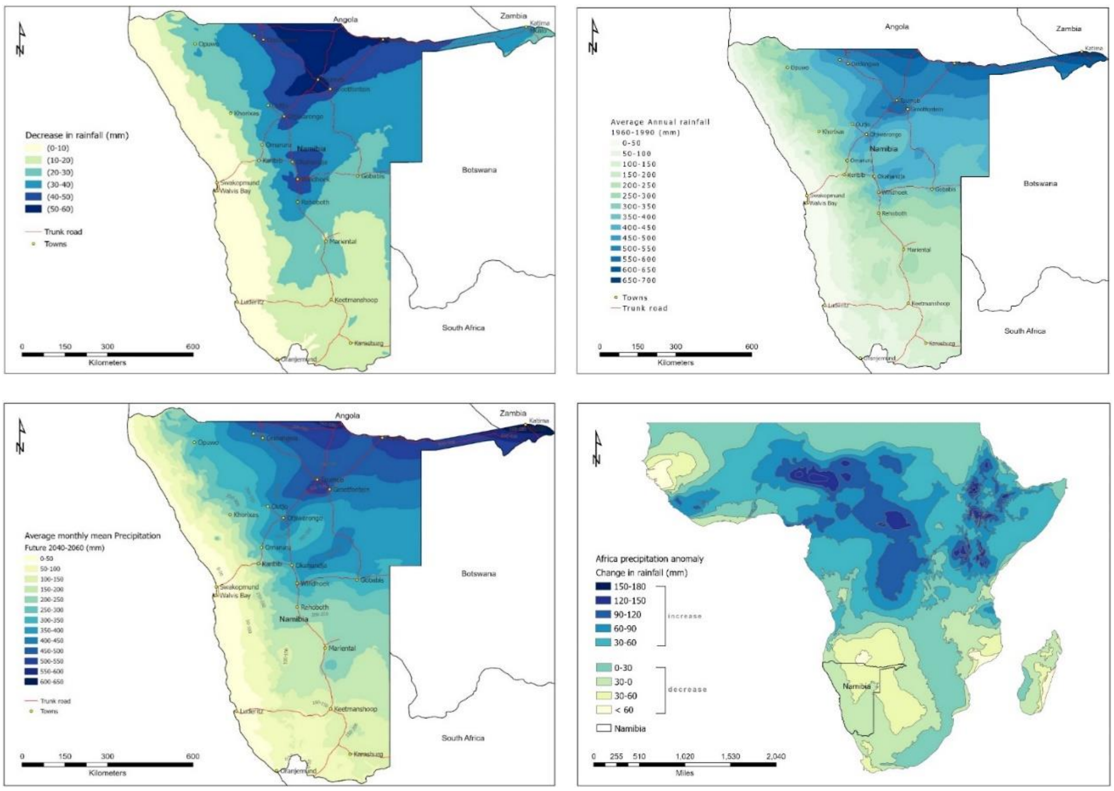


Figure 8: Projected changes in rainfall from 2040 to 2060. Data Source: Multi-Model (CMIP5) Ensemble Projected Changes (32 GCMs) in Precipitation by 2040–2059 (left), Relative to 1986–2005 Baseline under RCP8.5. (Source: SASSCAL 2022)

2.4 Daytime Land Surface Temperatures of Namibia 2021 and Historic (2001 to 2020)

Land Surface Temperature (LST) is the brightness temperature of land surface and is driven by solar radiation and related to air temperature. It translates into the temperature your hand would perceive if you lay it on the land surface. It is often used as an indicator for monitoring the state of crops and vegetation and assessing plant stress. Figures (9 and 10) below provide information on daytime land surface temperature in Namibia.

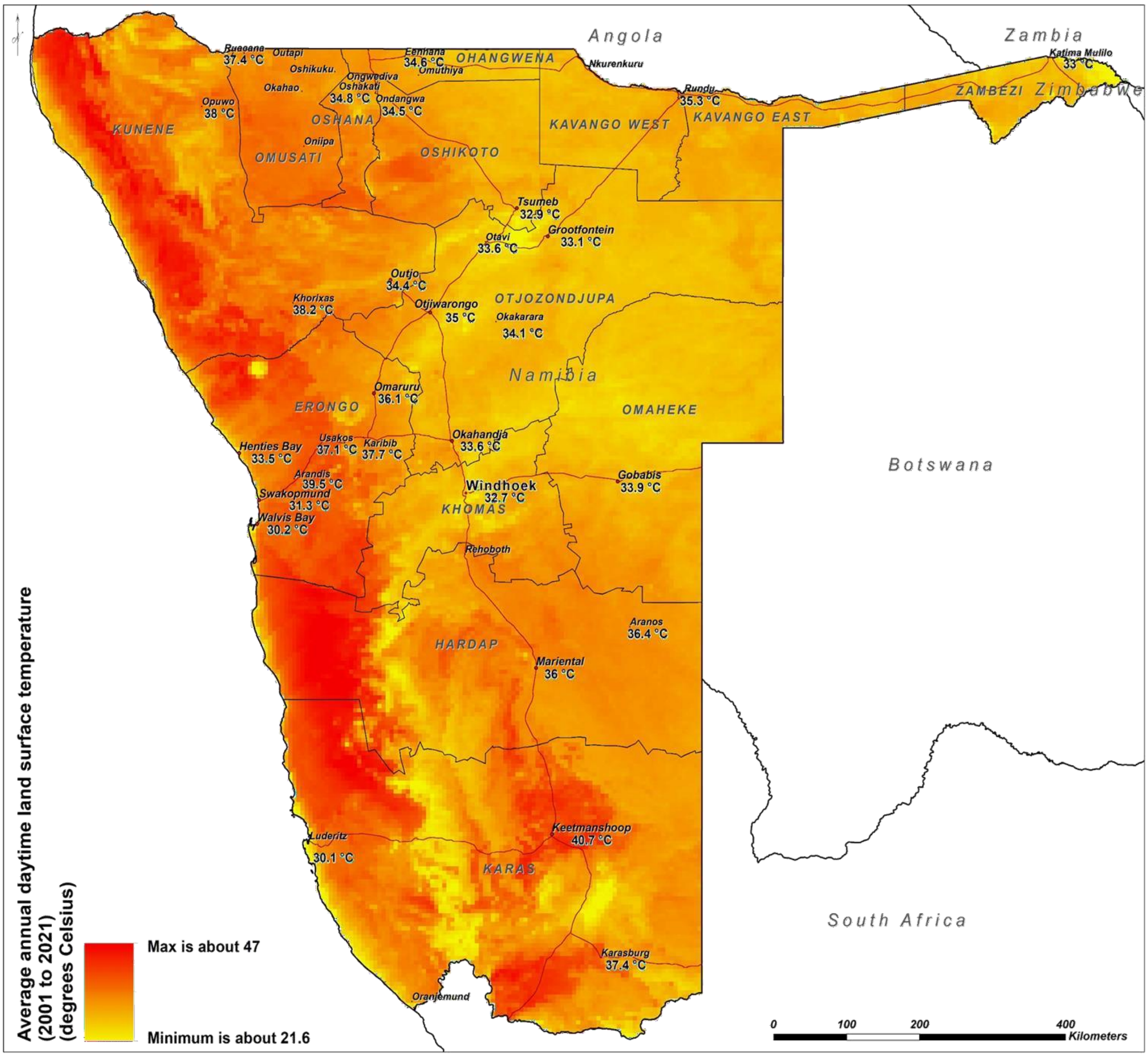


Figure 9: Average annual daytime land surface temperature. Source: (SASSCAL 2022). Data source: MODIS MOD11C3

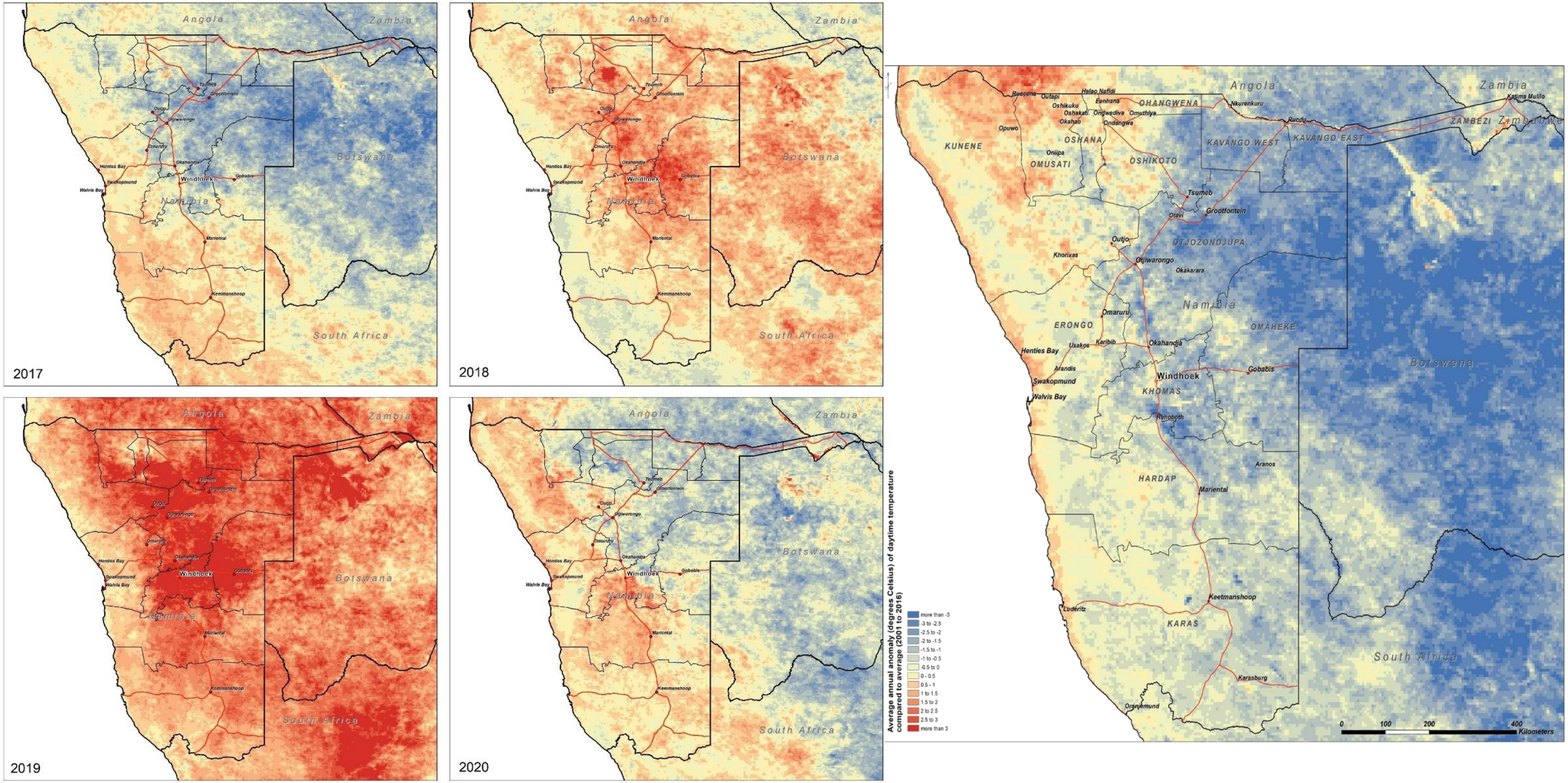


Figure 10: Average Annual Anomaly Daytime Land Surface Temperatures in Namibia. Source: SASSCAL 2022. Data Source: MODIS MOD11C3 Monthly Daytime Land Surface Temperature (2000 to 2021).

1

CHAPTER 3: INFORMATION WATER SOURCES IN NAMIBIA

Namibia has no perennial rivers within its borders (Dirkx et al., 2008). This makes the water availability situation direr, especially in the driest parts of the country. In addition to the ephemeral rivers and boreholes as the main water sources, providing 22% and 50% of Namibia's freshwater respectively, the only other source is perennial rivers which are at Namibia's borders with the neighbouring countries; and thus, Namibians cannot use these rivers as a source for large water extractions without the consent of the neighbours. This is because Namibia has international obligations regarding the abstraction of water from these rivers, as well as other uses. Instead of having a sustained surface flow, there are ephemeral rivers that feed the groundwater table, causing Namibia to have a wide range of aquifer containing groundwater with an overall national groundwater safe yield of 300 million m^3 /year (Iiyambo, 2010). However, groundwater resources in Namibia are vulnerable to over abstraction and pollution (Zeidler et al., 2010). High temperature that leads to high evaporation has been so far compromising the situation of water insecurity across the country. The shortage of water clearly calls for intervention by the relevant water authorities as well as action from all the consumers. In the quest to meet the needs through using available freshwater sources, it is important to consider the sustainability of the environment. It is, therefore, necessary that the sustainability of the water sources and their environments be well looked after for the provision of freshwater to continue in mining sector and others. For example, capturing of ephemeral surface water may affect downstream users as well as the natural environment (ecosystems) which leads to insufficient vegetation for livestock as well as little or no freshwater for groundwater recharge (Lendelvo et al., 2018). So far, one of the big consumers of water are the mines (KPMG Global Mining Institute, 2014). Due to international uranium prices that are going up, Namibia has offered prospecting and mining licences to a number of new mines that are expected to be commissioned in the near future with uranium increasingly being considered as a source for long-term clean energy; and this is largely motivated by the current debate on clean energy and climate change (Iiyambo, 2010). Additional mines will inevitably lead to an increase in demand for freshwater due to high demands for water for them to operate, placing huge stress on the few water resources available.

3.1 Mines and water in central-Namib

The main source of water in central Namib is groundwater and this is due to the fact that this part of Namibia receives less than 22 mm of rainfall per annum (Iiyambo, 2010). The groundwater reserves are recharged through rainfall which falls over 200 km away from the region, with some people in this region obtaining water from wells; which is done manually, while others obtain water from boreholes (Henschel et al., 1998). One of the direct impacts of low precipitation is limited supply of freshwater. Limited artificial recharge takes place but only during years with abnormally high rainfall, which is a rare occasion (Dirkx et al., 2008).

It has been observed that due to increasing mining activities in the region, the demand of water is needed for operations. The Central Namib Water Scheme, the system of water supply comprising of alluvial aquifers in two ephemeral rivers; namely the Kuiseb River and the Omaruru River have been so far providing water to the mines in the region (Henschel et al., 1998). Water in this area is administered by the Namibian water cooperation (NAMWATER). NAMWATER is a publicly administered institution which supplies bulk water; and it is one of the two institutions tasked with the responsibility of supplying water to the end users. Another institution called Rural Water Supply which falls under the Ministry of Agriculture Water and Land Reforms makes use of small-scale technology, as opposed to bulk water supply which uses "large-scale dams, transport, and storage technology", with their end users being mining companies, other industries, urban centres etc, and whose water is transferred over much longer distances. Figure 11 depicts the distribution ephemeral rivers, the main water sources in the area. The mines use the underground water of the Swakop and Khan Rivers due to its lack of salinity in comparison to the seawater. However, if this usage is not monitored properly, there are concerns that the rivers will be depleted due to mining activities (Henschel et al., 1998).

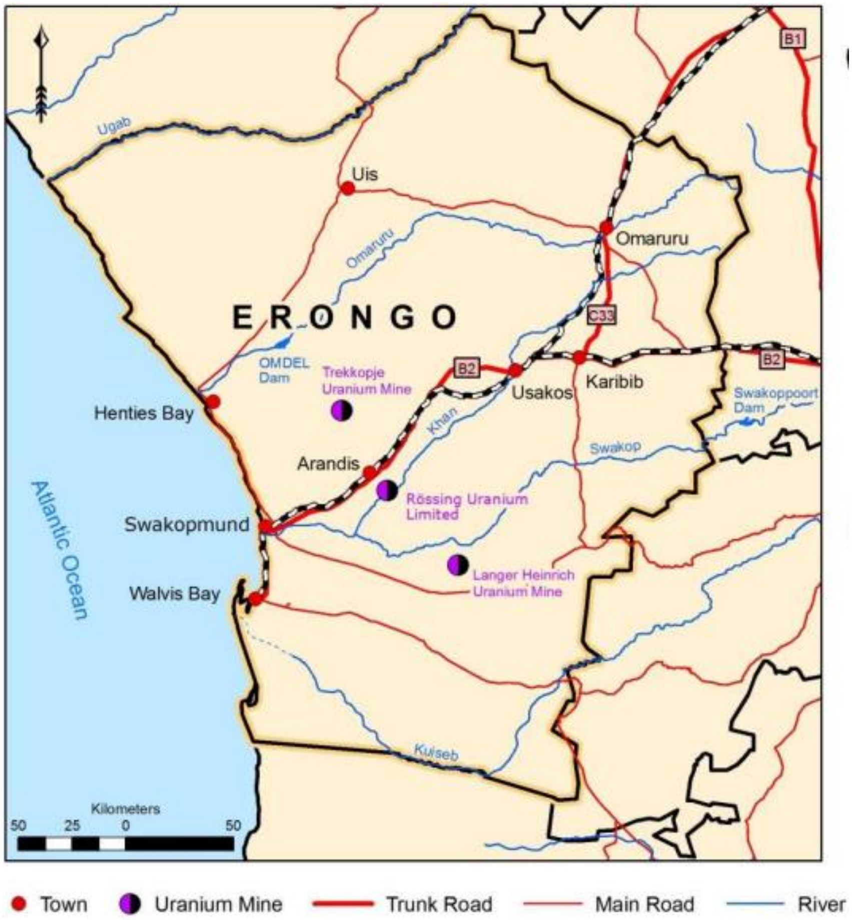


Figure 8: The Central Namib mines (Source: Iiyambo, 2010)

Despite the extraction of groundwater, there is still very high demand for water in this incredibly arid area. Mining operations use water mainly for cooling, underground procedures like hydraulic drills and processing including flotation and leaching. In addition, the mine requires adjacent supporting infrastructure such as housing and transport, which also requires water (Khawaji et al., 2008). Mines like uranium mine have built desalination plants to meet their demand such as the Trekkopje mine as it demands 25 million cubic meters per year. Water recycling includes the tailings storage facilities and recovery bore holes/trenches, and the treated effluent from the sewage treatment plant. Tailings at uranium mines are generally covered with water to keep the radon and radioactivity under control.

It is evident from Figure 12 that current water demand has exceeded supply of water predicted to 2030, under the scenario, where demand management and recycling are implemented.

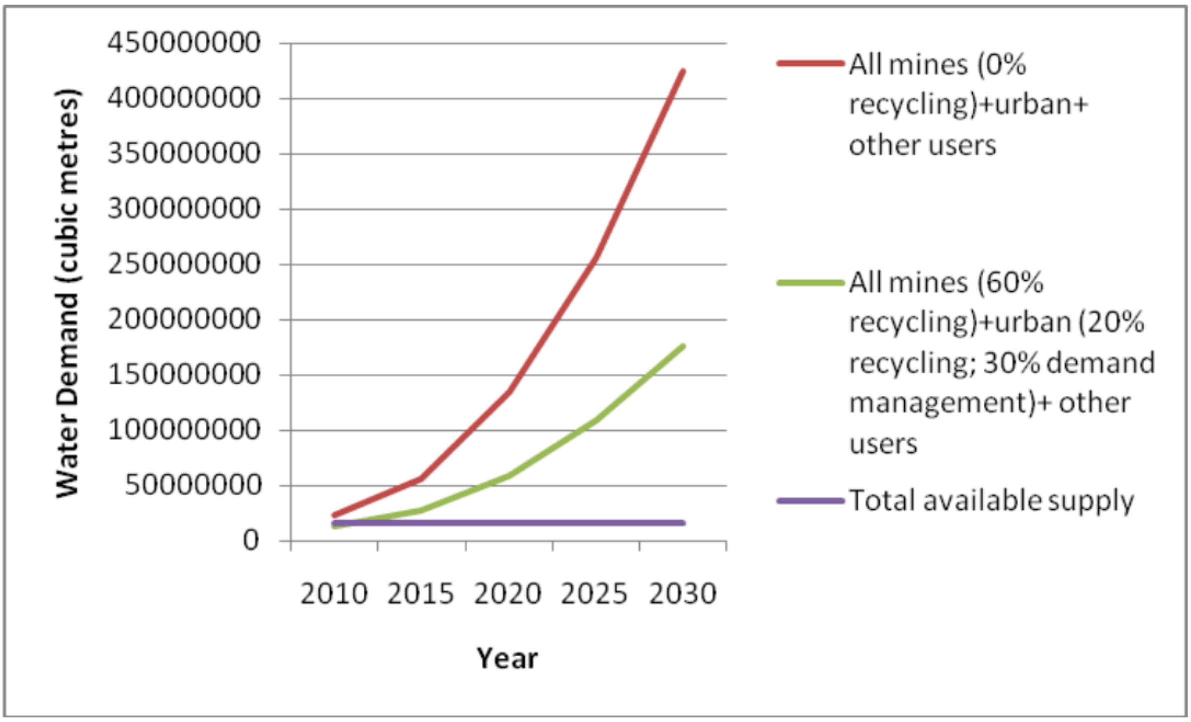


Figure 9: Total water demand versus total available supply in the Erongo Region (source: Iiyambo, 2010)

Since this region is so dry, there will be a need for alternative water sources if demand is to be met in the future. To secure sustainable water supply for the future; there is need to expand water use plans to reach many years in the future. Caution should be taken though with regards to making long-term projections because of the effects of variable environments as well as climate change.

One way of doing this is to align the countries development plans with the available freshwater resource and determine if the available resources will sufficiently cater for the socio-economic developments in the region. If the available freshwater resources are found to be insufficient, then the second step would be to explore alternatives for increasing supply which in this case more desalination plant for sea water.

3.2 Mines and water use in the north and central north of Namibia

Most of the mines in this area get their water from the Karst Aquifer sub-catchments in the vicinity of Grootfontein and Tsumeb. The Grootfontein, Tsumeb, Otavi and Karas area is endowed with large-scale high-quality groundwater resources that are extensively used for irrigation purposes and domestic use. In 2012, it was found that Tsumeb sub-catchments have a long-term sustainable safe yield of 18 million cubic metres per annum and the stored water in the aquifer is more than 800 million cubic metres (Krugmann & Alberts, 2012). However, the mines operating in the Karst area continue to compete for groundwater with irrigation activity. Krugmann and Alberts, 2012 reported that the mining industry was considered diligent when it comes to the management of water for industrial purposes. This diligence arises for several reasons such as large amounts of water required by the individual mines, high expenditure on fresh water supply, the need for precise inputs of water in the mining processes, proven financial benefits of alternatives such as recycling from the slime's dams and environmental obligations. Irrespective of this, it was also pointed out that water demand from mines will go high if not properly controlled due to climate change. Determining water withdrawals to meet demand for the mines is not straightforward. Water sources can include self-extracted water, distributed water, or reuse water, and sometimes water is abstracted from a combination of all three sources. In copper mining for example, water is fundamentally used as an input in the traditional flotation beneficiation process, in smelting and electro refining and, in the hydro-metallurgical process. However, every joint process or operation in mining requires a greater or lesser volume of water to contribute towards process efficiency.

3.3 Mines and water use in south-west Namibia

The common mine in south west Namibia is Namdeb Holdings of which 50% is owned by the Government of the Republic of Namibia and 50% by De Beers (Christina, 2006). Unlike other mines, the mines found in this part of the country such as Namdeb Holdings has long term mining concessions both on land and offshore, adjacent to the Orange River and offshore in the shallow waters. As such, water is not as problematic as other part of the country. However, the main challenges for mines in this area as documented by Victoria (2021) are changes in price, exchange rate factors and fuel are the biggest cost drivers and they place strain on the cash flow for the mines.

CHAPTER 4: POSSIBLE WAYS OF REACHING WATER DEMANDS IN MINING INDUSTRY

4.1 Recycling wastewater

Wastewater recycling is a viable alternative freshwater source for many water users. In addition to providing sanitation to urban inhabitants, wastewater systems are important because they allow for recycling which provides additional freshwater to urban dwellers and mines. However, when considering wastewater recycling it is important to consider both the economic as well as environmental dimensions (Tarrass et al., 2008). Some Namibian towns recycle wastewater, but only the capital city Windhoek recycles the wastewater to the quality of potable water, whilst the rest treat wastewater to a quality falling short of potable water quality and hence this water is only used for purposes such as landscape irrigation (AQUASTAT survey, 2015). Just like Windhoek which recycle up to 35% of potable water (du Pisani, 2006), likewise the mines can take up the challenge. Recycling does not only have the benefit of increasing available supply, but also the benefit to the environment by reducing the amount of waste that would otherwise be discharged into the natural environment. It is therefore at the best interest of mining companies to recycle wastewater to potable quality to meet water demand not only for operation but likewise for consumption.

4.2 Seawater desalination

More than 97% of water on earth is sea water, while freshwater constitutes only 2% of freshwater resources on earth, most of which is groundwater (Khawaji et al., 2008). Desalination is seen as a good solution to freshwater supply especially in arid Namibia. Due to increased population, better living standards as well as economic development, there is an urgent need for additional freshwater resources in many parts of the world (Khawaji, et al., 2008). Desalination is currently being used in all Arab countries (du Pisani, 2006), and is a source of freshwater to an estimated 75 million people across the world (Khawaji et al., 2008). Due to advances in technology, seawater desalination is not as expensive as it was in the past; and for this reason, more desalination plants can be utilised by mines in Namibia to meet water demand during their operations now and in the future.

4.3 Fog harvesting

According to Batisha (2003), fog is a feasible source of supplementary water supply in arid regions. Fog harvesting has proven a success in different parts of the world (Shanyengana et al., 2002). This makes water affordable to the rural poor and a cheap method of providing urban centres and industries. The quality of fog water is suitable for human consumption as well as other purposes including agriculture (Batisha, 2003). Parts of the coast of Namibia can go for long periods of time without recording any rainfall. This means fog harvesting could be a reliable supplementary source of water for areas such as these (along the Namibian coast), where its feasibility was first investigated in the year 1995 (Shanyengana et al., 2002).

In addition to low rainfall in coastal areas, fog occurs on up to 200 days per year and reaches distances of up 60 km inland and at the coast of Namibia, the amount of precipitation received from fog is said to be seven times higher than that received as rainfall (Leggett, 2006). The amount of water that can be collected, however, would mainly depend on three main factors, namely: fog bearing winds; the persistent occurrence of fog episodes and high fog occurrence. Also, the methods for collecting fog water are very ecological friendly, since it only uses water which is heading for the atmosphere and hardly deprives the ecosystems off freshwater (Shanyengana et al., 2002). It is therefore a challenge to mines especially those at the coast to exercise this technology which might be a solution to water scarcity.

CHAPTER 5: CONCLUSION

Namibia is a water stressed country with a limited amount of freshwater. Freshwater resources are under pressure from ore processing, industrialization, urbanization, and the demands of a growing population. In Namibia, ore processing, coupled with anticipated increase in water demand for human consumption and other uses, has created significant stress on the limited water resources of the country. Mining industries should therefore take very serious strategies of water recycling, reuse fog harvest as well as the minimization of losses. Mining industrial leaders should recognize that reducing the water footprint of mining activities must be one of the key performance indicators for management.

REFERENCES

AQUASTAT survey. (2015). Irrigation in Africa-Namibia. fao.org/nr/water/aquastat/countries/namibia/namibia_cp.pdf

Batisha, A. F. (2003). Fog collection as a complementary water resource in Egypt. Complementary Water Resource in Egypt. Seventh International Water Technology Conference IWTC7. Cairo, Egypt, 1–3.

Christina, M. (2006). *Environmental Impacts Of Prospecting And Mining In Namibian National Parks : Implications For Legislative Compliance (Issue April).*

Colin, C. (2010). *The Effect of Bush Encroachment on Groundwater Resources in Namibia: A Desk Top Study, Namibia Agriculture Union, Windhoek, Namibia.*

Cubasch, U., Meehl, G. A., Boer, G. J., Stouffer, R. J., Dix, M., Noda, A., Senior, C. A., Raper, S., Yap, K. S., A. Abe-Ouchi, Brinkop, S., Claussen, M., Collins, M., Evans, J., Flato, G., Fyfe, J. C., Ganopolski, A., Gregory, J. M., Hu, Z., … Zwiers, F. (2001). Chapter 9 - *Projections of Future Climate Change*. In Projections of Future Climate Change (pp. 525–582).

Dirkx, E., Hager, C., Tadross, M., Bethune, S., & Curtis, B. (2008). *Climate change vulnerability and adaptation assessment, Desert Research Foundation of Namibia and Climate Systems Analysis Group, Prepared for the Ministry of Environment and Tourism.*

du Pisani, P. L. (2006). Direct reclamation of potable water at Windhoek's Goreangab reclamation plant. *Desalination*, 188, 78–88.

Henschel, J., Mtuleni, V., Gruntkowski, N., Seely, M., & Shanyengana, S. E. (1998). *NAMFOG; Namibia Application of Fog-Collecting systems: Phase I: Evaluation of fog water harvesting.* https://doi.org/No.8, ISBN 99916-43-31-1

Iiyambo, I. (2010). *The implication of mining prospects on water demand and supply in the Erongo Region, Namibia* (Issue July). University of the Witwatersrand, South Africa.

IWRM Plan Joint Venture Namibia. (2010). *Integrated Water Resources Management Plan for Namibia. Ministry of Agriculture,* Water and Forest, Windhoek. http://www.iwrmnamibia.info.na/downloads/theme%02report-strategic-water-resources-assessm.pd

Khawaji, A. D., Kutubkhanah, I. K., & Wie, J. (2008). Advances in seawater desalination technologies. Desalination, 221, 47-69.

KPMG Global Mining Institute. (2014). *Namibia country mining guide.*

Krugmann, H., & Alberts, M. (2012). *Water use and demand in Namibia part of CORB.*

Leggett, K. E. A. (2006). Home range and seasonal movement of elephants in the Kunene Region, northwestern Namibia. *African Zoology*, 41(1), 17–36. https://doi.org/10.3377/1562-7020(2006)41[17:hrasmo]2.0.co;2

Lendelvo, S., Angula, M. N., Mogotsi, I., & Karl, A. (2018). Towards the Reduction of Vulnerabilities and Risks of Climate Change in the Community-Based Tourism, Namibia. *In Natural Hazards - Risk Assessment and Vulnerability Reduction* (pp. 88–103).

Musiyarira, H., Tesh, D., & Dzinomwa, G. (2017). An Analysis of Water Management Practices in Uranium Mines in Namibia. *International Journal of Georesources and Environment*, 3(4). https://doi.org/10.15273/ijge.2017.04.011

Noureldeen, N., Mao, K., Yuan, Z., Shen, X., Xu, T., & Qin, Z. (2020). Analysis of the Spatiotemporal Change in Land Surface Temperature for a Long-Term Sequence in. *Remote Sensing*, 12(488).

Rüttinger, L. (2016). *Climate change and mining*: A Foreign Policy Perspective. www.auswaertiges-amt.de

Shanyengana, E. S., Henschel, J. R., Seely, M. K., & Sanderson, R. D. (2002). Exploring fog as a supplement water source in Namibia. *Atmospheric Research*, 64, 251–259.

Tarrass, F., Benjelloun, M., & Benjelloun, O. (2008). Recycling wastewater after hemodialysis: An environmental analysis for alternative water sources in arid regions. *American Journal of Kidney Diseases*, 52(1), 154–158.

Victoria, N. (2021). *The Impact of Mining sector to the Namibia economy*.

Wilhelm, M. (2012). The impact of climate change in Namibia- a case study of Omusati region. *Ounongo Repository*, 1–101. http://ir.nust.na/handle/10628/381

World Bank Group. (2021). *Namibia Climate Risk Country Profile*. www.worldbank.org

Zeidler, J., Kandjinga, L., & David, A. (2010). *Study on the effects of Climate Change in the Cuvelai Etosha Basin and possible adaptation measures*.